

**AN ECONOMIC ANALYSIS OF LAND USE DYNAMICS IN
MAHARASHTRA**

By

Mr. Lembhe Jayesh Vasantao

(Reg. No. Ph.D./2017/40)

A Thesis submitted to the
**MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI – 413 722, DIST. AHILYANAGAR
MAHARASHTRA, INDIA**

in partial fulfillment of the requirements for the degree

of

DOCTOR OF PHILOSOPHY (AGRICULTURE)

in

AGRICULTURAL ECONOMICS



DEPARTMENT OF AGRICULTURAL ECONOMICS

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MAHARASHTRA, INDIA.**

2024

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institution
for a Degree or
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This is to certify that the thesis entitled, “**AN ECONOMIC ANALYSIS OF LAND USE DYNAMICS IN MAHARASHTRA**” submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri Dist. Ahilyanagar (M.S.) in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY (AGRICULTURE)** in **AGRICULTURAL ECONOMICS**, embodies the results of a piece of *bonafide* research work carried out by **Mr. LEMBHE JAYESH VASANTRAO**, under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Date : / /2024

(S. B. Kharbade)

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LIST OF ABBREVIATIONS

| | |
|-----------------|--------------------------------|
| % | : Per cent / Percentage |
| & | : And |
| / | : Per |
| Annon. | : Anonymous |
| H ₀ | : Null hypothesis |
| H ₁ | : Alternate hypothesis |
| e.g. | : Example gratia (For example) |
| <i>et al.</i> | : Et alia (other) |
| etc. | : Etcetera |
| G. | : Greater |
| ha | : Hectare |
| i.e. | : That is |
| Km. | : Kilometre |
| Km ² | : Kilometre square |
| Mha | : Million hectares |
| Mm. | : Millimetre |
| NGOs | : Non-Government Organisations |
| No. | : Number |
| P | : Provisional |
| SEZ | : Special Economic Zone |
| Sq. km. | : Square Kilometre |
| TE | : Triennium Ending |
| <i>viz.,</i> | : videlicet (Namely) |
| W. | : Western |

ABSTRACT

“AN ECONOMIC ANALYSIS OF LAND USE DYNAMICS IN MAHARASHTRA”

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Land, a vital natural resource, is indispensable for both agricultural and non-agricultural purposes. This includes establishing housing, industries, roads, parks, railway lines, and various commercial ventures. Development endeavors often require significant land allocation, raising concerns about potential encroachment on agricultural land, particularly fertile rural areas. Examining how land-use patterns evolve over time allows for deliberate and well-planned land management. In this context, this research delves into the “Economic Analysis of Land Use Dynamics in Maharashtra”.

The study was undertaken using data from secondary sources and the necessary districtwise and state level time series data on area under land use categories were compiled from various issues of Statistical Abstract of Maharashtra State and other publications of Government. The entire period of 1960-61 to 2016-17 was decomposed into three periods, *viz.*, Pre-liberalization, Post-liberalization and Overall Period. Temporal changes in land use patterns were estimated using several methods, including percentage change, compound growth rates, instability index, and location coefficients. Markov chain analysis was employed to examine the direction and magnitude 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 and crop diversification, a multiple regression model with a double log form was used. Finally, the annual rate of change was estimated to study both intra and inter-sectoral land use shifts.

Results revealed that, the temporal changes in land use dynamics of Maharashtra state, land put to non-agricultural uses, land under miscellaneous tree crops and groves, current fallow and fallow other than current fallow land showed an increase while, permanent pastures and other grazing lands, cultivable waste land, net area sown, area under forest and barren and unculturable land registered a decline during post-liberalization period over pre-liberalization period. Area under forest and net area sown have been increased by 8.62 and 1.02 per cent at the national level while in Maharashtra state, it was decreased by 2.23 and 2.75 per cent, respectively during post-liberalization.

At aggregate level of India, area under non-agricultural uses has increased by 36.52 per cent, while it has increased by 51.46 per cent in case of Maharashtra state during Period-II over Period-I, implying thereby almost one and a half times more increase in Maharashtra compared to that of India.

Apart from percentage change, growth rate analysis revealed that during Period-II, barren and uncultivable land, area under fallow other than current fallow, land under miscellaneous tree crops and groves, land put to non-agricultural uses and current fallow and in Maharashtra state as a whole, significantly increased, however, area under forest, net sown area, cultivable waste and permanent pastures and other grazing land significantly declined. The growth rates and instability for fallow land categories (fallow other than current fallow and current fallow) were found to be higher. As compared to Period-I, the few districts, mostly from Vidarbha and Marathwada region showed increasing growth rates of barren and uncultivable land during Period-II, which was the undesirable situation. During Period-II as well as Overall Period, more than half of the districts of Maharashtra registered a significant decline in area under permanent pastures and grazing lands, which is an alarming situation from ecological point of view and survival of the livestock in the state. During all the three periods, area sown more than once, net irrigated area and gross irrigated area significantly increased in Maharashtra state.

The spatial dynamics of current fallow land in Maharashtra proclaimed that the current fallow land was more concentrated in the Marathwada region of the state as compared to the other regions during all the periods. Also, Marathwada region was higher concentration in net area sown than other regions of Maharashtra. The concentration of net area sown in Marathwada region was inclining towards lower concentration in Period-II over Period-I. The concentration of barren and uncultivable land was gradually increased in Marathwada and Vidarbha regions of Maharashtra in Period-II over Period-I, which might be due to desertification of agricultural land as that land becomes uncultivable by means of scarcity of water. This is also intimating situation for agricultural production in these regions.

Markov chain analysis envisaged that the land put to non-agricultural uses was highly stable among all the land use categories with the retention of 98.95 per cent of its previous years' share while, barren and uncultivable land was most unstable with retention of 71.88 per cent of its previous years' share in Maharashtra. During Overall Period, net area sown was a major gainer among the different land use categories, which gain the mainly from barren and uncultivable land with the gain of 28.12 per cent share if its previous years'. Decreasing magnitude of retention in area under forest, land put to non-agricultural uses, permanent pastures and other grazing land and net area sown imply clearly the high competition for these land use categories with another, which is much concern for the policy makers.

The results of multiple regression analysis revealed that the area under forest was negatively and significant influenced by population density in Maharashtra during the period 1960-61 to 2016-17. As far as the barren and uncultivable land is concerned, it was negatively influenced by the net irrigated area and road length in the state. In respect of the area under fallow other than current fallow showed a significantly negative response to road length. During study period, the population density was observed negative impact on net area sown however, the extent of net irrigated area showed positive influence on the net area sown with the significant regression coefficient of 0.09 in Maharashtra state, which indicate crucial role of irrigation in the expanding area under crops. The regionwise study on factors responsible for change in land use pattern observed that the area under permanent pastures and other grazing land was negatively influenced by the population especially in Marathwada and Vidarbha regions.

Cropping intensity and crop diversification were influenced positively by changes area put to non-agricultural uses in Maharashtra state. Conversely, cultivable wasteland was showed significant and negative impact on cropping intensity and crop diversification. Except in some cases, it has been observed that almost in all the districts, regions and at the state level, changes in land use categories did not reflect considerable impact on cropping intensity and crop diversification in Maharashtra.

The results of ecological implications of land use dynamics in Maharashtra revealed that area shift under desirable ecology compared to undesirable ecology has not been favorable in Period-II, where land-use shift has been occurring from the desirable ecology towards either undesirable ecology and or non-agricultural sectors. Disaggregated inter-sectoral land use shift in Maharashtra implies that the area shifts under desirable ecology compared to undesirable ecology has not been found favorable across different districts.

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

1. INTRODUCTION

1.1 Preamble

Agriculture plays a noteworthy role in Indian economy and continues to be one of the most vibrant sectors ensuring food security to the country. The economic contribution of agriculture to India's GDP is steadily declining with the country's broad-based economic growth. Still, agriculture is demographically the broadest economic sector and plays a significant role in the overall socio-economic fabric of India and it continues to provide gainful employment and livelihood to majority of the population.

Primarily, agriculture is a land-based activity and as such, land and water are the crucial natural resources for any development activity. Consequently, access to land and control over its uses were the prime sources of conflict within and between communities throughout human history. The way people manage and use land resource is crucial to the social and economic well-being of peoples, as well as for its sustainability. Indian agriculture is undergoing technological transformation to ensure food security, export earnings and decentralized development to reduce rural poverty due to the increasing population pressure on the natural resource base of land, water, bio-diversity and other resources (Wani *et al.*, 2009).

Land continues to be a vital source of livelihood for a significant portion of population in rural India and it continues to be the basis for well-being of a large section of the rural poor. The highly skewed and fragmented distribution of land holdings makes it even more vital as an asset in the Indian countryside. Agriculture and other primary sector activities that are based on land continue to be the prime source of livelihood for a majority of the population.

Land and water resources and the way they are used are central to the challenge of improving food security across the world. Demographic pressures, climate change and the increased competition for land and water are likely to increase vulnerability to food insecurity, particularly in Asia and Africa. Providing sufficient food for everyone worldwide is the greater challenge now a day.

Land provides basic necessities like food, clothing and shelter to human being. Land has always been an important locus for the economic activity necessary for human life. Any developmental activity is nearly impossible to conceive without taking

land into consideration. The ability of land to provide space for production is limited by its physical and locational properties. Unlike goods, which can be moved around to where they are needed, land is immovable and cannot be physically passed by hand.

In India, rural population is still makes their living primarily from agriculture, depending directly on the land for their income, status and security. There is strong relationship between land, power and people. Human being cannot produce land and therefore the value of land is ever increasing.

Land use is highly a dynamic process. Land resources constitute the fundamental base for all human activities. It is the most important natural resource of a country like India where agricultural sector is relatively more prominent than the manufacturing sector. The way and the extent to which the land is utilized set the pace of a country's economic development. Land is important not only for producing foodstuffs, cereals, pulses and other crops for consumption but also for generating surpluses to meet increasing demands created by rising population and developing industrial sector, for laying down the transport network, communication, construction of dwellings and public institutions, etc. The pressure exerted by India's growing economy on land has intensified in the post liberalization phase in the pace of increasing demand for the conversion of agricultural land to non-agricultural uses. Large volumes of land are being acquired for various non-agricultural purposes like setting up of industrial parks and projects, roads, mining, SEZs etc. The last two decades have recorded a continuous change in the land use pattern. Such a pattern of land use shift has largely due to acquisition of agricultural and other fertile lands for industrial and other purposes. Pro-market economic reforms that began in the early 1990s also led to an increase in demand for rural land for infrastructure and industry including rapidly growing information technology sector in India. To meet this demand for land for the development of non-agricultural activities, it is a historical fact that the agricultural sector always sacrifices land. For the development of non-agricultural sectors, large chunks of land are acquired by the state or bought directly from the farmers by private entrepreneurs.

Another trend that has been observed is the changing cropping pattern. Land use has been continuously changing in relation to human needs and its capabilities. India is not only a large country but also a large populated country in the world. The level

of urbanization at the country as a whole increased from 27.7 per cent in 2001 to 31.1 per cent in 2011. An increase of 3.3 percentage points during 2001-11 compared to an increase of 2.1 percentage points during 1991-2001 (Bhagat, 2018). This clearly indicate that Indian urban population has been rapidly increasing in the recent years. Hence in urban areas, utilization of land is changing over time.

The challenge of natural resources management in India is evident from the fact that, an ever-increasing population put enormous demand on land resources, which are indispensable for a country like India with 2.4 per cent of the worlds' geographical area supporting over 16 per cent of the world's population. Further, the country has 0.5 per cent of the worlds grazing lands but has over 18 per cent of world's cattle population. The total wastelands area of the country was observed to be 55,766.55 thousand hectares in 2015-16, while it was 56,607.04 thousand hectares in 2008-09. This indicates a conversion of 840.49 thousand hectares of different wastelands categories in the country to non-wastelands during 2008- 09 to 2015-16. (Anonymous, 2023). However, the per capita availability of arable land in the country is only 0.15 ha, which is expected to come down to nearly 0.08 ha by 2025 (Chand and Raju, 2009).

1.2 Land

Land is the solid part of the celestial earth on which all the living beings survive. It includes the physical surface area and all the natural resources which are free gifts of nature as well as man-made resources which are the contributions of human beings. The natural resources include soil, natural water reservoirs such as rivers and oceans, hills and mountains, heat of sun and climate, forests and all the resources which are gifted by nature. The nature itself creates a natural cradle for human beings, but the beautiful cradle lasts forever with the full brightness when it is properly and honestly utilized in a truthful manner. Land, the survival platform for human beings is a distinguishable limited resource among the four factors of production which creates the base for every economic activity (Shijitha, 2021).

Land use is any kind of permanent or cyclic human intervention to satisfy human needs, either material or spiritual or both from the complex of natural and artificial resource, which together are called "land" (Vink, 1975).

Land is a basic input for agriculture and it occupies an important position among all the resources required for a modern economy (Ramasamy *et al.*, 2005). Like any other resource, it also has two dimensions *viz.*, quality and quantity; both of these are crucial components and are under serious threat due to their intensive and extensive use for agricultural and non-agricultural purposes.

The way people use land resources is decisive for their social and economic well-being as well as for the sustainability of land resources. The rapid pace of economic development along with population growth, urbanization and industrialization exerted tremendous pressure on the limited natural resource base in the country. This poses a serious challenge to researchers and policy makers to strike a balance in the use of natural resources, keeping in mind the need for conservation of sustainable development and livelihood security.

Land is a distinct limited resource which holds all human needs and activities. It provides three- fourth of the food needed for the people, timber, natural sources, urban agglomerations, corridors for transportation, recreation facilities and the base for energy sources. The land that is not used by human beings is covered by natural eco-systems which are helpful in controlling soil erosion, restricting pollutions, preserving quality and quantity of water. In precise, Land use refers to the expression of management of ecosystems in order to produce some of his needs (Karpagam, 1999).

Land is a finite natural national resource, efficient management of which is vital for the economic growth and development of the country. Land utilization or land use is basically and virtually an act played by the inhabitants of an area to meet their requirements. The land utilization is usually demand driven and is an adjustment or allocation of the finite land resource under agricultural and non-agricultural sectors. The way and the extent to which the land is utilized set the pace of a country's economic development. Land is important not only for producing food stuffs-cereals, pulses and other crops for consumption but also to generate surpluses to meet increasing demands of rising population. In developing industrial sector for laying down the transport network, communication, construction of dwellings and public institutions, planning its utilization for economic development and sustainable land use, options are kept as a priority for ecological reasons (Gairhe, 2011).

Land use surveys are of fundamental importance for land development planning only when all aspects of the present situation are known and further developmental plans can be made. While knowledge of current land use alone is not enough, it is, alongside an understanding of the land resources to be developed, a crucial prerequisite. Decisions on changes in land use should be made only after the present land use is investigated from all view points, including cultural, socio-economic and ecological conditions. These conditions often have also a direct bearing on the planning of land improvement, e.g., in soil conservation and land allotment projects. The ecological importance of existing land use obtains special attention in modern industrialized countries; the disturbance of existing cultural ecosystems, with a variety of habitats established through the ages of well adapted land use, has many serious ecological effects which have often been neglected in the past.

1.3 Land use pattern

The proportion of area under various types of uses denotes the term land use pattern, for example, the area under cultivation, forest land, fallow land, pasture land, area put to non-agricultural uses, barren land and so on. The land use pattern in an area depends upon the physical and environmental factors as well as pressure of population on land.

Land use pattern is a process which assigns each tract of land in an area to its proper class in a system of classes. The classes in the system are defined in terms of the qualities or characteristics with which the classification is concerned. The land use pattern of a country at any particular time is determined by the physical, economic and institutional framework taken together. In other words, the existing land use pattern at any point of time has been evolved as a result of the action and interaction of various factors such as the physical characteristics of land, the institutional framework, the structure of other resources such as capital, labour, etc., available land and the location of the region in relation to other aspects of economic development.

Dynamics in land use pattern is a complex phenomenon affected by several socio-economic, climatic conditions and institutional factors. Technological changes have also led to shift in land use pattern. Intensive cultivation, resulting in

changing marginal land into more productive agricultural lands through capital intensive cultivation, ignited by technological changes (Ramasamy *et al.*, 2005).

1.4 Land use classification

Till 1949-50, the land area in India was classified into five broad categories. Those categories were: (i) Forests, (ii) Area not available for cultivation, (iii) Other uncultivated land excluding the current fallows, (iv) Area under current fallows and (v) Net area sown.

This five-fold classification was however a very broad outline of land uses in the country and was not found adequate enough to meet the needs of agricultural planning in the country. The states were also finding it difficult to present comparable data according to this classification owing to the lack of uniformity in the definition and scope of classification covered by these five broad categories.

To remove the non-comparability and to break up the broad categories into smaller constituents for better comprehension, the Technical Committee on Co-ordination of Agricultural Statistics set up in 1948 by the Ministry of Food and Agriculture recommended the following nine-fold land use classification replacing the old five-fold classification and it also recommended to follow these standard concepts and definitions by all the states. The nine-fold classification of land is (i) Forests, (ii) Barren and uncultivable lands, (iii) Land put to non-agricultural uses, (iv) Permanent pastures and other grazing lands, (v) Cultivable wastes, (vi) Miscellaneous tree crops and groves not included in the net area sown, (vii) Current fallows, (viii) Fallows other than current fallow and (ix) Net area sown. The definitions of various terms and concepts used in the study are given in Appendix-I

1.5 Land use competition in India

India has the second largest population in the world but has scarce land resources. In 2011, India's population reached 121 crores, which is about 17 per cent of the world population while net sown area was about 140 million ha in 2012-13, about 0.12 hectare per capita and less than half of the world average of 0.23 hectare. This problem of limited availability of land has been compounded by growth in population, urbanization and diversion of productive agricultural land for non-agricultural purposes. During the last two decades, India's population has increased by about 18.4 crores, while

the total agricultural land has decreased by about 3.2 million hectares. According to the recent Land Use Statistics of the Ministry of Agriculture, Government of India, a total agricultural land of nearly 3.16 million hectares (1.5 lakh ha/year) was lost to other sectors in the years between Triennium Ending (TE) 1991-92 and (TE) 2012-13. On the other hand, area under non-agricultural uses has increased by over five million hectares (21.3 million ha to 26.4 million ha) during the same period. Considering the additional area added by reclamation and rehabilitation of culturable waste lands (about 2.4 million ha), it is estimated that a total net sown area of about 4 million hectares (1.8 lakh ha per year) has been lost during last two decades (Sharma, 2015).

1.6 National scenario

Land use pattern of India (1960-61 and 2019-20) is presented in Table 1.1 and Figure 1.1 and 1.2. India occupies 328 Mha area, country's growth in reported area for land use has increased from 298.46 Mha in 1960-61 to 306.54 Mha during 2019-20. Similarly, forest area has experienced increasing trend from 54.05 Mha to 71.75 Mha. As the share of forest area was 18.11 per cent in 1960-61, while it was increased to 23.41 per cent of total reported area in 2019-20. The land put to non-agricultural uses increased from 14.84 Mha (4.97%) to 27.78 Mha (9.06%) because of expanded area of urbanization. The barren and uncultivable land has favorably declined from 35.91 Mha (12.03 %) to 16.54 Mha (5.40 %) during the same period. Further, land under cultivable waste was declined from 19.21 Mha to 11.95 Mha, fallow land other than current fallow also declined from 11.64 Mha to 11.24 Mha. The percent share of cultivable waste and fallow land other than current fallow as well declined. Whereas, area under current fallow was increased from 11.18 Mha to 13.77 Mha and permanent pastures decreased substantially from 13.97 Mha (4.68%) in 1960-61 to 10.48 Mha (3.42%) in 2019-20. Similar trend was followed for land under miscellaneous trees crops and groves. It is important to note that net sown increased from 133.20 Mha to 139.90 Mha and it was rose from 44.63 per cent to 45.64 per cent of total reported area (Anonymous, 2019a and 2022a).

Table 1.1. Land use statistics of India

('000' ha)

| Sr. No. | Land use category | Year | | | |
|---------|--|---------|---------|-------------|---------|
| | | 1960-61 | | 2019-20 (P) | |
| | | Area | % Share | Area | % Share |
| 1 | Geographical area | 328726 | - | 328726 | - |
| 2 | Total reported area | 298458 | 100 | 306543 | 100.00 |
| 3 | Forest land | 54052 | 18.11 | 71751 | 23.41 |
| 4 | Barren and uncultivable land | 35911 | 12.03 | 16542 | 5.40 |
| 5 | Land put to non- agricultural uses | 14840 | 4.97 | 27777 | 9.06 |
| 6 | Permanent pastures and other grazing land | 13966 | 4.68 | 10480 | 3.42 |
| 7 | Land under miscellaneous tree crops and groves | 4459 | 1.49 | 3134 | 1.02 |
| 8 | Cultivable Waste land | 19212 | 6.44 | 11945 | 3.90 |
| 9 | Current fallow land | 11180 | 3.90 | 13770 | 4.49 |
| 10 | Fallow other than current fallow land | 11639 | 3.75 | 11242 | 3.67 |
| 11 | Net area sown | 133199 | 44.63 | 139902 | 45.64 |
| 12 | Area sown more than once | 19573 | 6.56 | 71456 | 23.31 |
| 13 | Gross cropped area | 152772 | 51.19 | 211359 | 68.95 |
| 14 | Agricultural land/Cultivable land | 179689 | 60.21 | 179993 | 58.72 |
| 15 | Cultivated land | 144838 | 48.53 | 153672 | 50.13 |
| 16 | Cropping intensity (%) | 114.69 | - | 151.08 | - |

(Source: Anon., 2019a and 2022a) (P-Provisional)

1.7 Maharashtra's scenario

Land use pattern of Maharashtra (1960-61 and 2019-20) is presented in Table 1.2 and Figure 1.3 and 1.4. Maharashtra State has noticed decline in reported area for land use from 30.759 Mha in 1960-61 to 30.758 Mha during 2019-20. Similarly, forest area has experienced declining trend from 5.41 Mha to 5.22 Mha. As the share of forest area was 17.57 per cent in 1960-61, while it was decreased to 16.98 per cent of total reported area in 2019-20 which might be due to deforestation and encroachment of forest area by local people. The barren and uncultivable land has unfavorably increased from 1.80 Mha (5.84%) to 1.88 Mha (6.12%) during the same period.

The land put to non-agricultural uses substantially increased from 0.70 Mha (2.28%) to 1.71 Mha (5.57%) because of expanded area of urbanization, industrial development etc. Further, land under cultivable waste was slightly increased from 0.93 Mha to 0.94 Mha merely, per cent share of cultivable waste increased from 3.03 to 3.04 per cent. Area under current fallow was increased from 1.20 Mha to 1.44 Mha during period of 59 years. On the other hand, fallow land other than current fallow declined from

1.218 Mha to 1.215 Mha with declined as little as from 3.96 to 3.95 per cent share to reporting area. Similar trend was followed in case of permanent pasture and other grazing land which was decreased from 1.44 Mha (4.68%) in 1960-61 to 1.35 Mha (4.40%) in 2019-20. The land under miscellaneous trees crops and groves occupied 0.19 Mha (0.60%) in 1960-61 and increased to 0.27 Mha (0.89%) in 2019-20. It is crucial note that net sown area decreased from 17.88 Mha to 16.72 Mha and it was falls from 58.12 per cent to 54.37 per cent of total reported area (Anonymous, 2019b, 2019c and 2022b).

Table 1.2. Land use statistics of Maharashtra

(‘000’ ha)

| Sr. No. | Land use category | Year | | | |
|---------|--|---------|---------|-------------|---------|
| | | 1960-61 | | 2019-20 (P) | |
| | | Area | % Share | Area | % Share |
| 1 | Geographical area | 30762 | - | 30758 | - |
| 2 | Total reported area | 30759 | 100.00 | 30758 | 100.00 |
| 3 | Forest land | 5411 | 17.59 | 5222 | 16.98 |
| 4 | Barren and uncultivable land | 1795 | 5.84 | 1882 | 6.12 |
| 5 | Land put to non- agricultural uses | 700 | 2.28 | 1712 | 5.57 |
| 6 | Permanent pastures and other grazing land | 1441 | 4.68 | 1353 | 4.40 |
| 7 | Land under miscellaneous tree crops and groves | 185 | 0.60 | 273 | 0.89 |
| 8 | Cultivable Waste land | 933 | 3.03 | 935 | 3.04 |
| 9 | Current fallow land | 1197 | 3.89 | 1444 | 4.69 |
| 10 | Fallow other than current fallow land | 1218 | 3.96 | 1215 | 3.95 |
| 11 | Net area sown | 17879 | 58.12 | 16722 | 54.37 |
| 12 | Area sown more than once | 945 | 3.07 | 6848 | 22.26 |
| 13 | Gross cropped area | 18823 | 61.19 | 23570 | 76.63 |
| 14 | Agricultural land/Cultivable land | 20489 | 66.61 | 20013 | 66.94 |
| 15 | Cultivated land | 19076 | 62.02 | 18502 | 59.06 |
| 16 | Cropping intensity (%) | 105.28 | - | 140.95 | - |

(Source: Anon., 2019b, 2019c and 2022b) (P-Provisional)

1.8 Rationale of land use shifting

Land continues to be a major source of power and symbol of wealth. In spite of the increasing competition for land and water resources in the state in the wake of industrial development and urban expansion, scientific land use plan is not in place, thus resulting in the coexistence of both over use and under use of this precious natural asset. Unless proper planning and management of land is done, it is difficult to achieve the sustainable development of State’s economy. Land use capacity varies overtime with changing spatial environmental and economic conditions. This necessitates the identification of land use capacity for alternative choice of land allocation among the

various uses. Since, the supply of land is fixed, use of land for one purpose is at the expense of the other and when huge investments are made on land for one purpose, it cannot be reverted back for other uses.

1.9 Research problem and its practical utility

With increasing urbanization, industrialization, human population with focus on 'Make in India' and need for creation of infrastructure such as roads, railways, irrigation, there is no doubt that these developments are continued to have impact on the Indian economy. One of the consequences is that these initiatives 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. The scarcity of land indicates the problem of choice of land and its uses. 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 economic analysis of land use dynamics in the land use pattern over a period of time provides scope for planned and judicious management of land. Rational management of land resources plays a crucial role in developing the national economy.

1.10 Importance of the study

Agriculture is dominant sector of Maharashtra's economy. Land enjoys the highest importance as a resource. Another important aspect of land is the rapid growth of population in some what stagnant economy puts tremendous pressure on land,

thereby adding scarcity value to a natural resource which is already in great demand. With the increase of population, use of land for non-farm and commercial activities as well as for housing and other purposes are increasing, thus gradually reducing the availability of cultivable land. This might create conflict between farmers and government and or with development agencies. The liberalization policy in 1991 adopted by India might have same effect on land use pattern in the country. Therefore, research study on land use dynamics in Maharashtra investigate the effect of liberalization on land use and also trend during the recent year on land use will help to suggest the scope for planned shifts in the pattern. A scientific study of land use dynamics is important for the formulation of agriculture development policies.

This is a first study of this kind in the state as little or no research attention has been paid to such a systematic study regarding land use dynamics in different districts and regions of Maharashtra. The present study aims to document the intra and inter-sectoral land use dynamics in Maharashtra during Pre and Post-Liberalization periods to examine the ecological implications of land use dynamics in Maharashtra.

A close study of the present land use pattern and the trends during recent years will help to suggest the scope for its planned shifts in the pattern. A scientific study of land use pattern is important for the formulation of appropriate land use options and agricultural development policies. The study of land use dynamics has a greater scope in the context of its use for agricultural production especially when agriculture forms a basic and primary sector of economy. An investigation reveals the direction and extent of its use and thereby guide the policy makers to make more advantageous sustainable long-term policy options more particularly towards agricultural uses. This study will also useful to the research workers and students working on this aspect hence, keeping these views in mind, the present study is undertaken with the following specific objectives,

1.11 Objectives

1. To study temporal changes in land use pattern in Maharashtra.
2. To find out nature and extent of structural variations 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 and crop diversification.
5. To analyze the ecological implications of land use dynamics in Maharashtra.

1.12 Hypotheses

The well-defined hypotheses are crucial because they acts as a guiding framework for the research process.

H₀ : There are no temporal changes in different land use categories.

H₁ : There are temporal changes in different land use categories.

H₀ : There are no structural variations in land use pattern.

H₁ : There are structural variations in land use pattern.

H₀ : Land use pattern does not influence by the number of factors.

H₁ : Land use pattern does influence by the number of factors.

H₀ : Cropping intensity and crop diversification does not change with changes in land use pattern.

H₁ : Cropping intensity and crop diversification does change with changes in land use pattern.

H₀ : There is no land shift from one ecological sub-sector to the other sectors.

H₁ : There is land shift from one ecological sub-sector to the other sectors.

1.13 Limitations of the study

Maharashtra is the third largest state of India in area formed on May 1, 1960 with initial 26 districts. Since then, 10 additional districts have been created, the most recent of which is Palghar district. The state currently has 36 districts. But, in order to maintain uniformity in analysis and due to ease of interpretation, study was confined to 26 districts only by considering the limitation of data of newly formed districts. The data of these newly formed districts were merged in its original districts for easy analysis and interpretation.

1.14 Presentation of the study

The research study is presented in six chapters. The first chapter of introduction deals with preamble, importance of land and its use pattern, land use classification, national and state scenario of land use dynamics, rational of land use shifting, research problems and its practical utility, importance of study, objectives, hypotheses and limitations of the study.

The second chapter is concerned with the review of relevant past literature available related to the objectives of study. The overview of study area, nature and

sources of data used, tools and techniques used for data analysis as per the objectives and various concepts used in the present study is explained in third chapter of methodology.

The fourth chapter of results and discussion explains the results of data analysis, their interpretation and outcomes of the results. The summary of main findings along with its policy implications have been presented in fifth chapter i.e. summary and conclusions. The last chapter (sixth) of literature cited includes the list of books, journals and other sources of information used for the study.

2. REVIEW OF LITERATURE

A review of past studies helps in identifying the conceptual and methodological issues relevant to the present study. This chapter attempts a brief review of the relevant past research outcome that has accumulated on the areas related to this study. Keeping in view the objectives of the study, the reviews so collected by author are presented under the following sub-headings.

- 2.1 Temporal changes in land use pattern.
- 2.2 Structural variation in land use pattern.
- 2.3 Factors responsible for temporal changes in land use pattern.
- 2.4 Impact of changes in land use pattern.
- 2.5 Ecological implications of land use dynamics.

2.1 Temporal changes in land use pattern

Singh (1990) analyzed the land use pattern in the problematic areas of all the five agro climatic regions of Uttar Pradesh, during the year 1988-89. The study revealed that, the hill region had the highest area under forest, permanent pastures, grazing land, tree crops and groves, non-cultivable waste lands and land under non-agricultural uses. The area sown more than once and the total cropped area, as well as the intensity of cropping had been found to be the highest in the eastern region and lowest in the hill region. He concluded that the slopes of the hilly areas of Uttar Pradesh could be successfully developed for the plantation of temperate fruits.

Ratna (1991) studied the trends of under-utilization of land in the districts of Andhra Pradesh for a period of 33 years from 1955-56 to 1987-88. The study showed that the underutilized lands included current fallows, other fallows, cultivable waste and grazing and pasture lands. The analysis suggested that under-utilization of land was associated with irrigation, tractors, commercialization and such other factors. Such under-utilization was attributed to the inability of the farmers to adjust to higher demand for resources. He concluded that land utilization largely depended on the availability of resources with the farmers and the nature of investment in relation with the expected returns.

Sravanthi (1991) investigated the land use pattern in Andhra Pradesh. The consequences of spatial and temporal analysis revealed that at the state level, area under

forest, land put to non-agricultural uses, miscellaneous trees and groves, current and other fallows, gross cropped area showed an increase over time while barren and uncultivated land, cultivable wastes, permanent pastures and grazing lands and net area sown had a declining trend.

Nagabhushan (1994) studied the dynamics of land use in Dharwad district of Karnataka from 1970 to 1991 for a period of 22 years. The study revealed that the growth rates of area under forests, land put to non-agricultural uses, current fallow, net area sown, total cropped area and area sown more than once were significant and positive. He opined that the improvement in the management practices was the main reason for the increase in area sown more than once. The growth rates were significant and negative for all remaining land use categories.

Goswami *et al.* (2001) studied the land use dynamics of Maharashtra for a period of 20 years (1976-77 to 1996-97). Results indicated that the land put to non-agricultural uses increases from 3.16 per cent in 1976-77 to 4.06 per cent in 1996-97, whereas permanent pasture and grazing land recorded slight decline by 0.77 per cent of the reported area as against 8 per cent increase in the cattle population. This may be due to shortage of fodder which has already been emerged as a serious problem in many other states of the country. Net area sown also maintained gradual decline up to 1996-97 followed by marginal increase during 1996-97. Area sown more than once, increased substantially during 1996-97. Area under a fallow and current fallow showed highest degree of variations. The study, however, does not indicate any significant change in overall land use types as evidenced by correlation studies.

Ramaswamy *et al.* (2005) examined the dynamics of land use pattern with special reference to fallow lands in Tamil Nadu and they noticed that area under cultivable waste, uncultivable waste and barren land were declined significantly while there was a sharp increase in the land put into non-agricultural uses. They also observed that, there was significant reduction in the area under common lands mainly because of diversion of these lands for non-agricultural purposes. Disturbing trend of land use pattern was noted in Tamil Nadu and it was sharp increase in other fallows took place during the last two decades probably due to instability of the area under total fallow lands surpassed 20 lakh ha during the last two decades. The location coefficients were

estimated to study the spatial dynamics of current fallow lands over the last 30 years across different districts of Tamil Nadu. The location coefficients for other fallow lands indicate that the other fallow lands were more concentrated in relatively dry and drought-prone regions of the state. The districts belong to these regions of state are predominantly tanked irrigated areas with very little area under wells, which are relatively more stable source of water supply. The sharp decrease in location coefficient in those districts has recorded steep increase in area under private well irrigation. The districts with high rainfall and industrially less progressive have very low concentration of other fallow lands. Apart from Tiruchirappalli district, the economically poorer districts such as Tirunelveli, Ramanathapuram and Pudukkottai have witnessed an increasing concentration of common lands thus leading scope for redistribution of common lands to poor people so as to put them under effective use.

Dharshan Singh (2006) studied the land use pattern and its implication in Haryana agriculture. The data pertaining the year 1966-1967 to 2003-2004 were obtained from the secondary sources to examine the decadal change in land use pattern to analyse the actual increase or decrease in the area under different categories of land. It was noticed that forest area was increased (14.28%) in between 1966-67 to 1976-77 but the area under barren and uncultivable land was favorable for ecological balance. The net sown area in 1966-67 to 1975-76 increased to 23.04% in zone-1 while the area under barren and unculturable land has substantially decreased i.e. by (-84.37%) during 1966-67 to 1975-76 in Zone-III as compared to zone-I and Zone-II.

Goswami and Challa (2006) studied the land use scenario in Meghalaya for the period from 1987-88 to 1998-99. The results found that area under current fallows increased to 11.61 per cent whereas, the area other than current fallows declined by 6.74 per cent during the study period. Net area sown registered an increase of 11.58 per cent during the same period.

Takle *et al.* (2007) examined dynamics of land use pattern in Maharashtra for 30 year's period from 1970 – 71 to 1999 – 2000. The study showed that the land use pattern of Maharashtra was dominated by different crops (57.34%) followed by area under forest and fallow land (7.67%). Regarding temporal changes in different land use

categories, it was observed that, the proportionate area in each decade under different categories was remain more or less same with meager changes in each decade.

Aravind (2010) examined the land use and cropping pattern in Northern transitional zone of Karnataka. The percentage changes in the land use pattern between two periods were calculated using the data for the first period from 1977-78 to 1990-91 (pre-liberalization period) and for the second period from 1991-92 to 2006-07 (post-liberalization period). Results showed that, there was decrease in area under barren and uncultivable land, cultivable waste and permanent pasture by 3.09, 6.51 and 0.17 per cent, respectively. The area under current fallow and fallow other than current fallow exhibited a sharp rise over the time. He also estimated the growth rates for area under different land use categories, which showed a significant positive growth in area under forest, land put to non-agriculture use, permanent pastures, net area sown and total cropped area in Period-I (1977-78 to 1990-91). The land under miscellaneous tree crops and groves registered positive and significant growth in Period-II (1991-92 to 2006-07). During overall period, land under miscellaneous tree crops has shown significant positive growth, while area under permanent pastures and other grazing land has shown significant but negative growth.

Bardhan and Tewari (2010) investigated the state-wise distribution of different categories of land use in India at two periods of time, viz., T.E. 1992-93 and T.E. 2005-06. The study reveals that, the area under forests as a percentage of the total reporting area was increased from 22.35 to 22.84 per cent at national level. In Maharashtra state, the share of land area under forest has declined since 1992-93. Within the agricultural sector, net sown area (NSA) accounts for the largest share (46%) of total reporting area at all-India level. There was no change in the share of NSA during the period 1992-93 to 2005-06 at national level. However, the proportion of NSA has registered a decline in several states during the period, most noticeably in Tamil Nadu and Orissa, where the share of NSA decreased from 43 per cent and 41 per cent in 1992-93 to 38 per cent and 37 per cent in 2005-06, respectively. Maharashtra also declined shares of NAS by 1.66 per cent during the study period of 1992-93 to 2005-06.

Seethalakshmi (2010) examined the shifting of land use patterns in Andhra Pradesh. Analysis of data related to land put to non-agricultural purposes and current

fallows for the period 1990-91 and 2007-08 in the state revealed that the extent of area under both categories has been steadily increasing over time. However, land under permanent pastures has been coming down from 8.42 lakh hectares in 1990-91 to 5.71 lakh hectares in 2007-08 (-32%). She analysed the data related to net sown area indicated a negative or declining growth rate of 2.4 per cent for the period while there has been only a marginal increase of 2.8 per cent in the total cropped area. The area sown more than once revealed a growth rate of 29 per cent for the 18-year period at the State level which indicated expansion in irrigation infrastructure, private investments in bore wells etc. during the period.

Gairhe *et al.* (2011) studied land use dynamics in Karnataka based on the secondary data. The growth rate analysis revealed that miscellaneous tree crops, cultivable wastes and barren and uncultivated land declined while, land put to non-agricultural uses, fallows other than current fallow, area sown more than once and net irrigated area showed positive growth rate. Highest instability index was found in case of current fallows, followed by area sown more than once, fallows other than current fallow, permanent pastures and the least growth was observed in area under forest during overall period (1980-81 to 2007-08).

Singh (2012) examined the structural changes in land utilization pattern and shifting of area among different land use classes in India. Decadal changes in the share of land use classes and land use ecological groups estimated for the period 1950-51 to 2006-07. The results indicated that the share of area under non-agricultural uses has increased significantly, while area under barren land, waste land and miscellaneous trees class has declined during entire period of study. The share of net sown area drastically increased during pre-green revolution period (1950-51 to 1967-68) from 41 to 45 per cent to reported area for land utilization, but showed a constant share of about 46 per cent since green revolution period. The share of land under non-agricultural uses has increased by about three times during entire period of study.

Swain *et al.* (2012) in their study in the state of Gujarat agriculture found that during the last two decades, net area sown has grown from 93 lakh hectares (1990-91) to 103 lakh hectares (2009-10). Comparatively, the gross cropped area in the state has fluctuated a lot during the period of 1990-91 to 2009-10. It has increased from 105.8 lakh

hectares in 1990-91 to 121.1 lakh hectares in 2007-08. Thereafter, it declined continuously to the level of 111.4 lakh hectares in 2009-10. Interestingly, the land put to non-agricultural uses has not increased during last two decades. In fact, the share of non-agricultural area has declined from 6.0 per cent in 1990-91 to 5.4 per cent in 2009-10.

Bhat (2013) examined the agricultural land use pattern in Pulwama district of Kashmir Valley. The results revealed that the total forest area of the Pulwama district decreased from 732 hectares in 1990-91 to 661 hectares in 2000-01 and 412 hectares in 2010 – 2011. Similarly, area not available for cultivation (barren and uncultivable land and land put to non-agricultural uses) decreased from 1990-91 (14015 hectares) to 2000-01 (12037 hectares) and in 2010-11 (8387 hectares). Contrary to this, the area under other uncultivated land excluding fallow land increased from 15534 to 18005 hectares during the period 1990-91 to 2000-01, but it registered a drastic decrease of 40.73 per cent due to separation of Shopian from the Pulwama district. Due to adoption of new agricultural technology in Pulwama district, there has been major decline in fallow land, during the year 1990-91 (8206 hectares) to 2010-11 (6707 hectares). If we put a glance over the net sown area which were 57005 hectares (1990-91) decreased to 53229 hectares (2000-01) and the area sown more than once increased from 26828 hectares (1990-91) to 30907 hectares (2000-01), net irrigated area from 35372 hectares (1990-91) to 35770 hectares (2000-01) and gross irrigated area from 58092 hectares (1990-91) to 58142 hectares (2001). But at the same time, the areas under these categories have declined over the last decade *i.e.* 2000-01 to 2010-2011, to the tune of 21177, 5955, 14487 and 19684 hectares, respectively.

Gharke *et al.* (2013) analysed the levels of agricultural development in Maharashtra. The study revealed that the linear and compound growth rates of area under forest increased significantly in Period-I (1990-91 to 1999-2000) but in Period-II (2000-01 to 2009-10) and Period-III (1990-91 to 2009-10), it remained non-significant. Similarly, the area under barren and uncultivable land increased significantly in Period-III but in Period-I and Period-II, it remained non-significant. It was also found that the land under non-agricultural use increased significantly in Period-II and Period-III. Though the land under permanent pasture, during Period-I and III increased at the rate of 2.09, 0.46 and 2.07, 0.48 per cent in respect of linear and compound growth rates,

respectively; in Period-II, both showed a non-significant trend. On the contrary, land under miscellaneous trees and grooves showed negatively significant linear growth at the rate of 2.99, 0.98 per cent in Period-I and III, and positively significant compound growth rate of 1.46 per cent was noticed in Period-III while it remained non-significant in Period-II under both the growth rates. The total trend in net sown area was negatively significant during 1990-91 to 2009-10. Despite a decrease in growth rate in net sown area, the gross cropped area in Maharashtra state increased significantly by linear and compound growth rates of 0.23 (non-significant), 0.17, 0.42 and 0.24, 0.17, 0.42 per cent in Period-I, II and III, respectively.

Karande and Khadke (2013) examined the relationship of population and land utilization in the Maharashtra state during the period 1970-71 to 2009-10. The population, density of population and urbanization are increased in the state. This has affected the decrease of forest (0.7%), net area sown (2.7%), permanent pasture and grazing land (0.4%) and increase of the land under non-agriculture use (2.5%), cultivable waste land (0.7%), fallow land (0.6%) and area sown more than once (13.1%). The percentage of small size of land holders increased from 13.8 to 23.1 per cent and large size land holders decreased from 1.9 to 0.05 per cent. However, per capita availability of forest and agriculture land decreased from 0.11 to 0.046 hectare and 0.38 to 0.20 hectare, respectively during the study period in the state.

Premakumara and Seema (2013) analysed the agricultural land use pattern in India and Karnataka. The study was based on data collected from secondary sources. The study gave a brief explanation on the aspects responsible for declining of agricultural land in the present years. Furthermore, they revealed that the net sown area has increased from 54.49 per cent to 55.22 per cent in Karnataka and decreased from 46.90 per cent to 46.27 per cent in India during 1990-91 to 2010-11.

Shah *et al.* (2013) studied land use and cropping pattern dynamics being experienced in district Budgam, which is located in central part of Kashmir valley and is mostly dominated by agriculture occupation. The study was based on data mainly of secondary sources. A multi-temporal analysis was carried out in order to analyze the extent as well as direction of change. The study revealed that an increase of about 628 hectares has been found in non-agricultural land in Chadoora tehsil which may mainly

because of the construction of houses, markets, roads, complexes *etc.* due to increase in population. However, the district of Budgam as a whole has showed a decrease of 781 hectares. Among the tehsils, Beerwah has shown a decrease of about 50.58 hectares in barren and uncultivated land while Budgam tehsil showed an increase of about 637.79 hectares. The net sown area of Budgam district has decreased from 53398 hectares in 1987-88 to 46576 hectares in 2010-11, resulting into the decrease of about 3822 hectares (4.91 %). Net area sown is directly proportional to the availability of irrigation. The overall decrease in net sown area was observed mainly because, the people of Budgam have now shifted to secondary and tertiary activities which in turn resulted into less interest towards the primary sector, particularly by the young generation. The change was mainly because of shifting to horticultural activities which are economically more beneficial and also due to increasing pressure of population.

Thorat *et al.* (2013) studied the shift in land-use classes in the Konkan region of Maharashtra using secondary data for the period 1981-82 to 2010-11. Growth and instability in land-use classes have also been studied. The land under non-agricultural use, miscellaneous trees, current fallows and net sown area has registered a significant growth, while, area under barren and uncultivable land, cultivable waste and permanent pasture has declined significantly during the period under study. The instability indices have revealed that area under miscellaneous trees, current fallows and other fallows was instable. The transition probabilities matrix has shown that forest, barren and uncultivable land and net sown area are more stable than other land-use classes. The land put to non-agricultural use retained 36.9 per cent of its previous share, while net sown area retained 86.7 per cent of its original share. The transition probabilities matrix has revealed that area under undesirable sector is more instable as compared to other ecological sectors in this region. The study has observed that the shift in area from agricultural to non-agricultural uses, particularly in Thane and Raigad districts is not a healthy sign.

Ashrit (2014) studied temporal and spatial variation of land usage pattern in the selected states and All India level during 1990-91 to 2010-11. Most of the selected States showed a declining trend for land usage under the category of culturable waste land. Maharashtra state as a whole as well as All India has declined culturable waste land by 4.8 and 15.6 per cent during aforesaid period, respectively. Though there is a small

increase under current fallow lands at All India level (3.1%), Odisha by 63.7 per cent, Kerala by 92 per cent and Maharashtra (52%) showed a higher increase during study period. Net area sown in the country has decreased during 1990-91 to 2010-11 to the tune of 0.9 per cent at All India level with highest decline in Jharkhand State (38.7%) followed by Orisha (25.7%), Tamil Nadu (11.2%), Kerala (7.8%), Himachal Pradesh (7.4%) and Maharashtra (6.2%). The results of the study revealed that the states like, Maharashtra and Chhattisgarh showed a marginal increase in forest cover along with increase in total cropped area. The state of Jharkhand showed a decline in forest cover which needs to be investigated further, also shows the same pattern as Chhattisgarh.

Geetika Rathee (2014) studied the trends for land-use in India for 58 years from 1950-51 to 2008-09. She revealed that, as country evolves economically, more land was diverted to non-agricultural uses. For the last two decades, urbanization has become priority in the country's development strategy, which in part resulted in greater than average decadal increase in land area under non-agricultural activities. The percentage of land area under non-agricultural uses increased from 3.3 per cent in 1950-51 to 8.6 per cent in 2008-09. During the same period, barren and non-arable land declined from 13 to 5.5 per cent. Arable land area had ever-increasing trend except for the last two decades resulting in its decline from 66.7 per cent in 1950-51 to 59.7 per cent in 2008-09. The arable land area decline has made the direction of land-use change an interesting exercise. In order to bolster the argument that current policy focus prioritizing urbanization has partially resulted in a greater increase in land area under non-agricultural activities that has immediate bearing on arable land area.

Kar (2014) studied agricultural land use in arid Western Rajasthan. The results of the study revealed that the intra-zonal variations in land uses were more conspicuous in Agro-climatic Zone (ACZ)-II where land available for cultivation varied from 17 per cent in Jaisalmer district to 84 per cent in Jodhpur district. Bikaner and Barmer districts have 60 per cent and 77 per cent area, respectively, under this category. Jaisalmer district has 67.2 per cent of its area under culturable waste, followed by Bikaner (25.6%), Barmer (7.7%) and Jodhpur (0.5%) districts. When compared with situation during the three-year period *i.e.* 1981-82 to 1983-84, a sharp decline in 'wastelands' by 5 to 9 per cent was noticed in ACZ-I and ACZ-II. Surprisingly, the net

sown area has also declined in ACZ-I, where irrigated crop lands were dominant, whereas other zones have registered 1 to 6 per cent increase. Area sown more than once has increased by 20.1 per cent in ACZ-I (mostly due to expanding canal irrigation during *rabi* season), followed by 9.5 per cent in ACZ-III (due to well irrigation) and by 4.4 per cent in ACZ-II (due to canal and well irrigation) and 4.0 per cent in ACZ-IV (due to tank irrigation and well irrigation).

Musande (2014) studied the changes in land use pattern in Marathwada region of Maharashtra. He pointed out that about 0.03 to 0.75 per cent negative change in forest area was experienced in Jalana, Nanded and Hingoli districts during the period of investigation. The area under forest decreased due to the cutting of trees in the above-mentioned districts. About 0.53 to 1.39 per cent negative change in area not available for cultivation was experienced in Hingoli, Nanded and Jalana districts, whereas 0.27 to 2.7 per cent positive change in area not available for cultivation was experienced in Osmanabad, Beed, Parbhani, Aurangabad and Latur districts during the period of investigation (1981-82 to 1985-86 and 2004-05 to 2009-10). About 0.32 to 3.00 per cent negative change in other uncultivable land was noticed in Aurangabad, Nanded, Parbhani, Beed and Hingoli districts and 0.83 to 2.57 per cent positive change in other uncultivable land was experienced in Jalana, Osmanabad and Latur districts during the period under study. Negative change in fallow land was noticed only in Beed district (-3.9%), while, 1.49 to 10.00 per cent positive change in fallow land was found in Parbhani, Latur, Nanded, Aurangabad, Jalana, Hingoli and Osmanabad districts. Current fallow land increased in seven districts due insufficient rainfall, lowering of groundwater table, poverty of farmers, lack of perennial and protective irrigation facilities.

Anandan *et al.* (2015) studied the spatio-temporal changes in land use in Chittur taluk of Palakkad district in Kerala state. The results of the study revealed that except non-agricultural land use and barren and uncultivable land, all other land uses decreased between 2001 and 2011. A remarkable increase under non-agricultural use was registered in the panchayats of Vadavannur, Puthunagaram, Nalleppilly, Koduvayur, Pallassana, Perumatty, Ayalur and Nemmara panchayats. The plain area with well agricultural development favoured more developmental activities in these areas, which led to sizable increase in area under non-agricultural uses. A slight increase under barren

and uncultivable land was noticed in the taluk mainly in irrigated areas of the taluk. The decline in area under other categories of land use is resulted mainly due to the expansion of residential areas and transport and communication networks.

Baba *et al.* (2015) examined dynamics in land-use shifts, changes in agricultural land use and its intensity in relation with urbanization and other socio-economic variables. The land under permanent pastures and miscellaneous tree crops significantly contributed to the village economy and ecology and was quite vulnerable to demand for non-agricultural uses. Hence, the declining trends in both of these land-use classes need to be checked. It is distressing to note that culturable waste areas have shown a declining trend since 1970-71. It has fallen to 135 thousand hectares in 2011-12 with some fluctuations, thereby showing a decline of 15000 hectares. The total land under other uncultivated land use class has declined by 69 thousand hectares between 1970-71 and 2011-12, with compound growth rate of (-) 0.38 per cent. The decline in these land-use classes is in consonance with the increase in the area under cultivation and barren and unculturable land. On the other hand, fallow land has increased by 17 thousand hectares though current fallows have declined. The net sown area has shown an increase of about 43 thousand hectares between 1970-71 and 2011-12, however, there was paralytic growth since 2000-01 in the state and Kashmir province in particular.

Mouzam *et al.* (2015) studied the dynamics of shift among different land-use classes and cropping pattern in the state of Andhra Pradesh. The results of study documented that though the area under utilization remaining same, there have been marked changes in the area allocation for different land use categories during the period under consideration. A declining trend has been observed in the area under forests. If depletion of forest resources continues, it will result into poor economic returns from agriculture to local people. The unfavourable increasing trends in the area put to non-agricultural uses are likely to have serious implications on ecological balance. The decreasing trend has been observed under barren and uncultivable land. This indicates that the area for cultivation has increased in Andhra Pradesh. While the net sown area showed decreasing trend, the area sown more than once has an increasing trend. This indicates that there is intensive use of agriculture land for production in the state.

Sharma (2015) studied the dynamics of land use competition in India. The share of barren and unculturable waste lands has declined from 13.1 per cent of total reporting area in TE 1952-53 to 5.6 per cent in TE 2011-12. The evidence showed that agricultural land conversion has become a serious issue in the country but the extent and intensity varied across different states. Between triennium ending TE 1991-92 and TE 2011-12, net sown area in the country declined by about 1.8 Mha. The highest loss in net sown area was recorded in Odisha (1.71 Mha), followed by Bihar (1.24 Mha) and Maharashtra (0.76 Mha). However, total cropped area in the country witnessed an increasing trend during this period. For example, total cropped area increased from 183.4 Mha in TE 1991-92 to 187.2 Mha in TE 2001-02 and reached about 194.9 Mha in TE 2011-12, an increase of about 5.4 per cent between 1991 and 2011. The rate of increase in total cropped area was higher (3.53%) during the 2000s compared with 1990s (2.1%) mainly due to increase in area under irrigation. The net irrigated area increased from 48.2 Mha in TE 1991-92 to 63.6 Mha in TE 2011-12, an increase of 24.2 per cent. The gross irrigated area increased from 63.6 Mha to 88.4 Mha during the same period. The enhanced coverage of irrigation has led to increase in cropping intensity from 128.9 per cent in early-1990s to 138 per cent in TE 2011-12. It is however puzzling to note that gross irrigated area increased by over 25 Mha between TE 1991-92 and TE 2011-12 but total cropped area increased by only 10.4 Mha. Area under non-agricultural uses increased from 21.3 Mha in TE 1991-92 to 26.3 Mha in TE 2011-12 and almost all states witnessed an increase in area under non-agricultural uses. India has lost about 1.9 Mha of pastures and grazing lands during the last decade. Himachal Pradesh lost close to 1.01 Mha of pastures and grazing lands, followed by Madhya Pradesh (0.72 Mha), Chhattisgarh (0.44 Mha), Maharashtra (0.36 Mha) and Andhra Pradesh (0.19 Mha).

Premakumara and Vinothkanna (2015) analysed the spatio-temporal variations in different type of land use in Palakkad District, Kerala during 2001 and 2011. The analysis of the general land use pattern and its changes reveals that area under forest, barren uncultivable land, tree crops and grazing lands decreased in most of the blocks. An increase in land under cultivable waste and fallow lands observed in the district. Area under cultivation increased in 9 blocks and decreased in 4 blocks during this period of the study in Palakkad district.

Suryawanshi *et al.* (2016) studied temporal land use and cropping pattern in Amravati district of Maharashtra state. They reported that the land under current fallow contributed the highest positive but non-significant growth rate of 3.61 per cent in Achalpur tehsil. The negative growth rate was observed in Chandur Bazar (2.01%) and Bhatkuli (1.72%). The area under current fallow of Amravati district was 0.70 per cent, which was positive and significant at 5 per cent level of significance. Other fallow land includes all land which were cultivated earlier and were temporarily unsown for a period of not less than one year and not more than five years. The fallow land other than current fallow reported to have negative growth in Chandur Bazar (3.04%) and Bhatkuli (0.88%) tehsils. The positive growth rate observed in Achalpur tehsil (6.23 per cent), which was significant at 5 per cent level of significance. The district as a whole observed positive growth with 3.29 per cent per annum. In majority of tehsils of Amravati district, the growth rates were estimated for area under different land use categories. There was a positive and significant growth in area under current fallow, while net sown area registered a significant negative growth.

Sinha *et al.* (2017) studied the changes in land use pattern in Bihar. The results of agro-climatic zone-wise analysis revealed that net sown area has reduced sharply in Zone-III as compared to Zone-I and Zone-II. Further, net sown area for the state as a whole has also shown a declining trend, which might be due to increase in the categories of land such as area under non-agricultural uses, area put to trees and groves and area under current fallow in the state. The pressure of rising population on land has led to shift of cropped land towards the categories of non-agricultural uses. The scarcity of irrigation water, labour, *etc.* might be the probable cause for shift of land to tree crops and current fallows. From the above study, it is also revealed that between triennium ending (TE) 1991-92 and TE 2011-12, net sown area in the country declined by about 1.8 Mha but it increased in some states, *e.g.* Rajasthan and Gujarat. Gujarat is the only state which had been able to add about 0.3 Mha to its total agricultural land during last two decades. At national level and almost all states witnessed an increase in area under non-agricultural uses.

Ahmad *et al.* (2018) conducted a study on secondary data of land use pattern at the district and state level in Bihar for the period 1970-71 to 2012-13. The

study revealed that marginal increase in forest land from 6.32 to 6.64 % has been noticed in first four decades i.e. 1970s, 1980s, 1990s and 2000s, after that it was almost constant; the rise in forest land in earlier decades. Other categories of lands such as barren land, culturable waste land and permanent pastures and grazing land have shown decreasing trend. The decreasing trend in these types of land may be on account of fast rise in area under non-agricultural uses, area under tree crops and groves as well as area under fallow lands. Construction of buildings, institutions and set up of factories on large scale are responsible for shift of land towards non-agricultural uses, as this category registered an increase over decades i.e. 11.77 per cent in 1970s to 17.85 per cent in the recent decade (2003-13). In other words, almost 5 per cent growth in non-agricultural lands has been observed, most probably due to developmental activities such as industrialization, infrastructures (road) and dwelling houses for shelter of ever rising population. Land under miscellaneous tree crops and groves revealed rising trend. Decreasing trend in other fallow lands and net sown area has also been noticed. Current fallows declined since 1970s to 2000s, however the striking feature is that it began to rise since 2000s and afterwards. They were also estimated location coefficients for the examination of the spatial dynamics of current fallow lands over the last 32 years across the different districts of the state. The results of this analysis indicated that there has been a sharp increase in the concentration of current fallow lands in Gaya, Patna, Purnea, Munger, Jehanabad and Kishanganj districts and so on, this may probably be due to erratic rainfall and decline in water table in these areas. On the other hand, there has been a reduction in concentration of fallow lands in the districts such as Rohtas, West Champaran, Bhojpur, Saharsa, Madhubani, Muzaffarpur, Katihar, Araria, Sitamarhi, Siwan, Madhepura and Khagaria and so on; where ground water irrigation facilities have improved.

Amale and Shiyani (2018) undertaken a study to assess the trend of land use dynamics in different regions of Gujarat. The study was carried out by using data from secondary sources and the necessary data at the state level were compiled for the period from 1970-71 to 2014-15. The trend of land use pattern was examined with the compound growth rates and instability indices for different land use categories. During Period-II (1991-92 to 2014-15), permanent pastures and other grazing, land put to non-agricultural use and net area sown in Gujarat state as a whole 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.

Amale *et al.* (2018) made an attempt to study the temporal and spatial changes in land use categories based on secondary data on land use for the period from 1970–71 to 2014–15. The results revealed that the share of barren and un-culturable lands at all India level has declined from 7.10 per cent of total reporting area in Period-I (1970-71 to 1990-91) to 5.57 per cent in Period-II (1991-92 to 2014-15), while in case of Gujarat state, it slightly declined from 13.95 to 13.69 per cent of total reporting area in the same period. 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 these two periods, implying thereby almost three times more increase in India compared to that of Gujarat. Permanent pastures and other grazing lands have declined by 12.86 per cent at national level which indicates gradual conversion of permanent pastures and other grazing lands. In Gujarat state also, it has declined, but it is marginal as compared to national level. The area under cultivable waste declined by 18.19 per cent in India during the Period-II over Period-I, while a decline was only 1.82 per cent at the Gujarat state as a whole. The increase in the net area sown was observed at Gujarat state as well as at an aggregate level of India, but Gujarat recorded 4.66 per cent increase, while it was only 0.28 per cent increase at national level. Area sown more than once and total cropped area increased by 51.67 and 9.95 per cent at country level, and 56.02 and 9.69 per cent at Gujarat state particularly during the aforesaid period. 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 Gujarat state during Period-II over Period-I.

Gulve *et al.* (2018) studied the changes in land use pattern over a period of time in Maharashtra and results indicates that forest area in Maharashtra is decreasing

from 17.39 per cent (1986-87) to 16.88 per cent (2015-16). Land not available for cultivation is increasing over the base year from 2831.50 kha to 3251.00 kha during the year 1986-87 to 2015-16. Net cropped area (NCA) is decreased from 58.41 per cent in 1986-87 to 55.87 per cent in 2015-16, which showed the negative trend i.e. (-) 4.51 per cent over the base year in Maharashtra. Land put to non-agricultural use increased by 31.90 per cent over the base year. Irrigation use indicators i.e. gross irrigated area, net irrigated area and area sown more than once showed an increasing trend.

Jangid *et al.* (2018) undertook a study to examine the changes in land use in Humid South-Eastern Plain of Rajasthan. The study was based on secondary data to examine the changes in land use pattern and changes in cropping pattern from TE 1994 to TE 2014 from various published sources of Government of Rajasthan. The results of the study revealed that there has been considerable increase in concentration of land under miscellaneous tree crops and groves (location coefficient 2.14 to 3.19) due to the decline in concentration in current fallow and fallow lands other than current fallow and net sown area.

Pandey and Ranganathan (2018) examined dynamics of land-use pattern in India with a focus on fallow lands from 1984-85 to 2011-12. Locational coefficients were estimated to know the pattern of concentration of fallow lands. The fallow lands were 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. There is a sharp increase in the concentration of fallow lands in Tamil Nadu, Rajasthan, Assam, Bihar, Uttar Pradesh and Andhra Pradesh. 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.

Siwana *et al.* (2018) conducted a study with the objective of exploring dynamics of the land-use pattern at Chhattisgarh state and Bastar plateau. The secondary data on land use statistics for 32 year's period from 1984-85 to 2000-15 were collected

from the different publication of Government of Chhattisgarh. For the estimation, the data were grouped under two periods based on formation of Chhattisgarh state i.e., first period (1984-2000) and second period (2000-15). Regarding the temporal changes in different land use categories, it was observed that during 1984-2000 net area sown was decreased, whereas, other categories had a non- significant growth rate. During 2000-15, the forest land and permanent pasture had significant growth rate and the net area sown was estimated to be significant and decreased in period 1984-2000, whereas, the growth rate for permanent pasture and other fallow land were estimated to be non-significant but they increased by 0.28 and 0.86 per cent annually. During the period of 1984-2000 in Bastar plateau, culturable waste land had positive and significant growth rate (0.98 per cent per annum), whereas, during 2000-15 the forest land increased significantly by 0.130 per cent annually.

Karthik (2019) carried out an economic appraisal of land use dynamics in Mysuru district of Karnataka by using data from secondary sources. The entire period of 1974-75 to 2016-17 was decomposed into three periods, viz; Pre-liberalization (1974-75 to 1990-91), Post liberalization (1991-92 to 2016-17) and Overall Period (1974-75 to 2016-17). The temporal changes in land use dynamics of Mysuru district revealed that area under forest, land put to non-agricultural use, barren and uncultivable land, current fallow, net area sown and total cropped area showed an increase while, cultivable waste, permanent pastures and other grazing lands and land under miscellaneous tree crops and groves registered a decline during Period-II. Mysuru district had recorded 7.39 per cent of increase in the net area sown, while it was only 2.37 per cent at state level during the study period.

Nirpal *et al.* (2019) made an attempt to analysed the changes in land use and cropping pattern of Kolhapur district. For a period of 34 years (1980-81, 1995-96 and 2013-14), the scenario of land use and cropping pattern in the district showed a drastic change because of population growth and industrialization. The area under forest was 146.90 thousand hectares (18.69%) in 1980-81, which was decreased to 140.10 thousand hectares (4.42%) in 2013-14, which may be due to industrialization and population growth in Kolhapur district. The area under barren and uncultivable land was decreased from 5.34 per cent to 5.15 per cent. Land under non-agricultural use was increased from

31.70 thousand hectares to 35.90 thousand hectares during the period from 1980-81 to 2013-14. It was used for buildings, industries and other non-agricultural purposes. The cultivable waste land area showed decline, which was 65.70 thousand hectares in 1980-81 and decreased upto 36.90 thousand hectares (4.75%) of the total geographical area in 2013-14. The area under permanent pastures and land under miscellaneous trees increased over a period of time. Permanent pastures increased from 41.50 thousand hectares to 41.80 thousand hectares. The land under miscellaneous trees showed increasing trend continuously over the period of time. The proportion of permanent pastures to the total geographical area from 1980-81 to 2013-14 is increasing continuously. The current fallow land was 24.10 thousand hectares (3.06% of the total geographical area) in 1980-81, which suddenly decreased to 10.70 thousand hectares in 1995-96 (1.39%) and further declined to 4.90 thousand hectares in 2013-14 (0.63%). As compared with the base year 1980-81, it was decreased by 1.37 per cent. The intensity of cropping, which is measure of land use efficiency did not show considerable change during the period from 1980-81 to 1995-96, it was change from 104.69 to 115.85 per cent (10.66% change), however, it was from 104.69 to 154.43 per cent (47.51% change) during 1980-81 to 2013-14.

Anupama *et al.* (2020) studied the dynamics of shift among different land-use classes in the North- Eastern Karnataka region. A significant decline has been observed in the total reported area, which necessitates a proper land-use survey through remote sensing. A declining trend has also been observed in the area under forests. The unfavorable increasing trends in the area put to non-agricultural uses and the growth rate in land put to non-agricultural uses was significantly increased. On contrary, area under permanent pastures and other grazing lands declined in the study districts. The positive growth in net area sown was noticed in Kalaburgi (0.20%) and Koppal (0.56%) districts, while negative growth was observed in Ballari (1.36%), Bidar (0.70%) and Raichur (0.56%) districts. Markov chain analysis showed that the area under forest, other uncultivable land excluding fallow land and net sown area were stable during study period. However, net sown area and fallow land were more stable in 1995-96 to 2004-05 compared to 2005-06 to 2014-15.

Rosalin *et al.* (2020) explored the dynamics of land use in Madurai district of Tamil Nadu. Time series data on nine-fold classification for the Madurai district was

collected from 1997-98 to 2017-18 were analyzed using compound growth rates, Cuddy Della instability index. The retention probability of land use pattern and forecasting was done using Markov Chain Analysis. The results revealed an increasing trend of Common Property Land Resources (CPLRs) due to declining nature of net sown area (-2.24% per annum) and low retention capacity of current fallows. The erratic distribution of rainfall and water stress due to dry climatic conditions extends the current fallows into other fallow lands (4.54% per annum). The predicted land use changes have also reflected the threatening scenario of increasing nature of current fallows and other fallow lands and declining nature of net sown area for the next decade. The study found that socio-economic developments like population growth, urbanization and climatic conditions were drivers of change in land use pattern in Madurai district.

Manjunatha *et al.* (2021) conducted a study to analyze the growth of land use pattern in Haveri and Uttara Kannada districts of Karnataka. The secondary data collected for a period of 21 years (1998-99 to 2018-19) was analyzed and results of this study revealed that in both the districts land put to non-agricultural uses shown a positive significant growth over study period. The cultivable waste, permanent pastures and current fallow land have shown significant negative growth in both the districts, however, the growth was more rapid in Uttara Kannada district than in Haveri district. In Haveri district, the forest land and barren and uncultivable land have shown no growth whereas, in Uttara Kannada district same have shown significant declined trends during aforesaid period.

Thanuja *et al.* (2021) examined the dynamics of land use patterns in Rajasthan, with a particular emphasis on land growth and instability, temporal changes in land during the period 1973-74 to 2017-18. The results of compound growth analysis showed that forest land has increased significantly in all agro-climatic zones of Rajasthan. In all zones, area under forest, total cropped area, area sown more than once and area under non-agricultural uses increased significantly, whereas area under barren unculturable land and permanent pastures and other grazing land in almost all agro-climatic regions of Rajasthan has significantly decreased. It depicts that agriculture development and infrastructure development are improving in Rajasthan. Significant decrease in current fallow land in most of the zones followed by increase in old fallow

land in corresponding zones is a serious problem. The Cuddy-Della valle index (CDVI) showed that land under tree crops and groves was highly instable, whereas permanent pastures and grazing land was less instable. The location coefficient results showed that land was mostly concentrated in fallow land and less in forest.

Padder and Mathavan (2022) present investigation on dynamics of land use and land cover change in Jammu and Kashmir from 1990 to 2018 of period of 28 years. The results of percentage change revealed that area under forests, land under miscellaneous tree crops not included in area sown, cultivable land, fallow land other than current fallow and current fallow have declined with the tune of 0.52, 2.02, 0.2, 0.09 and 1.86 per cent, respectively. On the contrast, land put to non-agricultural uses, barren and uncultivable land and net sown area were increased by 0.71, 0.76 and 3.21 per cent, respectively during the period 28 years. However, the area under permanent pastures and other grazing land has remained stagnant at 125 thousand over the study years.

To summarize, the above literature indicated that the different studies conducted in various districts/states viz; Rajasthan, Karnataka, Andhra Pradesh, Madhya Pradesh, Maharashtra, Gujarat etc. revealed that barren and uncultivated land showed declining trend in growth rate while, increasing growth rate were found in land put to non-agricultural uses, current fallow, fallows other than current fallow, area sown more than once and net irrigated area. This study on 'An Economics Analysis of Land Use Dynamics in Maharashtra' was conducted for assessing effect of liberalization in India on the changes in land use pattern of Maharashtra was taken up to explore temporal changes in various land uses over the time and space.

2.2 Structural variation in land use pattern

Harish (2006) in his study employed the Markov chain analysis to examine structural changes in the land use pattern and cropping pattern of Mandya district of Karnataka for two periods viz., Period-I (1980-81 to 1991-92) and Period-II (1992-93 to 2003-04). The results showed that except forests and fallow land, other land use categories showed stability in Period-I. Net area sown showed the highest stability by retaining 85 per cent of its previous year's share. The major competing categories for net area sown were previous year's share of net area sown, other uncultivable land excluding fallow land and land not available for cultivation. It gained major share of its previous

year's area from fallow land (84%). Forest area showed instability by retaining zero per cent of its previous years share. The major competing category for forest is other uncultivable land except fallow, while it gained from land not available for cultivation. Land not available for cultivation could retain 67 per cent of its previous year's share. The major competing category for land not available for cultivation is forest. The major source of its previous period's share is other uncultivated land except fallow. The area under forest became more stable in second period by retaining 80 per cent of its previous year's share. Fallow land continued to be unstable in Period-II also. Other categories have become less stable than in Period-I. In second period, net area sown gained its previous year's acreage from fallow land (64 %) and other uncultivated land except fallow land (50 %). But, the major competing categories for net area sown were land not available for cultivation and other uncultivated land except fallow.

Zubair (2006) examined the changes in land use and land cover of Ilorin in Kwara State of Nigeria. The study revealed that, farm land has 0.1495 probability of remaining as farm land and 0.5553 probability of changing to waste land in 2015. This shows an undesirable change (reduction), with a probability of change which is much higher than stability. Waste land during this period will likely maintain its position as the highest class with 0.5132 probability of remaining waste land in 2015. Built-up land also has a probability as high as 0.5029 to remain as built-up land in 2015, which signifies stability. On the other hand, the 0.4050 probability of change from forest land to waste land showed that there might likely be a high level of instability in forest land during this period. Water body, which is the last class has a 0.0133 probability of remaining as water body and 0.4378 probability of changing to waste land; which may not however be a true projection of this class, except there is an occurrence of drought in the region.

Gairhe (2011) studied land use dynamics in Karnataka and used Markov chain analysis, which indicated that except the land not available for cultivation, all other land use categories showed some stability in Period-I (1980-81 to 1994-95). Other uncultivated land excluding fallow land showed the highest stability by retaining most of its previous year's shares. The major competing land use categories for other uncultivated land excluding fallow were forest land and fallow land. This land use category also gained some share of fallow land and net sown area. The analysis of the land use

dynamics in Period-II (1995-96 to 2007-08) indicated that the forest land showed similar stability as was in the first period. On the contrary, against high instability in Period-I, land not available for cultivation showed the highest stability in Period-II. Other uncultivated land was found to be stable in Period-II and was almost comparable with its similar share in Period-I. The fallow land which was less stable in Period-I became highly unstable in the Period-II. The major competing land use category was net sown area. This revealed that with better rainfall distribution, there could be diversion of fallow land to net sown area to a larger extent.

Adhikari and Sekhon (2014) employed the Markov chain analysis for analysing the shift in land use pattern in Punjab. It could be inferred from the results that during the Period-I (1980-81 to 1994-95), all land use categories have shown stability. But the highest stability was acquired by forest land as reflected in high probability of retention at 1.000 *i.e.* the probability that forest land retains its share from one period to another period was 100 per cent. Similar interpretation could be made for land not available for cultivation, other uncultivated land excluding fallow land, fallow land and net area sown with probability of retention of 0.635, 0.521, 0.659 and 0.954, respectively. The major gainer among the different land use categories during Period-I was net area sown which had a transfer probability of 0.325 from land not available for cultivation, 0.229 from other uncultivated land excluding fallow land and 0.340 from fallow land and showed the highest probability of retention *i.e.* 0.951 during the Period-II (1995-96 to 2009-10). The results implied that the area under other uncultivated land excluding fallow land, fallow land and net sown area were likely to lose their share in the coming years. The area under forest and land not available for cultivation were likely to retain their share in the future. Thus, these results clearly implied that in the years to come, there would be a very high pressure towards land put to non-agricultural uses due to increasing population demands. This is of much concern especially in respect of losing shares in case of net sown area.

Tirlapur and Mundinamani (2015) made an economic analysis on land use and cropping pattern of Dharwad district. The data were analysed by using Markov analysis. The results revealed that in case of land utilization pattern, forest area retained its share of 71.5 per cent and lost remaining 28.5 per cent to agriculture land (13.6%),

cultivable waste land (7.70%) and fallow land (2.80%), while cultivable waste land lost its share to land not available for cultivation (54.60%) and forest (45.40%). Agriculture land lost its share to forest land (53.20%), cultivable waste land (20.30%) and land not available for cultivation (16.90%).

Amale *et al.* (2018) carried out an economic analysis of land use dynamics in Gujarat by using secondary data of the land use from 1970-71 to 2014-15 and studied the structural changes in the land use pattern over the period. Markov chain analysis revealed that at the national level, 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. In Gujarat state also, during all the three periods, net area sown was a major gainer among the different land use categories 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 projected land use dynamics of Gujarat implying that the land use categories viz; forest, land not available for cultivation and other uncultivable land except fallow land are likely to lose their area in coming years, whereas the net area sown is likely to remain same or very marginally increase in the future in Gujarat state as a whole.

Sreya and Vidhyavathi (2018) studied the dynamic changes of land use pattern in Kerala for which panel data of land use pattern was used from 1970-71 to 2016-17. The collected data was analyzed using Markov chain analysis. The transition probability matrix revealed that the area under miscellaneous tree crops and non-agricultural land had the highest retention probability which were 76% and 70%, respectively, while barren and uncultivable land and cultivable waste land were failed to retain their previous year's area share. Estimated land use share during 2006-07 to 2016-17 revealed that the shift in land use pattern is in favour of barren and uncultivable land and fallow lands in recent years. The net sown area was found to be losing its shares. The projected share of land use pattern showed a drastic decline in the case of land under net sown area.

Karthik (2019) investigated on an economic appraisal of land use dynamics in Mysuru district of Karnataka by using secondary sources of data from 1974-

75 to 2016-17. Markov chain analysis envisaged that, 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, while land not available for cultivation retained 74.30 per cent of its previous years' share in Mysuru. During all the three periods, net area sown was a major gainer among the different land use categories 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 results of first order Markov chain employed for analyzing the land use shift revealed that area under forest land shown stability in all the periods and net area sown gained more land from all the other categories and probability of retention in all the periods has increased, indicating the shift of land to agriculture uses.

Rosalin *et al.* (2020) explored the dynamics of land use in Madurai district of Tamil Nadu during 1997-96 to 2017-18 where in retention probability of land use pattern and forecasting was done using Markov Chain analysis. The results indicated that the forest cover and permanent pastures and other grazing lands had shown the higher stability (100%), miscellaneous trees and groves (83%), land under non-agricultural uses (74%), cultivable wastelands (71%), other fallow lands (66%) and barren and uncultivable lands (26.10%). Current fallows had shown poor retention capacity of about 2.2 per cent. This could be evidenced that 76.6 per cent of current fallows have transformed to other fallow lands over the past two decades. The predicted result of forecasting of land use was done based on the transitional probability matrix. The results showed an alarming nature of gradual reduction in net sown area and an increasing trend would be observed in current fallows and other fallow lands for the next decades.

Manjunatha *et al.* (2021) worked out some the probabilities of land use pattern in Haveri and Uttara Kannada districts of Karnataka by using Markov Chain analysis in the form of matrix for a period of 21 years (1998-99 to 2018-19). For convenience, nine-fold land use classes were merged into five meaningful classes based on relevancy and result of this study revealed that transitional probability matrix of land use categories in Haveri district, area under forest (1.0000), land not available for cultivation (0.9659) and net sown area (0.9648) were the most stable land use classes. Land under fallow was the most unstable land use class with transitional probability value of 0.2993, however, which was lost its area to net sown area with probability of

0.6813 and probability that it gained from other uncultivated land excluding fallow land was 0.5749. The forest land has neither gained nor lost its area. The probability that land not available for cultivation lost its area to other uncultivated land excluding fallow land was 0.034. The net sown area gained most of the area from fallow land with probability of 0.6813 and lost a meagre area to land not available for cultivation, other uncultivated land excluding fallow land and fallow land.

The results of Transitional probability matrix of land use categories in Uttara Kannada district revealed that all the land use classes were likely to be stable with higher transitional probability values. The probability that forest land retained its area was found to be 0.9904. The probability that it gained from fallow land was 0.0573 and from net sown area was 0.0596 and probability of losing to land not available for cultivation was 0.0964. The probability that land not available for cultivation retained its area from previous period was 0.8241. Its probability of loss to net sown area was 0.169 and that of gain was 0.0964 from forest and 0.014 from fallow land. The probability that other uncultivated land excluding fallow land retained its previous share by 0.9874 and the probability of loss to land not available for cultivation was 0.0125. The probability of retention of fallow land was found to be 0.7816 and probability that it gained from net sown area was 0.0395 and that of loss were 0.1471 to net sown area and 0.0573 to forest land. Net sown area has the probability of retention of 0.8967. The probabilities of gain were 0.169 from land not available for cultivation and 0.1471 from fallow land.

The projected land use dynamics of Haveri district implying that the land use categories viz; forest, land not available for cultivation and other uncultivable land except fallow land are likely to retain their area in future, whereas the fallow land might increase and share of net area sown is likely to decrease in the future in Haveri district of Karnataka. The result pertaining to Uttara Kannada district revealed the forest area is likely to lose its substantial share whereas, the remaining land use categories are likely to increase their share in future. The land not available for cultivation, other uncultivated land excluding fallow land, fallow land and net sown area likely to increase their share in future.

To summaries the above reviews, all researchers have used Markov Chain analysis for examining the stability of the area under the different land use categories in

Karnataka, Kerala, Gujarat, Tamil Nadu, Kwara state of Nageria, etc., The direction and the volume of change in the land use categories were predicted by using transitional probability matrix over time. The above studies exhibited that, fallow land found to be most unstable category among all land use categories and land under forest and net sown area were stable in different areas during different periods. The consequences of alterations in land use categories are prone to variation across different times and locations. Consequently, it becomes imperative to regularly conduct studies for examining the recent fluctuations in the land use pattern. This need arises from the paramount importance of comprehending this subject matter.

2.3 Factors responsible for temporal changes in land use pattern

Shrivastava *et al.* (1991) studied the dynamics of land use and cropping system in the Tawa Command Area of Hoshangabad district of Madhya Pradesh. They assessed the impact of the Tawa irrigation project on cropping pattern and land use in the area during the pre-project period (1970-71 to 1974-75) and the post project period (1975-76 to 1979-80). They observed a decline in the forest land as a result of illegal cutting of trees for domestic purposes. They also reported that fallow land had increased since the introduction of the Tawa irrigation project.

Goswami and Challa (2004) studied the socio-economic factors affecting land use in India. According to them, population pressure and prices of essential commodities were the most important factors contributing to change in land use pattern. The study indicated that high population pressure on cultivable land induced the rural people to bring more land under cultivation. There was a pressure to substitute land from low value output to high value output.

Sreeja (2004) studied the change in land use pattern in Kollam district of Kerala. The results indicated that there was a substantial growth in the current fallow, which reflected the consequence of year to year rainfall variations showing inverse relationship between rainfall and current fallow. Barren and uncultivated land, permanent pastures, land under miscellaneous tree crops and groves and cultivable waste recorded a significant negative growth.

Ramasamy *et al.* (2005) examined the dynamics of land use pattern with special reference to fallow lands in Tamil Nadu from 1960 to 2000 by using multiple

linear regression analysis. The length of road was found to have a negative effect on the extent of other fallows mainly because, the extension of road facilities in rural areas facilitated better access to market and provide impetus to agricultural development. Similarly, increase in the area under irrigation as a percentage of gross cropped area had a negative impact on the extent of other fallow lands primarily because of the area under other fallow lands had decreased with increase in the area under assured irrigation sources. The expansion in irrigation facilitated to reduce the instability in cropped area, thus reduced the probability of continuous fallowing of lands thereby, reduced the area under other fallows. Non-agricultural income of the farm households, size of the holding, labour availability, credit availability and extent of irrigated area in the farm were found to be statistically significant in explaining the changes in area under fallow lands across farms.

Harish (2006) in his study on 'An economic appraisal of land use dynamics in Mandya district' found that several factors influences land use pattern *viz.*, natural factors, physical limitations and socio-economic factors that prevailed within a macro prospective often spell out how land could be put to use. Since the impact of all these factors cannot be captured by secondary data due to the non-availability of data on some of the factors discussed above, an opinion survey was conducted as a part of the research to know the key official's rationale for the changes in the land use pattern in the Mandya district over the study period. The result revealed an increase in the cultivable waste land which is mainly due to non-remunerative cultivation of crops, problems of soil like salinity and alkalinity and erratic rainfall in the district. Land under non-agricultural uses has not registered considerable growth. This is due to lesser infrastructural developments like establishment of industries, major irrigation projects and major road projects in the district over the study period. The decrease in area under permanent pasture was due to the diversion of these areas for the non-agricultural purposes. The results also revealed that the area under fallows (current fallow and fallow other than current fallow) showed a positive growth over the periods. The opinions of the key officials revealed that non-agricultural income of the farm house holds, size of the holdings, labour availability, credit availability and extent of irrigated area were the reasons for increase in area under this category. Net area sown and area sown more than

once has decreased over the years. This was mainly due to frequent drought in the district over the years.

Aravind (2010) conducted the study on economics of land use and cropping pattern in Northern transitional zone of Karnataka from (1977-78 to 2006-07). The study indicated that the area under forest, land not available for cultivation, other uncultivated land excluding fallow land and fallow land were positively influenced by population density. Land not available for cultivation was positively influenced by road length whereas, it was negatively influenced by population density and rainfall. Similarly, area under other uncultivated land excluding fallow land was positively influenced by population density and rainfall while, it was negatively influenced by road length. However, fallow land was positively influenced by population density and motor vehicles. But, the net area sown was positively influenced by population and negatively by literacy rate.

Bardhan and Tewari (2010) investigated land use dynamics in India and land under-utilization for the period of 1992-93 to 2005-06. The linear regression was employed to explore the factors affecting other fallows and cultivable wastes. The results revealed that cultivable wastes increased with an increase in the area under large holdings and decreased with increase in the proportion of leased-in land. The findings underlined the need for revisiting tenancy laws so as to have beneficial effects on the livelihood options for the rural poor and land owners alike.

Seethalakshmi (2010) investigated the nature and extent of diversion of agricultural land to other purposes and the impact of that shift on agriculture and food production. The study revealed that the major factors responsible for diversion of farm land in Vishakapatnam district of Andhra Pradesh were industries in the form of Special Economic Zones (SEZs), IT and Pharma Parks and creation of infrastructure such as power plants in the vicinity, followed by a boom in real estate activities.

Chaturvedi *et al.* (2011) expressed the reorienting of land use strategies for socio-economic development in Uttar Pradesh. They pointed out that the land use pattern of any region/country at any point of time is governed by the prevailing physical, economic and institutional framework. The interaction of these parameters keeps the land use system dynamic in the long term, but stable in the short term. In other words, the land

use pattern in India keeps evolving as the result of action and interaction of various factors such as physical characteristics (productivity, location, geography, *etc.*) of land, the institutional framework (social, legal, *etc.*) and the availability of resources (water, capital, labour, *etc.*). As the economy is growing, the demand for land for purposes other than agriculture is continuously increasing.

Premakumara and Seema (2013) examined the agricultural land use pattern in India and Karnataka. The results of study revealed that the main cause of decline in the agricultural land was rapid growth of population. According to population census, India accounts for only 2.4 per cent of the world surface area and yet it sustains 16.9 per cent of the world population. Not only population pressure causes the decline of agricultural land, there are some other factors affecting the agricultural land use pattern such as industrialization, energy production, urban development or urbanization, mining, residential and commercial as well as supporting infrastructure, which are forcing to conversion of agricultural land to various non-agricultural purposes. Therefore, an expanding population, an urbanization and continued development programme exerts increasing pressure on agricultural land uses in India.

Govinda Prasad and Manikandan (2014) worked on thematic analysis on the causes of the agricultural land conversion and impacts of the conversion on food security. The results of the analysis revealed that the factors that influence agricultural land on the demand side are population growth, economic growth, urban sprawl and infrastructure development, real estate growth including residential sector, commercial, construction and speculation. The increasing operations of these factors results in increase in the demand for agricultural land for various non-agricultural purposes due to its lower price and other characteristics suitable for non-agricultural uses. The increasing demand with limited supply of agricultural land will cause to increase in the prices of agricultural land. Along with high price, other factors operating on the supply side push the farmers to sell or convert the agricultural land to non-agricultural purposes.

Andrews (2016) examined the drivers of agricultural land conversion in Kerala. The regression analysis result shows that the major drivers of agricultural land conversions are fall in agricultural income and remittances along with the interplay of other factors that affect the competition for land. These variables are classified as

endogenous and exogenous variables, respectively. The factors that affect the fall in agricultural income are mainly the agrarian reform measures coupled with density of population which led to an increased fragmentation of holding and made the cultivation unviable.

Sinha *et al.* (2016) tried to investigate agro-climatic zone wise land use of the state and state as a whole. The study revealed that the net sown area has declined both at Zonal and also at state level. Decline in net sown area in agro-climatic Zone-III was more pronounced than that of Zone-I and Zone-II. Being centre of the state, urbanization has taken place in faster way in the Zone-III. The other reasons for changes undergoing in land use pattern may be increasing population, fragmentation of land holdings and declining water table in this region. Zone-I and zone-II come under flood prone area, farmers put their land as current fallow due to devastating flood threat causing damage to their crops. Land under trees and groves have also witnessed positive percentage change over the decade and also in growth rate, this may be the other reason for decline in net sown area in the state.

Prabha *et al.* (2017) examined the scenario of population growth, agricultural land use and food security in Jammu district. The results of the study revealed that Jammu district is the most important administrative centre attracting the population and there is rapid demographic change. The agriculture area which is more productive and fertile is being diverted to other purposes for fulfilling the demand of rising population. On the other hand, there is rapid development in infrastructure sector which covers more and more fertile land under different occupations. This is leading to imbalance in the growth of population and production of food crops. The fertile land is now shrinking very fast. Because of this, food security of the district is at risk as it is not self-sufficient in agriculture sector. For fulfilling the demand of existing population, it has lot of importance for food material from other regions. There is mismanagement in land use, as it has uneven topography having the characteristics of Kandi region. Since agriculture land is limited, there is a need of proper land utilization and the diversion of agriculture land for different purposes should be stopped so that we can enhance our most valuable resource in a very sustainable manner.

Bareliya *et al.* (2021) studied the time series secondary data (2001-02 to 2015-16) of 51 districts of Madhya Pradesh which were related to net area sown, rainfall, total fallow land, area under non-agricultural uses and net irrigated area. The whole Madhya Pradesh was subdivided into two head i.e. major (14) and other fallow land (37) districts for the study. The area under fallow land showed decreasing trend by (-) 19.26 per cent from 601.90 thousand ha (The base year) to 485.99 thousand ha (The current year) with the fluctuation of 9.94 per cent (56.80 thousand ha) and magnitude of (-) 8.97 thousand ha per year has also showed a negative compound growth of 0.98 per cent per year during the period under study. The 1.00 per cent increase in net area irrigated to net area sown resulting highly significant decrease in share of total fallow land to total net sown area by 0.27 per cent.

To conclude, above studies used the multiple linear regression analysis to explore the factors affecting land use shift. The results revealed that, some socio-economic factors *viz*; population pressure, income, prices, tastes and preferences, rural-urban interferences, infrastructure development and government policy were the drivers of change in land use pattern. Other studies revealed that the factors for the changes in land use were rainfall, total population, population density, literacy, motor vehicles, road length, irrigation facilities, non-agricultural income of the farm households, size of the holdings, labour availability and credit availability, profitability of crops, salinity and alkalinity of the soil and drought. As the outcomes of changes in land use categories are varied across the time and location, frequent studies need to be conducted to examine recent shifts in the land use pattern.

2.4 Impact of changes in land use pattern

Ratna (1991) studied the trends of under-utilization of land in the districts of Andhra Pradesh for a period of 33 years from 1955-56 to 1987-88. The study showed that the under-utilized lands included current fallows, other fallows, cultivable waste and grazing and pasture lands. The analysis suggested that under-utilization of land was associated with irrigation, tractors, commercialization and such other factors. Such under-utilization was attributed to the inability of the farmers to adjust to higher demand for resources. He also concluded that land utilization largely depended on the availability of

resources with the farmers and the nature of investment in relation with the expected returns.

Wani *et al.* (2009) studied the land use dynamics in Jammu and Kashmir from 1966-67 to 2004-05. The exponential function was fitted to quantify the determinants of productive land use. The study revealed that the net irrigated area, literacy level and area not available for cultivation were positive and significant determinants for the variation in cropping intensity. The regression coefficient of the average holding size (0.15) revealed its positive contribution to the improvement of cropping intensity, although the relation has not been found statistically significant. The regression coefficient for area not available for cultivation (0.79) indicated that further increase in this area may significantly improve cropping intensity. The increasing demand for land for urbanization and infrastructural development due to increasing population may increase pressure on area left for cultivation and improve cropping intensity.

Gairhe (2011) studied impact of changes in land use pattern on cropping intensity in Karnataka. The results revealed that the fallows other than current fallow land showed a positive influence on cropping intensity. This was mainly due to increase in population pressure and correspondingly the diversion of cultivable land to non-agricultural activities and an increase in fallows other than current fallow land to fulfil the need of increasing cropping intensity to feed the growing population. Except these *i.e.*, land put to non-agricultural uses and fallows other than current fallow, all other variables were unable to exert any significant effect on the cropping intensity.

Rituraj (2014) examined the factors responsible for change in gross cropped area in Madhya Pradesh. She highlighted that the area under gross cropped area was positively influenced by current fallow, area under old fallow, net area sown, area sown more than once and net irrigated area, while area under forest, barren and uncultivable land, land put to non-agricultural uses, permanent pasture and other grazing land, area under cultivable waste land, miscellaneous tree crops and grooves were the factors which negatively influenced the gross cropped area.

Tirlapur and Mundinamani (2015) revealed that the main determinants of land use are land availability, type of land and soil type. In case of agriculture, regional

specific cropping patterns are followed by farmers. Agricultural land in Dharwad District is declining due to more exhaustive cultivation of land by using excessive chemical fertilizers. To meet food security demand, forest land has been converted to agricultural land but the exploitation of forest land is dangerous and farmers should use organic components in agriculture and can bring back their own land to its original status. Cropping intensity can be increased by growing two or more crops in the particular area.

Ahlawat and Renu (2016) analysed the relation and impact of irrigation on cropping intensity in Haryana. The results revealed that the regression coefficient was found to be positive at five per cent level of significance indicating moderate level positive impact of irrigation on cropping intensity. The value of R^2 has slightly improved from 2004-05 (0.24) to 2013-14 (0.25). It indicated that 25 per cent of variation in cropping intensity was explained by the irrigation ratio. However, minimum R^2 value was observed in 2006-07 (0.18) and contrary to it, the highest value was found in 2009-10 (0.47). Similarly, trend of beta (β) coefficient was increasing with the highest value of 0.37 (2009-10) which indicated that cropping intensity have an increase of 0.37 per cent due to one per cent increase in irrigation ratio. Regression coefficient was positive (ranging from 0.22 to 0.37) with five per cent level of significance over the years, except for 2006-07 (*i.e.* significant at ten per cent level). It can be seen that β value is significant (p -value < 0.05), so irrigation ratio variable significantly predicted the cropping intensity variable. It showed that irrigation ratio has a moderate level positive impact on cropping intensity. For the year 2006-07, insignificant impact may be due to comparatively more influence of other factors such as use of fertilizers, modern equipments, rainfall and availability of labour. Durbin Watson value indicates autocorrelation in the variables. Durbin Watson value over the period under study lies between 1.5 and 2.5 (except 1.13 in 2009-10 and 1.16 in 2010-11), indicated the absence of autocorrelation. While a low autocorrelation was found in 2009-10 and 2010-11 in time series data under study. It means that present cropping intensity have low positive autocorrelation with the past year cropping intensity.

From the above studies, it is concluded that the increasing demand for land for urbanization and infrastructural development due to increasing population may increase pressure on area left for cultivation and improve cropping intensity.

2.5 Ecological implications of land use dynamics

Pandey and Tewari (1987) studied the ecological implications of land use dynamics in Uttar Pradesh from 1967-68 to 1983-84. Both linear and log-linear time trend equations were estimated using time-series data on the land use for the state as well as different economic regions to find out the annual rate of change in various land use classes. Inter-sectoral land budgeting revealed that substantial land shifts had taken place from the undesirable part E_2 of the ecological sector, *i.e.* from barren and uncultivable lands to other sectors throughout the state and this favoured highly to both the desirable part E_1 of the ecological sector and the agricultural sector. It appeared that almost half of the land released from E_2 sector has gone to the non-agricultural sector and the remaining half was shared by the ecological sector E_1 and agricultural sector.

Sharma and Pandey (1992) examined the trends and dynamics of annual shifts among different land use classes in Indian states which may have adverse implications for agricultural growth and ecological balance. A general declining trend was observed in the area under permanent pastures, grazing lands and barren and uncultivable lands. The area under non-agricultural uses, cultivable wastes and fallow showed a positive growth in most of the states. Inter-sectoral land budgeting revealed that the area shifts were occurring from both desirable and undesirable ecological sectors towards agricultural as well as non-agricultural sectors. Further, the study identified the operation of vicious circle of land use dynamics within agricultural sector.

Takle *et al.* (2007) investigated the dynamics of shift in land use in Maharashtra. It was revealed from study that over a period of 30 years, 494 thousand hectares of area was shifted from ecological sector towards agricultural and non-agricultural sector. But the shift in area towards agricultural sector was comparatively less (24%) than that of non-agricultural sector. This is also supported by higher rate of CGR (1.46%) in area shifting towards non-agricultural sector. This shift towards non-agricultural sector was mainly because of urbanization and industrial expansion. Other reasons for this were expansion in irrigation project, market yard and roads which form the supporting infrastructure of agricultural growth of the particular region. However, this trend of shifting land from ecological sector to non-agriculture is not favourable, as it affects the ecological balance badly.

Wani *et al.* (2009) conducted the study on land use dynamics in Jammu and Kashmir from 1966-67 to 2004-05. The inter-sectoral budgeting analysis was carried out to find the pattern and extent of dynamics in land use shifts in the state. The study found that land use shift has been occurring from the desirable ecology towards undesirable ecology, agricultural and non-agricultural sectors. There was a positive shift of land towards the agricultural sector during the Period-I (1966-67 to 1984-85) which tilted unfavourably towards undesirable ecology during the Period- II (1985-86 to 2004-05). The shift of land from the agricultural sector to undesirable ecology may have serious implications towards agricultural growth and requires an immediate check. Inter-sectoral budgeting estimates for non-agricultural sector have indicated a significant increase in Period-I, which, later showed a decline and shifted towards undesirable ecology.

Bardhan and Tewari (2010) investigated land use dynamics in India and land under-utilization from 1992-93 to 2005-06. The study revealed that at an aggregate country level, there has been substantial land shifts from the undesirable ecology *i.e.*, barren and uncultivable land thereby mitigating the pressure for diversion of agricultural land to meet the growing needs of the non-agricultural sector. Moreover, the lands released from undesirable ecology sector are going to the non-agricultural sector and to a smaller extent to the desirable ecological sector, mainly forests. In West Bengal, Jammu and Kashmir, Karnataka and Kerala, lands shifts have occurred from all other sectors to the non-agricultural sector.

Gairhe (2011) examined the inter-sectoral land use dynamics in Karnataka which revealed that land shifts have taken place from all ecological sub-sectors to the other sectors except forests in all periods. In the agricultural sector, except net sown area, all other sub-sectors of land use have declined in first period (1980-81 to 1994-95) while, in second period (1995-96 to 2007-08), except current fallow and fallow other than current fallow, the area in the other sub-sectors have declined. In the overall period (1980-81 to 2007-08), land shift has been taken place from all agricultural sub-sectors, except fallow other than current fallow. It has been observed that land use shift has been occurring from desirable ecology (E_1) and undesirable ecological (E_2) sectors to agricultural as well as non-agricultural sectors. The magnitude of decline in area in both

the desirable and undesirable ecological sectors was found to be very large in the first period as compared to the second period. Similar trends of decline in the overall period were also noticed.

Singh (2012) examined the structural changes in land utilization patterns and shifting of area among different land use classes in India. The results of decadal changes in ecological groups revealed that there was no significant change in the ecological sector during the entire study period, while the share of the undesirable ecological sector declined substantially, especially during the 1980s. It was also noticed that the maximum positive increment in the non-agricultural sector and agricultural sector in the 1980s, which might be due to land reclamation under the undesirable ecological sector, shifted to the non-agricultural sector and agricultural sector.

Sharma (2014) attempted a study to examine the shifts in land use in Rajasthan and its implications on agriculture and ecology. The data pertaining to the study was collected from 1990 to 2005. The inter-sectoral budgeting method was used for accomplishing the objective. The results reported that permanent pastures and grazing lands and miscellaneous trees and groves were declining, having serious unfavorable implications for the ecology of Rajasthan. The land use dynamics show substantial shifts in the land use pattern towards the non-agricultural sector. The shift was mainly from the cultivable waste land, part of the agricultural sector and the undesirable part of the ecological sector. The forest area in Rajasthan was increasing at a meagre rate of 0.96%. The rapid growth of the non-agricultural sector's tendency should be controlled before a sizeable portion of land mass gets blocked under non-agricultural uses.

Pushpa and Akashraj (2014) analyzed the districtwise intra and inter-sectoral shifts in land use in Karnataka. From the results, it could be inferred that thirteen districts have registered a positive shift in area towards the desirable ecological sector. This can be mainly attributed to efforts made to improve area under forest through implementation of different afforestation programmes. On the other hand, a nearly equal number of districts in the state, *i.e.*, fourteen districts have registered a negative shift in area under the desirable ecological sector, indicating that there has been a decline in area under the desirable ecological sector in these districts. More area was being brought under land use classes which are ecologically desirable. The negative shift ranged from as high as 74.6

thousand ha in Bangalore (rural) to as low as 0.01 thousand ha in Koppal. Nearly eleven districts have registered positive shift in land towards agricultural sector. While sixteen districts have registered negative shift in land use indicating that the lands have moved away from agricultural sector. The highest negative shift was experienced by Kolar, Bangalore (rural), Bagalkot, Bangalore (urban) and Koppal.

Baba *et al.* (2015) investigated dynamics of land-use shifts, agricultural land-use and its intensity in relation with urbanization and other factors in Jammu and Kashmir, a mountainous state of India. They found that the area under ecological class (E) has declined in ten out of fourteen districts. The area under ecological class (E) has increased by 10.3 thousand hectares in Jammu district and 1.8 thousand hectares in district Budgam. It is desired that the decline in area under ecological class (E) should be on account of equal or more decline in undesirable ecology class (E_2), however, it is interesting to note that the scenario of area shifts under desirable ecology (E_1) compared to undesirable ecology (E_2) has not been favourable across different districts. The area under undesirable ecological class (barren land) has increased (as in Pulwama, Budgam, Leh, Kupwara, Jammu, Udhampur and Kathua) when area under desirable ecological classes in these districts has declined. Undesirable ecological class (E_2) has declined less than a decline of area under desirable ecological classes (as in Anantnag, Srinagar and Doda districts). This clearly implies that the area has shifted from desirable to undesirable ecological class which may have long term negative environmental implications.

Amale and Shiyani. (2019) carried out inter-sectoral budgeting analysis to find the pattern and extent of dynamics in land-use shifts. For the Gujarat state as a whole, 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 than 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 ecological sector and the same was reflected during the Period-I. However, it is interesting to note that the scenario of area shifts under desirable ecology (E_1) compared to undesirable ecology (E_2) 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 in area under non-agricultural sector at the national level, Gujarat has experienced eight times lower annual increase in area under non-agricultural sector during Period-II (2187 ha/annum) over Period-I (17555 ha/annum).

Thanuja (2022) studied the land use pattern in Rajasthan. The study was relied on secondary data collected from the years 1973-74 to 2017-18. The study revealed that sectoral budgeting of land use found to be 10,99,440 hectares of land area had been reduced in ecological sector (E), while areas in non-agricultural sector (NA) and agricultural sector (A) have increased by 5,96,729 and 5,18,666 hectares, respectively. The shift from ecological to non-agricultural sector was greater than agricultural sector. This shift is thought to be harmful to the environment. Rajasthan's non-agricultural sector has grown as a result of urbanization and industrialization. Land conversion to agriculture is viewed favorably because it ensures food availability in Rajasthan. The rising trend in net sown area has revealed a promising potential for agricultural production.

To conclude, most of the researchers have used the annual rate of change to study the intra and inter-sectoral shift in between the land use categories. The research findings indicated that substantial land shifts have taken from undesirable ecological sector, *i.e.* barren and uncultivable land to other sectors which favoured to both desirable ecological sub-sectors as well as agricultural sector and non-agricultural sector thereby mitigating the pressure for diversion of agricultural land to meet the growing needs of the non-agricultural sector. Moreover, the lands released from undesirable ecology sector are going to the non-agricultural sector and to a smaller extent to the desirable ecological sector and agricultural sector. Another studies indicated that area shifts were occurring from both desirable and undesirable ecological sectors towards agricultural as well as non-agricultural sectors. Further, the studies identified the operation of vicious circle of land use dynamics within agricultural sector.

3. METHODOLOGY

An attempt has been made in this chapter to describe the selection of study area, nature and sources of the data collection and statistical tools adopted for analyzing the data in the light of the objectives. The various concepts and steps followed in methodological aspects used to carry out the present study entitled “An economic analysis of land use dynamics in Maharashtra” are discussed under the following three broad sub-headings.

- 3.1 Delineation of the study area
- 3.2 Nature and sources of data
- 3.3 Analytical framework

3.1 Delineation of the study area

3.1.1 Geographical location

Maharashtra is a state in the western peninsular region of India occupying a substantial portion of the Deccan Plateau. It has a total area of 307,713 km² (118,809 sq. miles). It is the third-largest state in India after Rajasthan and Madhya Pradesh in terms of area and constitutes 9.36 per cent of India's total geographical area. The State lies between 15°35' N to 22°02' N latitude and 72°36' E to 80°54' E longitude. It occupies the western and central part of the country and has a coastline stretching of 720 kilometers along the Arabian Sea. The dominant physical feature of the state is its plateau character, which is separated from the Konkan coastline by the mountain range of the Western Ghats, which runs parallel to the coast from North to South. The Western Ghats, also known as the Sahyadri Range, has an average elevation of 1,200 meters (4,000 ft); its slopes gently descending towards the East and Southeast. The Western Ghats (or the Sahyadri Mountain range) provide a physical barrier to the state on the West, while the Satpura Hills along the north and Bhamragad–Chiroli-Gaikhuri ranges on the East serve as its natural borders. The state expands from North to South is 720 km and East to West is 800 km. To the West of these hills lie the Konkan coastal plains, 50–80 kilometers in width. To the East of the Ghats lies the flat Deccan Plateau. The main rivers of the state are the Krishna and its tributary Bhima, the Godavari and its main tributaries Manjara and Wardha-Wainganga and the Tapi and its tributary Purna.

Maharashtra State is sub-divided into four geographical regions, *viz.*, Konkan in the western coastal region, between the Western Ghats and the sea. Western Maharashtra region is in the central part of the state. Marathwada, which was a part of the princely state of Hyderabad until 1956, is located in the south eastern part of the state. Vidarbha is the eastern most region of the state, formerly part of the Central Provinces and Berar.

Maharashtra state, bordered by the Arabian Sea to the West, the Indian states of Karnataka and Goa to the South, Telangana to the Southeast and Chhattisgarh to the East, Gujarat and Madhya Pradesh to the North and Indian union territory of Dadra and Nagar Haveli and Daman and Diu to the Northwest.

The state has limited area under irrigation, low natural fertility of soils and large areas prone to recurrent droughts. Due to this, the agricultural productivity of Maharashtra is generally low as compared to the national averages of various crops. Maharashtra has nine agro-climatic zones on the basis of annual rainfall, soil types, vegetation and cropping pattern.

Maharashtra experiences a tropical wet and dry climate with hot, rainy and cold weather seasons. The rainfall patterns in the state vary by the topography of different regions of Maharashtra. The south west monsoon usually arrives in the last week of June and lasts till mid-September. Pre-monsoon showers begin towards the middle of June and post-monsoon rains occasionally occur in October. The highest average monthly rainfall is during July and August. The Konkan coastal area, west of the Sahyadri Mountains receives very heavy monsoon rains with an annual average rainfall of more than 3,000 mm. However, just 150 km to the East, in the rain shadow area of the mountain range, only 500–700 mm/year rains will fall and long dry spells leading to drought are a common occurrence. Maharashtra has many of the 99 Indian districts identified by the Indian Central Water Commission as prone to drought. The average annual rainfall in the state is 1,181 mm and 75 per cent of it is received during the Southwest monsoon from June to September. However, under the influence of the Bay of Bengal, Eastern Vidarbha receives good rainfall in July, August and September. The month of March marks the beginning of the summer and the temperature rises steadily until June. In the central plains, summer temperatures rise to between 40 °C or 104.0 °F and 45 °C or

113.0 °F. May is usually the warmest and January the coldest month of the year. More than 90 per cent of Maharashtra is made up of basalt rock which is made up of igneous rock. As a result, black soils formed from basalt rock is found in large proportion in Maharashtra. But at the same time, different types of soils are also found in Maharashtra like, laterite soil, alluvile soil, red soil, marshy and peaty soil.

Agriculture is one of the primary occupations of people in Maharashtra state. Maharashtra being the 2nd most populous state in the country, around half of population depends greatly on agriculture for their livelihood. The number of operational holdings were 0.50 crore during the first Agriculture Census (1970-71), which increased to 1.53 crore during the tenth Agriculture Census (2015-16). Agriculture and allied activities sector are one of the important sectors of the state economy. The average share of agriculture and allied activities in the state economy is 11.9 per cent. Average share of crop sector is 63.7 per cent in agriculture and allied activities sector of the state. Average share of horticulture in total crop production is about 28.4 per cent. Over a few decades, the state has significantly diversified its production base from coarse cereals to high value crops like cotton, sugarcane, soybean, maize, fruits, vegetables and flowers.

Both the cash crops and food crops are grown in Maharashtra viz; rice, jowar, bajra, wheat, lentils, turmeric, onions, cotton, sugarcane and a number of oil seeds like peanut, sunflower and soybean are among the main crops. Mangoes, bananas, grapes and oranges are the primary fruits grown throughout the state. About 33,500 square km of irrigated land have been utilized for crop cultivation. Most of the state's agriculture is rain-fed. The state contains 24 per cent of the nation's drought-prone territory. An erratic rain, climate change, erosion and degradation of soil quality, high input cost, market uncertainties, etc. are major challenges of agriculture sector in the State. Despite these obstacles, the state's agricultural economy has room for expansion.

According to the Livestock Census of 2019, Maharashtra holds the seventh position in terms of total livestock, with approximately 330.80 lakh animals. This represents an overall increase of 1.82 per cent compared to the previous census conducted in 2012. Bovine livestock, including cattle and buffalo, make up a significant portion, accounting for 195.96 lakh animals, which is about 59.24 per cent of the total livestock population. The cattle population in Maharashtra is 139.92 lakh, experiencing a decline

of 9.63 per cent compared to the previous census and the state ranks fifth nationally in terms of total cattle population. Buffalo population in Maharashtra is 56.04 lakh, securing the seventh position at the national level. Additionally, Maharashtra achieved a total milk production of 12,024 thousand tons in the year 2019-20.

At the initial stage, Maharashtra has 26 districts, 10 more districts are formed after 1981 and thus, at present there are 36 districts in the state (geographical map of 36 districts of Maharashtra is shown in Figure 3.1) with the state capital being Mumbai, the most populous urban area in India and Nagpur is serving as the winter capital of Maharashtra.

3.1.2 Demographic indicators

Maharashtra is the second-most populous state in India, after Uttar Pradesh and the fourth-most populous country sub division globally. As per Census 2011, the state has a population of over 11.23 crores people with 5.82 crores men and 5.41 crores women. The population growth in this decade was 15.99 per cent while in previous decade, it was 22.57 per cent. The share of urban and rural population in the total population of the state is 45.23 per cent and 54.78 per cent, respectively. The most populous city in Maharashtra is Mumbai, which is also the most populous city in India. Other major cities in Maharashtra include Pune, Nagpur and Aurangabad. Literacy rate has shown an upward trend and it increased from 76.88 per cent in 2001 to 82.34 per cent in 2011. Among this, male literacy stands at 88.38 per cent while female literacy stands at 75.87 per cent. The population density of Maharashtra is 365 per sq. km which is less than the national average of 382 per sq. km. According to 2011 census, the sex ratio of Maharashtra was 929 females per 1000 males. Sex ratio (rural) was 952 females per 1000 males and Sex ratio (urban) were 903 females per 1000 males.

3.2 Nature and sources of data

The present study was carried out for the 26 districts and 4 regions of Maharashtra state during the period 1960-61 to 2016-17. Presently, the state is having 36 districts out of which 10 districts were formed after 1981, however, newly formed districts were included in their respective parent districts for the reason that separate data were not available for these districts for the period considered for the study. The time series data for a period of last 57 years (1960-61 to 2016-17) was further divided into two

sub-periods as Period-I (Pre-liberalization) i.e. from 1960-61 to 1990-91 and Period-II (Post- liberalization) i.e. from 1991-92 to 2016-17 and also overall period (1960-61 to 2016-17).

The districtwise and regionwise data of the state on area under various land use categories (forest, barren and uncultivable lands, land put to non-agricultural uses, cultivable wastes land, permanent pasture and other grazing land, land under miscellaneous tree crops and groves, current fallows, other fallows and net area sown), population density, annual rainfall, number of land holders, industrial units, road length, net irrigated area etc., were obtained from various issues of Statistical Abstract of Maharashtra State, Statistical Outline of Maharashtra State, Economic Survey of Maharashtra, District Socio-Economic Review, Infrastructure Statistics of Maharashtra, Selected Indicators for Districts in Maharashtra and State in India, Handbook of Basic Statistics of Maharashtra State published by the Directorate of Economics and Statistics (DES), Government of Maharashtra, Mumbai. Along with these, Irrigation Status Report published by Water Resource Department, Government of Maharashtra, Mumbai was also referred. Besides, other sources like various journals, newsletters and other online information sites and websites like indiastat.com, agricoop.nic.in, dacnet.nic.in etc., were also accessed for retrieving the secondary data.

3.3 Analytical framework

The details on the methods and tools employed for the analysis of the data are presented as under.

3.3.1 Temporal changes in land use pattern

3.3.1.1 Percentage change

For the meaningful interpretation of the data such as land use pattern and changes in land use pattern in Maharashtra for Period-I and Period-II, the tabular analysis was employed to work out the percentages and averages. The temporal change has been calculated by using the following formula,

$$\text{Change (V}_1\text{)} = \frac{St_1 - St_2}{St_1} \times 100$$

Where,

V₁ = Change in any variable,

St₁ = Status at Period-I, and

St₂ = Status at Period-II

3.3.1.2 Compound growth rate analysis

Growth of any variable indicates its past performance. The analysis of growth is usually used in economic studies to find out the trend of a particular variable over a period of time (Gairhe *et al.*, 2011; Adhikari and Sekhon, 2014; Sinha *et al.*, 2016; Sinha *et al.*, 2017; Amale and Shiyani, 2018; Gulve *et al.*, 2018; Thanuja *et al.*, 2021). It clearly indicates the performance of the variables under consideration and hence it can be very well used for making interpretations and to evolve policy decisions. The growth in the area under different land use categories were estimated by using the exponential growth functions of the form,

$$Y_t = ab^t u_t \dots\dots\dots (1)$$

Where,

- Y_t : Dependent variable (area under forest, barren and uncultivable lands, land put to non-agricultural uses, land under miscellaneous tree crops and groves, permanent pastures and other grazing lands, cultivable wastes, current fallow, fallow other than current fallow and net area sown);
- a : Intercept;
- b : Regression coefficient;
- t : Years which takes values 1, 2, ..., n (57)
- u_t : Disturbance term for the year t.

The non-linear equation was transformed into log linear form for estimating the magnitudes of the various parameters and was estimated by using Ordinary Least Square (OLS) technique. The compound growth rate (CGR) in percentage is then computed from the relationship,

$$CGR (g) = (\text{Antilog of } \log b^1 - 1) \times 100$$

The significance of estimated regression coefficients was tested using the student's 't' test.

3.3.1.3 Instability index

Instability index is a simple analytical technique to find out the fluctuation or instability in any time series data (Ramasamy *et al.*, 2005; Gupta and Sharma, 2010;

Amale and Shiyani, 2018; Gulve *et al.*, 2018; Thanuja *et al.*, 2021). It is estimated as follows,

1. Estimate the parameter of a log-linear trend line for the variable (Y_t) for which instability is to be estimated
2. If the estimated parameter is statistically significant, then the instability index (IIN) is defined as

$$IIN = CV \times (1-r^2)^{0.5}$$

Where,

CV = Coefficient of variation;

r^2 = Coefficient of determination;

CV = (SD/ Mean) X 100.

Where,

SD = Standard deviation

3. If the estimated parameter in the regression equation is not significant, then the CV itself is the instability index

3.3.1.4 Location Coefficient

Location coefficient (b) identifies spatial distribution of a land category across different districts/regions of state (Ramasamy *et al.*, 2005; Pandey and Ranganathan, 2018, Siwana *et al.*, 2018) and can be defined as,

$$b = \frac{L_{ij} / L_i}{L_j / L_s}$$

Where,

L_{ij} = Area of j^{th} category of land in i^{th} district,

L_i = Area of all categories of land in i^{th} district,

L_j = Area of j^{th} category of land in the state,

L_s = Area of all categories of land in the state.

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

3.3.2 Nature and extent of structural variations in land use pattern

Markov chain analysis

The Markov chain analysis is an application of dynamic programming to the solution of a stochastic decision process that can be described by a finite number of states. The Markov process was used to study the shifts in the shares of land use categories thereby gain in understanding about the dynamics of the changes in land use (Singh, 2012; Adhikari and Sekhon, 2014; Kumar *et al.*, 2014; Tirlapur and Mundinamani, 2015; Amale, 2018; Sreya and Vidhyavathi, 2018). Markov chain analysis was carried out by taking time series data of nine land use categories. LINGO software was used to estimate the transitional probability matrix in Markov chain analysis.

3.3.2.1 Markov probability model

Any sequence of trials (land use category) that can be subjected to probabilistic analysis is called a stochastic process. For a stochastic process, it is assumed that the movements (transitions) of objects from one state (possible outcome) to another are governed by a probabilistic mechanism or system. A finite Markov process is a stochastic process whereby the outcome of a given land use category t ($t=1, 2, \dots, r$) depends only on the outcome of the preceding land use category ($t-1$) and this dependence is the same at all stage in the sequence of trials. Consistent with this definition, let,

S_i = be the i^{th} state of r possible outcomes; $i=1, 2, \dots, r$

W_{it} = be the probability that state S_i occurs on land use category t or the proportion observed in land use category t in alternate outcome state I of the multinomial population based on a sample of size n , i.e. $P_r(S_{it})$.

P_{ij} = represents the transitional probability which denotes the probability that if for any time t the process is in state S_i , it moves onto next trial to state S_j , i.e., $P_r(S_{j,t+1}/S_{jt}) = P_{ij} \dots \dots \dots (1)$

$P=(P_{ij})$ = represents the transitional probability matrix which denotes the transitional probability for every pair of states ($i, j=1,2, \dots, r$) and has the following properties.

$$0 < P_{ij} < 1, \dots \dots \dots (2)$$

and

$$\sum_j P_{ij} = 1, 2, \dots, r \dots \dots \dots (3)$$

Given this set of notations and definitions for a first order Markov chain, the probability of a particular sequence S_i on land use category t and S_j on land use category $t+1$ may be represented by

$$P_r(S_{it}, S_{j,t+1}) = P_r(S_{it}) P_r(S_{j,t+1}/S_{it}) = W_{it} P_{ij} \dots \dots \dots (4) \text{ and}$$

the probability of being in state j at land use category $t+1$ may be represented by,

$$P_r(S_{j,t+1}) = \sum_i W_{it} P_{ij} \text{ or } W_{j,t+1} = \sum_i W_{it} P_{ij} \dots \dots \dots (5)$$

The data for the study was the proportion of area under land use. The proportionate change from year to year as a result of different factors. It is reasonable to assume that the combined influence of these individually systematic forces approximates a stochastic process and the propensity of farmers to move from one land use category to another category differs according to the land use category involved. If these assumptions are acceptable, then the process of land use dynamics may describe in the form of a matrix P of first order transition probabilities. The element P_{ij} of the matrix indicates the probability of a farmer in land use category i in one period was move to land use category j during the following period. The diagonal element P_{ij} measures the probability that the proportionate share of i^{th} category of land use was retained.

The transition probability matrix was estimated using the Minimum Absolute Deviation (MAD) estimator. The elements P_{ij} of the matrix are the conditional probabilities of the area under a particular land use category in time t given its share in time $t-1$. The diagonal elements P_{ij} ($i=j$) indicate the extent of stability of land use categories. Hence, as the diagonal elements approach zero, area under a particular land use become less and less stable and as they approach one, the land use categories tend to exhibit more and more stability over time. The off-diagonal elements P_{ij} ($i \neq j$) are the probabilities of switching over between different land use categories. If P_{ij} is the diagonal element corresponding to the i^{th} land use category, the other elements in the i^{th} row give the proportions of previous period's area of i^{th} land use category to other categories in the current period. The elements of the i^{th} column give the proportions of areas gained by i^{th} land use category from other land use categories.

3.3.2.2 Estimation of transition probability matrix

Equation (4) can be used as a base for specifying the statistical model for estimation of the transition probabilities. If errors are incorporated in equation (4) to account for the difference between the actual and estimated occurrence of $W_j(t+1)$, the sample observations may assume to be generated by the following linear statistical model,

$$W_{jt} = \sum_i W_{i,t-1}P_{ij} + U_{jt} \dots\dots\dots (6)$$

or in matrix form it can be written as,

$$Y_j = X_j P_j + U_j \dots\dots\dots (7)$$

Where, Y_j is a $(T \times 1)$ vector of observations reflecting the proportion in land use pattern in time t , X_j is a $(T \times r)$ matrix of realized values of the proportion in land use pattern I in time $t-1$, P_j is a $(r \times 1)$ vector of unknown transition parameters to be estimated and U_j is a vector of random disturbances.

3.3.2.3 The minimum absolute deviations estimator

A method to derive parameter estimates when equality or inequality restrictions are present is to make use of Minimum Absolute Deviations (MAD) estimator. If we employ this method in obtaining estimates of the transition probabilities, our problem may be specified as follows,

To find a vector P this minimizes

$$Y - XP \text{ | ' E } \dots\dots\dots (8)$$

Subject to:

$$Y = XP + u \dots\dots\dots (9)$$

$$RP = e \dots\dots\dots (10)$$

$$P \geq 0 \dots\dots\dots (11)$$

Where, E is a unit vector of order $(r \times 1)$. In order to solve the above LP problem, non-negative variables are introduced for u such that

$$U = \theta - p \dots\dots\dots (12)$$

Where,

$$\theta = [\theta_{jt}] = [\theta_{11}, \theta_{12} \dots \theta_{1T}, \theta_{21} \dots \theta_{rT}]' \geq \dots\dots\dots (13) \text{ and}$$

$$p = [p_{jt}] = [p_{11}, p_{12}, \dots \dots \dots p_{1T}, p_{21}, \dots \dots \dots p_{rT}]' \geq 0 \dots\dots\dots (14)$$

By redefining u in this way, the LP problem may be transformed to the following form.

To minimize:

$$(\theta + p)' E \dots\dots\dots(15)$$

Subject to:

$$Y = XP + u = XP = [1, -1] - [\theta/p] e \dots\dots\dots (16)$$

$$RP = e \dots\dots\dots (17)$$

and

$$P, \theta, p > 0 \dots\dots\dots (18)$$

3.3.2.4 Projections

After estimating transition probability matrix (P), proportion of area under land use categories can be predicted using the following equation:

$$Y'_{(t)} = Y'_{(0)} P^t \dots\dots\dots (19)$$

Where,

$Y_t = (r \times 1)$ vector of proportion of area under land use categories in year t ;

$Y_0 = (r \times 1)$ vector of proportion of area under land use categories in year 0;

$P^t = (r \times r)$ transition probability matrix to the power of time (t) and $Y'_{(t)}$ and $Y'_{(0)}$

are transpose of vector $Y_{(t)}$ and $Y_{(0)}$, respectively.

3.3.3 Factor responsible for temporal changes in land use pattern

Multiple linear regression analysis (Log-Log Model)

Multiple regression of double log analysis was carried out on the time series data to identify the important factors responsible for the changes in the area under use (Aravind, 2010; Bardhan and Tewari, 2010; Gairhe, 2011; Amale, 2018). The functional form of the equation used was,

$$\ln Y = b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + b_6 \ln X_6 + U$$

Where,

Y = Area under a specific land use category ('00' ha)

b_0 = Intercept

b_1 to b_6 = Slope of X_1 to X_6 explanatory variables

The explanatory variables considered were,

X_1 = Annual rainfall (mm);

X_2 = Net irrigated area ('00' hectares);

X_3 = Road length (Km);

X_4 = Population density (per sq.km);

X_5 = Factories (numbers);

X_6 = Land holders (numbers);

U = Error term.

Based on R^2 fit, the multiple linear regressions was selected. The equation was estimated by using Ordinary Least Square (OLS) technique and the significance of the regression coefficient was tested using the student 't' test and significance of the R^2 by F-test.

3.3.4 Impact of change in land use pattern on cropping intensity and crop diversification

3.3.4.1 Cropping Intensity

Cropping intensity is a ratio of gross cropped area to the net cultivable area and was estimated as,

$$CI (\%) = \frac{\text{Gross cropped area}}{\text{Net sown area}} \times 100$$

3.3.4.2 Crop Diversification

To measure the extent and nature of crop diversification, the Herfindahl Index (HI) was worked out.

Herfindahl Index (HI)

It is the sum of square of the proportion of acreage under each crop to the total cropped area and is given by equation

$$HI = \sum_{i=1}^N P_i^2$$

Where, P_i represents acreage proportion of the i^{th} crop in total cropped area

$$P_i = \frac{A_i}{\sum A_i}$$

The Herfindahl index (HI) takes the value of the one when there is specialization and approaches zero when there is complete diversification.

3.3.4.3 Multiple Regression Analysis

Multiple regression was carried out by taking log on both sides for time series data to identify the impact of land use pattern on cropping intensity and crop

diversification. Multiple regression function earlier used by Gairhe (2011) and Amale (2018) to study the impact of changes in land use pattern on cropping intensity where, the cropping intensity was regressed with all land use categories was followed.

The functional form used was,

$$Y = b_0 X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} X_6^{b_6} X_7^{b_7} X_8^{b_8} X_9^{b_9}$$

Where,

Y = Cropping intensity in percentage / Crop diversification index

b_0 = Intercept

b_1 to b_9 = Slope of X_1 to X_9 explanatory variables

The explanatory variables to be considered were,

X_1 = Area under forest ('00' hectares);

X_2 = Barren and uncultivable lands ('00' hectares);

X_3 = Land put to non-agricultural uses ('00' hectares);

X_4 = Cultivable wastes ('00' hectares);

X_5 = Permanent pastures and other grazing lands ('00' hectares);

X_6 = Miscellaneous tree crops and groves ('00' hectares);

X_7 = Current fallows ('00' hectares);

X_8 = Fallows other than current fallow ('00' hectares);

X_9 = Net area sown ('00' hectares).

Based on R^2 fit, the double log model was selected. The equation was transformed into double log form for estimation purpose and was estimated using Ordinary Least Square (OLS) technique. Significance of the regression coefficient was tested by using the student 't' test.

3.3.5 Ecological implication of land use dynamics

Annual rate of change

The dynamics of land use shifts was examined with help of simple identity of linearly additive land-use changes (Pandey and Tewari, 1987; Sharma and Pandey, 1992; Takle *et al.*, 2007 and Wani *et al.*, 2009). The first accounting identity was linearly sum up the area under all land-use classes which was equal to the total reported area, given by equation (20):

$$R = Fr + P + M + N + U + W + Fc + Fo + C \dots \dots \dots (20)$$

Where,

- R = Total reporting area ('00' hectares);
- Fr = Area under forest ('00' hectares);
- P = Area under permanent pastures ('00' hectares);
- M = Area under miscellaneous tree crops ('00' hectares);
- N = Area under non-agricultural uses ('00' hectares);
- U = Barren and uncultivable lands ('00' hectares);
- W = Cultivable wastes ('00' hectares);
- Fc = Current fallows ('00' hectares);
- Fo = Fallows other than current fallow ('00' hectares);
- C = Net area sown ('00' hectares).

Also,

$$\Delta R = \Delta Fr + \Delta P + \Delta M + \Delta N + \Delta U + \Delta W + \Delta Fc + \Delta Fo + \Delta C \dots \dots \dots (21)$$

The total land endowment can be conveniently grouped into three broad sectors, viz., (i) ecological sector (E) comprising Fr, P, M and U, (ii) agricultural sector (A) comprising W, C, Fc and Fo and (iii) non-agricultural (NA) sector. The ecological sector was further be divided into two sub sectors, viz., (i) the desirable ecology (E1) comprising Fr, P and M and (ii) undesirable ecology (E2) comprising U. Then, the net changes within each sector can be budgeted as,

$$\Delta E = \Delta E1 + \Delta E2 = (\Delta Fr + \Delta P + \Delta M) + (\Delta U) \dots \dots \dots (22)$$

$$\Delta A = \Delta Fc + \Delta Fo + \Delta W + \Delta C \dots \dots \dots (23)$$

$$\Delta R = \Delta E1 + \Delta E2 + \Delta A + \Delta N \dots \dots \dots (24)$$

For finding the annual rate of change in various land use classes, linear time trend equations were estimated on the land use time series data for the State.

The annual rates of change in different classes were worked out using equations (22), (23) and (24) which facilitate the analysis of direction of land use shifts and their dynamics.

4. RESULTS AND DISCUSSION

The results of the present study derived after analyzing the data using several tools and techniques are presented and discussed in this chapter under the following heads,

1. Temporal changes in land use pattern in Maharashtra.
2. Nature and extent of structural variations in land use pattern.
3. Factors responsible for temporal changes in land use pattern.
4. Impact of changes in land use pattern on cropping intensity and crop diversification.
5. Ecological implications of land use dynamics in Maharashtra.

4.1 Temporal changes in land use pattern in Maharashtra

4.1.1 Percentage change in land use pattern

Since the establishment of Maharashtra state in 1960, substantial changes in land use pattern have taken place, mainly due to biophysical factors and human needs. In this section, the comparative changes in land use pattern at all India level and Maharashtra state as a whole during Pre-liberalization (Period-I: 1960-61 to 1990-91) and Post-liberalization (Period-II: 1991-92 to 2016-17) period are presented in Table 4.1 and districtwise changes in land use pattern during the said period are presented in Table 4.2 to 4.8.

4.1.1.1 Comparative changes in different land use categories in Maharashtra and India

The land use pattern is determined by the factors like relief features, climate, soil, density of population, technical and socio-economic parameters. The type of land use is for different categories like residential, commercial, industrial, agricultural and recreational public use infrastructure development. The changes in these land use categories are observed over the period of time due to infrastructure and other development activities.

The average land use pattern of India and Maharashtra state as a whole was worked out for the Pre-liberalization (Period-I) and Post-liberalization (Period-II) period, along with the changes in land use pattern between the two periods and the same are presented in Table 4.1 and Figure 4.1.

It can be referred from Table, at the all India level, land put to non-agricultural uses, current fallow, area under forest, fallow other than current fallow and net area sown in the country have increased by 36.52, 13.32, 8.62, 7.25 and 1.02 per cent, respectively during Period-II over Period-I; while barren and uncultivable land, cultivable waste, permanent pastures and other grazing land and area under miscellaneous tree crops and groves have declined by 31.19, 19.99, 17.17 and 12.50 per cent, respectively. In Maharashtra, land put to non-agricultural uses, the area under miscellaneous tree crops and groves, current fallow land and fallow other than current fallow have increased by 51.46, 23.78, 21.91 and 17.35 per cent, respectively during Period-II over Period-I, but permanent pastures and other grazing land, cultivable waste, net area sown, area under forest and barren and uncultivable land have declined by 14.17, 4.24, 2.75, 2.23 and 1.91 per cent, respectively during the same period.

A perusal of comparison between India and Maharashtra state clearly indicates that during both the periods, the share of forest area in Maharashtra state was comparatively lower than the share of forest area to the total reported area at national level. The results revealed that the area under forest has increased by 8.62 per cent at the national level while it was decreased by 2.23 per cent in Maharashtra state during Period-II over the Period-I.

At All India level, the share of barren and unculturable land has declined from 8.39 per cent to total reporting area in Period-I to 5.73 per cent in Period-II, while in case of Maharashtra state, it was slightly declined from 5.70 to 5.59 per cent to the total reporting area during the same period.

At national level, area under non-agricultural uses has increased by 36.52 per cent, while in Maharashtra it was increased by 51.46 per cent during these two periods, implying thereby Maharashtra has higher increase in area under non-agricultural uses than India. Permanent pastures and other grazing lands have declined by 17.17 per cent at national level while, in Maharashtra state, it has declined by 14.17 per cent, indicating gradual conversion of permanent pastures and other grazing lands towards either to agriculture or to non-agricultural uses both at national and state level. At national level, land under miscellaneous tree, crops and groves had decreased by 12.50

per cent, on the contrary it had increased by 23.78 per cent in state level during the Period-II over the Period-I.

The area under cultivable waste has declined by 19.99 per cent in India during the Period-II over the Period-I alike a decline of only 4.24 per cent was observed in Maharashtra state, indicating conversion of this land towards agriculture or non-agricultural uses.

Table 4.1. Changes in land use categories of Maharashtra and India
(Area in '00' hectares)

| Sr. No. | Land use category | Maharashtra | | | India | | |
|---------|--|-----------------------|-----------------------|---------|------------------------|------------------------|---------|
| | | Period-I | Period-II | %Change | Period-I | Period-II | %Change |
| 1 | Forest land | 53738.13 (17.47) | 52540.06 (17.08) | -2.23 | 647225.81 (21.27) | 703047.69 (22.96) | 8.62 |
| 2 | Barren and uncultivable land | 17520.49 (5.70) | 17185.70 (5.59) | -1.91 | 255148.06 (8.39) | 175567.31 (5.73) | -31.19 |
| 3 | Land put to non- agricultural uses | 8969.42 (2.92) | 13585.19 (4.42) | 51.46 | 180608.06 (5.94) | 246566.15 (8.05) | 36.52 |
| 4 | Permanent pastures and other grazing land | 15081.90 (4.90) | 12944.54 (4.21) | -14.17 | 127829.68 (4.20) | 105886.54 (3.46) | -17.17 |
| 5 | Land under miscellaneous tree crops and groves | 1890.58 (0.61) | 2340.23 (0.76) | 23.78 | 3914.45 (0.13) | 3425.05 (0.11) | -12.50 |
| 6 | Cultivable Waste land | 9633.58 (3.13) | 9225.58 (3.00) | -4.24 | 167174.84 (5.49) | 133759.62 (4.37) | -19.99 |
| 7 | Current fallow land | 10179.23 (3.31) | 12409.35 (4.03) | 21.91 | 95892.90 (3.15) | 108664.23 (3.55) | 13.32 |
| 8 | Fallow other than current fallow land | 9914.74 (3.22) | 11635.42 (3.78) | 17.35 | 135878.71 (4.47) | 145731.92 (4.76) | 7.25 |
| 9 | Net area sown | 180692.77 (58.74) | 175715.19 (57.13) | -2.75 | 1393791.29 (45.81) | 1408073.46 (45.99) | 1.02 |
| 10 | Total reported area | 307620.85 (100.00) | 307581.26 (100.00) | -0.01 | 3042693.87 (100.00) | 3061547.31 (100.00) | 0.62 |
| 11 | Area sown more than once | 15432.75 (5.02) | 47471.15 (15.43) | 207.60 | 288934.52 (9.50) | 502963.46 (16.43) | 74.08 |
| 12 | Gross cropped area | 196125.52 (63.76) | 223186.35 (72.56) | 13.80 | 1682725.81 (55.30) | 1911035.38 (62.42) | 13.57 |
| 13 | Net irrigated area | 16674.86 (5.42) | 31312.40 (10.18) | 87.78 | 349408.06 (11.48) | 595006.42 (19.43) | 70.29 |
| 14 | Gross irrigated area | 20273.69 (6.59) | 39889.43 (12.97) | 96.75 | 437871.5 (14.39) | 820949.97 (26.81) | 87.49 |
| 15 | Cropping intensity (%) | 108.53 | 127.09 | 17.10 | 120.68 | 135.73 | 12.48 |

Note: Figures in parentheses indicate percentage to the total reported area
(Source: Anon., 2019a, 2019b and 2019c)

At the All-India level, area under current fallow as well as fallow other than current fallow increased by 13.32 and 7.25 per cent, respectively during Period-II over Period-I. Accordingly, area under current fallow and other fallow registered an increase of 21.91 and 17.35 per cent, respectively in Maharashtra during the same period. This would be an alarming situation and may be the prime concern for the policy makers.

The increase in the net area sown was observed at national level by 1.02 per cent but in Maharashtra it was decrease by 2.75 per cent. The reasons behind shrinking of this land category might be due to uncertainty of monsoon, fragmentation of lands, expensive inputs, labor scarcity, better employment opportunities in urban areas, low profit margins, etc., these all are making cultivation costlier.

Area sown more than once and gross cropped area increased by 74.08 and 13.57 per cent, at the national level and 207.60 and 13.80 per cent in Maharashtra particularly during the aforesaid period. The increase in area sown more than once was due to an increase in net irrigated area by 70.29 and 87.78 per cent at the national and state level, respectively during Period-II over Period-I. A Notable increase in gross irrigated area was observed to the extent of 87.49 per cent and 96.75 per cent in India and Maharashtra during Period-II over Period-I, respectively. The incremental area sown more than once could be justified with the above discussed increase in gross and net irrigated area at the state and national levels. The increasing trends of cropping intensity were observed during Period-II over Period I in Maharashtra as well as India.

4.1.1.2 District and region wise changes in land use categories in Maharashtra

In order to understand the magnitude of changes in different land use categories amongst the different districts and regions in Maharashtra, tabular analysis was carried out for 26 districts and 4 regions of the Maharashtra state. The results of period wise changes (Period-I; 1960-61 to 1990-91 and Period-II; 1991-92 to 2016-17) in different land use categories are presented and discussed under following sub sections,

4.1.1.2.1 Forest

The district and regionwise percentage change in area under forest was calculated and presented in Table 4.2 and Figure 4.2. For Maharashtra state as a whole, area under forest has declined by 2.23 per cent during Period-II over Period-I. Regionwise analysis revealed that, the forest area increased in Konkan (3.48 %) and

Marathwada (1.65%), while it was declined in Western Maharashtra and Vidarbha region by 5.38 and 1.62 per cent, respectively during the Period-II over the Period-I. The region wise change in area under forest was graphically portrayed in Figure 4.2.

The area under forest has declined in 16 districts in the range of 0.64 to 18.06 per cent in the Period-II over the Period-I. However, it was observed to be increased in 10 districts, amongst them, highest increase in Osmanabad (246.31%), followed by Parbhani (16.38%), Beed (10.52%), Thane (7.51%) and Nanded (5.14%).

Proper implementation of afforestation, reforestation and other forest development programmes were the reasons for increase in forest area in some districts. On the other hand, deforestation, a wide gap between rates of forestation and deforestation, encroachments by locals, acquisitions for infrastructural developments were the reasons for reduction in area under forests in few districts of Maharashtra.

4.1.1.2.2 Land under miscellaneous tree, crops and groves

The information on land under miscellaneous tree, crops and groves is given in Table 4.2 and Figure 4.3. It is revealed from the table that area under miscellaneous tree, crops and groves increased by 23.78 per cent during Period-II over Period-I in Maharashtra. All regions of Maharashtra showed an increase in area under miscellaneous tree, crops and groves except Konkan region. The maximum increase in area under miscellaneous tree, crops and groves was observed in Western Maharashtra (116.33%) followed by Marathwada (49.46%) and Vidarbha region (0.13%), whereas, it was declined in Konkan region by 1.26 per cent during Period-II over Period-I.

The district wise analysis showed that the area under miscellaneous tree, crops and groves has declined in 8 districts of Maharashtra in the range of 2.14 to 100 per cent in Period-II over the Period-I. The maximum declined in area under miscellaneous tree, crops and groves was noticed in Greater Bombay (100%), followed by Buldhana (30.41%), Raigad (29.38%) and Amravati (22.80%). However, it has observed to be increased in 18 districts in the range of 2.02 to 2880.77 per cent during the Period-II over the Period-I. The maximum change in area was recorded in Ahmednagar followed by Pune, Satara, Jalgaon, Osmanabad and Thane by 2880.77, 2446.43, 319.52, 216.01, 139.59 and 119.66 per cent, respectively.

Table 4.2. District and region wise change in area under forest and land under miscellaneous tree, crops and groves in Maharashtra

(Area in '00' hectares)

| Sr. No. | Districts / Regions | Forest | | | Land under miscellaneous tree, crops and groves | | |
|---------|------------------------------|-----------------|-----------------|--------------|---|----------------|---------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | 15.10 | 15.00 | -0.64 | 0.81 | 0.00 | -100.00 |
| 2 | Thane | 3668.74 | 3944.15 | 7.51 | 79.39 | 174.38 | 119.66 |
| 3 | Raigad | 1628.65 | 1535.04 | -5.75 | 319.97 | 225.96 | -29.38 |
| 4 | Ratnagiri | 299.03 | 312.69 | 4.57 | 292.52 | 283.62 | -3.04 |
| | Konkan Region | 5611.52 | 5806.88 | 3.48 | 692.68 | 683.96 | -1.26 |
| 5 | Pune | 1881.42 | 1641.46 | -12.75 | 4.52 | 115.00 | 2446.43 |
| 6 | Solapur | 339.55 | 354.00 | 4.26 | 36.58 | 61.27 | 67.49 |
| 7 | Satara | 1480.13 | 1430.12 | -3.38 | 17.35 | 72.81 | 319.52 |
| 8 | Sangli | 479.26 | 450.42 | -6.02 | 112.71 | 135.54 | 20.25 |
| 9 | Kolhapur | 1509.10 | 1543.15 | 2.26 | 63.16 | 87.62 | 38.72 |
| 10 | Ahmednagar | 1865.29 | 1642.12 | -11.96 | 1.13 | 33.65 | 2880.77 |
| 11 | Nashik | 3388.84 | 3199.56 | -5.59 | 10.42 | 19.23 | 84.57 |
| 12 | Jalgaon | 1708.39 | 1569.15 | -8.15 | 8.58 | 27.12 | 216.01 |
| 13 | Dhule | 5653.23 | 5491.15 | -2.87 | 9.35 | 18.46 | 97.35 |
| | W. Maharashtra Region | 18305.19 | 17321.14 | -5.38 | 263.81 | 570.69 | 116.33 |
| 14 | Aurangabad | 813.35 | 686.77 | -15.56 | 93.65 | 97.58 | 4.20 |
| 15 | Nanded | 812.61 | 854.35 | 5.14 | 58.81 | 60.12 | 2.23 |
| 16 | Osmanabad | 15.55 | 53.85 | 246.31 | 78.35 | 187.73 | 139.59 |
| 17 | Parbhani | 372.81 | 433.88 | 16.38 | 57.39 | 86.46 | 50.66 |
| 18 | Beed | 210.26 | 232.38 | 10.52 | 16.42 | 23.38 | 42.42 |
| | Marathwada Region | 2224.58 | 2261.23 | 1.65 | 304.61 | 455.27 | 49.46 |
| 19 | Buldhana | 1195.10 | 979.31 | -18.06 | 15.42 | 10.73 | -30.41 |
| 20 | Akola | 766.13 | 655.04 | -14.50 | 17.58 | 16.38 | -6.80 |
| 21 | Amravati | 3350.45 | 3113.27 | -7.08 | 89.03 | 68.73 | -22.80 |
| 22 | Yavatmal | 2622.32 | 2469.19 | -5.84 | 151.32 | 132.35 | -12.54 |
| 23 | Wardha | 673.94 | 623.65 | -7.46 | 85.68 | 83.85 | -2.14 |
| 24 | Nagpur | 1838.03 | 1716.77 | -6.60 | 46.39 | 78.65 | 69.56 |
| 25 | Bhandara | 2565.58 | 2678.73 | 4.41 | 77.26 | 89.85 | 16.29 |
| 26 | Chandrapur | 14585.29 | 14914.85 | 2.26 | 146.81 | 149.77 | 2.02 |
| | Vidarbha Region | 27596.84 | 27150.81 | -1.62 | 629.48 | 630.31 | 0.13 |
| | Maharashtra | 53738.13 | 52540.06 | -2.23 | 1890.58 | 2340.23 | 23.78 |

The increasing trend in area under miscellaneous tree, crops and groves was due to massive movement of government/NGOs by sensitizing people towards their participation in tree plantation programmes. Further, it was also emphasized through the worldwide consensus of the people regarding climate change, causing erratic rainfall and water table depletion.

4.1.1.2.3 Barren and uncultivable land

The per cent change in barren and uncultivable land between Period-I and Period-II for different districts and regions of Maharashtra were assessed and the results are given in Table 4.3 and Figure 4.4. In Maharashtra state as a whole, barren and uncultivable land has decreased by 1.91 per cent during Period-II over Period-I, which might be due to land shifted to industrial area, special economic zones and or brought under farming to some extent. The results revealed that the area under barren and uncultivable land has declined in Konkan and Western Maharashtra by 5.49 and 4.17 per cent, respectively. On the other hand, it has increased by 21.35 and 7.26 per cent in Marathwada and Vidarbha region, respectively during Period-II over the Period-I. Uncultivated land was formed mostly might be due to deforestation, overgrazing, over-cultivation and inadequate irrigation.

Though at state level, barren and uncultivable land was declined by 1.91 per cent (Table 4.3) during the period of investigation, the area under barren and uncultivable land showed notable increase in 14 districts with the highest increase in Nagpur (79.33%), followed by Buldhana (57.29%), Osmanabad (52.94%), Wardha (52.20%), Beed (46.96%) and Parbhani (35.29%). The remaining districts of Maharashtra registered a decline within the range of 0.32 to 26.27 per cent in the aforesaid land use category during Period-II over the Period-I.

4.1.1.2.4 Land put to non-agricultural uses

In order to examine changes in area under non-agricultural uses during two different sub-periods (Period-I and Period-II), percentage change in land put to non-agricultural uses in different districts and regions of Maharashtra were computed and presented in Table 4.3 and Figure 4.5.

It is revealed that in Maharashtra state, area under non-agricultural uses increased by 51.46 per cent during Period-II over Period-I. Amongst the regions and districts of Maharashtra, excepts Nanded district showed increase in land put to non-agricultural uses and maximum increase of (130.54%) in Western Maharashtra followed by Konkan, Vidarbha and Marathwada region.

Table 4.3. District and regionwise change in barren and uncultivable land and land put to non-agricultural uses in Maharashtra

(Area in '00' hectares)

| Sr. No. | Districts / Regions | Barren and uncultivable land | | | Land put to non-agricultural uses | | |
|---------|------------------------------|------------------------------|-----------------|--------------|-----------------------------------|-----------------|---------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | 71.48 | 73.00 | 2.12 | 162.61 | 271.58 | 67.01 |
| 2 | Thane | 804.45 | 597.88 | -25.68 | 401.32 | 891.69 | 122.19 |
| 3 | Raigad | 1257.39 | 1286.12 | 2.28 | 265.94 | 554.96 | 108.68 |
| 4 | Ratnagiri | 3427.00 | 3298.00 | -3.76 | 283.68 | 322.42 | 13.66 |
| | Konkan Region | 5560.32 | 5255.00 | -5.49 | 1113.55 | 2040.65 | 83.26 |
| 5 | Pune | 1627.52 | 1513.27 | -7.02 | 348.55 | 1217.23 | 249.23 |
| 6 | Solapur | 683.29 | 636.92 | -6.79 | 30.55 | 117.85 | 285.77 |
| 7 | Satara | 1068.26 | 1217.35 | 13.96 | 220.32 | 298.69 | 35.57 |
| 8 | Sangli | 428.23 | 384.96 | -10.10 | 196.03 | 471.23 | 140.38 |
| 9 | Kolhapur | 446.42 | 455.08 | 1.94 | 294.84 | 390.96 | 32.60 |
| 10 | Ahmednagar | 1532.23 | 1306.42 | -14.74 | 58.03 | 145.42 | 150.59 |
| 11 | Nashik | 1777.23 | 1754.28 | -1.29 | 60.26 | 334.58 | 455.24 |
| 12 | Jalgaon | 807.94 | 805.35 | -0.32 | 69.68 | 151.46 | 117.38 |
| 13 | Dhule | 627.52 | 549.35 | -12.46 | 179.00 | 232.08 | 29.65 |
| | W. Maharashtra Region | 8998.61 | 8622.97 | -4.17 | 1457.26 | 3359.50 | 130.54 |
| 14 | Aurangabad | 244.81 | 215.54 | -11.96 | 601.16 | 792.77 | 31.87 |
| 15 | Nanded | 183.42 | 186.27 | 1.55 | 372.16 | 366.38 | -1.55 |
| 16 | Osmanabad | 157.45 | 240.81 | 52.94 | 250.55 | 374.12 | 49.32 |
| 17 | Parbhani | 176.03 | 238.15 | 35.29 | 380.68 | 403.08 | 5.88 |
| 18 | Beed | 170.03 | 249.88 | 46.96 | 315.68 | 434.69 | 37.70 |
| | Marathwada Region | 931.74 | 1130.65 | 21.35 | 1920.23 | 2371.04 | 23.48 |
| 19 | Buldhana | 250.45 | 393.92 | 57.29 | 305.94 | 495.23 | 61.87 |
| 20 | Akola | 290.55 | 225.42 | -22.41 | 403.77 | 557.23 | 38.01 |
| 21 | Amravati | 188.33 | 194.77 | 3.42 | 348.13 | 436.69 | 25.44 |
| 22 | Yavatmal | 534.52 | 394.08 | -26.27 | 373.35 | 584.54 | 56.56 |
| 23 | Wardha | 68.48 | 104.23 | 52.20 | 392.13 | 451.58 | 15.16 |
| 24 | Nagpur | 155.65 | 279.12 | 79.33 | 676.13 | 869.92 | 28.66 |
| 25 | Bhandara | 162.26 | 175.73 | 8.30 | 810.23 | 888.42 | 9.65 |
| 26 | Chandrapur | 379.58 | 409.81 | 7.96 | 1168.71 | 1530.38 | 30.95 |
| | Vidarbha Region | 2029.81 | 2177.08 | 7.26 | 4478.39 | 5814.00 | 29.82 |
| | Maharashtra | 17520.49 | 17185.70 | -1.91 | 8969.42 | 13585.19 | 51.46 |

It is also evident from the results that the area under non- agricultural uses has increased in all the districts, except Nanded. Nashik district showed the maximum (455.24%) increase, followed by Solapur (285.77%), Pune (249.23%), Ahmednagar (150.59%), Sangli (140.38%), Thane (122.19%), Jalgaon (117.38%) and Raigad

(108.68%). While, district of Parbhani recorded the lowest (5.88%) increase in area under non-agricultural uses during same period.

4.1.1.2.5 Permanent pastures and other grazing lands

The changes in area under permanent pastures and other grazing lands in different districts and regions of Maharashtra were worked out and depicted in Table 4.4 and Figure 4.6.

It is showed from Table that area under permanent pastures and other grazing land was declined by 14.17 per cent during the period under study. The reasons for decline in area under permanent pastures and other grazing lands might be due to over grazing and or conversion of this land to either agriculture or non-agriculture uses, illegal encroachment for expansion of cultivation on common pasture lands, etc. The results revealed that the permanent pastures and other grazing lands have decreased in all the regions of Maharashtra except Konkan region during Period-II over the Period-I and it decreased by 23.49, 12.84 and 3.68 per cent in case of Vidarbha, Marathwada and Western Maharashtra regions, respectively. While the Konkan region had shown slight increase by 0.13 per cent during same period due to heavy rains in the Konkan region.

The area under permanent pastures and other grazing lands has declined in 20 districts (76.92%) out of the 26 districts considered for this study. The extent of increase in area under permanent pastures and other grazing lands were ranged from 2.77 to 48.33 per cent in Period-II over the Period-I. Whereas, decline in area under permanent pastures and other grazing lands was the highest in Greater Bombay (48.33%), followed by Nagpur (38.79%), Jalgaon (35.67%), Chandrapur (34.67%) and Amravati (32.67%). However, the increase in the descending order of the districts were Raigad, Satara, Ahmednagar, Ratnagiri, Pune and Kolhapur district by 53.75, 27.51, 11.32, 11.27, 6.41 and 0.93 per cent, respectively during the period under study.

4.1.1.2.6 Cultivable waste

Tabular analysis was carried out to examine the changes in cultivable waste land In Maharashtra during the pre-liberalization and post liberalization periods and the results of same are depicted in Table 4.4 and Figure 4.7. It was inferred that area under cultivable waste was declined by 4.24 per cent in Maharashtra in Period-II over the Period-I. This might be due to conversion of this category of land to agricultural or non-agricultural uses. All regions of Maharashtra showed decrease in area under cultivable waste except Marathwada region. The highest decline in area under cultivable waste was

recorded in Konkan (16.06%), followed by Vidarbha (6.07%) and Western Maharashtra (5.98%), while an alarming increase was experienced in Marathwada region (24.20%). The probable reasons for increased cultivable waste area in Marathwada region might be due to prolonged drought conditions coupled with migration towards urban area.

Table 4.4. District and regionwise change in permanent pastures and other grazing land and area under cultivable waste in Maharashtra
(Area in '00' hectares)

| Sr. No. | Districts / Regions | Permanent pastures and other grazing land | | | Cultivable waste | | |
|---------|------------------------------|---|-----------------|---------------|------------------|----------------|---------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | 11.61 | 6.00 | -48.33 | 19.77 | 5.19 | -73.74 |
| 2 | Thane | 723.00 | 577.62 | -20.11 | 358.61 | 361.50 | 0.81 |
| 3 | Raigad | 260.74 | 400.88 | 53.75 | 457.52 | 380.23 | -16.89 |
| 4 | Ratnagiri | 108.68 | 120.92 | 11.27 | 2632.13 | 2164.08 | -17.78 |
| | Konkan Region | 1104.03 | 1105.42 | 0.13 | 3468.03 | 2911.00 | -16.06 |
| 5 | Pune | 685.39 | 729.31 | 6.41 | 316.29 | 380.69 | 20.36 |
| 6 | Solapur | 635.77 | 554.31 | -12.81 | 340.58 | 398.15 | 16.90 |
| 7 | Satara | 616.52 | 786.12 | 27.51 | 303.74 | 388.54 | 27.92 |
| 8 | Sangli | 180.06 | 165.31 | -8.20 | 112.16 | 132.38 | 18.03 |
| 9 | Kolhapur | 442.52 | 446.62 | 0.93 | 695.71 | 383.54 | -44.87 |
| 10 | Ahmednagar | 367.94 | 409.58 | 11.32 | 127.48 | 193.19 | 51.54 |
| 11 | Nashik | 271.45 | 232.85 | -14.22 | 230.42 | 200.27 | -13.08 |
| 12 | Jalgaon | 624.77 | 401.92 | -35.67 | 88.03 | 63.15 | -28.26 |
| 13 | Dhule | 561.35 | 498.42 | -11.21 | 110.61 | 46.00 | -58.41 |
| | W. Maharashtra Region | 4385.77 | 4224.42 | -3.68 | 2325.03 | 2185.92 | -5.98 |
| 14 | Aurangabad | 737.45 | 635.96 | -13.76 | 231.48 | 302.19 | 30.55 |
| 15 | Nanded | 656.32 | 533.08 | -18.78 | 270.06 | 350.69 | 29.86 |
| 16 | Osmanabad | 384.94 | 374.27 | -2.77 | 522.68 | 715.00 | 36.80 |
| 17 | Parbhani | 407.26 | 331.69 | -18.55 | 329.32 | 362.73 | 10.14 |
| 18 | Beed | 406.06 | 384.27 | -5.37 | 368.16 | 407.77 | 10.76 |
| | Marathwada region | 2592.03 | 2259.27 | -12.84 | 1721.71 | 2138.38 | 24.20 |
| 19 | Buldhana | 487.81 | 380.00 | -22.10 | 142.68 | 221.04 | 54.92 |
| 20 | Akola | 605.00 | 466.27 | -22.93 | 91.55 | 89.00 | -2.78 |
| 21 | Amravati | 612.35 | 412.27 | -32.67 | 123.35 | 100.54 | -18.50 |
| 22 | Yavatmal | 658.77 | 600.58 | -8.83 | 283.97 | 231.38 | -18.52 |
| 23 | Wardha | 467.84 | 388.23 | -17.02 | 179.97 | 154.69 | -14.04 |
| 24 | Nagpur | 1070.61 | 655.31 | -38.79 | 285.94 | 345.62 | 20.87 |
| 25 | Bhandara | 1355.32 | 1314.42 | -3.02 | 273.84 | 277.38 | 1.29 |
| 26 | Chandrapur | 1742.35 | 1138.35 | -34.67 | 737.52 | 570.62 | -22.63 |
| | Vidarbha Region | 7000.06 | 5355.42 | -23.49 | 2118.81 | 1990.27 | -6.07 |
| | Maharashtra | 15081.90 | 12944.54 | -14.17 | 9633.58 | 9225.58 | -4.24 |

It is explicitly observed that area under cultivable waste was declined in 12 districts (46.15%) out of 26 districts of Maharashtra considered for the study. The decline in cultivable waste land was ranged between 2.78 to 73.74 per cent during Period-II over the Period-I. The decline was higher in Greater Bombay district (73.74%), followed by Dhule (58.41%), Kolhapur (44.87%), Jalgaon (28.26%), Chandrapur (22.63%), Yavatmal (18.52%) and Amravati (18.50%).

Though the per cent increase in cultivable waste land was higher in the Buldhana district (54.92%), increase in area under cultivable waste in absolute terms was highest in Osmanabad (19232 ha), followed by Satara (8480 ha), Nanded (8063 ha), Buldhana (7836 ha), Aurangabad (7071 ha), Ahmednagar (6571 ha), Pune (6440 ha), Nagpur (5968 ha) and Solapur (5757 ha) during aforesaid period. The reasons behind the increase in cultivable waste land were prolonged drought situation, water logging conditions, soil degradation due to soil erosion, soil salinity and alkalinity, uneconomic cultivation around the city area due to increased population, etc.

It is concluded that the decline in area under cultivable waste in Maharashtra state was only 4.24 per cent, which was less than the per cent decline at the All India level (19.99%), indicating that government/institutions pay more attention towards the conversion of cultivable wasteland to agriculture or other purposes in Maharashtra.

4.1.1.2.7 Current fallow

The changes in area under current fallow between Period-I and Period-II for different districts and the regions of Maharashtra were worked out and presented in Table 4.5 and Figure 4.8. In Maharashtra, magnitude of increase (21.91%) in area under current fallow was observed and this might be due to uncertainty of rainfall, poor irrigation facility, higher prices and timely unavailability of inputs supply, scarcity of labor for farm operations, timely unavailability of credit, etc.

The results of regionwise analysis revealed that the highest increase in area under current fallow was observed in Vidarbha region (103.68%), followed by Western Maharashtra (38.34%) and Marathwada (2.48%) during Period-II over the Period-I. While, Konkan region of Maharashtra showed a decline in area under current fallow by 37.71 per cent during aforesaid period, which might be due to increased

irrigation facilities coupled with intensive cultivation and rapid urbanization in and around metropolitan cities.

The results of area under current fallow indicated that 17 districts (65.38%) in Maharashtra showed an increase within the range of 8.30 to 684.88 per cent. The increase in area under current fallow was higher in Wardha district (684.88%), followed by Ahmednagar (203.07%), Chandrapur (151.00%), Akola (127.91%), etc. On the other hand, it has been remarkably decreased in Greater Bombay, Thane, Jalgaon, Kolhapur, Raigad, Beed, Satara, Parbhani and Ratnagiri districts by 90.06, 69.85, 47.59, 40.47, 38.56, 36.30, 25.1, 16.19 and 14.63 per cent, respectively during Period-II over the Period-I.

4.1.1.2.8 Area under fallow other than current fallow

Temporal changes in area under fallow other than current fallow in Maharashtra state was carried out and results are presented in Table 4.5 and Figure 4.9. Area under fallow other than current fallow was increased by 17.35 per cent in Period-II over the Period-I in Maharashtra, which might be due to climate change, uneconomical returns from agriculture, inadequate supply of water, *etc.* The area under fallow other than current fallow increased by 58.22, 15.79 and 13.55 per cent in Marathwada, Konkan and Western Maharashtra, respectively while in Vidarbha it was decreased by 14.75 per cent in Period-II over the Period-I. It can be observed from the results that the remarkable increase in area under fallow other than current fallow was observed in 12 districts of Maharashtra during Period-II over Period-I, where the magnitude of increase was ranged from 6.01 to 118.83 per cent. During the aforesaid period, per cent increase was highest in Osmanabad (118.83%) followed by Wardha (118.16%), Aurangabad (118.11%), Ahmednagar (93.82%), Solapur (70.66%), Nagpur (37.54%), Parbhani (37.29%), *etc.* Whereas, 14 districts had observed the decrease in area under fallow other than current fallow with the maximum decrease in Greater Bombay (85.15 %) followed by Jalgaon, Pune, Amravati, Akola and Bhandara with 51.41, 45.57, 44.80, 39.76 and 36.87 per cent, respectively.

Table 4.5 District and regionwise change in area under current fallow and fallow other than current fallow in Maharashtra

(Area in '00' hectares)

| Sr. No. | Districts / Regions | Current fallow | | | Fallow other than current fallow | | |
|---------|------------------------------|-----------------|-----------------|---------------|----------------------------------|-----------------|---------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | 3.87 | 0.38 | -90.06 | 27.19 | 4.04 | -85.15 |
| 2 | Thane | 312.81 | 94.31 | -69.85 | 244.94 | 159.31 | -34.96 |
| 3 | Raigad | 237.58 | 145.96 | -38.56 | 431.16 | 457.08 | 6.01 |
| 4 | Ratnagiri | 453.29 | 386.96 | -14.63 | 1793.00 | 2269.96 | 26.60 |
| | Konkan Region | 1007.55 | 627.62 | -37.71 | 2496.29 | 2890.38 | 15.79 |
| 5 | Pune | 275.77 | 302.81 | 9.80 | 513.97 | 279.77 | -45.57 |
| 6 | Solapur | 817.32 | 1152.42 | 41.00 | 724.10 | 1235.77 | 70.66 |
| 7 | Satara | 353.32 | 264.62 | -25.11 | 414.65 | 534.81 | 28.98 |
| 8 | Sangli | 291.29 | 393.73 | 35.17 | 662.84 | 538.42 | -18.77 |
| 9 | Kolhapur | 249.39 | 148.46 | -40.47 | 327.19 | 253.50 | -22.52 |
| 10 | Ahmednagar | 392.81 | 1190.46 | 203.07 | 480.03 | 930.38 | 93.82 |
| 11 | Nashik | 553.13 | 767.77 | 38.80 | 374.77 | 304.81 | -18.67 |
| 12 | Jalgaon | 163.06 | 85.46 | -47.59 | 100.68 | 48.92 | -51.41 |
| 13 | Dhule | 74.94 | 81.15 | 8.30 | 173.45 | 156.27 | -9.91 |
| | W. Maharashtra Region | 3171.03 | 4386.88 | 38.34 | 3771.68 | 4282.65 | 13.55 |
| 14 | Aurangabad | 693.74 | 1245.65 | 79.56 | 317.74 | 693.04 | 118.11 |
| 15 | Nanded | 535.84 | 669.58 | 24.96 | 141.81 | 185.85 | 31.06 |
| 16 | Osmanabad | 1161.84 | 1272.62 | 9.53 | 503.03 | 1100.81 | 118.83 |
| 17 | Parbhani | 921.03 | 771.88 | -16.19 | 353.45 | 485.27 | 37.29 |
| 18 | Beed | 1457.48 | 928.46 | -36.30 | 538.87 | 469.88 | -12.80 |
| | Marathwada Region | 4769.94 | 4888.19 | 2.48 | 1854.90 | 2934.85 | 58.22 |
| 19 | Buldhana | 141.48 | 159.92 | 13.03 | 311.03 | 229.85 | -26.10 |
| 20 | Akola | 112.65 | 256.73 | 127.91 | 224.42 | 135.19 | -39.76 |
| 21 | Amravati | 140.77 | 255.38 | 81.41 | 255.23 | 140.88 | -44.80 |
| 22 | Yavatmal | 255.26 | 342.35 | 34.12 | 406.39 | 261.46 | -35.66 |
| 23 | Wardha | 75.16 | 589.92 | 684.88 | 101.55 | 221.54 | 118.16 |
| 24 | Nagpur | 166.94 | 204.96 | 22.78 | 168.10 | 231.19 | 37.54 |
| 25 | Bhandara | 119.68 | 148.27 | 23.89 | 124.71 | 78.73 | -36.87 |
| 26 | Chandrapur | 218.77 | 549.12 | 151.00 | 200.45 | 228.69 | 14.09 |
| | Vidarbha Region | 1230.71 | 2506.65 | 103.68 | 1791.87 | 1527.54 | -14.75 |
| | Maharashtra | 10179.23 | 12409.35 | 21.91 | 9914.74 | 11635.42 | 17.35 |

4.1.1.2.9 Net area sown

To examine the temporal changes in net area sown in different districts and regions of Maharashtra, tabular analysis was used and the results are furnished in Table 4.6 and Figure 4.10.

Table 4.6. District and regionwise change in net area sown and area sown more than once in Maharashtra

(Area in '00' hectares)

| Sr. No. | Districts / Regions | Net area sown | | | Area sown more than once | | |
|---------|------------------------------|------------------|------------------|--------------|--------------------------|-----------------|---------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | 66.68 | 4.81 | -92.79 | 1.97 | 0.00 | -100.00 |
| 2 | Thane | 2741.74 | 2536.04 | -7.50 | 102.26 | 103.27 | 0.99 |
| 3 | Raigad | 2009.97 | 1882.65 | -6.33 | 199.90 | 277.38 | 38.76 |
| 4 | Ratnagiri | 3496.84 | 3629.46 | 3.79 | 163.52 | 273.50 | 67.26 |
| | Konkan Region | 8315.23 | 8052.96 | -3.15 | 467.65 | 654.15 | 39.88 |
| 5 | Pune | 9974.00 | 9440.54 | -5.35 | 1160.03 | 2159.58 | 86.17 |
| 6 | Solapur | 11401.10 | 10499.35 | -7.91 | 688.68 | 1031.54 | 49.79 |
| 7 | Satara | 6110.13 | 5588.00 | -8.55 | 855.42 | 1132.15 | 32.35 |
| 8 | Sangli | 6147.48 | 5937.96 | -3.41 | 354.87 | 996.62 | 180.84 |
| 9 | Kolhapur | 4149.58 | 4471.27 | 7.75 | 199.90 | 2356.58 | 1078.86 |
| 10 | Ahmednagar | 12194.94 | 11170.35 | -8.40 | 1016.90 | 3205.73 | 215.24 |
| 11 | Nashik | 8967.23 | 8820.58 | -1.64 | 540.58 | 970.35 | 79.50 |
| 12 | Jalgaon | 8068.71 | 8486.46 | 5.18 | 1035.06 | 3892.31 | 276.04 |
| 13 | Dhule | 6984.52 | 7303.58 | 4.57 | 625.65 | 1092.15 | 74.56 |
| | W. Maharashtra Region | 73997.68 | 71718.08 | -3.08 | 6477.10 | 16837.00 | 159.95 |
| 14 | Aurangabad | 12538.65 | 11602.62 | -7.47 | 1060.74 | 5131.58 | 383.77 |
| 15 | Nanded | 7300.26 | 7124.69 | -2.40 | 390.88 | 1360.85 | 248.15 |
| 16 | Osmanabad | 10952.71 | 9707.73 | -11.37 | 1290.39 | 4719.19 | 265.72 |
| 17 | Parbhani | 9505.45 | 9389.77 | -1.22 | 1379.13 | 5389.15 | 290.77 |
| 18 | Beed | 7685.94 | 8038.27 | 4.58 | 589.97 | 1807.31 | 206.34 |
| | Marathwada Region | 47983.00 | 45863.08 | -4.42 | 4711.10 | 18408.08 | 290.74 |
| 19 | Buldhana | 6856.35 | 6801.08 | -0.81 | 605.13 | 1847.62 | 205.33 |
| 20 | Akola | 8048.48 | 8162.50 | 1.42 | 409.65 | 2864.46 | 599.25 |
| 21 | Amravati | 7112.39 | 7494.50 | 5.37 | 319.74 | 2607.77 | 715.59 |
| 22 | Yavatmal | 8231.55 | 8499.35 | 3.25 | 179.23 | 1228.19 | 585.28 |
| 23 | Wardha | 4247.35 | 3671.31 | -13.56 | 155.71 | 440.00 | 182.58 |
| 24 | Nagpur | 5496.26 | 5522.38 | 0.48 | 302.48 | 599.04 | 98.04 |
| 25 | Bhandara | 3750.26 | 3587.65 | -4.34 | 1202.52 | 905.42 | -24.71 |
| 26 | Chandrapur | 6654.23 | 6342.31 | -4.69 | 602.45 | 1079.42 | 79.17 |
| | Vidarbha Region | 50396.87 | 50081.08 | -0.63 | 3776.90 | 11571.92 | 206.39 |
| | Maharashtra | 180692.77 | 175715.19 | -2.75 | 15432.75 | 47471.15 | 207.60 |

The results of analysis at Maharashtra state revealed that net sown area was declined by 2.75 per cent during the Period-II over the Period-I. Also, all the regions in Maharashtra recorded decrease in net area sown during the aforesaid period. The conversion to non-agricultural uses and or fallow categories might have been caused such decline in net sown area.

It is explicitly observed that net area sown decreased in majority of the districts (17 out of 26) of Maharashtra within the range of 0.81 to 92.79 per cent during the Period-II over the Period-I. The decrease in net area sown was higher in Greater Bombay (92.79%), followed by Wardha (13.56%), Osmanabad (11.37%), Satara (8.55%), Ahmednagar (8.40%), Solapur (7.91%), etc. districts of Maharashtra. On the other hand, it was increased in 9 districts, where it was more in Kolhapur district (7.75 %), followed by Amravati (5.37%), Jalgaon (5.18%), Beed (4.58%) and Dhule (4.57%), etc. during Period-II over the Period-I.

4.1.1.2.10 Area sown more than once

The changes in area sown more than once during Period-I and Period-II were examined by tabular analysis and the districtwise as well as regionwise per cent changes were worked out and are presented in Table 4.6 and Figure 4.11. The results of analysis revealed that area sown more than once was increased by 207.60 per cent during the Period-II over the Period-I at state level and reasons might be change in cropping pattern, availability of irrigation facilities, *etc.* The changes in area sown more than once at regional level indicates that Marathwada recorded the highest increase (290.74%), followed by Vidarbha (206.39%), Western Maharashtra (159.95%) and Konkan (39.88%).

It can be observed from the Table that in all the districts of the Maharashtra, area sown more than once have increased in the range of 0.99 to 1078.86 per cent during Period-II over Period-I except Greater Bombay and Bhandara districts. The increase in area sown more than once was the highest in Kolhapur (1078.86%), followed by Amravati (715.59%), Akola (599.25%), Yavatmal (585.28%), Aurangabad (383.77%), Parbhani (290.77%), *etc.* during the aforesaid period. Urbanization in Greater Bombay and shifts in cropping patterns might be responsible for the decline in area sown more than once.

4.1.1.2.11 Gross cropped area

In order to investigate the change in total cropped area in Maharashtra between Period-I and Period-II, districtwise and regionwise analysis was done and the results are given in Table 4.7 and Figure 4.12. Gross cropped area was increased by 13.80 per cent in Period-II over the Period-I in Maharashtra state. The results of regionwise

analysis revealed that except Konkan region, all the regions recorded increase in gross cropped area during the aforesaid period. Highest increase in gross cropped area was recorded in Marathwada (21.97%), followed by Vidarbha (13.81%) and Western Maharashtra (10.04%), while it was slightly decreased in Konkan by 0.86 per cent.

The results revealed that area under gross cropped area increased in majority of districts (19 out of 26) of Maharashtra within the range of 2.27 to 56.98 per cent. Highest increase in gross cropped area in Maharashtra was observed in Kolhapur (56.98%), followed by Jalgaon (35.97%), Amravati (35.93%), Parbhani (35.78%), Akola (30.37%), Aurangabad (23.05%), Beed (18.97%), etc. On the other hand, during aforesaid period, the total cropped area has declined in Greater Bombay, Bhandara, Thane, Wardha, Solapur, Satara and Raigad districts by 93.00, 9.28, 7.20, 6.63, 4.62, 3.52 and 2.25 per cent, respectively.

4.1.1.2.12 Cropping intensity

The districtwise and regionwise analysis of cropping intensity in Maharashtra state was carried out and the results are depicted in Table 4.7 and Figure 4.13. The results of analysis of cropping intensity in Maharashtra revealed that cropping intensity was increased by 17.10 per cent during the Period-II over the Period-I. The cropping intensity has expanded by 27.84, 14.58, 13.57 and 2.29 per cent in Marathwada, Vidarbha, Western Maharashtra and Konkan, respectively during Period-II over the Period-I.

Table 4.7. District and regionwise change in gross cropped area and cropping intensity in Maharashtra

| Sr. No. | Districts / Regions | Gross cropped area ('00' ha) | | | Cropping intensity (%) | | |
|---------|----------------------|------------------------------|----------------|--------------|------------------------|---------------|-------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | 68.65 | 4.81 | -93.00 | 102.86 | 19.23 | -81.31 |
| 2 | Thane | 2844.00 | 2639.31 | -7.20 | 103.77 | 104.01 | 0.24 |
| 3 | Raigad | 2209.87 | 2160.04 | -2.25 | 110.17 | 114.74 | 4.15 |
| 4 | Ratnagiri | 3660.35 | 3902.96 | 6.63 | 104.74 | 107.54 | 2.68 |
| | Konkan Region | 8782.87 | 8707.12 | -0.86 | 105.70 | 108.12 | 2.29 |
| 5 | Pune | 11134.03 | 11600.12 | 4.19 | 111.64 | 123.11 | 10.27 |
| 6 | Solapur | 12089.77 | 11530.88 | -4.62 | 106.07 | 109.88 | 3.60 |
| 7 | Satara | 6965.55 | 6720.15 | -3.52 | 114.41 | 120.28 | 5.13 |
| 8 | Sangli | 6502.35 | 6934.58 | 6.65 | 105.86 | 116.76 | 10.30 |
| 9 | Kolhapur | 4349.48 | 6827.85 | 56.98 | 104.77 | 152.50 | 45.56 |
| 10 | Ahmednagar | 13211.84 | 14376.08 | 8.81 | 108.41 | 128.83 | 18.83 |
| 11 | Nashik | 9507.81 | 9790.92 | 2.98 | 106.03 | 111.01 | 4.70 |

Table 4.7 contd....

| Sr. No. | Districts / Regions | Gross cropped area ('00' ha) | | | Cropping intensity (%) | | |
|---------|------------------------------|------------------------------|------------------|--------------|------------------------|---------------|--------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 12 | Jalgaon | 9103.77 | 12378.77 | 35.97 | 112.77 | 145.82 | 29.30 |
| 13 | Dhule | 7610.16 | 8395.73 | 10.32 | 109.03 | 114.98 | 5.46 |
| | W. Maharashtra Region | 80474.77 | 88555.08 | 10.04 | 108.77 | 123.53 | 13.57 |
| 14 | Aurangabad | 13599.39 | 16734.19 | 23.05 | 108.49 | 144.43 | 33.13 |
| 15 | Nanded | 7691.14 | 8485.54 | 10.33 | 105.34 | 119.15 | 13.12 |
| 16 | Osmanabad | 12243.10 | 14426.92 | 17.84 | 111.71 | 149.11 | 33.48 |
| 17 | Parbhani | 10884.58 | 14778.92 | 35.78 | 114.38 | 157.54 | 37.74 |
| 18 | Beed | 8275.90 | 9845.58 | 18.97 | 107.59 | 122.59 | 13.94 |
| | Marathwada Region | 52694.10 | 64271.15 | 21.97 | 109.77 | 140.33 | 27.84 |
| 19 | Buldhana | 7461.48 | 8648.69 | 15.91 | 108.84 | 127.32 | 16.98 |
| 20 | Akola | 8458.13 | 11026.96 | 30.37 | 105.04 | 135.14 | 28.66 |
| 21 | Amravati | 7432.13 | 10102.27 | 35.93 | 104.44 | 134.76 | 29.02 |
| 22 | Yavatmal | 8410.77 | 9727.54 | 15.66 | 102.13 | 114.45 | 12.06 |
| 23 | Wardha | 4403.06 | 4111.31 | -6.63 | 103.62 | 112.11 | 8.19 |
| 24 | Nagpur | 5798.74 | 6121.42 | 5.56 | 105.47 | 110.84 | 5.09 |
| 25 | Bhandara | 4952.77 | 4493.08 | -9.28 | 132.16 | 125.24 | -5.23 |
| 26 | Chandrapur | 7256.68 | 7421.73 | 2.27 | 109.03 | 117.03 | 7.33 |
| | Vidarbha Region | 54173.77 | 61653.00 | 13.81 | 107.46 | 123.13 | 14.58 |
| | Maharashtra | 196125.52 | 223186.35 | 13.80 | 108.53 | 127.09 | 17.10 |

4.1.1.2.13 Net irrigated area

The districtwise and regionwise analysis of temporal changes in net irrigated area in Maharashtra state was carried out and the results are presented in Table 4.8 and Figure 4.14. In Maharashtra, results revealed that net irrigated area was increased by 87.78 per cent during the Period-II over the Period-I. The net irrigated area has increased by 124.57, 99.33, 90.34 and 68.25 per cent in Konkan, Marathwada, Western Maharashtra and Vidarbha regions, respectively during Period-II over the Period-I.

It can be observed from the Table, that all the districts of Maharashtra recorded a remarkable increase in net irrigated area and the corresponding change ranged from 35.79 to 272.54 per cent during Period-II over Period-I. For the aforesaid period, the per cent increase of net irrigated area was the highest in Thane (272.54%), followed by Yavatmal (190.00%), Amravati (177.39%), Nagpur (145.56%), Kolhapur (141.80%), Parbhani (136.90%), Nanded (131.81%) and Sangli (126.05%).

Table 4.8 District and regionwise change in net irrigated area and gross irrigated area in Maharashtra

(Area in '00' hectares)

| Sr. No. | Districts / Regions | Net irrigated area | | | Gross irrigated area | | |
|---------|------------------------------|--------------------|-----------------|---------------|----------------------|-----------------|---------------|
| | | Period-I | Period-II | % Change | Period-I | Period-II | % Change |
| 1 | Greater Bombay | NA | NA | NA | NA | NA | NA |
| 2 | Thane | 47.50 | 176.94 | 272.54 | 53.61 | 211.79 | 295.04 |
| 3 | Raigad | 72.50 | 144.26 | 98.99 | 78.30 | 180.69 | 130.76 |
| 4 | Ratnagiri | 156.99 | 300.80 | 91.61 | 177.54 | 363.42 | 104.70 |
| | Konkan Region | 276.98 | 622.00 | 124.57 | 309.45 | 756.12 | 144.34 |
| 5 | Pune | 1378.26 | 2820.41 | 104.64 | 1680.74 | 3553.12 | 111.40 |
| 6 | Solapur | 1249.36 | 2259.79 | 80.88 | 1535.99 | 2829.88 | 84.24 |
| 7 | Satara | 938.88 | 1726.95 | 83.94 | 1202.66 | 2378.52 | 97.77 |
| 8 | Sangli | 656.15 | 1483.21 | 126.05 | 816.52 | 1777.74 | 117.72 |
| 9 | Kolhapur | 553.50 | 1338.37 | 141.80 | 629.43 | 1509.40 | 139.80 |
| 10 | Ahmednagar | 1841.48 | 3332.95 | 80.99 | 2269.18 | 3960.68 | 74.54 |
| 11 | Nashik | 929.08 | 1881.98 | 102.56 | 1223.41 | 2424.21 | 98.15 |
| 12 | Jalgaon | 830.49 | 1386.39 | 66.94 | 1044.94 | 1694.85 | 62.20 |
| 13 | Dhule | 553.35 | 768.74 | 38.92 | 745.16 | 980.32 | 31.56 |
| | W. Maharashtra Region | 8930.56 | 16998.79 | 90.34 | 11148.03 | 21114.42 | 89.40 |
| 14 | Aurangabad | 1032.32 | 1934.44 | 87.39 | 1320.30 | 2662.99 | 101.70 |
| 15 | Nanded | 292.10 | 677.12 | 131.81 | 365.44 | 957.81 | 162.10 |
| 16 | Osmanabad | 989.92 | 1677.43 | 69.45 | 1210.46 | 2126.63 | 75.69 |
| 17 | Parbhani | 433.37 | 1026.66 | 136.90 | 557.43 | 1569.60 | 181.58 |
| 18 | Beed | 880.88 | 1917.35 | 117.66 | 1027.82 | 2452.63 | 138.62 |
| | Marathwada Region | 3628.59 | 7233.00 | 99.33 | 4481.45 | 9772.39 | 118.06 |
| 19 | Buldhana | 221.58 | 377.46 | 70.35 | 276.86 | 483.46 | 74.62 |
| 20 | Akola | 147.97 | 200.93 | 35.79 | 183.71 | 297.36 | 61.86 |
| 21 | Amravati | 239.79 | 665.17 | 177.39 | 316.77 | 886.37 | 179.81 |
| 22 | Yavatmal | 157.43 | 456.54 | 190.00 | 205.45 | 594.74 | 189.48 |
| 23 | Wardha | 151.83 | 282.19 | 85.87 | 183.76 | 405.11 | 120.45 |
| 24 | Nagpur | 423.88 | 1040.89 | 145.56 | 504.97 | 1384.07 | 174.09 |
| 25 | Bhandara | 1359.08 | 1865.64 | 37.27 | 1477.79 | 2362.11 | 59.84 |
| 26 | Chandrapur | 1137.18 | 1569.79 | 38.04 | 1185.44 | 1830.96 | 54.45 |
| | Vidarbha Region | 3838.73 | 6458.60 | 68.25 | 4334.77 | 8246.50 | 90.24 |
| | Maharashtra | 16674.86 | 31312.40 | 87.78 | 20273.69 | 39889.43 | 96.75 |

NA- Not available

4.1.1.2.14 Gross irrigated area

The analysis of districtwise and regionwise temporal changes in gross irrigated area in Maharashtra state was carried out and the results are presented in Table 4.8 and Figure 4.15. The results revealed that gross irrigated area was increased by 96.75 per cent during the Period- II over the Period-I in Maharashtra. The gross irrigated area

has expanded by 144.34, 118.06, 90.24 and 89.40 per cent in Konkan, Marathwada, Vidarbha and Western Maharashtra, respectively during Period-II over the Period-I. It is evident from the results that all the districts of Maharashtra registered remarkable increase in gross irrigated area during Period-II over Period-I, to the extent of 31.56 to 295.04 per cent. For the aforesaid period, per cent increase was the highest in Thane (295.04%), followed by Yavatmal (189.48%), Parbhani (181.58%), Amravati (179.81%), Nagpur (174.09%), Nanded (162.10%), Kolhapur (139.80%), Beed (138.62%), *etc.*

In brief, results of temporal change using tabular method for estimating percentage change in land use categories of Maharashtra revealed that area under forest and net sown area declined in Period-II over Period-I. This is unfavorable conditions to maintain ecosystem as well as growth of agriculture in Maharashtra. There were decrease in barren and uncultivable land and cultivable waste land and the conversion rate of unproductive land was slow in Maharashtra as compared to India. So, there is a need to accelerate the conversion rate of unproductive land in Maharashtra.

Similar observations were noticed by other researchers in different states *viz*; Ramasamy *et al.* (2005) in Tamil Nadu, Takle *et al.* (2007) in Maharashtra, Wani *et al.* (2009) in Jammu and Kashmir, Gairhe *et al.* (2011) in Karnataka, Ashrit (2014) and Sharma (2015) in India, Amale (2018) in Gujarat and Gulave *et al.* (2018) in Maharashtra.

4.1.2 Growth rates and instability indices of different land use categories

The annual compound growth rates and instability indices for different land use categories at All India level and Maharashtra state as a whole were worked out for Period-I (1960-61 to 1990-91), Period-II (1991-92 to 2016-17) and Overall Period (1960-61 to 2016-17) and the results are discussed elaborately with tabular and graphically in this section.

4.1.2.1 Growth rates and instability indices of different land use categories in India

The results of annual compound growth rates and instability indices for different land use categories at All India level are presented in Table 4.9. Growth rates of different land use categories for Overall Period are graphically depicted in Figure 4.16 and 4.17.

Table 4.9 Annual compound growth rates and instability indices of different land use categories in India

| Sr. No. | Land use categories | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|--|--|-----------|---------|-----------------------|-----------|---------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Forest land | 0.52** | 0.27** | 0.34** | 3.32 | 0.49 | 2.70 |
| 2 | Barren and uncultivable land | -2.41** | -0.49** | -1.39** | 8.29 | 2.03 | 10.38 |
| 3 | Land put to non-agricultural uses | 1.42** | 1.01** | 1.17** | 2.51 | 0.87 | 1.91 |
| 4 | Permanent pastures and other grazing lands | -0.84** | -0.41** | -0.67** | 2.35 | 0.86 | 1.79 |
| 5 | Land under miscellaneous tree crops and groves | -0.80** | -0.84** | -0.54** | 5.60 | 2.08 | 4.63 |
| 6 | Cultivable waste | -0.53** | -0.73** | -0.73** | 3.87 | 0.88 | 1.68 |
| 7 | Current fallow | 1.08** | 0.27 | 0.47** | 11.70 | 11.81 | 13.04 |
| 8 | Fallow other than current fallow | 0.13 | 0.44** | 0.30** | 6.82 | 3.92 | 5.22 |
| 9 | Net area sown | 0.14** | -0.07 | 0.05** | 1.52 | 1.54 | 1.77 |
| 10 | Area sown more once | 2.70** | 1.33** | 2.11** | 4.43 | 4.71 | 4.98 |
| 11 | Gross cropped area | 0.57** | 0.29** | 0.46** | 1.66 | 2.20 | 1.53 |
| 12 | Net irrigated area | 2.31** | 1.31** | 1.98** | 2.15 | 2.43 | 2.85 |
| 13 | Gross irrigated area | 2.81** | 1.55** | 2.36** | 2.34 | 3.01 | 3.55 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively

Land use pattern for the entire period showed that the net area sown, fallow other than current fallow, area under forest, current fallow and land put to non-agricultural use increased significantly by 0.05, 0.30, 0.34, 0.47 and 1.17 per cent per annum, respectively at all India level. In contrast, land under miscellaneous tree crops and groves, permanent pastures and other grazing, cultivable waste and barren and uncultivable land significantly declined by 0.54, 0.67, 0.73 and 1.39 per cent per annum, respectively. During the Overall Period, the results of instability indices revealed that among all land use categories, the current fallow was more unstable (13.04%) while cultivable waste was more stable (1.68%) at all India levels.

During the Period-I (1960-61 to 1990-91), net area sown, area under forest, current fallow and land put to non-agricultural use increased significantly by 0.14,

0.52, 1.08 and 1.42 per cent per annum, respectively. In contrast, cultivable waste, land under miscellaneous tree crops and groves, permanent pastures and other grazing land and barren and uncultivable land have declined significantly by 0.53, 0.80, 0.84 and 2.41 per cent per annum, respectively. Except fallow other than current fallow, the growth rates in all land use categories were significant at 1 per cent level. The results of instability indices showed that the current fallow was most unstable (11.70%) among all the land use categories, followed by barren and uncultivable land (8.29%), fallow other than current fallow (6.82%) and land under miscellaneous tree, crops and groves (5.60%), while net area sown was least unstable (1.52%) among all land use categories at All India level during the Period-I.

During Period-II (1991-92 to 2016-17), area under forest, fallow other than current fallow and land put to non-agricultural use increased significantly by 0.27, 0.44 and 1.01 per cent per annum, respectively at All India level. Sharma (2015) also found similar results. Permanent pastures and other grazing, barren and uncultivable land, cultivable waste and land under miscellaneous tree crops and groves declined by 0.41, 0.49, 0.73 and 0.84 per cent per annum, respectively. Except current fallow and net area sown, the growth rates in all land use categories were significant at 1 per cent level. The results of instability indices revealed that among all land use categories, the current fallow (11.81%) was more unstable while area under forest (0.49%) was most stable land use category in India during the Period-II.

During all the three study periods, area sown more than once, gross cropped area, net irrigated area and gross irrigated area significantly increased in India. The compound growth rates of area sown more than once, total cropped area, net irrigated area and gross irrigated area were low during Period-II as compared to Period-I. Whereas, gross cropped area, net irrigated area and gross irrigated area were found more unstable in Period-II as compared to Period-I. At the Overall Period, gross cropped area, net irrigated area, area sown more than once and gross irrigated area increased by 0.46, 1.98, 2.11 and 2.36 per cent, respectively at All India level.

Across three study periods, forests and land used for non-agricultural purposes showed increasing trends. Population growth, urbanization and industrialization likely explain the rise in non-agricultural land use. However, at the national level, there was a significant decrease in barren land, pastures and other uncultivated areas. This suggests these lands are being converted to either forests or, more likely, non-agricultural uses. Interestingly, the area sown for crops showed a non-significant decline during the second period. Similar trend of changes in all the land use categories was found by Ashrit (2014) and Singh (2012).

4.1.2.2 Growth rates and instability indices of different land use categories in Maharashtra

The compound annual growth rates and instability indices for different land use categories in Maharashtra estimated and the results are presented in Table 4.10. Growth rates of different land use categories for Overall Period are graphically presented in Figure 4.18 and 4.19.

The results showed that during the Period-I, land under permanent pastures and other grazing, area under culturable waste and land put to non-agricultural use significantly increased by 0.38, 0.75 and 1.95 per cent per annum, respectively. In contrast, area under forest, barren and uncultivable land, fallow other than current fallow and current fallow significantly declined by 0.05, 0.17, 0.79 and 1.62 per cent per annum, respectively during the Period-I. The significance level of all significant land use categories was at 1 per cent level, except, fallow other than current fallow, which was at 5 per cent level. However, land under miscellaneous tree crops and groves and net area sown shows non-significant growth rates in Period-I. The results of instability indices showed that, current fallow was more unstable (27.35%) while area under forest land was most stable (0.71%) as compared to other land use categories in Maharashtra state as a whole.

Table 4.10. Annual compound growth rates and instability indices of different land use categories in Maharashtra

| Sr. No. | Land use categories | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|--|--|-----------|---------|-----------------------|-----------|---------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Forest land | -0.05** | -0.13** | -0.08** | 0.71 | 0.76 | 0.43 |
| 2 | Barren and uncultivable land | -0.17** | 0.05** | -0.07** | 0.77 | 0.46 | 1.20 |
| 3 | Land put to non-agricultural uses | 1.95** | 1.18** | 1.55** | 6.53 | 2.64 | 4.27 |
| 4 | Permanent pastures and other grazing lands | 0.38** | -0.56** | -0.39** | 5.62 | 2.90 | 4.88 |
| 5 | Land under miscellaneous tree crops and groves | 0.02 | 1.17** | 0.66** | 4.73 | 5.28 | 2.61 |
| 6 | Cultivable waste | 0.75** | -0.20* | 0.01 | 12.90 | 3.48 | 14.55 |
| 7 | Current fallow | -1.62** | 1.75** | 0.49** | 27.35 | 5.05 | 31.47 |
| 8 | Fallow other than current fallow | -0.79* | 0.61** | 0.38** | 15.48 | 2.86 | 15.60 |
| 9 | Net area sown | 0.005 | -0.18** | -0.09** | 2.51 | 0.46 | 2.06 |
| 10 | Area sown more than once | 4.01** | 2.83** | 4.04** | 14.80 | 6.64 | 7.84 |
| 11 | Gross cropped area | 0.32** | 0.42** | 0.43** | 3.02 | 1.16 | 1.38 |
| 12 | Net irrigated area | 2.89** | 2.36** | 2.91** | 6.61 | 4.11 | 4.56 |
| 13 | Gross irrigated area | 3.30** | 2.00** | 3.07** | 7.40 | 3.60 | 5.74 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively

During the Period-II, barren and uncultivable land, area under fallow other than current fallow, land under miscellaneous tree crops and groves, land put to non-agricultural uses and current fallow significantly increased by 0.05, 0.61, 1.17, 1.18 and 1.75 per cent per annum, respectively. However, area under forest, net sown area, cultivable waste and permanent pastures and other grazing land significantly declined by 0.13, 0.18, 0.20 and 0.56 per cent per annum. The results of instability indices revealed that among all land use categories, land under miscellaneous tree crops and groves (5.28%) was more unstable while, barren and uncultivable land (0.46%) and net sown area (0.46 %) both were least unstable in Maharashtra state as a whole.

The results showed that during the Overall Period, area under fallow other than current fallow, current fallow, land under miscellaneous tree crops and groves and land put to non-agricultural uses significantly increased by 0.38, 0.49, 0.66 and 1.55 per cent per annum, respectively. In contrast, barren and uncultivable land, area under forest,

net area sown and permanent pastures and other grazing in Maharashtra significantly declined by 0.07, 0.08, 0.09 and 0.39 per cent per annum, respectively during the Overall Period. The results of instability indices during the Overall Period showed that in all land use categories, the current fallow was more unstable (31.47%) while area under forest was most stable (0.43%) as compared to other land use categories in Maharashtra state as a whole.

For the Overall Period, the growth rates of gross cropped area, net irrigated area, gross irrigated area and area sown more than once increased by 0.43, 2.91, 3.07 and 4.04 per cent, respectively in Maharashtra state as a whole. Growth rates of area sown more than once, net irrigated area and gross irrigated area were low in Period-II as compared to Period-I. During all the three study periods, area sown more than once, gross cropped area, net irrigated area and gross irrigated area significantly increased in Maharashtra state. Among these four categories, instability indices during Overall Period revealed that area sown more than once was more unstable (7.84%) whereas gross cropped area was more stable (1.38%) in Maharashtra State as a whole.

To sum up, the results revealed that, area under forest was appeared significant negative growth rates, however positive and significant growth rates were observed in case of land put non-agricultural uses during all study periods. Growth rate of permanent pastures and other grazing lands was negative and significant during Period-II, which might be due to conversion of area under this land use category to non-agricultural uses and or some extent to barren and uncultivable land. However, barren and uncultivable land, current fallow and fallow other than current fallow land were significantly increased during Period-II. As in case of net area sown, growth rate has been found negative and significant in state as a whole during Period-II, as the land is shifting towards non-agricultural uses due to infrastructure development and or cultivators are leaving their land uncultivated to uncertainty of rainfall, poor economic condition of farmer, which is a prime concern for sustaining food security to ever increasing population.

4.1.2.3 District and regionwise growth rates and instability indices of different land use categories in Maharashtra

District and regionwise growth rates and instability indices of area under different land use categories were worked out separately for Period-I (1960-61 to 1990-91), Period-II (1991-92 to 2016-17) and also for the Overall Period (1960-61 to 2016-17) and the results are discussed elaborately in this section.

4.1.2.3.1 Forest

A perusal of Table 4.11 indicates the growth rates and instability indices of area under forest. During the Period-I, mixed trend of growth rate was observed in area under forest where, eleven districts showed significantly negative growth rates, within the range of -0.04 to -1.05 per cent; while in case of Ratnagiri, Solapur, Sangli, Nanded, Osmanabad, Parbhani, Beed, Wardha, Bhandara and Chandrapur districts, the growth rates were significantly positive which ranged between 0.07 and 2.27 per cent per annum. In contrast, during the Period-II, only Bhandara (0.08%) and Osmanabad (2.84%) districts registered a significant positive growth rates while, majority of districts experienced significant and negative growth rate in forest area which ranging from 0.03 to 1.35 per cent.

During the Overall Period, more than half of the districts (i.e. 15 districts) of Maharashtra registered a negative and significant growth rates (ranging between -0.09 to -0.69% per annum), whereas some of the districts (i.e. 10 districts) showed positive and significant growth rates (ranging in-between 0.06 to 3.96% per annum) for the area under forest. The growth rate of some districts of Maharashtra viz., Ratnagiri, Sangli, Nanded, Beed and Chandrapur were observed to be negative and significant during Period-II, where they showed prominently positive growth rate within Period-I.

Instability analysis of area under forest during Period-I showed that Osmanabad was the most unstable district in area under forest, followed by Beed, Ratnagiri, Parbhani, Akola and Greater Bombay while the Satara was most stable, followed by Nashik, Raigad, Buldhana and Chandrapur as compared to the other districts of Maharashtra. During Period-II, the district of Osmanabad was most unstable in forest area, followed by Buldhana, Thane, Nagpur, Sangli, Wardha, etc. and Chandrapur was found to be most stable, followed by Dhule, Kolhapur, Bhandara, Satara Ratnagiri, etc.

Table 4.11. District and regionwise annual compound growth rates and instability indices of area under forest in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|----------------|----------------|-----------------------|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | -0.07 | 0.00 | -0.02 | 6.25 | - | 6.25 |
| 2 | Thane | 0.01 | 0.27 | 0.21** | 1.52 | 6.96 | 1.23 |
| 3 | Raigad | -0.06** | -0.37** | -0.20** | 0.79 | 1.78 | 0.47 |
| 4 | Ratnagiri | 1.30** | -0.07** | 0.35** | 9.16 | 0.65 | 12.16 |
| | Konkan Region | 0.05* | 0.07** | 0.10** | 1.15 | 4.60 | 1.09 |
| 5 | Pune | -0.21** | -0.24** | -0.41** | 1.61 | 2.13 | 0.89 |
| 6 | Solapur | 0.21* | -0.01 | 0.15** | 4.73 | 1.15 | 4.26 |
| 7 | Satara | -0.05** | -0.03** | -0.10** | 0.38 | 0.53 | 0.23 |
| 8 | Sangli | 0.26** | -0.53** | -0.17** | 2.17 | 2.74 | 2.71 |
| 9 | Kolhapur | 0.01 | 0.01 | 0.06** | 2.15 | 0.29 | 1.83 |
| 10 | Ahmednagar | -0.40** | -0.03 | -0.40** | 1.72 | 1.00 | 1.39 |
| 11 | Nashik | -0.04** | -0.38** | -0.19** | 0.47 | 1.93 | 0.30 |
| 12 | Jalgaon | -0.33** | -0.12** | -0.28** | 2.95 | 1.49 | 1.97 |
| 13 | Dhule | -0.07 | -0.03** | -0.09** | 2.60 | 0.27 | 2.05 |
| | W. Maharashtra Region | -0.11** | -0.13** | -0.18** | 1.03 | 0.70 | 0.49 |
| 14 | Aurangabad | -0.45** | -0.16** | -0.53** | 3.09 | 1.82 | 1.81 |
| 15 | Nanded | 0.26** | -0.20** | 0.15** | 2.85 | 1.23 | 2.81 |
| 16 | Osmanabad | 2.27** | 2.84** | 3.96** | 26.36 | 18.26 | 14.23 |
| 17 | Parbhani | 1.70** | 0.07 | 0.71** | 7.25 | 2.42 | 10.25 |
| 18 | Beed | 1.97** | -0.21** | 0.61** | 12.05 | 1.46 | 16.08 |
| | Marathwada Region | 0.40** | -0.08** | 0.10** | 2.36 | 0.69 | 3.72 |
| 19 | Buldhana | -0.13** | -1.35** | -0.69** | 0.93 | 8.15 | 0.83 |
| 20 | Akola | -1.05** | 0.02 | -0.56** | 6.36 | 2.09 | 6.70 |
| 21 | Amravati | -0.22** | -0.10* | -0.24** | 2.15 | 1.47 | 1.34 |
| 22 | Yavatmal | -0.53** | -0.38** | -0.27** | 5.49 | 1.35 | 5.21 |
| 23 | Wardha | 0.19** | -0.06 | -0.18** | 2.23 | 2.57 | 2.16 |
| 24 | Nagpur | -0.03 | -0.78** | -0.26** | 1.50 | 2.87 | 0.98 |
| 25 | Bhandara | 0.18** | 0.08** | 0.15** | 1.97 | 0.32 | 1.32 |
| 26 | Chandrapur | 0.07** | -0.05** | 0.06** | 1.01 | 0.19 | 0.78 |
| | Vidarbha Region | -0.06* | -0.16** | -0.07** | 1.28 | 0.71 | 1.00 |
| | Maharashtra | -0.05** | -0.13** | -0.08** | 0.71 | 0.76 | 0.43 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively

During the Overall Period, Beed (16.08%) was the most unstable district in area under forest, followed by Osmanabad, Ratnagiri, Parbhani and Akola. While the Satara (0.23%) was most stable followed by Nashik, Raigad and Chandrapur as compared to the other districts of Maharashtra.

Regionwise growth rate analysis of area under forest revealed that during the Period-I, Marathwada and Konkan regions of Maharashtra recorded the significant positive growth rate of 0.40 and 0.05 per cent per annum, respectively. On the other hand, area under forest significantly declined by 0.11 per cent per annum in Western Maharashtra and 0.06 per cent in Vidarbha regions of Maharashtra. During Period-II, area under forest significantly decreased in all regions of Maharashtra except, Konkan region. The negative growth rate of area under forest in Marathwada, Western Maharashtra and Vidarbha regions of Maharashtra were 0.08, 0.13 and 0.16 per cent, respectively.

At the Overall Period, area under forest significantly increased by 0.10 per cent per annum in Konkan and Marathwada regions of Maharashtra. In contrast, it has significantly declined by 0.07 and 0.18 per cent per annum in Vidarbha and Western Maharashtra respectively. The Marathwada was most unstable region while, Western Maharashtra region was most stable during the Period-I and Overall Period, however, Konkan region was found to be most unstable and Marathwada was found most stable region during Period-II in case of area under forest.

In Maharashtra state as a whole, forest area significantly decreased by 0.05, 0.13 and 0.08 per cent per annum during Period-I, Period-II and Overall Period, respectively. At the state level, as compared to Period-II, forest area was reported little more stable during Period-I.

The reasons for negative growth in forest area among most of the districts in Maharashtra were rotational felling, deforestation, diversion of forest areas for non-forestry purposes, encroachment etc. during entire study period. On the other hand, afforestation, reforestation, mangrove rehabilitation and other forest development programmes were the reasons behind significant positive growth in forest area particularly in Konkan region.

4.1.2.3.2 Barren and uncultivable land

Trend of area under barren and uncultivable land of different districts and regions of Maharashtra state was analyzed and the results are presented in Table 4.12. The results of the Period-I indicated the growth rates in area under barren and uncultivable land; where ten districts showed significant and negative growth rates ranging between -0.18 to -2.39 per cent and five districts registered positive and

significant growth rates ranging between 0.26 to 1.55 per cent per annum. The annual rate of decline was the highest in Yavatmal (2.39%), followed by Akola (2.14%), Chandrapur (0.94%), Dhule (0.75%), Solapur (0.63%), Wardha (0.47%), etc. On the other hand, the districts *viz.*, Raigad (0.26%), Satara (0.90%), Buldhana (0.93%), Beed (1.06%) and Parbhani (1.55%) showed significantly positive growth rates.

During the Period-II, area under barren and uncultivable land observed mixed pattern of growth rate in districts of Maharashtra; whereas, major district showed a significant and negative annual growth rate. The annual rate of increment was the highest in Buldhana (3.35%), followed by Nagpur (2.77%), Nanded (1.01%), Osmanabad (0.43%), Pune (0.39%), etc. On the other hand, the districts *viz.*, Thane (0.84%), Sangli (0.65%), Aurangabad (0.36%), Nashik (0.34%), Ahmednagar (0.24%), etc. showed significant negative growth rates. As compared to Period-I, the few of districts showed increasing growth rates of barren and uncultivable land in Period-II, which was the undesirable situation since it implies that uncultivable land might have brought under cultivation. During the Overall Period, the annual rate of decline was the highest in Yavatmal (1.10%), followed by Akola (0.96%), Thane (0.84%), Ahmednagar (0.50%), Dhule (0.47%), etc. On the other hand, the districts *viz.*, Nagpur (1.76%), Buldhana (1.44%), Osmanabad (1.21%), Beed (1.19%), Parbhani (1.07%), Wardha (1.06%), Satara (0.52%) and Bhandara (0.39%) showed positive and significant growth rate.

The Greater Bombay district was the most unstable district in area under barren and uncultivable land during the Period-I, followed by Nagpur, Amravati, Parbhani, Nanded, Akola, etc. while, the district of Raigad was most stable, followed by Ratnagiri, Jalgaon, Ahmednagar, Nashik, Solapur, etc. During the Period-II, Buldhana was the most unstable district in area under barren and uncultivable land, followed by Nagpur, Wardha, Thane, Nanded, etc. On the other hand, Jalgaon was found most stable, followed by Yavatmal, Kolhapur, Dhule, etc. For the Overall Period, Greater Bombay was the most unstable and Ahmednagar was the most stable district, followed by Ratnagiri, Raigad, Jalgaon, Thane etc. in area under barren and uncultivable land in Maharashtra state as compared to other districts.

Regionwise growth rate analysis of area under barren and uncultivable land revealed that during the Period-I, only Marathwada region registered the positive

growth rate of 0.51 per cent per annum. On the other hand, area under barren and uncultivable land has significantly declined by 0.13 and 1.03 per cent per annum in Western Maharashtra and Vidarbha regions, respectively.

Table 4.12. District and regionwise annual compound growth rates and instability indices of barren and uncultivable land in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|---|----------------|----------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 0.77 | 0.00 | 0.25 | 25.37 | - | 25.37 |
| 2 | Thane | 0.15 | -0.84** | -0.84** | 6.08 | 7.60 | 3.47 |
| 3 | Raigad | 0.26** | 0.04 | 0.11** | 1.84 | 0.84 | 2.17 |
| 4 | Ratnagiri | -0.18** | -0.04 | -0.13** | 1.90 | 0.81 | 1.46 |
| | Konkan Region | -0.03 | -0.12** | -0.16** | 1.66 | 0.69 | 0.87 |
| 5 | Pune | -0.29** | 0.39** | -0.20** | 4.70 | 3.51 | 4.56 |
| 6 | Solapur | -0.63** | 0.01 | -0.28** | 3.97 | 1.40 | 4.70 |
| 7 | Satara | 0.90** | 0.17** | 0.52** | 9.69 | 0.85 | 8.49 |
| 8 | Sangli | -0.33** | -0.65** | -0.39** | 5.48 | 3.16 | 3.65 |
| 9 | Kolhapur | -0.11 | -0.04* | 0.04 | 8.72 | 0.52 | 8.72 |
| 10 | Ahmednagar | -0.39** | -0.24** | -0.50** | 2.55 | 1.52 | 1.36 |
| 11 | Nashik | 0.04 | -0.34** | -0.06* | 3.92 | 0.81 | 3.78 |
| 12 | Jalgaon | -0.01 | -0.03** | -0.01 | 2.17 | 0.22 | 2.17 |
| 13 | Dhule | -0.75** | -0.14** | -0.47** | 7.29 | 0.60 | 6.06 |
| | W. Maharashtra Region | -0.13** | -0.05* | -0.14** | 1.93 | 0.87 | 1.31 |
| 14 | Aurangabad | -0.10 | -0.36** | -0.37** | 8.53 | 1.18 | 6.19 |
| 15 | Nanded | -0.35 | 1.01** | 0.09 | 12.51 | 6.05 | 12.51 |
| 16 | Osmanabad | 0.29 | 0.43** | 1.21** | 11.19 | 4.37 | 5.46 |
| 17 | Parbhani | 1.55** | -0.22** | 1.07** | 14.63 | 0.71 | 12.07 |
| 18 | Beed | 1.06** | -0.17** | 1.19** | 9.89 | 0.87 | 6.58 |
| | Marathwada Region | 0.51** | 0.09* | 0.60** | 2.95 | 1.54 | 1.94 |
| 19 | Buldhana | 0.18 | 3.35** | 1.44** | 6.36 | 14.23 | 3.72 |
| 20 | Akola | -2.14** | -0.17 | -0.96** | 11.33 | 3.45 | 14.33 |
| 21 | Amravati | 0.29 | 0.10** | 0.18 | 21.89 | 0.86 | 21.89 |
| 22 | Yavatmal | -2.39** | 0.04** | -1.10** | 9.51 | 0.24 | 14.45 |
| 23 | Wardha | -0.47** | 0.38 | 1.06** | 5.82 | 8.82 | 4.66 |
| 24 | Nagpur | -0.17 | 2.77** | 1.75** | 23.24 | 10.90 | 13.41 |
| 25 | Bhandara | 0.93** | 0.08** | 0.39** | 11.18 | 0.90 | 11.69 |
| 26 | Chandrapur | -0.94** | -0.22** | 0.05 | 10.97 | 0.80 | 14.02 |
| | Vidarbha Region | -1.03** | 0.87** | 0.11 | 7.68 | 3.92 | 12.45 |
| | Maharashtra | -0.17** | 0.05** | -0.07** | 0.77 | 0.46 | 1.20 |

Note : ** and * shows significant level at 1 % and 5 % level, respectively

During Period-II, area under barren and uncultivable land increased significantly in Marathwada and Vidarbha by 0.09 and 0.87 per cent per annum, respectively. Contrary to this, it declined significantly in Western Maharashtra and Konkan by 0.05 and 0.12 per cent per annum, respectively. For the Overall Period, area under barren and uncultivable land increased significantly by 0.60 per cent per annum in Marathwada region of Maharashtra. On the other hand, it has significantly decreased by 0.14 and 0.16 per cent per annum in Western Maharashtra and Konkan, respectively during the Overall Period. The Vidarbha region was most unstable, whereas, Konkan region was found to be the most stable region in barren and uncultivable land during all three study periods.

The growth rate of barren and uncultivable land was declined by 0.17 and 0.07 per cent per annum during Period-I and Overall Period for the Maharashtra state as a whole, respectively. On the other hand, it significantly increased by 0.05 per cent per annum during Period-II. As compared to Period-I, area under barren and uncultivable land was more stable in Period-II in Maharashtra state. Area under barren and uncultivated land has shown a raising trend because of desertification of land due to scarcity of water and or soil degradation by soil erosion.

4.1.2.3.3 Land put to non-agricultural uses

Growth rates and instability indices of area under non-agricultural uses at districts and regional level were worked out for all the three periods under study and the results are given in Table 4.13.

During the Period-I, all the districts were recorded a significantly positive growth rates whereas, Nanded and Parbhani districts recorded non-significant and positive growth in area under non-agricultural uses. Annual rate of growth was highest in Sangli (18.17%), followed by Thane (15.67%), Raigad (14.22%), Ahmednagar (12.47%), Nashik (10.95%), Jalgaon (10.70%), etc. during the Period-I. During Period-II also, majority of districts (23 out of 26) of the Maharashtra registered positive and significant growth rates in area under non-agricultural uses in which the annual increase ranged between 0.19 and 6.65 per cent. The growth rate in area under non-agricultural uses was recorded significantly negative in Aurangabad district. As compared to Period-I, majority of the districts showed lower growth rates in Period-II, which was the desirable situation

since it implies that conversion of agricultural land to non-agricultural uses might be reduced in recent years. During the Overall Period, all the districts recorded a positive and significant growth rates in area under non-agricultural uses. However, Nanded district was found non-significant positive growth rate. The district of Nashik remained top with magnitude of 7.94 per cent per annum, followed by Sangli (7.53%), Thane (6.55%), Ahmednagar (5.80%), Solapur (5.31%), etc.

Table 4.13. District and regionwise annual compound growth rates and instability indices of land put to non-agricultural uses in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|---|---------------|---------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 3.70** | 1.10** | 2.20** | 16.56 | 8.11 | 14.95 |
| 2 | Thane | 15.67** | 0.90** | 6.55** | 36.82 | 8.32 | 45.07 |
| 3 | Raigad | 14.22** | 0.97** | 5.94** | 36.35 | 4.94 | 44.72 |
| 4 | Ratnagiri | 0.96* | 0.19** | 0.55** | 14.55 | 0.28 | 13.39 |
| | Konkan Region | 6.33** | 0.81** | 3.13** | 24.33 | 4.35 | 26.85 |
| 5 | Pune | 3.96** | 3.33** | 4.44** | 27.65 | 20.04 | 15.13 |
| 6 | Solapur | 6.30** | 6.65** | 5.31** | 19.38 | 21.78 | 14.76 |
| 7 | Satara | 6.39* | 0.78** | 2.97** | 41.67 | 1.71 | 40.65 |
| 8 | Sangli | 18.17** | 0.38** | 7.53** | 38.20 | 2.08 | 47.47 |
| 9 | Kolhapur | 1.85** | 0.39** | 1.11** | 4.54 | 1.00 | 5.98 |
| 10 | Ahmednagar | 12.47** | 1.04** | 5.80** | 26.96 | 3.43 | 39.61 |
| 11 | Nashik | 10.95** | 4.84** | 7.94** | 39.47 | 17.10 | 29.24 |
| 12 | Jalgaon | 10.91** | 0.79** | 4.91** | 25.61 | 1.50 | 38.54 |
| 13 | Dhule | 1.55** | 1.41** | 1.08** | 7.68 | 5.19 | 6.20 |
| | W. Maharashtra Region | 4.48** | 2.12** | 3.35** | 20.60 | 6.71 | 13.99 |
| 14 | Aurangabad | 2.35** | -0.15** | 1.15** | 7.75 | 1.20 | 11.90 |
| 15 | Nanded | 0.03 | 1.20** | 0.06 | 5.73 | 6.93 | 5.73 |
| 16 | Osmanabad | 0.52* | 2.11** | 1.32** | 9.73 | 4.67 | 4.74 |
| 17 | Parbhani | 0.43 | 0.87** | 0.32** | 16.68 | 7.61 | 15.56 |
| 18 | Beed | 1.46** | 0.08** | 1.11** | 9.63 | 8.67 | 8.22 |
| | Marathwada Region | 1.15** | 0.62** | 0.81** | 4.32 | 2.86 | 3.59 |
| 19 | Buldhana | 1.29** | 0.95** | 1.58** | 7.69 | 1.82 | 3.73 |
| 20 | Akola | 1.30** | 0.86* | 1.13** | 6.41 | 10.73 | 6.78 |
| 21 | Amravati | 1.42** | 0.37** | 0.88** | 7.09 | 1.10 | 6.12 |
| 22 | Yavatmal | 0.60** | 1.50** | 1.40** | 7.45 | 8.75 | 3.71 |
| 23 | Wardha | 0.69** | 0.50** | 0.54** | 6.24 | 2.08 | 4.25 |
| 24 | Nagpur | 0.93** | 1.86** | 0.97** | 3.74 | 6.29 | 3.61 |
| 25 | Bhandara | 0.70** | 0.14 | 0.37** | 2.70 | 2.79 | 3.54 |
| 26 | Chandrapur | 0.42** | 1.34** | 0.89** | 2.55 | 4.84 | 1.60 |
| | Vidarbha Region | 0.80** | 1.01** | 0.91** | 2.11 | 3.24 | 1.41 |
| | Maharashtra | 1.95** | 1.18** | 1.55** | 6.53 | 2.64 | 4.27 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively

During the Period-I, Satara was the most unstable (41.67%) district in area under non-agricultural uses, followed by Nashik, Sangli, Thane, Raigad, Pune, Ahmednagar, Jalgaon, Solapur, etc. while the district of Chandrapur was most stable in case of area under non-agricultural uses, followed by Bhandara, Nagpur, Kolhapur, Nanded, etc. During Period-II, Solapur was most unstable (21.78%) in area under non-agricultural uses, followed by Pune, Nashik, Akola, Yavatmal, Beed, Thane, Greater Bombay, etc. On the other hand, Parbhani was most stable, followed by Nanded, Kolhapur and Osmanabad. At the Overall Period, the district of Sangli was most unstable (47.47%) and Chandrapur was most stable district in area under non-agricultural uses in Maharashtra state. Regional trend of area under non-agricultural uses revealed that during the Period-I, Konkan, Western Maharashtra, Marathwada and Vidarbha regions recorded significant growth in it by 6.33, 4.48, 1.15 and 0.80 per cent per annum, respectively. In Period-II, area under non-agricultural uses significantly increased in Western Maharashtra, Vidarbha, Konkan and Marathwada by 2.12, 1.01, 0.81 and 0.62 per cent per annum, respectively. For the Overall Period, area under non-agricultural uses significantly increased by 3.35, 3.13, 0.91 and 0.81 per cent per annum in Western Maharashtra, Konkan, Vidarbha and Marathwada regions, respectively. Konkan was found to be most unstable region during Period-I and Overall Period, while Western Maharashtra was reported to be most unstable during the Period-II. On the other hand, area under non-agricultural uses was more stable in Vidarbha region during Period-I and Overall Period, while in case of Marathwada, it was during Period-II.

At the state level, area under non-agricultural uses significantly increased by 1.95, 1.18 and 1.55 per cent per annum during Period-I, Period-II and Overall Period, respectively. During Period-II, the growth rate of non-agricultural land use slowed significantly compared to the Period-I, indicating a desirable situation to agricultural sector. At state level, as compared to Period-I, area under non-agricultural uses was more stable in Period-II. It is a notable observation that the rate of growth in area under non-agricultural uses was significantly increased in all regions as well as Maharashtra as a state during the study Periods. This might be due to urbanization and industrial expansion in Maharashtra state. Another reason for this is expansion in irrigation project, market yard and roads which forms the supporting infrastructure of agricultural growth of the particular region.

4.1.2.3.4 Permanent pastures and other grazing lands

In order to capture the trend of area under permanent pastures and other grazing lands at district and regional level, growth rates and instability indices were worked out for Period-I, Period-II and also for Overall Period and the results are presented in Table 4.14.

During the Period-I, mixed pattern of annual growth rate of districts of Maharashtra was found in area under permanent pastures and other grazing lands. The ten districts were observed with negative and significant growth rate within the range of -0.40 to -1.45 per cent per annum. Annual growth rate of decline was the highest in Nashik (1.45%), followed by Dhule (1.16%), Buldhana (0.98%), Wardha (0.97%), Chandrapur (0.86%), etc. Whereas, eight districts experienced significantly positive growth rates ranging between 0.79 and 8.85 per cent per annum, among which, Ratnagiri district topped the list with the growth rate of 8.85 per cent per annum. During the Period-II, majority of districts of Maharashtra registered negative and significant growth rates in area under permanent pastures and other grazing lands in which, the annual decline ranged between -0.13 and -2.68 per cent while, only three districts showed significant and positive growth rates for the same period. At the overall period, majority of the districts registered negative and significant growth rates with the magnitude of -0.11 to -1.59 per cent per annum. A perusal of overall period indicates that most of the districts of Maharashtra registered a significant rate of decline in area under permanent pastures and grazing lands, which is an alarming situation from ecological point of view and survival of the livestock in the state. Especially in case of Thane, Solapur and Ahmednagar districts, annual growth rate of area under permanent pastures and other grazing lands were significantly positive during Period-I, but it was recorded significantly negative growth rate during Period-II.

District level instability analysis of area under permanent pastures and other grazing lands showed that during the Period-I, Greater Bombay district was the most unstable (85.09%), followed by Ratnagiri, Pune, Satara, Raigad, Thane, etc. while, the district of Nanded was most stable, followed by Aurangabad, Parbhani, Jalgaon, Beed and Wardha. During Period-II, Wardha district was most unstable (14.07%) in respect of area under permanent pastures and other grazing lands, followed by Amravati, Thane,

Jalgaon, Solapur, etc., on the other hand, Raigad district was most stable followed by Kolhapur, Dhule, Parbhani, Bhandara and Nashik. At the Overall Period, Greater Bombay was most unstable (85.09%) and Parbhani (1.87%) was the most stable district in area under permanent pastures and other grazing lands in Maharashtra state.

Table 4.14. District and regionwise annual compound growth rates and instability indices of area under permanent pastures and other grazing lands in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|---|----------------|----------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 1.92 | 0.00 | 0.54 | 85.09 | - | 85.09 |
| 2 | Thane | 2.86** | -0.64* | -0.08 | 19.91 | 12.33 | 30.16 |
| 3 | Raigad | 6.29** | 0.01 | 2.64** | 30.41 | 0.25 | 34.69 |
| 4 | Ratnagiri | 8.85** | 0.56** | 2.67** | 41.69 | 4.79 | 49.22 |
| | Konkan Region | 3.67** | -0.31 | 0.75** | 22.05 | 6.56 | 32.51 |
| 5 | Pune | 6.48** | -0.15 | 1.87** | 40.97 | 3.22 | 48.31 |
| 6 | Solapur | 0.79** | -2.16** | -0.46** | 11.88 | 10.85 | 12.48 |
| 7 | Satara | 8.44** | 0.07 | 2.90** | 40.92 | 1.91 | 48.16 |
| 8 | Sangli | 0.13 | -0.83** | -0.28** | 5.00 | 2.79 | 3.82 |
| 9 | Kolhapur | -0.46** | 0.06** | -0.04 | 6.28 | 0.57 | 7.56 |
| 10 | Ahmednagar | 1.46** | -0.44** | 0.51** | 12.70 | 4.66 | 14.75 |
| 11 | Nashik | -1.45** | -0.23** | -0.62** | 11.62 | 1.75 | 12.99 |
| 12 | Jalgaon | -0.53** | -0.67* | -1.31** | 3.59 | 12.03 | 2.55 |
| 13 | Dhule | -1.16** | 0.11** | -0.47** | 5.30 | 1.05 | 7.80 |
| | W. Maharashtra Region | 1.29** | -0.45** | 0.10 | 12.18 | 2.02 | 16.27 |
| 14 | Aurangabad | -0.55** | -0.39 | -0.52** | 3.37 | 7.99 | 3.26 |
| 15 | Nanded | 0.06 | -1.26** | -0.68** | 2.89 | 9.85 | 1.92 |
| 16 | Osmanabad | 0.10 | 0.04 | -0.05 | 4.87 | 3.34 | 4.87 |
| 17 | Parbhani | -0.40** | -0.13** | -0.61** | 3.42 | 1.18 | 1.87 |
| 18 | Beed | -0.09 | -0.45** | -0.20** | 3.87 | 4.20 | 3.04 |
| | Marathwada Region | -0.20** | -0.47** | -0.44** | 1.68 | 2.62 | 0.87 |
| 19 | Buldhana | -0.98** | 0.19 | -0.78** | 4.40 | 4.85 | 4.75 |
| 20 | Akola | 0.03 | -0.17 | -0.69** | 6.48 | 6.86 | 4.03 |
| 21 | Amravati | -0.04 | -2.68** | -1.35** | 10.80 | 13.50 | 6.38 |
| 22 | Yavatmal | 1.19* | 0.04 | 0.01 | 17.98 | 3.26 | 20.19 |
| 23 | Wardha | -0.97** | -0.14 | -0.66** | 3.98 | 14.07 | 6.00 |
| 24 | Nagpur | -0.64** | -1.98** | -1.59** | 6.27 | 9.85 | 3.00 |
| 25 | Bhandara | -0.06 | -0.26** | -0.11** | 4.82 | 1.48 | 4.33 |
| 26 | Chandrapur | -0.86** | -1.00** | -1.34** | 4.72 | 4.56 | 2.40 |
| | Vidarbha Region | -0.37** | -0.74** | -0.83** | 2.97 | 4.07 | 1.47 |
| | Maharashtra | 0.38** | -0.56** | -0.39** | 5.62 | 2.90 | 4.88 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively

The Vidarbha (-0.37%) and Marathwada (-0.20%) regions showed a significantly negative growth rates during the Period-I regarding area under permanent pastures and other grazing lands, whereas Konkan (3.67%) and Western Maharashtra (1.29%) regions recorded positive and significant growth. During Period-II, area under permanent pastures and other grazing lands significantly declined in Western Maharashtra, Marathwada and Vidarbha by 0.45, 0.47 and 0.74 per cent per annum respectively, while non-significant decrease was recorded in case of Konkan (-0.31%).

The notable observation was that, the growth rate for area under permanent pastures and other grazing lands was pessimistic during the Period-II as compared to Period-I. A decrease in grazing lands indeed a bad sign for livestock enterprise which has also greater bearing on the rural economy, besides it's helpful for ecological balance. At the Overall Period, Vidarbha (-0.83%) and Marathwada (-0.44%) regions showed a negative and significant growth rates in area under permanent pastures and other grazing lands. Growth rate of area under permanent pastures and other grazing lands has significantly increase in case of Konkan (0.75%), while, in Western Maharashtra (0.10%), the increase during the overall period was not statistically significant. In respect of the instability at regional level, the Konkan region was most unstable during all the three study periods, while, Marathwada was most unstable during the Period-I and Overall Period. On the other hand, area under permanent pastures and other grazing lands was more stable in Western Maharashtra region during Period-II.

The area under permanent pastures and other grazing lands increased by 0.38% per annum during Period-I, however, it significantly decreased by 0.56 and 0.39% per annum within Period-II and Overall Period, respectively at the state level. This might be due to overgrazing, poor management and or conversion of this land to non-agricultural uses. For Maharashtra state as a whole, the area under permanent pastures and other grazing lands was more stable during Period-II as compared to Period-I.

4.1.2.3.5 Land under miscellaneous tree crops and groves

Mixed trend was observed for annual growth rate in land under miscellaneous tree crops and groves in the districts of Maharashtra during Period-I (Table 4.15). The positive and significant growth rate was observed, which ranged from 0.73 to 5.03 per cent per annum. An annual rate of increase in land under miscellaneous tree

crops and groves was the highest in Solapur (5.43%), followed by Dhule (3.68%), Nashik (3.26%), Aurangabad (2.76%), Akola (1.20%), etc. During Period-II, majority of districts (i.e. 15 districts) were recorded significantly positive growth rates, which ranged between 0.18 and 8.47 per cent in area under miscellaneous tree crops and groves. At the overall period also, most of districts showed positive growth rates of land under miscellaneous tree crops and groves. The results of instability analysis showed that the district of Jalgaon was the most unstable districts during Period-I and Overall Period, whereas, Thane district was most unstable during Period-II. On the other side, Nanded, Raigad and Bhandara were found to be most stable districts during the Period-I, Period-II and Overall Period, respectively. The land under miscellaneous tree crops and groves significantly increased in Western Maharashtra (3.26%), followed by Marathwada (1.31%) regions of Maharashtra during the Period-I. Whereas, during the Period-II, Vidarbha region of Maharashtra showed decreased significantly in land under miscellaneous tree crops and groves (-0.23%), on the other hand, Konkan (2.36%), Western Maharashtra (1.56%) and Marathwada (1.02%) regions of Maharashtra appeared significantly positive. At the Overall Period, Western Maharashtra (2.86%), Marathwada (1.38%) and Konkan (0.05%) regions showed positive growth rates in land under miscellaneous tree crops and groves, among which, Konkan region showed non-significant growth rate. Positive significant growth rates were observed in Western Maharashtra and Marathwada whereas, it was significantly negative in Vidarbha during all three Periods.

With respect of instability in land under miscellaneous tree crops and groves, Western Maharashtra during Period-I and Konkan during Period-II and Overall Period were found most unstable regions. However, Marathwada during Period-I and Overall Period and Vidarbha during Period-II were the most stable regions.

At state level, land under miscellaneous tree crops and groves significantly increased by 1.17 and 0.66 per cent per annum during Period-II and Overall Period, respectively, however, during Period-I, annual growth rate of land under miscellaneous tree crops and groves was positive but non-significant. At the state level, land under miscellaneous tree crops and groves was more unstable in Period-II as compared to Period-I in Maharashtra.

Table 4.15. District and regionwise annual compound growth rates and instability indices of land under miscellaneous tree and groves in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|----------------|---------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | NA | NA | NA | NA | NA | NA |
| 2 | Thane | -2.20** | 8.47** | 2.01** | 21.65 | 31.18 | 26.25 |
| 3 | Raigad | -1.07** | -0.0001 | -1.05** | 10.19 | 0.26 | 6.69 |
| 4 | Ratnagiri | 0.07 | 1.79** | 0.24 | 37.15 | 14.03 | 37.15 |
| | Konkan Region | -0.81* | 2.36** | 0.05 | 15.42 | 9.88 | 16.81 |
| 5 | Pune | NA | 8.18** | NA | NA | 31.00 | NA |
| 6 | Solapur | 5.43** | 0.86** | 2.77** | 33.92 | 4.84 | 31.89 |
| 7 | Satara | NA | 0.33** | NA | NA | 2.51 | NA |
| 8 | Sangli | NA | 1.46** | NA | NA | 3.69 | NA |
| 9 | Kolhapur | -0.20 | 1.06** | 0.94** | 11.71 | 5.61 | 7.62 |
| 10 | Ahmednagar | NA | 9.60 | NA | NA | 21.21 | NA |
| 11 | Nashik | 3.26** | 0.18** | 2.60** | 56.81 | 2.31 | 43.93 |
| 12 | Jalgaon | -2.87** | 1.35 | 3.04** | 62.67 | 15.90 | 56.22 |
| 13 | Dhule | 3.68** | 0.67** | 2.68** | 26.39 | 5.22 | 19.60 |
| | W. Maharashtra Region | 3.26** | 1.59** | 2.86** | 21.02 | 8.12 | 12.96 |
| 14 | Aurangabad | 2.76** | 1.38** | 0.95** | 37.50 | 6.71 | 39.24 |
| 15 | Nanded | -0.76** | 0.30** | -0.03 | 5.46 | 3.70 | 8.64 |
| 16 | Osmanabad | 1.12* | 1.99** | 2.74** | 23.58 | 5.90 | 11.50 |
| 17 | Parbhani | 1.73 | -0.84** | 1.55** | 50.43 | 6.42 | 40.42 |
| 18 | Beed | 0.52 | 1.56** | 1.17** | 27.00 | 12.15 | 17.34 |
| | Marathwada Region | 1.31** | 1.02** | 1.38** | 8.68 | 3.15 | 4.34 |
| 19 | Buldhana | -1.42** | 0.26 | -1.06** | 31.08 | 14.81 | 26.88 |
| 20 | Akola | 1.20* | -0.32* | 0.12 | 41.32 | 5.20 | 44.25 |
| 21 | Amravati | -1.51** | -0.58** | -0.92** | 16.99 | 4.04 | 14.48 |
| 22 | Yavatmal | -2.00** | -0.65** | -0.67** | 15.96 | 3.42 | 20.52 |
| 23 | Wardha | -0.88** | 0.53** | -0.14 | 8.86 | 4.49 | 12.04 |
| 24 | Nagpur | -0.48 | 0.19 | 1.44** | 38.36 | 10.66 | 29.51 |
| 25 | Bhandara | 0.73** | 0.39** | 0.56** | 8.21 | 3.97 | 6.14 |
| 26 | Chandrapur | -1.05** | -0.71** | -0.18* | 7.00 | 7.93 | 11.60 |
| | Vidarbha Region | -0.97** | -0.23** | -0.16* | 9.41 | 2.23 | 12.74 |
| | Maharashtra | 0.02 | 1.17** | 0.66** | 4.73 | 5.28 | 2.61 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

4.1.2.3.6 Cultivable waste

The results furnished in Table 4.16 revealed that during the Period-I, mixed trend was observed in area under cultivable waste where, eleven of the districts of Maharashtra reported increase in area under cultivable waste and it was in the range of 1.30 to 8.46 per cent per annum. The rise in annual growth rate was the highest in Satara (8.46%), followed by Osmanabad (6.16%), Parbhani (6.12%), Pune (5.86%), Beed

(4.13%), Aurangabad (3.09%), *etc.* During Period-II also, mixed pattern was noticed, where ten districts were observed significantly decline of growth rates in area under cultivable waste, in which, the annual rate of decrease ranged between -0.01 to -1.34 per cent. Cultivable waste land increased in remaining districts of Maharashtra and the district of Buldhana remained at top with the positive and significant growth rate of 3.07 per cent per annum. During the Overall Period, as well, mixed tendency of the districts was revealed in area under cultivable waste and it was experienced significant increase in area under cultivable waste within the range of 0.44 to 3.09 per cent per annum. In a nutshell, it can be inferred that though area under cultivable waste increased in majority of the districts in both the periods, the rate of growth was lower in Period-II as compared to Period-I.

Instability analysis showed that during the Period-I, the district of Greater Bombay was found to be the most unstable (72.16%) in respect of area under cultivable waste, followed by Sangli, Dhule, Satara, Pune, Akola, *etc.* while, the district of Chandrapur was most stable, followed by Bhandara, Kolhapur, Nanded and Yavatmal. Sangli district was the most unstable (17.75%) during Period-II, which was followed by Ratnagiri, Buldhana and Nagpur. For the Overall Period also, the district of Sangli (64.08%) was found to be most unstable, while, Kolhapur (5.95%) was most stable district in terms of area under cultivable waste in Maharashtra state.

All the regions showed a positive growth rates for area under cultivable waste except Vidarbha region of Maharashtra during the Period-I. Marathwada (4.25%) and Konkan (1.31%) regions recorded positive and significant growth rates, while, in case of Western Maharashtra (0.21%), the growth was non-significant. Whereas, Vidarbha (-1.78%) region showed significantly negative growth rate in area under cultivable waste. In Period-II, area under cultivable waste significantly increased in Vidarbha and Western Maharashtra by 0.66 and 0.21 per cent per annum, respectively, while it declined in Konkan and Marathwada by 1.44 and 0.01 per cent per annum, respectively, however, Marathwada region was not found significant.

Table 4.16. District and regionwise annual compound growth rates and instability indices of area under cultivable waste in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|----------------|----------------|-----------------------|--------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | -5.32** | NA | NA | 72.16 | NA | NA |
| 2 | Thane | 2.44** | -0.78** | 0.44* | 19.34 | 6.02 | 25.24 |
| 3 | Raigad | -2.09** | -0.01** | -0.73** | 17.89 | 0.08 | 21.38 |
| 4 | Ratnagiri | 1.97** | -1.33** | -0.28 | 17.04 | 13.65 | 22.93 |
| | Konkan Region | 1.31** | -1.14** | -0.34* | 13.30 | 10.59 | 16.26 |
| 5 | Pune | 5.86** | 0.27** | 1.96** | 36.74 | 3.18 | 43.66 |
| 6 | Solapur | 2.54* | 0.44** | 1.20** | 34.80 | 2.95 | 34.06 |
| 7 | Satara | 8.46** | 0.22** | 3.09** | 48.36 | 2.15 | 52.27 |
| 8 | Sangli | -1.44 | 2.56** | 0.70* | 66.56 | 17.75 | 64.08 |
| 9 | Kolhapur | -2.02** | -0.63** | -1.88** | 8.82 | 4.83 | 5.95 |
| 10 | Ahmednagar | 1.74** | 0.69** | 1.59** | 36.99 | 6.21 | 27.60 |
| 11 | Nashik | -1.45* | 0.05 | -0.45* | 35.70 | 2.02 | 37.31 |
| 12 | Jalgaon | -2.70** | -0.01 | -1.15** | 25.23 | 1.24 | 27.27 |
| 13 | Dhule | -5.59** | -0.81** | -2.58** | 55.85 | 5.89 | 61.50 |
| | W. Maharashtra Region | 0.21 | 0.21** | -0.06 | 20.58 | 1.05 | 20.58 |
| 14 | Aurangabad | 3.09** | -0.11 | 1.40** | 31.26 | 5.80 | 31.95 |
| 15 | Nanded | 1.30** | 0.33** | 0.96** | 10.73 | 2.29 | 7.81 |
| 16 | Osmanabad | 6.16** | 0.12 | 2.24** | 26.08 | 9.27 | 35.28 |
| 17 | Parbhani | 6.12** | -0.16** | 1.86** | 43.53 | 1.61 | 50.79 |
| 18 | Beed | 4.13** | -0.33** | 1.11** | 20.51 | 3.97 | 31.23 |
| | Marathwada Region | 4.25** | -0.01 | 1.49** | 23.30 | 4.11 | 29.98 |
| 19 | Buldhana | -0.80* | 3.07** | 1.26** | 15.67 | 13.01 | 12.65 |
| 20 | Akola | 0.29 | -0.45** | 0.10 | 45.78 | 1.89 | 45.78 |
| 21 | Amravati | -1.61** | -1.34** | -0.84** | 24.88 | 9.62 | 23.78 |
| 22 | Yavatmal | -1.40** | -0.27** | -0.75** | 11.69 | 2.30 | 10.99 |
| 23 | Wardha | -2.62** | 0.30** | -0.69** | 15.31 | 3.30 | 25.60 |
| 24 | Nagpur | -4.19** | 1.94** | 0.22 | 26.93 | 12.99 | 46.20 |
| 25 | Bhandara | -0.15 | 0.17** | 0.03 | 8.00 | 1.23 | 8.00 |
| 26 | Chandrapur | -1.94** | 0.47** | -0.89** | 6.96 | 3.65 | 11.24 |
| | Vidarbha Region | -1.78** | 0.66** | -0.35** | 8.14 | 3.50 | 16.65 |
| | Maharashtra | 0.75** | -0.20* | 0.01 | 12.90 | 3.48 | 14.55 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

At the overall period, Konkan and Vidarbha showed significantly negative while Marathwada region showed positive and significant annual growth rate, whereas for Western Maharashtra region the growth was negative and non-significant. The results of instability index inferred that Marathwada was the most unstable during Period-I and Overall Period, whereas, Konkan was the most unstable during Period-II. However, Vidarbha, Western Maharashtra and Konkan regions were observed stable regions during

Period-I, Period-II and overall period, respectively. At the state level, area under cultivable waste was significant during Period-I and Period-II, while, it was non-significant for overall period. Area under cultivable waste was more stable during Period-II as compared to Period-I in Maharashtra.

The negative growth rate would have been because of the fact that most of land might has been brought under cultivation with the innovation of farm mechanization and reclamation of water-logged area.

4.1.2.3.7 Current fallow

A perusal of Table 4.17 indicates the trend of area under current fallow at district and regional level separately for all the periods. During the Period-I, mixed trend was observed in area under current fallow where, seven districts recorded a significantly positive growth rate and it was found in the range of 1.56 to 20.64 per cent per annum. Annual rate of increase in area under current fallow was the highest in Sangli (20.64%), followed by Ahmednagar (8.98%), Amravati (3.61%), Akola (2.86%), Nagpur (2.84%), etc. During Period-II, majority of districts showed positive growth rates in area under current fallow and the annual increment was in the range of 0.96 and 4.82 per cent. For Overall Period also, most of the districts were noticed positive growth rate of area under current fallow.

The annual growth rate in area under current fallow in Vidarbha region was significant and positive during Period-I, however, Konkan and Marathwada regions revealed that, area under current fallow have significantly declined by 3.45 and 3.44 per cent, respectively. In Period-II, area under current fallow increased among all the regions of Maharashtra, where, highest growth rate was observed in Western Maharashtra by 2.06 per cent per annum. However, Konkan region showed non-significant positive growth rate. For Overall Period, Vidarbha (2.31%) and Western Maharashtra (1.39%) regions showed a significant and positive growth rates in area under current fallow, whereas, Konkan (1.57%) recorded significantly declined trend in area under current fallow. The notable observation recorded that, area under current fallow in Vidarbha region performed significant and positive growth rate during all the three periods. The results of instability indices showed that Western Maharashtra, Vidarbha and Marathwada were most unstable during the Period-I, Period-II and Overall Period, respectively. However, Vidarbha was most stable region in Maharashtra state during the

Period-I and Overall Period. While, Marathwada region was most stable among all other regions of Maharashtra during Period-II. In Maharashtra state as a whole, area under current fallow significantly decreased by 1.62 per cent per annum during Period-I and that trend has been reversed during Period-II and Overall Period, where it significantly increased by 1.75 and 0.49 per cent per annum, respectively. As compared to Period-I, area under current fallow was more stable in Period-II at the state level in Maharashtra.

Table 4.17. District and regionwise annual compound growth rates and instability indices of area under current fallow in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|---------------|----------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | NA | NA | NA | NA | NA | NA |
| 2 | Thane | -6.70** | -9.94 | -5.52** | 30.44 | 21.80 | 58.88 |
| 3 | Raigad | -1.77** | -0.25 | -1.45** | 23.89 | 6.30 | 18.82 |
| 4 | Ratnagiri | -2.34** | 1.24** | -0.56* | 24.21 | 10.12 | 29.05 |
| | Konkan Region | -3.45** | 0.37 | -1.57** | 22.41 | 6.88 | 26.10 |
| 5 | Pune | -0.61 | 3.75** | 0.93* | 81.12 | 15.88 | 77.50 |
| 6 | Solapur | -0.02 | 2.78** | 1.54** | 103.34 | 10.50 | 85.49 |
| 7 | Satara | -4.42** | 3.38** | -0.57 | 61.35 | 24.81 | 71.17 |
| 8 | Sangli | 20.64** | -1.15* | 6.89** | 76.54 | 16.45 | 80.61 |
| 9 | Kolhapur | 2.65** | -2.61** | -1.09** | 25.59 | 10.77 | 29.42 |
| 10 | Ahmednagar | 8.98** | 2.91** | 5.47** | 38.05 | 20.80 | 33.91 |
| 11 | Nashik | 1.75 | 1.89** | 1.74** | 69.63 | 5.57 | 56.48 |
| 12 | Jalgaon | 0.74 | 1.60** | -0.98 | 74.06 | 5.31 | 69.73 |
| 13 | Dhule | -1.30 | 3.66** | 1.31 | 110.21 | 6.62 | 105.18 |
| | W. Maharashtra Region | 1.04 | 2.06** | 1.39** | 57.31 | 7.42 | 42.67 |
| 14 | Aurangabad | 1.62 | 1.99** | 2.47** | 76.95 | 5.89 | 56.37 |
| 15 | Nanded | -2.63** | 0.96** | 0.37 | 23.57 | 7.06 | 33.61 |
| 16 | Osmanabad | -4.26** | 1.38** | 0.01 | 35.41 | 5.88 | 51.82 |
| 17 | Parbhani | -6.22** | 2.60** | -0.77 | 31.10 | 14.43 | 63.29 |
| 18 | Beed | -3.61** | 1.58** | -1.40** | 28.44 | 6.50 | 36.33 |
| | Marathwada Region | -3.44** | 1.68** | -0.16 | 25.53 | 5.78 | 42.78 |
| 19 | Buldhana | 1.56* | 2.14** | 0.93** | 37.05 | 9.19 | 35.05 |
| 20 | Akola | 2.86* | 1.15** | 3.14** | 41.91 | 6.20 | 29.78 |
| 21 | Amravati | 3.61** | 4.82** | 2.65** | 31.03 | 20.94 | 25.69 |
| 22 | Yavatmal | -0.84** | 1.11** | 0.76** | 14.09 | 2.49 | 12.48 |
| 23 | Wardha | 1.91** | 1.17** | 6.44** | 87.73 | 8.75 | 43.28 |
| 24 | Nagpur | 2.84** | -0.14 | 1.18** | 31.64 | 4.69 | 32.97 |
| 25 | Bhandara | 0.94 | 1.65 | 0.90** | 45.87 | 39.14 | 42.60 |
| 26 | Chandrapur | 1.10 | 2.77** | 2.93** | 32.33 | 14.55 | 16.64 |
| | Vidarbha Region | 1.44** | 1.74** | 2.31** | 17.08 | 8.38 | 8.25 |
| | Maharashtra | -1.62** | 1.75** | 0.49** | 27.35 | 5.05 | 31.47 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

At state level, the highest instability was seen in area under current fallow than all other land use categories indicating very high year-to-year fluctuation due to the variations in rainfall, about 80 per cent of the cultivated area in Maharashtra is under rainfed farming and susceptible to land degradation.

4.1.2.3.8 Area under fallow other than current fallow

Growth rates and instability indices of area under fallow other than current fallow was worked out for all the three periods and the results are presented in Table 4.18. During the Period-I, the majority of districts of Maharashtra recorded negative and significant growth rates of area under fallow other than current fallow that ranged from 0.50 to 6.90 per cent per annum. Annual rate of decrease in area under fallow other than current fallow was highest in Thane (6.90%), followed by Greater Bombay (6.73%), Pune (6.41%), Akola (3.14%), etc. On the Contrary, during the Period-II, majority of districts showed positive growth rates in area under fallow other than current fallow in which the annual increase ranged between 0.38 and 3.25 per cent. Thane district was recorded highest growth rate in area under fallow other than current fallow. At overall period, mix trend of growth rate of area under fallow other than current fallow in different districts of Maharashtra was observed, where, Aurangabad (2.75%) recorded highest in annual growth rate. The result of instability showed that Wardha (76.75%), Nanded (18.39%) and Thane (81.48%) were most unstable in terms of area under fallow other than current fallow during Period-I, Period-II and Overall Period, respectively. On the other hand, Raigad was most stable district in area under fallow other than current fallow during the Period-I and Overall Period. However, Kolhapur district was most stable district during the Period-II.

Area under fallow other than current fallow was declined in all the regions, except, Marathwada region during Period-I. However, during Period-II, area under fallow other than current fallow of all regions observed significant positive growth rate, excluding Vidarbha region of Maharashtra. The highest positive growth rate was found within Marathwada (1.14%) region followed by Konkan (0.75%) and Western Maharashtra (0.38%) in area under fallow other than current fallow. At the overall Period, Marathwada (1.42%) and Western Maharashtra (0.34%) regions of Maharashtra showed positive and significant growth rates in area under fallow other than current

fallow, while, Vidarbha region was appeared significantly declined annual rate of growth (0.57%). It can be inferred that the Konkan was most unstable regions during the all the three study periods. However, Western Maharashtra region in Maharashtra state was most stable during Period-I and Overall Period, while, Vidarbha region was most stable during Period-II in area under fallow other than current fallow.

Table 4.18. District and regionwise annual compound growth rates and instability indices area under fallow other than current fallow in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|---------------|----------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | -6.73** | NA | NA | 37.04 | NA | NA |
| 2 | Thane | -6.90** | 3.25** | -1.16* | 53.33 | 16.73 | 81.48 |
| 3 | Raigad | -0.50** | 0.10 | 0.09 | 5.33 | 2.15 | 7.00 |
| 4 | Ratnagiri | -1.46* | 0.78** | 0.58* | 30.86 | 7.29 | 31.77 |
| | Konkan Region | -1.87** | 0.75** | 0.27 | 27.31 | 5.78 | 32.38 |
| 5 | Pune | -6.41** | -0.35 | -2.02** | 39.20 | 10.84 | 59.13 |
| 6 | Solapur | 3.04** | 0.14 | 2.05** | 20.18 | 7.25 | 16.67 |
| 7 | Satara | 2.88** | 1.70** | 1.56** | 38.07 | 4.77 | 35.15 |
| 8 | Sangli | -1.03* | 0.71** | -0.59** | 18.84 | 3.62 | 17.92 |
| 9 | Kolhapur | 0.25 | -1.46** | -0.76** | 11.75 | 1.47 | 7.97 |
| 10 | Ahmednagar | 1.92** | 0.79** | 2.28** | 33.59 | 8.84 | 21.07 |
| 11 | Nashik | -0.34 | -0.41** | -0.56** | 26.40 | 6.40 | 23.22 |
| 12 | Jalgaon | -0.23 | -0.27* | -1.82** | 35.81 | 5.45 | 23.45 |
| 13 | Dhule | -1.51** | 0.04 | -0.44** | 21.51 | 5.46 | 23.98 |
| | W. Maharashtra Region | -0.27 | 0.38** | 0.34** | 13.82 | 3.76 | 12.23 |
| 14 | Aurangabad | 2.00* | 1.31 | 2.75** | 44.21 | 4.15 | 27.11 |
| 15 | Nanded | -0.06 | 1.88** | 0.90** | 30.37 | 18.39 | 25.88 |
| 16 | Osmanabad | 0.49 | 1.61** | 2.31** | 16.82 | 8.70 | 7.60 |
| 17 | Parbhani | 0.02 | -0.17 | 1.22** | 51.81 | 8.07 | 47.42 |
| 18 | Beed | -0.68 | 0.88** | -0.27 | 40.31 | 6.20 | 40.31 |
| | Marathwada Region | 0.20 | 1.14** | 1.42** | 27.00 | 3.16 | 17.73 |
| 19 | Buldhana | -0.73 | 2.07** | -0.71** | 17.41 | 9.93 | 15.27 |
| 20 | Akola | -3.14** | 0.38** | -1.55** | 32.92 | 2.59 | 32.49 |
| 21 | Amravati | -2.97** | 0.44** | -1.81** | 25.57 | 3.35 | 23.54 |
| 22 | Yavatmal | -2.15** | -0.36** | -1.46** | 11.36 | 2.80 | 9.55 |
| 23 | Wardha | -0.14 | -0.45 | 2.45** | 76.75 | 8.75 | 59.59 |
| 24 | Nagpur | 0.67 | -0.47* | 0.99** | 36.79 | 7.22 | 28.72 |
| 25 | Bhandara | -0.71 | -1.00** | -1.35** | 21.55 | 4.21 | 12.74 |
| 26 | Chandrapur | 0.08 | -0.59** | 0.32** | 15.23 | 7.57 | 14.22 |
| | Vidarbha Region | -1.29** | 0.01 | -0.57** | 16.71 | 2.70 | 16.87 |
| | Maharashtra | -0.79* | 0.61** | 0.38** | 15.48 | 2.86 | 15.60 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

The trend of area under fallow other than current fallow at state level showed significant increase by 0.61 and 0.38 per cent per annum during Period-II and Overall Period, respectively. A significant increase in the area under fallow land in Maharashtra state over the time could be attributed mainly to the erratic rainfall. At state level, area under fallow other than current fallow was more stable in Period-II as compared to Period-I in Maharashtra.

4.1.2.3.9 Net area sown

The results given in Table 4.19 revealed that during the Period-I, districts of Maharashtra showed mixed trend of growth rate in net area sown, which ranged from 0.08 to 0.48 per cent per annum. Annual rate of increase was highest in case of Yavatmal (0.48%) followed Beed (0.41%), Dhule (0.37%), Parbhani (0.35%), Chandrapur (0.25%), etc. Contrary to this, majority of the districts showed negative and significant growth rates in net sown area during the Period-II, where, among these districts, Thane district showed highest decline in growth rate of 0.67 per cent per annum. At the overall period, most of the districts observed significantly negative annual growth rates in net area sown. Interestingly, some districts showed an increasing trend of net area sown during Period-I, on the flip side, these districts observed negative trend in Period-II, implying that, the conversion of agricultural land to other purposes has taken place in these districts in Period-II and same was replicated at the state level too. During Overall Period, all districts of Maharashtra (except, Ratnagiri, Nashik and Parbhani) showed significant growth in net sown area.

During Period-I, Greater Bombay was the most unstable (13.47%) district in respect of net area sown, followed by Solapur, Satara, Beed, Thane, etc., while Buldhana district was the most stable as compared to other. Thane and Solapur districts were the most unstable district during the Period-II and Overall Period, respectively. However, Yavatmal and Amravati were the most stable districts in net area sown in Maharashtra state during Period-II and Overall Period. Annual growth rate of net sown area in Vidarbha (0.16%) region showed a significant positive growth while, Konkan (-0.46%) indicated significant decline during the Period-I. Whereas, Western Maharashtra and Marathwada registered non-significant growth rate. In Period-II, net area sown decreased significantly in all the regions of Maharashtra except Konkan

region, which declined non-significantly. At overall period, growth rates of net area sown significantly decreased all the regions excluding Vidarbha region. Where, Vidarbha region showed non-significant positive growth rate.

Table 4.19. District and regionwise annual compound growth rates and instability indices of net sown area in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|---|----------------|----------------|-----------------------|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | -1.69** | NA | NA | 13.47 | NA | NA |
| 2 | Thane | -0.42** | -0.67** | -0.33** | 6.38 | 5.05 | 5.47 |
| 3 | Raigad | -0.67** | 0.003 | -0.27** | 4.02 | 0.53 | 5.03 |
| 4 | Ratnagiri | -0.35** | 0.27** | 0.07 | 3.34 | 2.97 | 4.55 |
| | Konkan Region | -0.46** | -0.11 | -0.17** | 3.28 | 2.37 | 4.19 |
| 5 | Pune | -0.02 | -0.59** | -0.21** | 3.61 | 3.12 | 2.81 |
| 6 | Solapur | -0.20 | -0.25** | -0.26** | 8.92 | 1.44 | 7.92 |
| 7 | Satara | -0.76** | -0.41** | -0.38** | 7.86 | 1.65 | 7.50 |
| 8 | Sangli | -0.40** | 0.02 | -0.15** | 5.54 | 1.34 | 5.80 |
| 9 | Kolhapur | 0.11* | 0.18** | 0.23** | 2.22 | 0.72 | 1.10 |
| 10 | Ahmednagar | -0.29** | -0.32** | -0.31** | 2.66 | 2.34 | 1.65 |
| 11 | Nashik | 0.02 | -0.08** | -0.04 | 5.10 | 0.60 | 5.10 |
| 12 | Jalgaon | 0.08* | 0.04 | 0.15** | 1.81 | 0.82 | 1.10 |
| 13 | Dhule | 0.37** | -0.05** | 0.17** | 2.28 | 0.51 | 2.65 |
| | W. Maharashtra Region | -0.13 | -0.19** | -0.12** | 3.84 | 0.66 | 3.18 |
| 14 | Aurangabad | -0.21 | -0.24** | -0.26** | 5.57 | 0.52 | 3.86 |
| 15 | Nanded | 0.13** | -0.12** | -0.05** | 1.72 | 1.14 | 1.92 |
| 16 | Osmanabad | 0.17 | -0.51** | -0.33** | 4.64 | 1.43 | 3.12 |
| 17 | Parbhani | 0.35** | -0.18** | 0.01 | 3.42 | 0.89 | 4.66 |
| 18 | Beed | 0.41* | -0.19** | 0.18** | 7.79 | 1.24 | 7.81 |
| | Marathwada Region | 0.14 | -0.26** | -0.12** | 3.85 | 0.63 | 3.34 |
| 19 | Buldhana | -0.01 | -0.25** | -0.05** | 1.07 | 0.85 | 0.95 |
| 20 | Akola | 0.17** | -0.08** | 0.06** | 1.86 | 0.70 | 2.13 |
| 21 | Amravati | 0.17** | 0.05* | 0.17** | 1.19 | 0.80 | 0.76 |
| 22 | Yavatmal | 0.48** | 0.004 | 0.16** | 2.01 | 0.38 | 3.40 |
| 23 | Wardha | 0.06 | -0.22** | -0.39** | 3.33 | 1.35 | 1.87 |
| 24 | Nagpur | 0.12** | 0.01 | 0.03* | 1.95 | 0.59 | 2.11 |
| 25 | Bhandara | -0.32** | -0.02 | -0.17** | 3.24 | 1.60 | 3.13 |
| 26 | Chandrapur | 0.25** | -0.20** | -0.10** | 2.40 | 1.80 | 2.92 |
| | Vidarbha Region | 0.16** | -0.08** | 0.001 | 1.48 | 0.47 | 2.03 |
| | Maharashtra | 0.005 | -0.18** | -0.09** | 2.51 | 0.46 | 2.06 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

The Marathwada region was most unstable in net sown area during Period-I, while Konkan was the most unstable region in case of net area sown during Period-II and Overall Period. As a result of conversion of agricultural land to non-

agricultural uses the negative and significant growth rate (-0.18% per annum) of net area sown during the Period-II. Instability of net area sown at state level tend to decline from 2.51 per cent during Period-I to 0.46 per cent during Period-II, implying that net area sown was stable in recent days.

4.1.2.3.10 Area sown more than once

It can be seen from Table 4.20 that during Period-I, all the districts, except Dhule and Bhandara, recorded a positive growth rates in area sown more than once and it ranged from 1.33 to 13.68 per cent per annum. Annual rate of increase in area sown more than once was the highest in Amravati (13.68%), followed by Akola (12.02%), Osmanabad (8.49%), Nagpur (8.16%), Buldhana (7.87%), etc. During Period-II, majority of the districts showed positive growth rates which ranged between 0.94 to 11.19 per cent. Wardha (11.09%) was an uppermost district in highest growth rate in area sown more than once. At the Overall Period, almost all districts of Maharashtra showed positive growth rates of area sown more than once, except, Bhandara and Thane, were negative and significant growth rate was observed.

The results of instability analysis inferred that the districts of Aurangabad (55.23%), Kolhapur (40.06%) and Wardha (44.70%) were most unstable during Period-I, Period-II and Overall Period, respectively. On the other side, Pune was most stable district during Period-I (17.21%) and Overall Period (10.22%). However, Raigad district was found to be most stable districts during the Period-II. It is markedly observed that, in majority of the districts, the growth rates for area sown more than once declined towards lower side during Period-II as compared to Period-I, which ultimately reflected at the state level also, where the growth rate of area sown more than once declined from 4.01 to 2.83 per cent significantly per annum.

Area sown more than once increased significantly in all the regions of Maharashtra during all the three study periods except, Konkan that showed significant decrease in Period-II. It was observed that, the highest rate of increase was registered by Marathwada, followed by Vidarbha, Western Maharashtra and Konkan regions of Maharashtra during Period-II and Overall Period. Among all the regions of Maharashtra, Konkan was found the most unstable during Period-I and Overall Period. Whereas, Western Maharashtra was the most unstable region during Period-II. However, Vidarbha appeared most stable region during Period-I and Overall Period. At

state level, area sown more than once significantly increased by 4.01, 2.83 and 4.04 per cent per annum during Period-I, Period-II and Overall Period, respectively. The positive and significant growth rates in all the periods were good sign implying the impact of irrigation projects in the state. At the state level, area sown more than once was more stable in Period-I as compared to Period-II in Maharashtra.

Table 4.20. District and regionwise annual compound growth rates and instability indices of area sown more than once in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|---|----------------|---------------|-----------------------|--------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | NA | NA | NA | NA | NA | NA |
| 2 | Thane | 2.82** | -5.85** | -0.21 | 34.20 | 24.64 | 41.53 |
| 3 | Raigad | 3.87** | -0.44** | 1.67** | 25.64 | 2.79 | 30.14 |
| 4 | Ratnagiri | 3.48** | 0.10 | 2.23** | 39.11 | 3.77 | 32.59 |
| | Konkan Region | 3.45** | -1.04** | 1.54** | 27.44 | 3.45 | 30.78 |
| 5 | Pune | 2.78** | 1.97** | 2.36** | 17.21 | 6.62 | 10.22 |
| 6 | Solapur | 2.44** | 4.30** | 1.87** | 26.18 | 11.56 | 21.45 |
| 7 | Satara | 3.89** | 0.43 | 1.66** | 31.34 | 10.54 | 35.00 |
| 8 | Sangli | 3.35** | 4.25** | 3.79** | 33.76 | 17.54 | 18.75 |
| 9 | Kolhapur | 7.47** | 4.61* | 8.72** | 43.81 | 40.06 | 29.95 |
| 10 | Ahmednagar | 3.01* | 2.75** | 4.12** | 40.89 | 11.89 | 25.50 |
| 11 | Nashik | 1.33* | 2.14** | 2.05** | 28.78 | 8.94 | 17.99 |
| 12 | Jalgaon | 5.20** | 0.95 | 4.73** | 26.71 | 27.07 | 20.56 |
| 13 | Dhule | -2.29** | 5.61** | 1.57** | 27.11 | 9.11 | 26.54 |
| | W. Maharashtra Region | 2.88** | 2.49** | 3.29** | 16.29 | 13.22 | 9.05 |
| 14 | Aurangabad | 2.91** | 3.29** | 5.28** | 55.23 | 7.74 | 25.53 |
| 15 | Nanded | 4.57** | 5.41** | 4.66** | 30.11 | 17.82 | 16.02 |
| 16 | Osmanabad | 8.49** | 3.45** | 5.80** | 21.44 | 9.98 | 20.16 |
| 17 | Parbhani | 5.81** | 2.30** | 5.21** | 26.47 | 5.91 | 17.19 |
| 18 | Beed | 3.57** | 4.37** | 4.16** | 41.03 | 12.89 | 21.95 |
| | Marathwada Region | 5.44** | 3.29** | 5.12** | 20.45 | 5.75 | 11.46 |
| 19 | Buldhana | 7.87** | 4.00** | 5.12** | 23.85 | 13.22 | 21.32 |
| 20 | Akola | 12.02** | 3.08** | 8.95** | 43.54 | 9.79 | 35.23 |
| 21 | Amravati | 13.68** | 0.88 | 9.71** | 44.40 | 21.33 | 41.28 |
| 22 | Yavatmal | 7.40** | 2.20** | 7.21** | 27.89 | 11.72 | 21.36 |
| 23 | Wardha | 7.30** | 11.19** | 4.70** | 44.93 | 36.34 | 44.70 |
| 24 | Nagpur | 8.16** | 4.96** | 4.24** | 42.06 | 16.63 | 42.04 |
| 25 | Bhandara | -0.26 | 2.61** | -0.59* | 21.35 | 24.33 | 20.25 |
| 26 | Chandrapur | 1.94** | 0.94* | 1.99** | 19.27 | 12.94 | 12.66 |
| | Vidarbha Region | 4.36** | 2.81** | 4.12** | 16.28 | 6.73 | 8.93 |
| | Maharashtra | 4.01** | 2.83** | 4.04** | 14.80 | 6.64 | 7.84 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

4.1.2.3.11 Gross cropped area

In order to examine the trend of gross cropped area in different districts and regions of Maharashtra, annual growth rates and instability indices were worked out for all the three study periods and the results are presented in Table 4.21.

Table 4.21. District and regionwise annual compound growth rates and instability indices of gross cropped area in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|----------------|----------------|-----------------------|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | -1.70** | NA | NA | 14.04 | NA | NA |
| 2 | Thane | -0.31* | -0.86** | -0.33** | 6.45 | 4.72 | 5.34 |
| 3 | Raigad | -0.26* | -0.06** | -0.10** | 5.00 | 0.44 | 5.06 |
| 4 | Ratnagiri | -0.17* | 0.25** | 0.17** | 3.47 | 2.75 | 3.12 |
| | Konkan Region | -0.25** | -0.18** | -0.08** | 3.79 | 2.05 | 4.11 |
| 5 | Pune | 0.25** | -0.11 | 0.14** | 3.91 | 2.70 | 3.83 |
| 6 | Solapur | -0.07 | 0.14** | -0.11 | 8.72 | 1.84 | 8.72 |
| 7 | Satara | -0.20 | -0.26** | -0.14* | 8.57 | 2.76 | 8.10 |
| 8 | Sangli | -0.20 | 0.58** | 0.19** | 5.60 | 3.22 | 4.91 |
| 9 | Kolhapur | 0.42** | 0.96* | 1.31** | 3.66 | 14.98 | 2.76 |
| 10 | Ahmednagar | 0.00 | 0.30** | 0.25** | 3.65 | 3.61 | 2.59 |
| 11 | Nashik | 0.10 | 0.14** | 0.11** | 5.36 | 1.15 | 4.92 |
| 12 | Jalgaon | 0.62** | 0.25 | 0.93** | 3.72 | 8.82 | 3.08 |
| 13 | Dhule | 0.18** | 0.64** | 0.34** | 2.67 | 1.22 | 1.39 |
| | W. Maharashtra Region | 0.11 | 0.25** | 0.29** | 4.13 | 2.69 | 2.59 |
| 14 | Aurangabad | 0.10 | 0.81** | 0.64** | 7.22 | 2.34 | 3.93 |
| 15 | Nanded | 0.35** | 0.70** | 0.38** | 2.12 | 3.93 | 1.84 |
| 16 | Osmanabad | 0.92** | 0.74** | 0.65** | 4.57 | 4.31 | 3.84 |
| 17 | Parbhani | 1.05** | 0.69** | 1.05** | 3.97 | 1.81 | 2.17 |
| 18 | Beed | 0.65** | 0.62** | 0.63** | 8.36 | 2.98 | 5.53 |
| | Marathwada Region | 0.61** | 0.72** | 0.69** | 4.36 | 1.99 | 2.07 |
| 19 | Buldhana | 0.51** | 0.65** | 0.53** | 2.15 | 3.39 | 1.56 |
| 20 | Akola | 0.60** | 0.71** | 0.86** | 3.67 | 2.75 | 1.75 |
| 21 | Amravati | 0.56** | 0.23 | 0.92** | 2.65 | 5.94 | 2.30 |
| 22 | Yavatmal | 0.62** | 0.24** | 0.51** | 1.72 | 1.28 | 1.47 |
| 23 | Wardha | 0.26* | 0.86** | -0.06 | 4.53 | 5.77 | 5.09 |
| 24 | Nagpur | 0.45** | 0.49** | 0.26** | 3.18 | 2.22 | 3.18 |
| 25 | Bhandara | -0.27* | 0.56** | -0.25** | 5.28 | 4.99 | 4.97 |
| 26 | Chandrapur | 0.39** | -0.06 | 0.12** | 2.59 | 2.93 | 3.78 |
| | Vidarbha Region | 0.44** | 0.44** | 0.45** | 1.68 | 1.35 | 0.86 |
| | Maharashtra | 0.32** | 0.42** | 0.43** | 3.02 | 1.16 | 1.38 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA: Not available

During Period-I, majority of districts have observed a positive growth in gross cropped area. Parbhani district remained top with significantly positive growth rates

of 1.05 per cent per annum, followed by Osmanabad (0.92%), Beed (0.65%), Yavatmal (0.62%) during Period-I, however, Greater Bombay was an only one district that experienced significant negative growth in gross cropped area.

During Period-II, the highest decline in gross cropped area was observed in Thane district (0.86%), which was mainly due to significant decline of annual growth rate in net sown area, current fallow and area sown more than once as well as due to positive growth in other fallow lands and land put non-agricultural uses (Table 4.19, 4.17, 4.20, 4.18 and 4.13). During Overall Period, majority of the districts noticed positive and significant growth in gross cropped area. The decline in area sown more than once as well as net area sown ultimately reflected into significant decline in gross cropped area during both Period-II and Overall Period in Thane district.

The results of instability analysis showed that Greater Bombay, Kolhapur and Solapur were the most unstable districts, while Yavatmal, Raigad and Dhule were most stable in case of gross cropped area among all the districts of Maharashtra during Period-I, Period-II and Overall Period, respectively. Moreover, regionwise results showed that during all the three periods, all regions excluding Konkan region showed a positive growth for gross cropped area.

It is therefore, encapsulated that almost in all the regions as well state level, the growth trend of gross cropped area was found to be encouraging in Period-II as compared to Period-I, which was rather anticipated to tolerate the pressure of increasing population to meet the food requirements. The notable observation was that during the overall period, the growth rate for gross cropped area was almost the same in Maharashtra (0.43% per annum) and India (0.46% per annum) as mentioned in Table 4.9 and 4.10.

4.1.2.3.12 Net irrigated area

From the results depicted in Table 4.22, it was found that during all the three study periods, most of the districts recorded a positive growth rates in net irrigated area, except, Ratnagiri, Jalgaon, Dhule, Aurangabad, Akola and Bhandara in Period-II. Annual rate of increase in net irrigated area during Period-I was found to be highest in Yavatmal (8.39%), followed by Parbhani (8.06%), Amravati (6.29%), Akola (6.14%), Beed (5.97%), Nanded (5.87%), etc.

Table 4.22. District and regionwise annual compound growth rates and instability indices of net irrigated area in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|---------------|---------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | NA | NA | NA | NA | NA | NA |
| 2 | Thane | 1.82** | 2.61** | 4.09** | 25.48 | 14.40 | 12.22 |
| 3 | Raigad | 4.37** | 2.19** | 2.88** | 11.77 | 11.05 | 12.45 |
| 4 | Ratnagiri | 1.67** | -0.38 | 2.00** | 18.31 | 10.92 | 12.40 |
| | Konkan Region | 2.35** | 0.94** | 2.66** | 10.14 | 7.80 | 7.07 |
| 5 | Pune | 2.94** | 1.13** | 2.56** | 8.92 | 5.26 | 6.82 |
| 6 | Solapur | 1.36** | 0.68** | 1.89** | 16.73 | 8.17 | 9.36 |
| 7 | Satara | 2.15** | 0.37** | 2.05** | 12.22 | 3.94 | 8.25 |
| 8 | Sangli | 2.58** | 1.91** | 2.80** | 6.84 | 8.45 | 4.92 |
| 9 | Kolhapur | 2.29** | 2.19** | 2.94** | 11.66 | 10.11 | 6.21 |
| 10 | Ahmednagar | 2.10** | 0.90** | 2.04** | 10.12 | 5.73 | 6.44 |
| 11 | Nashik | 4.12** | 0.13 | 2.72** | 11.26 | 4.80 | 13.71 |
| 12 | Jalgaon | 3.86** | -0.46** | 2.09** | 14.05 | 4.59 | 17.40 |
| 13 | Dhule | 2.32** | -0.30 | 1.29** | 17.68 | 10.55 | 17.17 |
| | W. Maharashtra Region | 2.51** | 0.77** | 2.24** | 6.17 | 4.91 | 6.01 |
| 14 | Aurangabad | 3.62** | -1.21** | 2.28** | 19.65 | 9.46 | 20.86 |
| 15 | Nanded | 5.87** | 1.43** | 3.66** | 20.05 | 6.49 | 19.27 |
| 16 | Osmanabad | 4.40** | 1.32** | 2.46** | 21.54 | 6.63 | 21.29 |
| 17 | Parbhani | 8.06** | 2.64** | 4.39** | 18.16 | 11.35 | 25.85 |
| 18 | Beed | 5.97** | 0.46* | 3.46** | 20.69 | 7.60 | 24.78 |
| | Marathwada Region | 5.05** | 0.53** | 2.96** | 14.94 | 4.24 | 18.78 |
| 19 | Buldhana | 3.21** | 0.38 | 2.18** | 32.11 | 7.61 | 25.60 |
| 20 | Akola | 6.14** | -0.25 | 2.13** | 23.07 | 12.77 | 33.28 |
| 21 | Amravati | 6.29** | 2.50** | 4.27** | 15.12 | 14.82 | 15.96 |
| 22 | Yavatmal | 8.39** | 1.50** | 4.94** | 21.85 | 14.58 | 25.55 |
| 23 | Wardha | 4.78** | 1.34** | 2.90** | 35.93 | 9.06 | 30.22 |
| 24 | Nagpur | 2.89** | 0.92* | 3.01** | 10.21 | 11.14 | 8.36 |
| 25 | Bhandara | 0.52* | -0.20 | 0.92** | 12.52 | 4.38 | 8.23 |
| 26 | Chandrapur | 0.94** | 0.42** | 1.05** | 4.45 | 3.82 | 2.90 |
| | Vidarbha Region | 1.95** | 0.56** | 1.77** | 7.33 | 6.25 | 5.78 |
| | Maharashtra | 2.89** | 0.67** | 2.28** | 6.61 | 4.83 | 7.44 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA- Not available

During Period-II, majority of districts noticed significantly positive growth rate, in which Parbhani (2.64%) ranked first, followed Thane (2.61%), Amravati (2.50%), Kolhapur (2.19%), Raigad (2.19%), Sangli (1.91%), Yavatmal (1.50%), etc. Interestingly, annual growth rate of area under net irrigated in Jalgaon and Aurangabad

districts were significantly negative during Period-II. At overall period, all districts showed positive and significant growth rates, among them, the highest growth was registered by Yavatmal (4.94%), followed by Parbhani (4.39%), Amravati (4.27%), Thane (4.09%), Nanded (3.66%), Beed (3.46%), etc. However, annual growth rate of net irrigated area was lowest in Bhandara (0.92%) district followed by Chandrapur, Dhule, Solapur, Ratnagiri, Ahmednagar, etc.

A perusal of results implied that all districts of Maharashtra registered higher growth rates for net irrigated area during Period-I over the Period-II, except Thane district. Hence the appropriate policy intervention is required to increase net irrigated area in Maharashtra.

District wise instability among all districts of Maharashtra showed that Wardha, Amravati and Akola were the most unstable districts in Period-I, Period-II and Overall Period, respectively. However, Chandrapur was the stable district in the net irrigated area during all the three study periods. In all districts of Maharashtra state, the magnitude of instability of net irrigated area decreased during Period-II over the Period-I, except, Sangli and Nagpur districts.

An annual growth rate of net irrigated area was significant in all the regions of Maharashtra during all the periods, where increase in net irrigated area was the highest in Marathwada during Period-I and Overall Period, however, the growth in Konkan was highest region in Period-II. As compared to Period-I, the annual rate of increase in net irrigated area turned out to be lower during Period-II in all the regions of Maharashtra. Especially Marathwada region has experienced a dramatic decrease in the growth rate of net irrigated area, where it reduced from 5.05 in Period-I to 0.53 per cent in Period-II. The findings of instability indices summarized that Marathwada was the most unstable region, whereas Vidarbha was the stable region of Maharashtra during the overall period.

In case of state level, net irrigated area significantly increased by 2.89, 0.67 and 2.28 per cent per annum during Period-I, Period-II and Overall Period, respectively. Despite slow growth rate, Period-II was found more stable compared to Period-I. Significant increasing growth rates in all the periods are the good sign indicating the impact of irrigation projects in the state.

4.1.2.3.13 Gross irrigated area

It is revealed from Table 4.23 that during Period-I, all the districts of Maharashtra registered a significant and positive growth rate in gross irrigated area and it ranged from 1.00 to 9.79 per cent per annum. The highest growth rate of gross irrigated area was found in Yavatmal (9.79%), followed by Parbhani (9.66%), Amravati (8.35%), Akola (7.65%), Nanded (6.70%), etc. All the districts recorded positive growth rate in gross irrigated area during Period-II, except Dhule district. Comparison of two periods explicitly revealed that most of the districts showed lower growth rates of gross irrigated area during Period-II than Period-I. It is remarkable observation that impression of all districts were significantly positive growth rates in gross irrigated area during Overall Period. All of districts of Maharashtra showed lower instability during Period-II than Period-I, which implies that the efforts had been made for giving stability to all districts regarding gross irrigated area.

Growth rate of gross irrigated area increased significantly in all the regions during all the three periods. During Overall Period, the highest annual growth rate was observed in Marathwada (3.44%), followed by Konkan (3.04%), Vidarbha (2.36%) and Western Maharashtra (2.30%). It was observed that, all regions of Maharashtra state showed more stable during the Period-II than Period-I. For the state as a whole, gross irrigated area increased significantly by 3.30, 1.43 and 2.56 per cent per annum during Period-I, Period-II and Overall Period, respectively.

If we compare the changes in annual growth rates of net irrigated area and gross irrigated area during Overall Period, all the regions as well as state as a whole reflected higher growth rates in gross irrigated area as compared to net irrigated area indicating limitations of expansion of net irrigated area to contribute to the increase in gross irrigated area. Therefore, to expand the gross irrigated area, there is a need to promote area irrigated more than once, which may push-up by increasing irrigation acreage through developing micro-level water resources such as village tanks, farm ponds and recharging of wells under various water conservation programmes as well as further increase in irrigation efficiency through more use of micro irrigation systems such as drip and sprinkler (Swain *et al.*, 2012).

The summarized results of temporal change by using compound growth rate and instability index in land use categories of Maharashtra presented here revealed that the area under forest and the net sown area declined in Period-II as well as Overall Period. These are unfavorable conditions for maintaining the ecosystem as well as the growth of agriculture in Maharashtra.

Table 4.23. District and regionwise annual compound growth rates and instability indices of gross irrigated area in Maharashtra

| Sr. No. | Districts / Regions | Compound growth rate (per cent per annum) | | | Instability index (%) | | |
|---------|------------------------------|--|---------------|---------------|-----------------------|-------------|--------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | NA | NA | NA | NA | NA | NA |
| 2 | Thane | 1.88** | 3.32** | 4.31** | 24.09 | 12.56 | 10.88 |
| 3 | Raigad | 4.99** | 2.96** | 3.48** | 11.53 | 9.56 | 11.31 |
| 4 | Ratnagiri | 2.40** | 0.56* | 2.42** | 17.90 | 8.18 | 11.38 |
| | Konkan Region | 2.90** | 1.79** | 3.08** | 9.44 | 6.28 | 5.94 |
| 5 | Pune | 2.99** | 1.92** | 2.71** | 7.74 | 4.60 | 4.77 |
| 6 | Solapur | 1.00** | 1.42** | 1.93** | 15.90 | 6.27 | 7.66 |
| 7 | Satara | 1.94** | 1.43** | 2.28** | 9.71 | 5.44 | 5.05 |
| 8 | Sangli | 3.02** | 2.35** | 2.83** | 8.88 | 5.93 | 4.91 |
| 9 | Kolhapur | 2.71** | 2.96** | 3.06** | 12.07 | 8.49 | 5.84 |
| 10 | Ahmednagar | 2.56** | 1.43** | 2.08** | 11.88 | 4.06 | 7.36 |
| 11 | Nashik | 3.54** | 1.09** | 2.60** | 9.97 | 5.10 | 8.92 |
| 12 | Jalgaon | 4.14** | 0.08 | 2.13** | 15.05 | 6.34 | 18.23 |
| 13 | Dhule | 2.90** | -0.04 | 1.28** | 14.20 | 7.63 | 17.68 |
| | W. Maharashtra Region | 2.60** | 1.46** | 2.30** | 6.53 | 3.91 | 4.52 |
| 14 | Aurangabad | 4.38** | 0.15 | 2.79** | 17.51 | 8.06 | 17.92 |
| 15 | Nanded | 6.70** | 2.48** | 4.30** | 20.42 | 6.28 | 19.65 |
| 16 | Osmanabad | 5.01** | 2.00** | 2.76** | 21.88 | 5.36 | 22.34 |
| 17 | Parbhani | 9.66** | 2.63** | 5.36** | 18.56 | 6.75 | 27.78 |
| 18 | Beed | 6.14** | 1.41** | 3.83** | 19.97 | 7.46 | 21.26 |
| | Marathwada Region | 5.70** | 1.45** | 3.44** | 14.98 | 3.95 | 18.01 |
| 19 | Buldhana | 4.55** | 0.99** | 2.60** | 29.45 | 6.17 | 26.76 |
| 20 | Akola | 7.65** | 0.47 | 3.06** | 22.97 | 12.07 | 33.60 |
| 21 | Amravati | 8.35** | 2.52** | 4.89** | 13.05 | 9.62 | 21.09 |
| 22 | Yavatmal | 9.79** | 1.28** | 5.35** | 20.10 | 9.65 | 30.09 |
| 23 | Wardha | 5.87** | 1.99** | 3.64** | 29.67 | 6.06 | 24.60 |
| 24 | Nagpur | 4.04** | 1.46** | 3.62** | 10.35 | 8.35 | 8.92 |
| 25 | Bhandara | 1.31* | 1.04** | 1.57** | 11.85 | 4.03 | 5.89 |
| 26 | Chandrapur | 1.25** | 1.21** | 1.47** | 4.56 | 3.84 | 2.35 |
| | Vidarbha Region | 2.89** | 1.32** | 2.36** | 7.77 | 4.82 | 6.09 |
| | Maharashtra | 3.30** | 1.43** | 2.56** | 7.40 | 3.87 | 6.73 |

Note: ** and * shows significant level at 1 % and 5 % level, respectively, NA- Not available

The barren and uncultivable land had an increased growth rate during Period-II, which was unfavorable for ecological balance, as the permanent pastures and other grazing lands, cultivable waste and net area sown declined during the same period, which might be due to overgrazing, degradation of soil, desertification etc.

Similar results were recorded by the different researchers in different states viz; Ramasamy *et al.* (2005), Harish (2006), Takle *et al.* (2007), Wani *et al.* (2009) Gairhe *et al.* (2011), Singh (2012), Raturaj (2014), Sharma (2015), Sinha *et al.* (2016), Amale (2018) and Thanuja *et al.* (2021).

4.1.3 Location coefficients of different land use categories in Maharashtra

The location coefficient in different categories of land use pattern over the last 57 years across 26 districts and 4 regions of Maharashtra were analyzed and presented from Table 4.24 to Table 4.28 and Figure 4.20 to 4.22. Location coefficient (L) was useful to identify the pattern of distribution of the given category of lands across different districts and regions. A higher value for location coefficient for the district and region indicated the higher concentration of that particular category of land in that district or the region.

4.1.3.1 Forest land

In order to know the spatial distribution of forest lands, the locational coefficients were estimated and are presented in Table 4.24. During Period-I, the notable feature was high concentration of area under forest in Chandrapur (3.23) district, followed by Dhule (2.25) and Thane (2.25), so on. Chandrapur was highest concentrated district among all districts of Maharashtra, followed by Thane and Dhule during Period-II and Overall Period. There was a sharp increase in the concentration of forest land in ten districts of Maharashtra. On the other hand, fifteen districts of Maharashtra were showed decline in the concentration of forest land while, remaining one district recorded same concentration of the forest land in Period-II over Period-I.

The location coefficient was observed more than one in ten districts which indicated high concentration of forest land in that districts as compare to forest land in state, while it was observed less than one in remaining sixteen districts of Maharashtra during Overall Period. The pattern of concentration in forest area were found to be highest in Chandrapur (3.30), followed by Thane (2.35) and Dhule (2.24), however,

lowest concentration was observed in Osmanabad (0.01), followed by Beed (0.11), Solapur (0.13) districts of Maharashtra during Overall Period. It was observed that Chandrapur was more concentrated district and Osmanabad district was less concentrated in forest land across the Maharashtra in all the periods.

During all the three study periods, Vidarbha region was showed high concentration, whereas, Marathwada was low accumulation of forest land than other regions of Maharashtra. The location coefficients for area under forest indicate that the forest area was less concentrated in relatively dry and drought-prone regions of the state such as Osmanabad, Beed and Solapur districts of Maharashtra. Whereas, more concentration of forest area was found in heavy rainfall area.

4.1.3.2 Land under miscellaneous tree crops and groves

The concentration pattern of land under miscellaneous tree crops and groves is presented in Table 4.24. The Raigad district was appeared highly concentrated district in land under miscellaneous tree crops and groves during all study periods. Among different districts during Period-I, Ahmednagar (0.01) district has showed least concentrated followed by Pune (0.05) and Dhule (0.11). Greater Bombay (0.00) district of Maharashtra has expressed least location coefficient followed by Buldhana (0.15) and Nashik (0.16) during Period-II. At the Overall Period, concentration pattern of land under miscellaneous tree crops and groves was showed low in Nashik (0.14), Ahmednagar (0.14) and Dhule (0.14), etc. The decrease in the concentration of land under miscellaneous tree crops and groves observed in twelve districts whereas, fourteen districts of Maharashtra noticed increase in concentration during Period-II over Period-I.

The Konkan region has shown high concentration of land under miscellaneous tree crops and groves than other regions of Maharashtra during all study periods, which might be due to heavy rainfall area, proper implementation of social forestry programmes on barren and uncultivable land and or area of mangrove cover increased in the southern coastal districts of Maharashtra. The lowest concentration in Western Maharashtra region with location coefficients of 0.37, 0.64, 0.51 in case of land under miscellaneous tree crops and groves were observed in Period-I, Period-II and Overall Period, respectively.

Table 4.24. District and regionwise location coefficients of area under forest and land under miscellaneous tree crops and groves in Maharashtra

| Sr. No. | Districts / Regions | Forest land | | | Land under miscellaneous tree crops and groves | | |
|---------|------------------------------|-------------|-------------|-------------|--|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 0.23 | 0.23 | 0.23 | 0.35 | 0.00 | 0.17 |
| 2 | Thane | 2.25 | 2.47 | 2.35 | 1.38 | 2.45 | 1.93 |
| 3 | Raigad | 1.36 | 1.31 | 1.34 | 7.58 | 4.32 | 5.92 |
| 4 | Ratnagiri | 0.13 | 0.14 | 0.14 | 3.72 | 2.91 | 3.31 |
| | Konkan Region | 1.09 | 1.16 | 1.12 | 3.84 | 3.06 | 3.44 |
| 5 | Pune | 0.69 | 0.62 | 0.66 | 0.05 | 0.97 | 0.52 |
| 6 | Solapur | 0.13 | 0.14 | 0.13 | 0.40 | 0.54 | 0.47 |
| 7 | Satara | 0.80 | 0.79 | 0.80 | 0.27 | 0.90 | 0.59 |
| 8 | Sangli | 0.32 | 0.31 | 0.31 | 2.13 | 2.07 | 2.10 |
| 9 | Kolhapur | 1.06 | 1.10 | 1.08 | 1.26 | 1.41 | 1.33 |
| 10 | Ahmednagar | 0.63 | 0.56 | 0.60 | 0.01 | 0.26 | 0.14 |
| 11 | Nashik | 1.24 | 1.20 | 1.22 | 0.11 | 0.16 | 0.14 |
| 12 | Jalgaon | 0.84 | 0.79 | 0.82 | 0.12 | 0.31 | 0.21 |
| 13 | Dhule | 2.25 | 2.24 | 2.24 | 0.11 | 0.17 | 0.14 |
| | W. Maharashtra Region | 0.90 | 0.87 | 0.89 | 0.37 | 0.64 | 0.51 |
| 14 | Aurangabad | 0.29 | 0.25 | 0.27 | 0.94 | 0.79 | 0.86 |
| 15 | Nanded | 0.45 | 0.48 | 0.47 | 0.93 | 0.76 | 0.84 |
| 16 | Osmanabad | 0.01 | 0.02 | 0.01 | 0.91 | 1.76 | 1.34 |
| 17 | Parbhani | 0.17 | 0.20 | 0.19 | 0.75 | 0.91 | 0.83 |
| 18 | Beed | 0.11 | 0.12 | 0.11 | 0.24 | 0.28 | 0.26 |
| | Marathwada Region | 0.20 | 0.21 | 0.20 | 0.77 | 0.93 | 0.85 |
| 19 | Buldhana | 0.70 | 0.59 | 0.65 | 0.26 | 0.15 | 0.20 |
| 20 | Akola | 0.42 | 0.36 | 0.39 | 0.27 | 0.20 | 0.24 |
| 21 | Amravati | 1.57 | 1.49 | 1.53 | 1.19 | 0.74 | 0.96 |
| 22 | Yavatmal | 1.11 | 1.07 | 1.09 | 1.82 | 1.29 | 1.55 |
| 23 | Wardha | 0.61 | 0.58 | 0.60 | 2.22 | 1.75 | 1.98 |
| 24 | Nagpur | 1.06 | 1.01 | 1.04 | 0.76 | 1.04 | 0.91 |
| 25 | Bhandara | 1.59 | 1.70 | 1.64 | 1.36 | 1.28 | 1.32 |
| 26 | Chandrapur | 3.23 | 3.38 | 3.30 | 0.92 | 0.76 | 0.84 |
| | Vidarbha Region | 1.62 | 1.63 | 1.63 | 1.05 | 0.85 | 0.95 |

4.1.3.3 Barren and uncultivable land

The estimate of location coefficients of pattern of concentration of barren and uncultivable land are given in Table 4.25. The template of concentration in barren and uncultivable land was highest in Ratnagiri district (4.71), followed by Grater Bombay (3.31), Raigad (3.21), Nashik (2.00), Pune (1.83), Satara (1.77), *etc.* during Period-I. There were ten districts that showed more than one concentration, which means these

districts had a higher concentration of barren and uncultivable land than the state level during Period-II. In contrast, Kolhapur district had a location coefficient of one, indicating that the concentration of this land in Kolhapur district matched with the proportionate state area.

The results from analysis revealed that, there was slight increase in the concentration of barren and uncultivable land in sixteen districts of Maharashtra during Period-II over Period-I. On the other hand, there were a decline in the concentration of barren and uncultivable land in ten districts of Maharashtra in Period-II over Period-I. During all the three study periods, the most troubling feature was the high concentration of barren and uncultivable land in Ratnagiri followed by Greater Bombay and Raigad. The pattern of concentration in barren and uncultivable land was found to be lowest in Wardha (0.24), followed by Osmanabad (0.25), Aurangabad (0.25), Chandrapur (0.27), Amravati (0.28), *etc.* during Overall Period.

Regionwise study of location coefficient revealed that, Konkan region of Maharashtra showed high concentration of barren and uncultivable land, which is due to terrain area whereas, Marathwada region observed lowest concentration of barren and uncultivable land than other regions during the three study periods. The concentration of barren and uncultivable land gradually increased in Marathwada and Vidarbha regions of Maharashtra in Period-II over Period-I. This might be due to desertification of agricultural land as that land becomes uncultivable by means of scarcity of water in Marathwada and Vidarbha.

4.1.3.4 Land put to non-agricultural uses

It is envisaged from Table 4.25 that the land put to non-agricultural uses in Greater Bombay was top with location coefficients of 14.71, 16.18 and 15.54 during Period-I, Period-II and Overall Period, respectively, followed by Bhandara (2.54) and Nagpur (2.14) district during Overall Period. The least concentration was found in Solapur district by 0.07, 0.18 and 0.13 during Period-I, Period-II and Overall Period, respectively. The increase in concentration of land put to non-agricultural uses were found in twelve districts of Maharashtra in Period-II as compared to Period-I. The mixed pattern of spatial distribution of land put to non-agricultural uses was observed in districts

of Maharashtra where, thirteen districts out of 26 districts showed high concentration and remaining were low concentration as compared to Maharashtra State at overall period.

Table 4.25. District and regionwise location coefficients of barren and uncultivable land and land put to non-agricultural uses in Maharashtra

| Sr. No. | Districts / Regions | Barren and uncultivable land | | | Land put to non-agricultural uses | | |
|---------|------------------------------|------------------------------|-------------|-------------|-----------------------------------|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 3.31 | 3.44 | 3.37 | 14.71 | 16.18 | 15.54 |
| 2 | Thane | 1.51 | 1.15 | 1.35 | 1.47 | 2.16 | 1.86 |
| 3 | Raigad | 3.21 | 3.35 | 3.28 | 1.33 | 1.83 | 1.61 |
| 4 | Ratnagiri | 4.71 | 4.62 | 4.67 | 0.76 | 0.57 | 0.65 |
| | Konkan Region | 3.32 | 3.20 | 3.27 | 1.30 | 1.57 | 1.45 |
| 5 | Pune | 1.83 | 1.73 | 1.79 | 0.76 | 1.76 | 1.32 |
| 6 | Solapur | 0.80 | 0.76 | 0.78 | 0.07 | 0.18 | 0.13 |
| 7 | Satara | 1.77 | 2.06 | 1.90 | 0.71 | 0.64 | 0.67 |
| 8 | Sangli | 0.87 | 0.80 | 0.84 | 0.78 | 1.24 | 1.04 |
| 9 | Kolhapur | 0.96 | 1.00 | 0.98 | 1.24 | 1.08 | 1.15 |
| 10 | Ahmednagar | 1.58 | 1.37 | 1.49 | 0.12 | 0.19 | 0.16 |
| 11 | Nashik | 2.00 | 2.01 | 2.00 | 0.13 | 0.48 | 0.33 |
| 12 | Jalgaon | 1.22 | 1.24 | 1.23 | 0.21 | 0.29 | 0.26 |
| 13 | Dhule | 0.77 | 0.68 | 0.73 | 0.43 | 0.37 | 0.39 |
| | W. Maharashtra Region | 1.35 | 1.32 | 1.34 | 0.43 | 0.65 | 0.55 |
| 14 | Aurangabad | 0.26 | 0.24 | 0.25 | 1.27 | 1.10 | 1.18 |
| 15 | Nanded | 0.31 | 0.32 | 0.32 | 1.24 | 0.80 | 0.99 |
| 16 | Osmanabad | 0.20 | 0.31 | 0.25 | 0.61 | 0.60 | 0.61 |
| 17 | Parbhani | 0.25 | 0.34 | 0.29 | 1.04 | 0.73 | 0.87 |
| 18 | Beed | 0.27 | 0.40 | 0.33 | 0.97 | 0.88 | 0.92 |
| | Marathwada Region | 0.25 | 0.31 | 0.28 | 1.02 | 0.83 | 0.92 |
| 19 | Buldhana | 0.45 | 0.73 | 0.58 | 1.08 | 1.16 | 1.12 |
| 20 | Akola | 0.48 | 0.38 | 0.44 | 1.31 | 1.19 | 1.25 |
| 21 | Amravati | 0.27 | 0.29 | 0.28 | 0.98 | 0.81 | 0.88 |
| 22 | Yavatmal | 0.69 | 0.52 | 0.62 | 0.95 | 0.98 | 0.97 |
| 23 | Wardha | 0.19 | 0.30 | 0.24 | 2.14 | 1.63 | 1.85 |
| 24 | Nagpur | 0.28 | 0.50 | 0.38 | 2.34 | 1.99 | 2.14 |
| 25 | Bhandara | 0.31 | 0.34 | 0.32 | 3.01 | 2.18 | 2.54 |
| 26 | Chandrapur | 0.26 | 0.28 | 0.27 | 1.55 | 1.34 | 1.43 |
| | Vidarbha Region | 0.37 | 0.40 | 0.38 | 1.58 | 1.35 | 1.45 |

The Vidarbha region showed highest concentration during Period-I whereas, during Period-II and Overall Period, among all regions of Maharashtra, Konkan region showed high concentration of land put to non-agricultural uses and Western

Maharashtra was lowest concentration during all study periods. Most of the districts except, Ratnagiri, Satara, Kolhapur and Dhule districts from Konkan and Western Maharashtra regions noticed increased concentration of the land put to non-agricultural uses in Period-II over Period-I. Reasons behind increase in concentration might be rapid urbanization, development of industrial area, construction of roads and irrigation canals, etc.

4.1.3.5 Permanent pastures and other grazing land

The spatial dynamics of permanent pastures and other grazing land of different districts and regions of Maharashtra were estimated by using locational coefficient analysis. The results from this analysis provided in Table 4.26 indicate mixed pattern of distribution of land in permanent pastures and other grazing land in the districts of Maharashtra during Period -I where, highest concentration was observed in Bhandara (2.99) district. On the flip side, lowest concentration was noticed in Ratnagiri district (0.17) followed by Nashik, Sangli, Ahmednagar and Osmanabad with location coefficient of 0.35, 0.43, 0.44 and 0.56, respectively. During Period-II, agglomeration of land under permanent pasture and other grazing was considerably increased in Bhandara district from 2.99 to 3.38 over Period-I. However, Nashik district did not change concentration of permanent pasture and other grazing land over the period of time. The high concentration of permanent pastures and other grazing land observed in Bhandara (3.15) followed by Nagpur (1.94) and Thane (1.53) during Overall Period. As compare to State area, it was mentioned that, eleven districts showed more than one concentration in permanent pasture and other grazing land during Overall Period.

There was sharp decrease in concentration of permanent pasture and other grazing land in Vidarbha region in Period-II over Period-I, even though the region showed higher concentration than other regions during all the three study periods with location coefficients of 1.47, 1.31 and 1.40 in Period-I, Period-II and Overall period, respectively. The decrease in concentration might be due to conversion of grazing land to other land use categories, over grazing, land acquisition and or encroachment of permanent pasture land and grazing land for non-agricultural uses by villagers.

4.1.3.6 Cultivable waste

A perusal of Table 4.26 indicates the spatial dynamics of cultivable waste at district and regional level separately for all the periods. In Period-I, few districts of Maharashtra showed higher concentration of cultivable waste across the area under this land category in Maharashtra state.

Table 4.26. District and regionwise location coefficients of permanent pastures and other grazing land and area under cultivable waste in Maharashtra

| Sr. No. | Districts / Regions | Permanent pastures and other grazing land | | | Cultivable waste | | |
|---------|------------------------------|---|-------------|-------------|------------------|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 0.62 | 0.38 | 0.52 | 1.67 | 0.46 | 1.13 |
| 2 | Thane | 1.58 | 1.47 | 1.53 | 1.23 | 1.29 | 1.26 |
| 3 | Raigad | 0.77 | 1.39 | 1.03 | 2.13 | 1.85 | 2.00 |
| 4 | Ratnagiri | 0.17 | 0.22 | 0.19 | 6.57 | 5.64 | 6.16 |
| | Konkan Region | 0.77 | 0.89 | 0.82 | 3.77 | 3.30 | 3.56 |
| 5 | Pune | 0.89 | 1.11 | 0.98 | 0.65 | 0.81 | 0.72 |
| 6 | Solapur | 0.86 | 0.88 | 0.87 | 0.72 | 0.88 | 0.80 |
| 7 | Satara | 1.19 | 1.77 | 1.43 | 0.92 | 1.22 | 1.05 |
| 8 | Sangli | 0.43 | 0.46 | 0.44 | 0.42 | 0.51 | 0.46 |
| 9 | Kolhapur | 1.10 | 1.30 | 1.18 | 2.72 | 1.56 | 2.20 |
| 10 | Ahmednagar | 0.44 | 0.57 | 0.50 | 0.24 | 0.38 | 0.30 |
| 11 | Nashik | 0.35 | 0.35 | 0.35 | 0.47 | 0.43 | 0.45 |
| 12 | Jalgaon | 1.09 | 0.82 | 0.98 | 0.24 | 0.18 | 0.21 |
| 13 | Dhule | 0.80 | 0.82 | 0.81 | 0.25 | 0.11 | 0.18 |
| | W. Maharashtra Region | 0.77 | 0.86 | 0.81 | 0.64 | 0.62 | 0.63 |
| 14 | Aurangabad | 0.92 | 0.93 | 0.93 | 0.45 | 0.62 | 0.53 |
| 15 | Nanded | 1.30 | 1.23 | 1.27 | 0.83 | 1.13 | 0.97 |
| 16 | Osmanabad | 0.56 | 0.63 | 0.59 | 1.19 | 1.70 | 1.42 |
| 17 | Parbhani | 0.66 | 0.63 | 0.65 | 0.84 | 0.97 | 0.90 |
| 18 | Beed | 0.74 | 0.82 | 0.77 | 1.05 | 1.22 | 1.13 |
| | Marathwada Region | 0.82 | 0.83 | 0.83 | 0.85 | 1.11 | 0.97 |
| 19 | Buldhana | 1.03 | 0.93 | 0.99 | 0.47 | 0.76 | 0.60 |
| 20 | Akola | 1.17 | 1.05 | 1.12 | 0.28 | 0.28 | 0.28 |
| 21 | Amravati | 1.02 | 0.80 | 0.93 | 0.32 | 0.27 | 0.30 |
| 22 | Yavatmal | 0.99 | 1.06 | 1.02 | 0.67 | 0.57 | 0.63 |
| 23 | Wardha | 1.52 | 1.47 | 1.50 | 0.91 | 0.82 | 0.87 |
| 24 | Nagpur | 2.20 | 1.57 | 1.94 | 0.92 | 1.16 | 1.03 |
| 25 | Bhandara | 2.99 | 3.38 | 3.15 | 0.95 | 1.00 | 0.97 |
| 26 | Chandrapur | 1.38 | 1.05 | 1.24 | 0.91 | 0.74 | 0.83 |
| | Vidarbha Region | 1.47 | 1.31 | 1.40 | 0.70 | 0.68 | 0.69 |

More than fifty per cent of the districts observed increase in concentration of cultivable waste land in Period-II over Period-I. The concentration of cultivable waste land was found to be higher in just nine districts as compared to state proportionate area under this category during Overall Period. Ratnagiri district was most concentrated with coefficient of 6.57, 5.64 and 6.16 in cultivable waste land during Period-I, Period-II and Overall Period, respectively. Among all the regions, Konkan region had highest concentration of cultivable waste land during all the three periods, though, there has been a sharp decrease in the concentration of cultivable waste in Konkan region in Period-II over Period-I. There has been a slight increase in the concentration of cultivable waste in Marathwada region of Maharashtra, which might be due to prolong drought condition coupled with migration of people towards urban area during Period-II.

4.1.3.7 Current fallow

It is envisaged from Table 4.27 that along with the Beed district, twelve districts of Maharashtra observed high concentration in current fallow land than the area of Maharashtra State during Period-I. Beed (3.94) was the top most district in concentration of current fallow followed by Osmanabad (2.50), Parbhani (2.23), Solapur (1.65), Nanded (1.57), Aurangabad (1.29), etc. During Period-II, twelve districts were appeared to more concentration of current fallow over Period-I. Here, Wardha (2.33) district was most concentrated district among all districts of Maharashtra followed by Osmanabad (2.25), Beed (2.06) Aurangabad (1.90), Solapur (1.90), etc. in current fallow during Period-II. Although, concentration of Beed district was found to be high in current fallow during Overall Period, accompanying with Beed district, fifteen districts were show up low concentration in current fallow in Period-II over Period-I.

Marathwada region of Maharashtra showed high concentration of current fallow than other regions of Maharashtra with location coefficient of 2.24, 1.88 and 2.06 during Period-I, Period-II and Overall Period, respectively. The location coefficients for current fallow lands indicate that the current fallow lands were more concentrated in predominantly rainfed areas such as Beed, Osmanabad, Parbhani, Solapur and Aurangabad districts of the state as all of these districts are relatively dry and drought-prone region of state where, uncertainty of rainfall, poor irrigation facility, higher prices and timely unavailability of inputs supply, scarcity of labor for farm operations, timely

unavailability of credit, etc. were the major reasons for concentration of current fallow land. Here, it may be suggested that there is need of development of groundwater irrigation facilities in the areas where larger concentration of current fallows exists so to enable the farmers to put their fallow land under cultivation.

Table 4.27. District and regionwise location coefficients of area under current fallow and fallow other than current fallow in Maharashtra

| Sr. No. | Districts / Regions | Current fallow | | | Fallow other than current fallow | | |
|---------|------------------------------|----------------|-------------|-------------|----------------------------------|-------------|-------------|
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 0.31 | 0.03 | 0.17 | 2.23 | 0.28 | 1.26 |
| 2 | Thane | 1.01 | 0.25 | 0.63 | 0.81 | 0.45 | 0.63 |
| 3 | Raigad | 1.05 | 0.53 | 0.78 | 1.95 | 1.76 | 1.85 |
| 4 | Ratnagiri | 1.07 | 0.75 | 0.91 | 4.35 | 4.69 | 4.52 |
| | Konkan Region | 1.04 | 0.53 | 0.78 | 2.64 | 2.60 | 2.62 |
| 5 | Pune | 0.53 | 0.48 | 0.51 | 1.02 | 0.47 | 0.75 |
| 6 | Solapur | 1.65 | 1.90 | 1.78 | 1.50 | 2.18 | 1.83 |
| 7 | Satara | 1.01 | 0.62 | 0.81 | 1.22 | 1.34 | 1.28 |
| 8 | Sangli | 1.02 | 1.13 | 1.08 | 2.39 | 1.65 | 2.02 |
| 9 | Kolhapur | 0.92 | 0.45 | 0.68 | 1.24 | 0.82 | 1.03 |
| 10 | Ahmednagar | 0.70 | 1.73 | 1.22 | 0.88 | 1.44 | 1.16 |
| 11 | Nashik | 1.07 | 1.22 | 1.14 | 0.74 | 0.52 | 0.63 |
| 12 | Jalgaon | 0.42 | 0.18 | 0.30 | 0.23 | 0.14 | 0.19 |
| 13 | Dhule | 0.16 | 0.14 | 0.15 | 0.37 | 0.29 | 0.33 |
| | W. Maharashtra Region | 0.82 | 0.93 | 0.88 | 1.00 | 0.97 | 0.99 |
| 14 | Aurangabad | 1.29 | 1.90 | 1.60 | 0.61 | 1.13 | 0.86 |
| 15 | Nanded | 1.57 | 1.61 | 1.59 | 0.43 | 0.48 | 0.45 |
| 16 | Osmanabad | 2.50 | 2.25 | 2.37 | 1.11 | 2.07 | 1.59 |
| 17 | Parbhani | 2.23 | 1.53 | 1.87 | 0.88 | 1.03 | 0.95 |
| 18 | Beed | 3.94 | 2.06 | 2.99 | 1.50 | 1.11 | 1.31 |
| | Marathwada Region | 2.24 | 1.88 | 2.06 | 0.90 | 1.21 | 1.05 |
| 19 | Buldhana | 0.44 | 0.41 | 0.42 | 0.99 | 0.63 | 0.81 |
| 20 | Akola | 0.32 | 0.60 | 0.46 | 0.66 | 0.34 | 0.50 |
| 21 | Amravati | 0.35 | 0.52 | 0.43 | 0.65 | 0.30 | 0.48 |
| 22 | Yavatmal | 0.57 | 0.63 | 0.60 | 0.93 | 0.51 | 0.72 |
| 23 | Wardha | 0.36 | 2.33 | 1.35 | 0.50 | 0.93 | 0.71 |
| 24 | Nagpur | 0.51 | 0.51 | 0.51 | 0.53 | 0.62 | 0.57 |
| 25 | Bhandara | 0.39 | 0.40 | 0.39 | 0.42 | 0.23 | 0.32 |
| 26 | Chandrapur | 0.26 | 0.53 | 0.39 | 0.24 | 0.23 | 0.24 |
| | Vidarbha Region | 0.38 | 0.64 | 0.51 | 0.57 | 0.42 | 0.49 |

4.1.3.8 Fallow other than current fallow

The results of districtwise and regionwise analysis of pattern of concentration of fallow other than current fallow is presented in Table 4.27 and revealed that majority of districts were to be appeared lower concentration of area under fallow other than current fallow than the area of Maharashtra State during Period-I. During same period, Ratnagiri district (4.35) was having much more concentration in fallow other than current fallow land than other districts of Maharashtra. Also, in Period-II, concentration under fallow other than current fallow land was found highest in Ratnagiri district (4.69). There has been a sharp increase in the concentration of fallow other than current fallow in ten districts of Maharashtra in Period-II over Period-I. For most of the districts (16 out of 26) concentration was less than one which means lower concentration while nine districts were having high concentration as compare to Maharashtra State in area under fallow other than current fallow during Overall Period. The regionwise analysis of location coefficient revealed that throughout all the three study periods, among the all regions of Maharashtra, Konkan region showed high concentration of fallow other than current fallow, which might be due to uneconomical farming coupled with migration of peoples towards urban areas for job opportunities.

Western Maharashtra and Marathwada regions witnessed an increase in the concentration of area under fallow other than current fallow in Period-II over Period-I.

4.1.3.9 Net area sown

Location coefficients were estimated to examine the spatial dynamics of net area sown across different districts and regions of the state. The results from the analysis as presented in Table 4.28 indicated that majority (14 out of 26) of the districts of Maharashtra were having high concentration of net area sown beyond the area of state during Period-I. However, Osmanabad (1.33) was leading district in concentration of net area sown followed by Aurangabad (1.31), Akola (1.30), Parbhani (1.29), Solapur (1.29), etc. during Period-I. During Period-II, fifteen districts showed higher concentration in net area sown against area under state. Half of the districts of Maharashtra noticed higher concentration in net area sown during Period-II over Period-I. The higher concentration of net area sown in Akola (1.32) district was found to be top most in net area sown followed by Parbhani (1.30), Aurangabad (1.28), Osmanabad (1.28), Solapur (1.26), etc. during Overall Period.

Table 4.28. District and regionwise location coefficients of net area sown in Maharashtra

| Sr. No. | Districts / Regions | Net area sown | | |
|---------|------------------------------|---------------|-------------|-------------|
| | | Period-I | Period-II | Overall |
| 1 | Greater Bombay | 0.30 | 0.02 | 0.17 |
| 2 | Thane | 0.50 | 0.48 | 0.49 |
| 3 | Raigad | 0.50 | 0.48 | 0.49 |
| 4 | Ratnagiri | 0.47 | 0.50 | 0.48 |
| | Konkan Region | 0.48 | 0.48 | 0.48 |
| 5 | Pune | 1.09 | 1.06 | 1.07 |
| 6 | Solapur | 1.29 | 1.22 | 1.26 |
| 7 | Satara | 0.98 | 0.92 | 0.96 |
| 8 | Sangli | 1.22 | 1.21 | 1.21 |
| 9 | Kolhapur | 0.86 | 0.96 | 0.91 |
| 10 | Ahmednagar | 1.22 | 1.15 | 1.19 |
| 11 | Nashik | 0.98 | 0.99 | 0.98 |
| 12 | Jalgaon | 1.18 | 1.28 | 1.22 |
| 13 | Dhule | 0.83 | 0.89 | 0.86 |
| | W. Maharashtra Region | 1.08 | 1.08 | 1.08 |
| 14 | Aurangabad | 1.31 | 1.25 | 1.28 |
| 15 | Nanded | 1.20 | 1.21 | 1.20 |
| 16 | Osmanabad | 1.33 | 1.21 | 1.28 |
| 17 | Parbhani | 1.29 | 1.31 | 1.30 |
| 18 | Beed | 1.17 | 1.26 | 1.21 |
| | Marathwada Region | 1.27 | 1.25 | 1.26 |
| 19 | Buldhana | 1.20 | 1.23 | 1.22 |
| 20 | Akola | 1.30 | 1.35 | 1.32 |
| 21 | Amravati | 0.99 | 1.07 | 1.03 |
| 22 | Yavatmal | 1.04 | 1.10 | 1.07 |
| 23 | Wardha | 1.15 | 1.02 | 1.09 |
| 24 | Nagpur | 0.94 | 0.98 | 0.96 |
| 25 | Bhandara | 0.69 | 0.68 | 0.69 |
| 26 | Chandrapur | 0.44 | 0.43 | 0.43 |
| | Vidarbha Region | 0.88 | 0.90 | 0.89 |

The regionwise analysis revealed that Marathwada region was higher concentration in net area sown than other regions of Maharashtra with location coefficient of 1.27, 1.25 and 1.26 during Period-I, Period-II and Overall Period, respectively. The concentration of net area sown in Marathwada region was inclining to lower concentration in Period-II over Period-I. This is serious problem regarding conversion of net area sown to other land use categories which may adversely affect agriculture production in future.

Summary of analysis of location coefficient over the 57 years in different regions of Maharashtra revealed that during the Overall Period, the location coefficient in Konkan region was highest in culturable waste land (3.56) followed by land under miscellaneous tree crops and groves (3.44), barren and unculturable land (3.27), fallow lands other than current fallow (2.62), area under non-agricultural uses (1.45) and forest area (1.12). The location coefficient was observed more than one which indicated higher concentration of land in these categories of land and it was lowest in permanent pastures and other grazing land (0.82), current fallow (0.78) and net sown area (0.48).

The location coefficient for spatial distribution of Western Maharashtra region during Overall Period examined and result showed that under the two categories of land i.e. barren and unculturable land (1.34) and net sown area (1.08), the location coefficient was observed more than one which indicated higher concentration of land in these categories of land, while it was observed less than one in remaining seven categories of land namely fallow lands other than current fallow (0.99), forest land (0.89), current fallow (0.88), permanent pastures and other grazing land (0.81), culturable waste land (0.63), land put to non-agricultural uses (0.55) and land under miscellaneous tree crops and groves (0.51). The spatial dynamics of Marathwada region of Maharashtra were estimated by using locational coefficient analysis. The study has revealed that top most concentration was observed in current fallow (2.06) followed by net sown area (1.26), fallow lands other than current fallow (1.05), while remaining six land use categories showed less than one concentration, which indicate less concentration as compare to area under this category in Maharashtra state, namely, culturable waste land (0.97), area under non-agricultural uses (0.92), land under miscellaneous tree crops and groves (0.85), permanent pastures and other grazing land (0.83), barren and unculturable land (0.28) and forest land (0.20) during Overall Period.

It is manifested from result of location coefficient of Vidarbha region during Overall Period that forest (1.63) registered prominent land use category among all other categories which followed area under non-agricultural uses (1.45), permanent pastures and other grazing land (1.40), and all remaining land use categories indicated the less concentration of land in Vidarbha region against area in Maharashtra. Those were land under miscellaneous tree crops and groves (0.95), net sown area (0.89), culturable

waste land (0.69), area under current fallow (0.51), fallow lands other than current fallow (0.49), and barren and unculturable land (0.38).

The summary of this results indicated that the current land was more concentrated in relatively dry and drought-prone Marathwada region of the state. The Konkan region, particularly Ratnagiri and Raigad districts had high concentration of barren and uncultivable land that might be use of this land for industrial purposes.

These findings are consistent with previous studies by Ramasamy *et al.* (2005), Ahmad *et al.* (2018), Pandey and Ranganathan (2018) and Sinha *et al.* (2017) who studied location coefficients of fallow lands only, whereas, Siwana *et al.* (2018) studied in all land use categories.

Based on the above results, the hypothesis stated that there are no temporal changes in different land use categories has not been proved i.e null hypothesis has been rejected.

4.2 Nature and extent of structural variations in land use pattern

4.2.1 Transitional probability matrix for different land use categories

This section illuminated the land use shift from one land use category to another. First order Markov chain approach was employed for analyzing the land use shift at national and state level for all the three periods under study. Figures in the diagonal elements of the transitional probability matrix (TPM) are the retention of concerned land use category, which is the proportion of its share from last year that is retained in current year. Row indicates lost to another land use category and column shows gain from each land use category. The sum of probability across rows leads to one which indicate what does not retained and it must be lost.

4.2.1.1 Transitional probability matrix for land use categories in India

The Markov chain analysis was carried out for three periods (i.e. Period-I: 1960-61 to 1990-91, Period-II: 1991-92 to 2016-17 and Overall: 1960-61 to 2016-17) to analyze the shift in land use pattern in India. The stability of the area share of the different land use categories and the direction and volume of change over time was captured by transitional probability matrix and the results are presented in Table 4.29.

Table 4.29. Transitional probability matrix for land use categories in India

| Sr. No. | Land use category | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
|---------|---|---------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | Period-I: 1960-61 to 1990-91 | | | | | | | | | |
| 1 | Forest land | 0.7802 | 0.0000 | 0.0087 | 0.0055 | 0.0000 | 0.0000 | 0.1861 | 0.0000 | 0.0196 |
| 2 | Barren and uncultivable land | 0.0000 | 0.8940 | 0.0000 | 0.0000 | 0.0473 | 0.0170 | 0.0000 | 0.0000 | 0.0417 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.9708 | 0.0000 | 0.0000 | 0.0000 | 0.0292 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.8770 | 0.0591 | 0.0110 | 0.0000 | 0.0000 | 0.0529 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.1690 | 0.0000 | 0.0000 | 0.6531 | 0.0000 | 0.0000 | 0.0000 | 0.1779 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5164 | 0.0000 | 0.0000 | 0.4836 |
| 7 | Current fallow | 0.0733 | 0.0000 | 0.0090 | 0.0000 | 0.0000 | 0.0000 | 0.0173 | 0.0156 | 0.8848 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0571 | 0.0000 | 0.5634 | 0.3795 |
| 9 | Net area sown | 0.0983 | 0.0000 | 0.0000 | 0.0108 | 0.0154 | 0.0047 | 0.0033 | 0.0283 | 0.8391 |
| | Period-II: 1991-92 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8648 | 0.0000 | 0.0328 | 0.0000 | 0.0000 | 0.0000 | 0.0398 | 0.0627 | 0.0000 |
| 2 | Barren and uncultivable land | 0.0000 | 0.5056 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4944 |
| 3 | Land put to non-agricultural uses | 0.0441 | 0.0000 | 0.8754 | 0.0000 | 0.0000 | 0.0000 | 0.0641 | 0.0164 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0645 | 0.0000 | 0.6999 | 0.0000 | 0.2356 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7115 | 0.0000 | 0.0000 | 0.0000 | 0.2885 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.2800 | 0.0000 | 0.5207 | 0.1565 | 0.0428 | 0.0000 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0267 | 0.0536 | 0.0000 | 0.0000 | 0.0083 | 0.0000 | 0.0000 | 0.0099 | 0.9016 |
| 8 | Fallow other than current fallow | 0.1162 | 0.0000 | 0.0906 | 0.0000 | 0.0000 | 0.0000 | 0.2665 | 0.5267 | 0.0000 |
| 9 | Net area sown | 0.0491 | 0.0422 | 0.0000 | 0.0152 | 0.0165 | 0.0006 | 0.0527 | 0.0000 | 0.8236 |
| | Overall: 1960-61 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8579 | 0.0000 | 0.0081 | 0.0000 | 0.0000 | 0.0000 | 0.1193 | 0.0147 | 0.0000 |
| 2 | Barren and uncultivable land | 0.0000 | 0.9056 | 0.0000 | 0.0000 | 0.0056 | 0.0094 | 0.0000 | 0.0000 | 0.0795 |
| 3 | Land put to non-agricultural uses | 0.0137 | 0.0000 | 0.9827 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0036 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.9409 | 0.0378 | 0.0214 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.1086 | 0.0000 | 0.0000 | 0.8554 | 0.0000 | 0.0000 | 0.0000 | 0.0360 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6468 | 0.0000 | 0.0000 | 0.3532 |
| 7 | Current fallow | 0.0000 | 0.0000 | 0.0023 | 0.0000 | 0.0000 | 0.0011 | 0.0465 | 0.0016 | 0.9485 |
| 8 | Fallow other than current fallow | 0.2803 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0099 | 0.0000 | 0.6927 | 0.0171 |
| 9 | Net area sown | 0.0480 | 0.0032 | 0.0000 | 0.0054 | 0.0064 | 0.0044 | 0.0386 | 0.0141 | 0.8800 |

It can be observed from Table 4.29 that during the Period-I, all land use categories have shown stability. But the highest stability was acquired by land put to non-agricultural uses as reflected in high probability of retention at 0.9708 i.e. the probability that land put to non-agricultural uses retains its share from one period to another period is 97.08 per cent. On the other hand, among all categories, area under current fallow was less retained 1.73 per cent and loss majority of its area to net area sown with 88.48 per cent of its previous years' share. During Period-I, barren and uncultivable land, cultivable waste, net area sown, forest land, permanent pastures and other grazing land, fallow other than current fallow and land under miscellaneous tree, crops and groves retained 89.40, 87.70, 83.91, 78.02, 65.31, 56.34 and 51.64 per cent, respectively of its previous years' share in current year. The major gainer among the different land use categories during Period-I was net area sown, which substantially gained 88.48 per cent from current fallow, 48.36 per cent from land under miscellaneous tree, crops and groves, 37.95 per cent from fallow other than current fallow and 17.79 per cent from permanent pastures and other grazing land. Net area sown was gained from all other land use categories except land put to non-agricultural uses with total TPM of 204.00 per cent during Period-I. Accordingly, at the national level, current fallow land was highly unstable and land put to non-agricultural uses was highly stable during Period-I.

The results of TPM for Period-II showed that at the national level also, land put to non-agricultural uses showed highest stability among all the land use categories with the retention of 87.54 per cent of its previous years' share, which was followed by forest area, net area sown, permanent pastures and other grazing land, cultivable waste, fallow other than current fallow, barren and uncultivable land, land under miscellaneous tree, crops and groves and current fallow with retention of 86.48, 82.36, 71.15, 69.99, 52.67, 50.56, 4.28 and 0.00 per cent of its previous years' share, respectively. During the Period-II, as a major gainer among the different land use categories, net area sown has gained 90.16 per cent from current fallow land, 49.44 per cent from barren and uncultivable land and 28.85 per cent from permanent pastures and other grazing land. At the all India level, current fallow land recorded as highly unstable land use category during the Period-II, which did not retain its previous years' share in current year.

It is evident from the results of TPM for the Overall Period that at the national level, land put to non-agricultural uses was more stable among all the land use categories with the retention of 98.27 per cent of its previous years' share followed by cultivable waste, barren and uncultivable land, net area sown, forest area, permanent pastures and other grazing land, fallow other than current fallow, land under miscellaneous tree, crops and groves and current fallow with retention of 94.09, 90.56, 88.00, 85.79, 85.54, 69.27, 64.68 and 4.65 per cent, respectively of its previous years' share during current year in India. As observed in Overall Period, net area sown was a major gainer among the different land use categories with the gain of 94.85, 35.32, 7.95, 3.60 and 1.71 per cent from current fallow land, land under miscellaneous tree, crops and groves, barren and uncultivable land, permanent pastures and other grazing land and fallow other than current fallow, respectively.

At the all India level, current fallow land was recorded as highly unstable land use category during the entire period of study, which experienced the retention of 4.65 per cent of its previous years' share in current year. As compared to Period-I, forest area and permanent pastures and other grazing land showed an increase in the magnitude of retention of its previous years' share in current year during the Period-II, indicating that these land use categories are going towards stability during recent year in India.

The notable observation recorded is that during Period-I and Period-II, land put to non-agricultural uses was highly stable and current fallow land was highly unstable at the national level. Markedly decrease in retention of barren and uncultivable land was noticed during Period-II over the Period-I. This could be attributed to loss from barren and uncultivable land to net area sown indicating that with the advancement in technologies, most of the uncultivable land could be brought under cultivation which in turn resulted to check encroachment for development on agricultural land and provided for additional cultivable area. It can be implied that in the years to come, there would be a very high pressure towards land put to non-agricultural uses due to increasing population demands.

4.2.1.2 Transitional probability matrix for land use categories in Maharashtra

In order to analyze the shift in land use pattern of Maharashtra state as a whole, the Markov chain analysis was separately used for three periods (i.e. Period-I: 1960-61 to 1990-91, Period-II: 1991-92 to 2016-17, Overall: 1960-61 to 2016-17). The stability of the area share of the different land use categories and direction and volume of change over time is captured by transitional probability matrix and the results are presented in Table 4.30.

It can be observed from the results that all land use categories have shown stability during the Period-I. But the highest stability was acquired by forest area as reflected in high probability of retention at 0.9957 i.e. the probability that forest area at Maharashtra state as a whole retained its share from one period to another period with the magnitude of 99.57 per cent followed by permanent pastures and other grazing land, net area sown, land put to non-agricultural uses, fallow other than current fallow, barren and uncultivable land, current fallow and land under miscellaneous tree, crops and groves retained 97.42, 95.11, 91.69, 77.02, 74.46, 57.24, 43.17 and 26.39 per cent of its previous years' share, respectively in current year. During the Period-I, the major gainer among different land use categories was net area sown, which gained from all other categories. Net area sown gained mostly from land under miscellaneous tree, crops and groves (68.70%) followed by area under current fallow, cultivable waste, barren and uncultivable land and forest area with 68.70, 51.06, 16.57, 6.79 and 0.43 per cent, respectively at the state level in Maharashtra. Accordingly, land under miscellaneous tree, crops and groves was highly unstable and forest land was highly stable during Period-I in Maharashtra.

Table 4.30 Transitional probability matrix for land use categories in Maharashtra

| Sr. No. | Land use category | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
|---------|---|---------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | Period-I: 1960-61 to 1990-91 | | | | | | | | | |
| 1 | Forest land | 0.9957 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0043 |
| 2 | Barren and uncultivable land | 0.0000 | 0.5724 | 0.0000 | 0.0000 | 0.0000 | 0.0350 | 0.1830 | 0.1417 | 0.0679 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.9169 | 0.0831 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0438 | 0.7702 | 0.0203 | 0.0000 | 0.0000 | 0.0000 | 0.1657 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0229 | 0.0000 | 0.9742 | 0.0029 | 0.0000 | 0.0000 | 0.0000 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0491 | 0.0000 | 0.0000 | 0.0000 | 0.2639 | 0.0000 | 0.0000 | 0.6870 |
| 7 | Current fallow | 0.0000 | 0.0492 | 0.0000 | 0.0000 | 0.0000 | 0.0085 | 0.4317 | 0.0000 | 0.5106 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0341 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2213 | 0.7446 | 0.0000 |
| 9 | Net area sown | 0.0013 | 0.0362 | 0.0000 | 0.0076 | 0.0004 | 0.0035 | 0.0000 | 0.0000 | 0.9511 |
| | Period-II: 1991-92 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.7129 | 0.0000 | 0.0258 | 0.0492 | 0.0000 | 0.0000 | 0.0000 | 0.0451 | 0.1670 |
| 2 | Barren and uncultivable land | 0.0000 | 0.8474 | 0.0000 | 0.1057 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0470 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0368 | 0.7938 | 0.0000 | 0.0000 | 0.0000 | 0.1615 | 0.0079 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.4403 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5597 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6077 | 0.0000 | 0.0000 | 0.0000 | 0.3923 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4420 | 0.5580 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0562 | 0.0163 | 0.1023 | 0.0208 | 0.0000 | 0.0415 | 0.7053 | 0.0455 | 0.0120 |
| 8 | Fallow other than current fallow | 0.0522 | 0.0000 | 0.0254 | 0.0396 | 0.0000 | 0.0699 | 0.0295 | 0.7442 | 0.0392 |
| 9 | Net area sown | 0.0778 | 0.0109 | 0.0000 | 0.0000 | 0.0282 | 0.0000 | 0.0000 | 0.0000 | 0.8831 |
| | Overall: 1960-61 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.9609 | 0.0122 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0197 | 0.0072 |
| 2 | Barren and uncultivable land | 0.0000 | 0.7188 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2812 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.9895 | 0.0040 | 0.0000 | 0.0064 | 0.0000 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0228 | 0.9219 | 0.0408 | 0.0000 | 0.0000 | 0.0144 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9419 | 0.0000 | 0.0000 | 0.0000 | 0.0581 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7324 | 0.2676 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0145 | 0.0316 | 0.0000 | 0.0000 | 0.0000 | 0.0280 | 0.7979 | 0.0688 | 0.0592 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0044 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.1045 | 0.8253 | 0.0653 |
| 9 | Net area sown | 0.0106 | 0.0214 | 0.0000 | 0.0038 | 0.0020 | 0.0011 | 0.0000 | 0.0000 | 0.9612 |

The results of TPM for Period-II revealed that for Maharashtra state as a whole, all land use categories showed stability in their previous years' share. Net area sown showed highest stability among all the land use categories with the retention of 88.31 per cent of its previous years' share during Period-II, followed by barren and uncultivable land, land put to non-agricultural uses, fallow other than current fallow, forest area, current fallow, permanent pastures and other grazing land, land under miscellaneous tree, crops and groves and cultivable waste retained 84.74, 79.38, 74.42, 71.29, 70.53, 60.77, 44.20 and 44.03 per cent of its previous years' share, respectively. During the Period-II, major gainer among the different land use categories was net area sown in Maharashtra, which gained 55.97 per cent from cultivable waste, 39.23 per cent from permanent pastures and other grazing land, 16.70 per cent from area under forest, 4.70 per cent from barren and uncultivable land, 3.92 per cent from fallow other than current fallow and 1.20 per cent from current fallow land. At Maharashtra state as a whole, cultivable waste was recorded as highly unstable land use category during Period-II, which experienced the retention of 44.03 per cent of its previous years' share in current year.

During Overall Period, for the Maharashtra state as a whole, all land use categories have showed more than 70.00 per cent retention of its previous years' share in current year. Among all the land use categories, land put to non-agricultural uses was highly stable with the retention of 98.95 per cent of its previous years' share, next to that, net area sown, forest area, permanent pastures and other grazing land, cultivable waste land, fallow other than current fallow, current fallow, land under miscellaneous tree, crops and groves and barren and uncultivable land retained 96.12, 96.09, 94.19, 92.19, 82.53, 79.79, 73.24 and 71.88 per cent, respectively of its previous years' share in current year during Overall Period at state level in Maharashtra. As observed in Overall Period, net area sown was major gainer among the different land use categories with the gain of 0.72, 28.12, 5.81, 5.92 and 6.53 per cent from forest land, barren and uncultivable land, permanent pastures and other grazing land, current fallow and fallow other than current fallow, respectively. For Maharashtra state as a whole, barren and uncultivable land recorded as mostly unstable land use category during the Overall Period, which experienced the retention of 71.88 per cent of its previous years share in current year. The area under forest, land put to non-agricultural uses, cultivable waste land, permanent

pastures and other grazing land, fallow other than current fallow and net area sown showed lower retention of its own previous years' share in current year during Period-II over the Period-I, indicating inclination of these land use categories towards the instability in recent years. Decreasing magnitude of retention in area under forest, land put to non-agricultural uses, permanent pastures and other grazing land and net area sown imply clearly the high competition for these land use categories with another, which is much concern for the policy makers.

4.2.1.3 Regionwise transitional probability matrix of land use categories

The shifting of land in the area under different categories at different regions of Maharashtra over the period of 57 years (1960-61 to 2016-17) were analyzed using transition probability matrix and are presented from Table 4.31 to 4.34.

4.2.1.3.1 Konkan region

The category wise land use shift given in Table 4.31, reveals that during the Period-I, all land use categories considered in Konkan region appeared stability. Among all the categories, barren and uncultivable land was observed more instability with 75.38 per cent of previous years' area in the current period and it gave away 12.43, 9.03, 2.91 and 0.25 per cent of its previous share in current year to net area sown, forest area, cultivable waste and permanent pastures and other grazing land, respectively. The highest retention in fallow other than current fallow with 99.83 per cent of its previous share in current year during Period-I, succeed by cultivable waste, land under miscellaneous tree, crops and groves, net area sown, forest area, land put to non-agricultural uses, current fallow, permanent pastures and other grazing land and barren and uncultivable land retained 94.34, 93.73, 90.23, 87.04, 86.95, 85.57, 84.76 and 75.38 per cent, respectively of the previous share in current year. During the Period-I, barren and uncultivable land was a major gainer among the different land use categories with the gain of 12.96, 5.39, 4.81 and 3.44 per cent from forest area, net area sown, cultivable waste and current fallow, respectively.

During the Period-II, all the land use categories were observed extent of retention of its previous years' share in current year. One of the all land use categories, land under miscellaneous tree, crops and groves showed highest retention with 100.00 per cent, whereas, permanent pastures and other grazing land had lowest retention with 32.41

Table 4.31. Transitional probability matrix for land use categories in Konkan

| Sr. No. | Land use category | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
|---------|---|---------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | Period-I: 1960-61 to 1990-91 | | | | | | | | | |
| 1 | Forest land | 0.8704 | 0.1296 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | Barren and uncultivable land | 0.0903 | 0.7538 | 0.0000 | 0.0291 | 0.0025 | 0.0000 | 0.0000 | 0.0000 | 0.1243 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.8695 | 0.0280 | 0.1025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0027 | 0.0481 | 0.0000 | 0.9434 | 0.0058 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.1438 | 0.0086 | 0.8476 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0242 | 0.9373 | 0.0211 | 0.0000 | 0.0175 |
| 7 | Current fallow | 0.0000 | 0.0344 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8557 | 0.0000 | 0.1099 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0017 | 0.9983 | 0.0000 |
| 9 | Net area sown | 0.0261 | 0.0539 | 0.0000 | 0.0000 | 0.0000 | 0.0059 | 0.0115 | 0.0004 | 0.9023 |
| | Period-II: 1991-92 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8337 | 0.0452 | 0.0127 | 0.0000 | 0.0000 | 0.0000 | 0.0054 | 0.0632 | 0.0397 |
| 2 | Barren and uncultivable land | 0.0000 | 0.7433 | 0.0233 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2334 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0881 | 0.6496 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2623 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.7958 | 0.0034 | 0.0000 | 0.0000 | 0.0000 | 0.2007 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.2764 | 0.3241 | 0.0000 | 0.0000 | 0.0000 | 0.3995 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.2912 | 0.0000 | 0.0813 | 0.0000 | 0.0000 | 0.0000 | 0.6275 | 0.0000 | 0.0000 |
| 8 | Fallow other than current fallow | 0.0703 | 0.0105 | 0.1510 | 0.0000 | 0.0000 | 0.0000 | 0.0459 | 0.5475 | 0.1747 |
| 9 | Net area sown | 0.0708 | 0.1083 | 0.0065 | 0.0329 | 0.0898 | 0.0000 | 0.0092 | 0.0533 | 0.6292 |
| | Overall: 1960-61 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.9867 | 0.0056 | 0.0033 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0044 |
| 2 | Barren and uncultivable land | 0.0000 | 0.9501 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0499 |
| 3 | Land put to non-agricultural uses | 0.0023 | 0.0000 | 0.9882 | 0.0000 | 0.0044 | 0.0000 | 0.0000 | 0.0003 | 0.0048 |
| 4 | Cultivable waste | 0.0000 | 0.0053 | 0.0000 | 0.9924 | 0.0024 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0087 | 0.0061 | 0.0000 | 0.9852 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.9948 | 0.0012 | 0.0000 | 0.0010 |
| 7 | Current fallow | 0.0000 | 0.0156 | 0.0000 | 0.0321 | 0.0000 | 0.0035 | 0.9288 | 0.0000 | 0.0199 |
| 8 | Fallow other than current fallow | 0.0021 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0006 | 0.0000 | 0.9924 | 0.0049 |
| 9 | Net area sown | 0.0082 | 0.0242 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0057 | 0.0028 | 0.9591 |

per cent of its previous years' share in Konkan region. During Period-II, net area sown was the major gainer with aggregate gain of 104.81 per cent from permanent pastures and other grazing land, barren and uncultivable land, cultivable waste, fallow other than current fallow and forest area. On the other hand, it gave its share to all other land use categories except, land under miscellaneous tree, crops and groves during Period-II. As the comparison of stability in different land use categories, all categories showed lower stability except, land under miscellaneous tree, crops and groves during Period-II over Period-I, which indicating that these land use categories tend to unstable in Period-II.

The results of TPM for Konkan revealed that during the Overall Period, all the land use categories showed retentions more than 90.00 per cent of its previous years' in current year. That means, all land use categories have more stability during Overall Period. The highest retention was observed in land under miscellaneous tree, crops and groves with the tune of 99.48 per cent of its previous year followed by fallow other than current fallow, cultivable waste, land put to non-agricultural uses, forest area, permanent pastures and other grazing land, net area sown, barren and uncultivable land and current fallow with retention of 99.24, 99.24, 98.82, 98.67, 98.52, 95.91, 95.01 and 92.88 per cent of its previous years' in current year, respectively during Overall Period. Net area sown was the major gainer with aggregate gain of 8.49 per cent from barren and uncultivable land (4.99%), forest area (0.44%), land put to non-agricultural uses (0.48%), land under miscellaneous tree, crops and groves (0.10%), current fallow (1.99%) and fallow other than current fallow (0.49%) during Overall Period.

4.2.1.3.2 Western Maharashtra region

It can be observed from Table 4.32 that during Period-I, different land use categories considered in the study have shown some extent of stability among which, high stability in land put to non-agricultural uses with the retention of 91.55 per cent of previous years' share during the current year was noticed, followed by net area sown, permanent pastures and other grazing land, cultivable waste, forest area, fallow other than current fallow, barren and uncultivable land, area under miscellaneous tree, crops and groves and current fallow with tune of 91.31, 91.30, 69.52, 67.69, 46.32, 44.19 and 6.26 per cent of its previous years' share in current year, respectively. The current fallow land was showed low stability during Period-I. It is notable observation that net area sown was

highest gainer and it gained total 143.15 per cent share from all other categories during Period-I. However, it gained from current fallow land, fallow other than current fallow and forest area with 80.17, 49.99 and 12.99 per cent of previous years' share in current year, respectively. On the flip side, it gave away 6.05 per cent to the forest area, 1.77 per cent to barren and uncultivable land, 0.71 per cent to fallow other than current fallow and 0.16 per cent to area under miscellaneous tree, crops and groves during Period-I.

During Period-II, all land use categories considered in the study have shown stability to a certain extent among which, net area sown was most stable category that retained 93.83 per cent of previous periods' share during the current period. But it gave away 2.97 per cent of its previous share to forest area, 1.86 per cent to permanent pastures and other grazing land and 1.33 per cent to cultivable waste. However, it was highest gainer and gained share of 32.19, 13.71, 9.51 and 4.88 per cent of previous years' share during the current year from permanent pastures and other grazing land, forest area, fallow other than current fallow and current fallow land, respectively were recorded. The cultivable waste found to be highly unstable with retention of 21.10 per cent of its previous year share and lost 44.21 per cent of its area to barren and uncultivable land, 29.94 per cent to forest area and 4.74 per cent to area under miscellaneous tree, crops and groves during Period-II. On the other hand, it gained from area under miscellaneous tree, crops and groves, barren and uncultivable land, current fallow, net area sown and fallow other than current fallow with 31.11, 4.79, 3.40, 1.33 and 0.84 per cent share, respectively. The land put to non-agricultural uses, cultivable waste and permanent pastures and other grazing land were found to be comparatively more unstable while, other remaining land use categories were more stable in Period-II than in Period-I.

As like in Period-I and Period-II, at Overall Period also, all land use categories retained some of its previous share during current year. The land put to non-agricultural uses was most stable category that retained 98.53 per cent share whereas, barren and uncultivable land was most unstable category with retention of 53.02 per cent of previous years' share during the current year. During all the three periods, net area sown was the major gainer from other land use categories in Western Maharashtra. The notable observation was the major competing categories of net area sown was forest area.

Table 4.32. Transitional probability matrix for land use categories in Western Maharashtra

| Sr. No. | Land use category | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
|---------|---|---------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | Period-I: 1960-61 to 1990-91 | | | | | | | | | |
| 1 | Forest land | 0.6769 | 0.1932 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1299 |
| 2 | Barren and uncultivable land | 0.1278 | 0.4419 | 0.0000 | 0.0765 | 0.0158 | 0.0000 | 0.1901 | 0.1480 | 0.0000 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.9155 | 0.0000 | 0.0821 | 0.0000 | 0.0024 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.6952 | 0.0000 | 0.0000 | 0.3048 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0327 | 0.0000 | 0.9130 | 0.0000 | 0.0543 | 0.0000 | 0.0000 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3329 | 0.6671 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0840 | 0.0291 | 0.0035 | 0.0000 | 0.0188 | 0.0004 | 0.0626 | 0.0000 | 0.8017 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0235 | 0.0000 | 0.0000 | 0.0000 | 0.0134 | 0.0000 | 0.4632 | 0.4999 |
| 9 | Net area sown | 0.0605 | 0.0177 | 0.0000 | 0.0000 | 0.0000 | 0.0016 | 0.0000 | 0.0071 | 0.9131 |
| | Period-II: 1991-92 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.7895 | 0.0734 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1371 |
| 2 | Barren and uncultivable land | 0.0889 | 0.7305 | 0.0000 | 0.0479 | 0.0000 | 0.0000 | 0.0000 | 0.1327 | 0.0000 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.7085 | 0.0000 | 0.0000 | 0.0000 | 0.2915 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.2994 | 0.4421 | 0.0000 | 0.2110 | 0.0000 | 0.0474 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6781 | 0.0000 | 0.0000 | 0.0000 | 0.3219 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.3111 | 0.0000 | 0.6889 | 0.0000 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0065 | 0.0174 | 0.1270 | 0.0340 | 0.0000 | 0.0105 | 0.7558 | 0.0000 | 0.0488 |
| 8 | Fallow other than current fallow | 0.0094 | 0.0000 | 0.1119 | 0.0084 | 0.0000 | 0.0084 | 0.0287 | 0.7381 | 0.0951 |
| 9 | Net area sown | 0.0297 | 0.0000 | 0.0000 | 0.0133 | 0.0186 | 0.0000 | 0.0000 | 0.0000 | 0.9383 |
| | Overall: 1960-61 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8025 | 0.1567 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0408 |
| 2 | Barren and uncultivable land | 0.2163 | 0.5302 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2535 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.9853 | 0.0000 | 0.0000 | 0.0104 | 0.0043 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.7134 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2866 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0179 | 0.9821 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9378 | 0.0000 | 0.0622 | 0.0000 |
| 7 | Current fallow | 0.0000 | 0.0321 | 0.0180 | 0.0136 | 0.0103 | 0.0000 | 0.9019 | 0.0000 | 0.0242 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0047 | 0.0000 | 0.0996 | 0.8958 | 0.0000 |
| 9 | Net area sown | 0.0216 | 0.0167 | 0.0000 | 0.0068 | 0.0000 | 0.0000 | 0.0000 | 0.0056 | 0.9492 |

4.2.1.3.3 Marathwada region

Perusal of Table 4.33 indicated the TPM for land use pattern in Marathwada region for aforesaid three periods. It can be seen from the results that all land use categories showed retention of their previous years' share in current year during Period-I. The highest retention was for cultivable waste that means this category was most stable with the tune of 97.22 per cent, however, most unstable land use category was area under miscellaneous tree, crops and groves which has lowest retention of 44.34 per cent of its previous years' share in current year and it had given up the area to land put to non-agricultural uses with 55.66 per cent of its previous years' share in current year in Period-I. Net area sown was the major gainer among all other categories of land use in Marathwada region with the total gain of 80.17 per cent from other land use categories during Period-I.

The results revealed that during Period-II, all of the land use categories observed retention of some extent of its previous years' share in current year except the cultivable waste. So, cultivable waste was failed to retain its previous years' share in current year that means it was highly unstable land use category. During Period-II, net area sown was most stable land use category with tune of 93.17 per cent of its previous years' share in current year, however, it was major gainer category among all other land use categories with total gain of 139.10 per cent and it gained 100 per cent from cultivable waste, 26.70 per cent from forest land and 12.40 per cent of its previous years' share in current year from permanent pastures and other grazing land.

During Overall Period, net area sown has highly stable with tune to 98.71 per cent of its previous years' share in current year in Marathwada region. Its markedly observed that the land put to non-agricultural uses was major gainer with gross gain of 45.92 per cent of its previous years' share, however, area under miscellaneous tree, crops and groves was lowest stable land use category with 63.92 per cent of its previous years' share in current year during Overall Period and it was lost its 34.76 and 1.32 per cent of its previous share to land put to non-agricultural uses and fallow other than current fallow, respectively which might be due to infrastructure development and or it may brought under cultivation in some areas of Marathwada.

Table 4.33. Transitional probability matrix for land use categories in Marathwada

| Sr. No. | Land use category | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
|---------|---|---------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | Period-I: 1960-61 to 1990-91 | | | | | | | | | |
| 1 | Forest land | 0.9066 | 0.0553 | 0.0000 | 0.0000 | 0.0000 | 0.0382 | 0.0000 | 0.0000 | 0.0000 |
| 2 | Barren and uncultivable land | 0.0000 | 0.8076 | 0.0000 | 0.0000 | 0.0294 | 0.0000 | 0.0000 | 0.0000 | 0.1630 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0167 | 0.7645 | 0.0154 | 0.0000 | 0.0389 | 0.0000 | 0.0000 | 0.1644 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0069 | 0.9722 | 0.0000 | 0.0090 | 0.0000 | 0.0000 | 0.0119 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6953 | 0.0000 | 0.0000 | 0.0000 | 0.3047 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.5566 | 0.0000 | 0.0000 | 0.4434 | 0.0000 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0016 | 0.0005 | 0.0000 | 0.0000 | 0.0185 | 0.0000 | 0.7914 | 0.0302 | 0.1578 |
| 8 | Fallow other than current fallow | 0.0161 | 0.0071 | 0.0000 | 0.0000 | 0.0000 | 0.0006 | 0.4445 | 0.5317 | 0.0000 |
| 9 | Net area sown | 0.0037 | 0.0002 | 0.0057 | 0.0000 | 0.0139 | 0.0000 | 0.0000 | 0.0147 | 0.9618 |
| | Period-II: 1991-92 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.5919 | 0.0691 | 0.0000 | 0.0720 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2670 |
| 2 | Barren and uncultivable land | 0.0000 | 0.2670 | 0.0000 | 0.0000 | 0.0000 | 0.0983 | 0.4498 | 0.1849 | 0.0000 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0495 | 0.8976 | 0.0000 | 0.0000 | 0.0117 | 0.0000 | 0.0411 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0010 | 0.0427 | 0.1729 | 0.6288 | 0.0000 | 0.0000 | 0.0306 | 0.1240 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2904 | 0.7096 | 0.0000 | 0.0000 |
| 7 | Current fallow | 0.0210 | 0.0102 | 0.0145 | 0.0511 | 0.0000 | 0.0260 | 0.8456 | 0.0316 | 0.0000 |
| 8 | Fallow other than current fallow | 0.0000 | 0.0000 | 0.0000 | 0.1494 | 0.0000 | 0.0205 | 0.0000 | 0.8302 | 0.0000 |
| 9 | Net area sown | 0.0178 | 0.0110 | 0.0017 | 0.0197 | 0.0181 | 0.0000 | 0.0000 | 0.0000 | 0.9317 |
| | Overall: 1960-61 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8860 | 0.0170 | 0.0915 | 0.0055 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2 | Barren and uncultivable land | 0.0000 | 0.9226 | 0.0000 | 0.0000 | 0.0000 | 0.0037 | 0.0000 | 0.0737 | 0.0000 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.8085 | 0.0193 | 0.0000 | 0.0390 | 0.0000 | 0.1332 | 0.0000 |
| 4 | Cultivable waste | 0.0025 | 0.0055 | 0.0192 | 0.9728 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9425 | 0.0000 | 0.0000 | 0.0000 | 0.0575 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.3476 | 0.0000 | 0.0000 | 0.6392 | 0.0000 | 0.0132 | 0.0000 |
| 7 | Current fallow | 0.0032 | 0.0000 | 0.0000 | 0.0000 | 0.0039 | 0.0000 | 0.9113 | 0.0000 | 0.0816 |
| 8 | Fallow other than current fallow | 0.0046 | 0.0075 | 0.0000 | 0.0000 | 0.0000 | 0.0240 | 0.0957 | 0.8682 | 0.0000 |
| 9 | Net area sown | 0.0048 | 0.0003 | 0.0010 | 0.0000 | 0.0025 | 0.0000 | 0.0043 | 0.0000 | 0.9871 |

4.2.1.3.4 Vidarbha region

The results of Markov chain analysis regarding land use pattern of Vidarbha region of Maharashtra are presented in the form of transition probability matrix in Table 4.34. It can be seen from results that during the Period-I, all land use categories considered in Vidarbha showed retention of its previous years' share in current year. The forest land was to be found as most stable category of land with tune of 88.76 per cent its previous years' share in current year. Whereas, fallow other than current fallow retained 35.09 per cent of its previous share in current year, which was most unstable land use category and lose its share during Period-I. Net area sown was major gainer with total gain of 98.30 per cent from permanent pastures and other grazing land, current fallow, fallow other than current fallow and forest area with 37.19, 34.26, 16.64 and 10.21 per cent of the previous share in current year during Period-I.

During Period-II, barren and uncultivable land did retain 100 per cent of its previous years' share in current year, hence, it become the most stable land use category. The most unstable land use category was area under miscellaneous tree, crops and groves which showed 59.44 per cent of its previous years' share and it was found to be loss their area to net area sown, cultivable waste and fallow other than current fallow with the extent of 30.80, 5.51 and 4.24 per cent its previous years' share in current year, respectively. Among all other land use categories, net area sown was observed to be major gainer with total gain of 77.52 per cent from area under miscellaneous tree, crops and groves, forest land, fallow other than current fallow and land put to non-agricultural uses with tune of 30.80, 19.87, 18.42 and 8.44 per cent of the previous share in current year, respectively during Period-II. It is noteworthy that barren and uncultivable land has become stable in Period-II as compared to Period-I, indicating the need for attention towards the efforts for diverting this land to other land use categories in Vidarbha region.

At Overall Period, net area sown was a major gainer, in which gain from cultivable waste, forest area, permanent pastures and other grazing land and barren and uncultivable land were 21.23, 14.04, 1.49 and 1.29 per cent, respectively of its previous years' share in current year. Permanent pastures and other grazing land was most stable land category however, fallow other than current fallow was unstable land use category during Overall Period.

Table 4.34. Transitional probability matrix for land use categories in Vidarbha

| Sr. No. | Land use category | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
|---------|---|---------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | Period-I: 1960-61 to 1990-91 | | | | | | | | | |
| 1 | Forest land | 0.8876 | 0.0099 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 | 0.0000 | 0.1021 |
| 2 | Barren and uncultivable land | 0.0000 | 0.4767 | 0.0000 | 0.0181 | 0.1456 | 0.0119 | 0.0000 | 0.3477 | 0.0000 |
| 3 | Land put to non-agricultural uses | 0.1234 | 0.0000 | 0.7313 | 0.0000 | 0.0000 | 0.0000 | 0.1453 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.8372 | 0.1628 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0371 | 0.0000 | 0.0427 | 0.5080 | 0.0161 | 0.0000 | 0.0241 | 0.3719 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0020 | 0.0000 | 0.6498 | 0.0000 | 0.3482 | 0.0000 |
| 7 | Current fallow | 0.0291 | 0.0000 | 0.1686 | 0.0000 | 0.0000 | 0.0105 | 0.4492 | 0.0000 | 0.3426 |
| 8 | Fallow other than current fallow | 0.1447 | 0.2773 | 0.0000 | 0.0000 | 0.0321 | 0.0286 | 0.0000 | 0.3509 | 0.1664 |
| 9 | Net area sown | 0.0443 | 0.0000 | 0.0203 | 0.0000 | 0.0545 | 0.0000 | 0.0000 | 0.0000 | 0.8809 |
| | Period-II: 1991-92 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8013 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1987 |
| 2 | Barren and uncultivable land | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 3 | Land put to non-agricultural uses | 0.0000 | 0.0000 | 0.9156 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0844 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0453 | 0.8884 | 0.0000 | 0.0153 | 0.0000 | 0.0509 | 0.0000 |
| 5 | Permanent pastures and other grazing land | 0.0164 | 0.0000 | 0.0301 | 0.0000 | 0.8555 | 0.0267 | 0.0000 | 0.0713 | 0.0000 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.0551 | 0.0000 | 0.5944 | 0.0000 | 0.0424 | 0.3080 |
| 7 | Current fallow | 0.0000 | 0.0000 | 0.1079 | 0.0000 | 0.0000 | 0.0000 | 0.8675 | 0.0246 | 0.0000 |
| 8 | Fallow other than current fallow | 0.1477 | 0.0000 | 0.0000 | 0.0429 | 0.0000 | 0.0000 | 0.0000 | 0.6252 | 0.1842 |
| 9 | Net area sown | 0.1008 | 0.0000 | 0.0000 | 0.0026 | 0.0148 | 0.0017 | 0.0072 | 0.0000 | 0.8729 |
| | Overall: 1960-61 to 2016-17 | | | | | | | | | |
| 1 | Forest land | 0.8427 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0044 | 0.0000 | 0.0126 | 0.1404 |
| 2 | Barren and uncultivable land | 0.0000 | 0.8689 | 0.0000 | 0.0912 | 0.0000 | 0.0025 | 0.0000 | 0.0245 | 0.0129 |
| 3 | Land put to non-agricultural uses | 0.0060 | 0.0293 | 0.9340 | 0.0000 | 0.0000 | 0.0000 | 0.0307 | 0.0000 | 0.0000 |
| 4 | Cultivable waste | 0.0000 | 0.0000 | 0.0000 | 0.7877 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2123 |
| 5 | Permanent pastures and other grazing land | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9664 | 0.0000 | 0.0000 | 0.0187 | 0.0149 |
| 6 | Land under miscellaneous tree, crops and groves | 0.0000 | 0.0000 | 0.0000 | 0.1931 | 0.0000 | 0.7754 | 0.0000 | 0.0316 | 0.0000 |
| 7 | Current fallow | 0.0000 | 0.0071 | 0.0576 | 0.0000 | 0.0000 | 0.0047 | 0.9306 | 0.0000 | 0.0000 |
| 8 | Fallow other than current fallow | 0.2749 | 0.0619 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6631 | 0.0000 |
| 9 | Net area sown | 0.0756 | 0.0000 | 0.0054 | 0.0022 | 0.0036 | 0.0000 | 0.0000 | 0.0000 | 0.9131 |

4.2.1.4 Districtwise transitional probability matrix of land use categories in Maharashtra

Markov chain analysis was separately employed to capture the shift in land use pattern of different districts of Maharashtra state for aforesaid three periods (i.e. Period-I: 1960-61 to 1990-91, Period-II: 1991-92 to 2016-17 and Overall: 1960-61 to 2016-17) and the results are depicted in Table 4.35 to 4.47.

As far as the forest is concerned, all the districts of Maharashtra showed some extent of retention of its previous years share in current year during Period-I. Parbhani district showed highest retention with 99.55 per cent of its previous years' share in current year. Whereas, Osmanabad district maintained lowest share of 39.26 per cent followed by Wardha and Pune with tune of 45.65 and 63.30 per cent, respectively of its previous years' share in current year in forest area during Period-I. Further, Osmanabad district likely to lose its remaining share of 60.74 per cent of previous years' in current year to fallow other than current fallow during Period-I.

On the other hand, during the Period-II, Wardha was observed the highest instability with 10.39 per cent retention of its previous years' share followed by Beed, Solapur, Ahmednagar and Ratnagiri with the tune of 18.05, 34.65, 40.19 and 48.75 per cent, respectively of its previous years' share in current year in forest land. Whereas, Greater Bombay remained at the top in terms of stability during the Period-II with retention of 100 per cent of its previous years' share in current year in forest area. Wardha district gave away its share of forest area to net area sown, barren and uncultivable land and land under miscellaneous tree, crops and groves with the tune of 87.19, 1.73 and 0.69 per cent of its previous years' share in current year.

During overall Period, all the districts of Maharashtra were manifested some retention between 83.06 and 100 per cent of their previous years' share in terms of forest area in current year. Wardha district showed least stability with 83.06 per cent followed by Ratnagiri with 87.33 per cent of previous years' share in current year. Here, Wardha district lost its shares to net area sown, land put non-agricultural uses, permanent pastures and other grazing land, fallow other than current fallow and land under miscellaneous tree, crops and groves with the tune of 9.81, 2.48, 2.04, 1.36 and 1.24 per cent of previous years' share in current year, respectively during Period-II. The top most

stable districts in forest area were Raigad, Satara, Aurangabad, Osmanabad and Buldhana which retained 100 per cent of its previous years' share in current year during Overall Period.

It is noteworthy to mention here that thirteen districts viz; Greater Bombay, Thane, Raigad, Pune, Satara, Nashik, Jalgaon, Osmanabad, Parbhani, Beed, Buldhana, Nagpur and Chandrapur were more stable during Period-II over Period-I, out of which Pune and Osmanabad districts showed comparatively high stability during Period-II over Period-I while, remaining thirteen districts become a more unstable in the same period in respect of area under forest. Among which, eight districts viz; Ratnagiri, Solapur, Kolhapur, Ahmednagar, Beed, Akola, Amravati and Wardha were found to be relatively high unstable during Period-II as compare to Period-I. The reason for conversion of forest land to net area sown might be due to encroachment of this land by the local people.

In majority of the districts, forest lost their previous years' share to barren and uncultivable land, net area sown and cultivable waste indicating that these are the most competitor land use categories for forest.

The results of districtwise TPM of land use pattern revealed that in case of barren and uncultivable land, all the districts of Maharashtra except Amravati district, retained some of its previous years' share in current year during Period-I. The retention of barren and uncultivable land in Amravati district was zero per cent of its previous years' share in current year and lose its share with 69.62 per cent to net area sown and 30.38 per cent to land put to non-agricultural uses during Period-I. Ten districts viz; Amravati, Osmanabad, Nagpur, Kolhapur, Jalgaon, Bhandara, Buldhana, Sangli, Nashik and Wardha were recorded its retention share below 50.00 per cent of its previous years' share in current year during Period-I. The periodwise TPM of different districts indicates that the Raigad district remained at top in terms of stability of barren and uncultivable land with the retention of 98.77 per cent of its previous years' share in current year. However, retention ranged from 0.00 to 98.77 per cent in barren and uncultivable land during Period-I.

During the Period-II, Greater Bombay, Raigad, Parbhani, Nagpur and Bhandara districts showed higher stability in barren and uncultivable land however,

Thane, Akola Amravati and Wardha districts of Maharashtra failed to retained its per cent share of previous years' share in current year. The majority of districts (16 out of 26) showed an increase in stability of barren and uncultivable land, on the other side, 9 districts of Maharashtra recorded decline in stability during Period-II over Period-I. Amravati district was highly unstable in barren and uncultivable land and there was no change in retention having zero per cent retention during Period-I and Period-II in Amravati district.

At the Overall Period, all the districts showed stability in barren and uncultivable land within the range of 0.71 to 99.79 per cent of its previous years' share in current year. Greater Bombay (99.79%) was highly stable district followed by Parbhani (99.70%) in barren and uncultivable land whereas, Amravati district (0.71%) has low stability followed by Bhandara and Osmanabad districts with retention of 11.47 and 43.46 per cent, respectively of its previous years' share in current year during Overall Period. It is important to note that, land use shift from net area sown, fallow other than current fallow and current fallow land to barren and uncultivable land might be due to the over-cultivation and or inadequate irrigation in the different districts of Maharashtra.

It can be concluded that in majority of districts, barren and uncultivable land has gained from net area sown, current fallow and fallow other than current fallow area, while in some districts from forest and land put to non-agricultural uses. It is important to note that in majority of districts, area from net area sown and fallow lands moved towards barren and uncultivable land; implying that though conversion of other land categories to non-agricultural use is unavoidable, it is better to use the barren and uncultivable land for the same.

As far as the land use category of land put to non-agricultural uses during the Period-I, all the districts showed some extent of retention of previous years' share in current year. The districts of Raigad and Jalgaon showed cent per cent retention of previous years' share in current year, while Nanded district observed highest instability with 20.43 per cent share followed by Osmanabad, Ahmednagar and Wardha districts that showed more instability with tune of 28.26, 65.01 and 70.00 per cent retention of its previous years' share, respectively.

During Period-II, Beed district of Maharashtra observed highly unstable in land put to non-agricultural uses, which retained zero per cent of its previous years' share followed by Ahmednagar district with 15.98 per cent share. However, all remaining districts showed some extent of stability within the range of 15.98 to 100 per cent of its previous years' share in current year. During Period-II, three districts were found to be highly stable viz; Greater Bombay, Raigad and Solapur with retention of 100 per cent of its previous years' share in current year with regard to land put to non-agricultural uses. Greater Bombay, Pune, Solapur, Nashik, Dhule, Nanded, Osmanabad and Parbhani districts were more stable, whereas, Ahmednagar, Beed and Akola districts were highly unstable in land put to non-agricultural uses during Period-II over Period-I.

At the Overall Period, all the districts were likely to retain more than 90.00 per cent of their previous years' share in current year in land put to non-agricultural uses. That means, all districts in land put to non-agricultural uses category have more stable during Overall Period. In majority of districts, land put to non-agricultural uses gained its share mostly from net area sown and current fallow land. This is prime concern to policy makers to devise measures to avoid use of agricultural land to non-agricultural purposes.

Districtwise TPM of land use pattern for different periods at a glance revealed that in case of cultivable waste, all the districts of the Maharashtra state retained some extent of their previous years' share in current year during Period-I. The district of Parbhani remained at top in terms of stability with 99.04 per cent of its previous years' share in current year in cultivable waste land followed by Ratnagiri, Osmanabad, Dhule and Beed with the tune of 98.96, 97.77, 96.36 and 95.00 per cent share, respectively during Period-I. However, Ahmednagar was the top most district with highest instability having 0.10 per cent retention of its previous years' share in cultivable waste land followed by Sangli, Akola, Bhandara and Amravati districts of Maharashtra during Period-I.

During the Period-II, Aurangabad district showed highest instability, it was failed to retain share of cultivable waste land, while remaining districts showed stability between the range of 7.49 to 100 per cent. On the other hand, Raigad, Jalgaon and Dhule districts were found to be highly stable districts have cent per cent of its

previous years' share in current year in cultivable waste land. As comparison between two periods, eleven districts *viz*; Raigad, Sangli, Ahmednagar, Jalgaon, Dhule, Buldhana, Akola, Amravati, Wardha, Nagpur and Bhandara observed more stability however, among the remaining districts, some of the districts *viz*; Thane, Solapur, Nashik, Aurangabad, Nanded, Osmanabad and Beed were highly unstable in cultivable waste land during Period-II over Period-I, out of which, majority of districts lost its share to the net area sown and in some districts, it shifted towards a meager to the current fallow. It is expectable for expansion of cropped area to serve the demand of food grains of increasing population in days to come.

At the Overall Period, all the districts of Maharashtra showed some amount of retention ranging from 49.98 to 99.46 per cent of their previous years' share in current year in cultivable waste land. That means, all districts in cultivable waste land use category have stability during Overall Period. Whereas, Beed was observed to be top most district in per cent retention of its previous years' share in current year in cultivable waste land. For most of the districts of Maharashtra, cultivable waste land, gained its share mostly from net area sown, current fallow and fallow other than current fallow land during Overall Period.

It is important to note that move from net area sown, fallow other than current fallow and current fallow to the cultivable waste land might be due to the soil degradation by water erosion, acidic, saline, etc. particularly in coastal and command areas in the different districts of Maharashtra. During all the three periods, in majority of districts of Maharashtra, the cultivable waste land was likely to lose its share to net area sown and permanent pasture and other grazing land. It's a positive sign that the share of cultivable waste land has decreased, making way for an increase in net sown area and permanent pasture and other grazing land.

The analysis of districtwise TPM of permanent pasture and grazing land divulged that all the districts of Maharashtra retained some extent of its previous years' share in current year during Period-I. Raigad was top most district in the retention of permanent pasture and grazing with cent per cent of its previous years' share in current year, however, Osmanabad district showed lowest retention with 20.65 per cent share followed by Nanded, Beed and Solapur with the retention of 46.65, 50.31 and 54.82 per

cent, respectively, of its previous years' share in current year in permanent pasture and grazing land during Period-I.

During the Period-II, Greater Bombay and Amravati districts of Maharashtra showed higher stability in permanent pasture and grazing land with retaining 100 per cent of its previous years' share in current year. On the other hand, Akola district was highly unstable with 1.03 per cent followed by Osmanabad, Yavatmal, Kolhapur, Ahmednagar and Ratnagiri with the tune of 2.79, 9.19, 10.31, 15.22 and 20.84 per cent of its previous years' share in current year, respectively, during Period-II. For 12 districts, there were decrease in stability of permanent pasture and grazing land, among which, Ratnagiri, Ahmednagar, Akola and Yavatmal districts observed tremendous decline in its retention per cent during Period-II over Period-I.

At the Overall Period, all the districts showed stability in permanent pasture and grazing land within the range of 49.93 to 100 per cent of its previous years' share in current year. Greater Bombay and Raigad were observed to be highly stable districts in permanent pasture and grazing land with 100 per cent of its previous years' share in current year whereas, Beed district (49.93%) has low stability during Overall Period. Most of the districts lost their area of permanent pasture and grazing land to net area sown and cultivable waste land during Overall Period.

In case of area under miscellaneous tree, crops and groves, Ahmednagar, Beed, Buldhana and Akola districts of the Maharashtra state were failed to retained its previous years' share in current year during Period-I. However, Yavatmal district remained at top in terms of stability with 98.77 per cent followed by Satara and Ratnagiri with 98.41 and 98.35 per cent, respectively, of its previous years' share in current year in area under miscellaneous tree, crops and groves during Period-I.

During Period-II, Raigad, Ahmednagar and Nagpur districts showed highest instability and it failed to retain share of area under miscellaneous tree, crops and groves, while. On the other hand, Thane, Ratnagiri and Buldhana districts were found to be highly stable districts having cent per cent of its previous years' share in current year in area under miscellaneous tree, crops and groves. Overview of two periods, fourteen districts *viz*; Thane, Ratnagiri, Pune, Solapur, Sangli, Kolhapur, Osmanabad, Beed, Buldhana, Akola, Amravati, Wardha, Bhandara and Chandrapur district were observed

more stable in area under miscellaneous tree, crops and groves during Period-II over Period-I.

During Overall Period, eight districts viz; Ratnagiri, Pune, Satara, Ahmednagar, Nashik, Dhule, Nanded and Yavatmal observed cent per cent of its previous years' share in current year in area under miscellaneous tree, crops and groves. That means, all these districts in area under miscellaneous tree, crops and groves land use category have high stability during Overall Period. Whereas, Akola was observed at bottom most district followed by Buldhana district with tune of 0.66 per cent retention of its previous years' share in current year in area under and miscellaneous tree, crops and groves.

As far as the current fallow land is concerned, all the districts of Maharashtra except, Solapur showed some amount of retention of its previous years share in current year during Period-I. Solapur district failed to maintain per cent share followed by Bhandara, Yavatmal and Raigad with tune of 12.65, 14.70 and 17.16 per cent, respectively of its previous years' share in current year in current fallow during Period-I. Further, Solapur district likely to lose its major share of 98.28 per cent to net area sown and 1.72 per cent of previous years' share in current year to barren and uncultivable land during Period-I. Whereas, Thane district showed highest retention with 95.60 per cent of its previous years' share in current year.

On the other hand, during Period-II, Amravati observed the highest stability with 100 per cent retention of its previous years' share followed by Satara, Dhule and Buldhana with the tune of 95.91, 95.09 and 94.23 per cent, respectively of its previous years' share in current year in current fallow land. Whereas, Greater Bombay remained at the top in terms of instability with zero per cent retention followed by Raigad and Akola with 8.45 and 15.31 per cent of its previous years' share in current year, respectively, in current fallow during the Period-II. Summary of two periods, seventeen districts were observed to be more stable in current fallow land during Period-II over Period-I among which, Solapur, Dhule, Amravati, Yavatmal, Wardha and Bhandara districts were observed to have high stability during Period-II as compare to Period-I.

During overall Period, all the districts of Maharashtra were manifested some retention within 49.00 and 99.33 per cent of its previous years' share in current year

of current fallow land. Jalgaon district showed least stability with 49.00 per cent of previous years' in current year. Here, most of the districts lost their per cent shares of previous years' in current year to net area sown, land put non-agricultural uses and barren and uncultivable land, respectively during Overall Period. Amravati district (99.33%) was the top most stable district in current fallow land followed by Thane, Ahmednagar, Aurangabad, Akola, Satara, Ratnagiri and Wardha showed higher retention per cent of its previous years' share in current year during Overall Period. By and large, fallow land was the most unstable land use category in almost all the districts of the Maharashtra, as it depends on the rainfall distribution in the area and in some cases, farmers keep some agricultural land fallow for a season from soil health point of view.

The analysis of land use shifting of fallow other than current fallow during the Period-I reveals that all the districts of Maharashtra showed some extent of retention with the range from 0.17 to 99.09 per cent of its previous years' share in current year. Chandrapur was lowest retained district with 0.17 per cent share followed by Beed, Jalgaon and Nagpur with the tune of 1.38, 10.91 and 18.15 per cent of its previous years' share in current year in fallow other than current fallow. However, among the all districts, Ratnagiri (99.09%) was high retention per cent followed by Ahmednagar, Pune, Parbhani and Thane districts with the tune of 97.92, 91.39, 90.64 and 90.30 per cent of its previous years' share in current year, respectively, in fallow other than current fallow.

During Period-II, Greater Bombay district was observed highly unstable in fallow other than current fallow which retained zero per cent of its previous years' share followed by Raigad, Amravati and Ratnagiri districts with 25.66, 48.97 and 49.65 per cent share, respectively. During Period-II, districts *Viz*; Nanded, Satara, Thane and Buldhana found to be highly stable with retention of 94.03, 92.25, 91.34 and 90.18 per cent of its previous years' share in current year in fallow other than current fallow land. Majority of the districts (17 out of 26 districts) were observed more stable among which, Jalgaon, Nanded, Beed and Nagpur districts have higher stability in fallow other than current fallow land during Period-II over Period-I.

Table 4.35 Transitional probability matrix for land use categories in Greater Bombay and Thane districts

| Particulars | Greater Bombay | | | | | | | | | Thane | | | | | | | | |
|------------------|----------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.8876 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1124 | 0.8907 | 0.0301 | 0.0000 | 0.0000 | 0.0000 | 0.0035 | 0.0000 | 0.0000 | 0.0757 |
| BU | 0.0044 | 0.7706 | 0.2250 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0700 | 0.8342 | 0.0000 | 0.0630 | 0.0328 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0033 | 0.0549 | 0.9222 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0197 | 0.0000 | 0.0000 | 0.9703 | 0.0000 | 0.0297 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.8466 | 0.0049 | 0.0000 | 0.0000 | 0.1485 | 0.0000 | 0.1965 | 0.0001 | 0.0464 | 0.7208 | 0.0361 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0521 | 0.9479 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0713 | 0.9287 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.2685 | 0.0000 | 0.7315 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6332 | 0.0826 | 0.0000 | 0.2842 |
| CF | 0.0000 | 0.0487 | 0.0000 | 0.1845 | 0.0000 | 0.0000 | 0.7668 | 0.0000 | 0.0000 | 0.0236 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9560 | 0.0205 | 0.0000 |
| OF | 0.0035 | 0.0068 | 0.0000 | 0.0000 | 0.0091 | 0.0000 | 0.0000 | 0.8887 | 0.0921 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0327 | 0.0000 | 0.9030 | 0.0643 |
| NAS | 0.0104 | 0.0826 | 0.0000 | 0.0080 | 0.0018 | 0.0000 | 0.0067 | 0.0101 | 0.8804 | 0.0991 | 0.0094 | 0.0000 | 0.0000 | 0.0000 | 0.0030 | 0.0000 | 0.0031 | 0.8854 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9933 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0028 | 0.0039 |
| BU | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0433 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9567 |
| NA | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0280 | 0.0000 | 0.9567 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0056 | 0.0097 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.7778 | 0.0000 | 0.0000 | 0.0745 | 0.0000 | 0.1477 | 0.0000 | 0.1795 | 0.0000 | 0.1895 | 0.5001 | 0.0000 | 0.0112 | 0.0000 | 0.1196 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1814 | 0.0000 | 0.1811 | 0.5054 | 0.0000 | 0.0113 | 0.0000 | 0.1209 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4921 | 0.0000 | 0.5079 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0866 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9134 | 0.0000 |
| NAS | 0.0000 | 0.0000 | 0.0000 | 0.2401 | 0.0000 | 0.0000 | 0.0000 | 0.7599 | 0.0000 | 0.0000 | 0.1662 | 0.0000 | 0.0733 | 0.0393 | 0.0000 | 0.0155 | 0.0000 | 0.7057 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9900 | 0.0100 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9999 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 |
| BU | 0.0010 | 0.9979 | 0.0010 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9929 | 0.0000 | 0.0044 | 0.0027 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0003 | 0.0000 | 0.9997 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.9979 | 0.0016 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0001 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.9729 | 0.0000 | 0.0000 | 0.0000 | 0.0271 | 0.0000 | 0.0002 | 0.0031 | 0.0048 | 0.9866 | 0.0035 | 0.0000 | 0.0002 | 0.0000 | 0.0015 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0038 | 0.0000 | 0.0010 | 0.9950 | 0.0000 | 0.0002 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7315 | 0.0000 | 0.2685 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9998 | 0.0000 | 0.0002 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0000 | 0.0700 | 0.0000 | 0.0000 | 0.9300 | 0.0000 | 0.0000 | 0.0000 | 0.0044 | 0.0008 | 0.0000 | 0.0000 | 0.0000 | 0.9894 | 0.0000 | 0.0055 |
| OF | 0.0006 | 0.0000 | 0.0231 | 0.0045 | 0.0000 | 0.0000 | 0.0064 | 0.9433 | 0.0221 | 0.0000 | 0.0000 | 0.0015 | 0.0000 | 0.0000 | 0.0003 | 0.0000 | 0.9982 | 0.0001 |
| NAS | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0184 | 0.9814 | 0.0000 | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.0000 | 0.9994 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.36. Transitional probability matrix for land use categories in Raigad and Ratnagiri districts

| Particulars | Raigad | | | | | | | | | Ratnagiri | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9863 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0137 | 0.0000 | 0.8947 | 0.0155 | 0.0000 | 0.0815 | 0.0083 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0123 | 0.9877 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0056 | 0.9207 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0738 |
| NA | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0292 | 0.0181 | 0.9527 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0004 | 0.0000 | 0.0000 | 0.7860 | 0.0000 | 0.0000 | 0.2092 | 0.0044 | 0.0000 | 0.0000 | 0.0097 | 0.0007 | 0.9896 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0048 | 0.9850 | 0.0101 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7372 | 0.2203 | 0.0000 | 0.0424 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9835 | 0.0000 | 0.0000 | 0.0165 |
| CF | 0.0000 | 0.0084 | 0.0000 | 0.4265 | 0.0000 | 0.0617 | 0.1716 | 0.0708 | 0.2611 | 0.0026 | 0.0170 | 0.0000 | 0.0000 | 0.0000 | 0.0063 | 0.8926 | 0.0394 | 0.0421 |
| OF | 0.0047 | 0.0340 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3570 | 0.6043 | 0.0021 | 0.0071 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9909 | 0.0000 |
| NAS | 0.0023 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0334 | 0.0119 | 0.1178 | 0.8347 | 0.0004 | 0.0608 | 0.0035 | 0.0000 | 0.0000 | 0.0000 | 0.0143 | 0.0006 | 0.9204 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9977 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0005 | 0.0018 | 0.0000 | 0.4875 | 0.3525 | 0.0655 | 0.0945 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0391 | 0.9563 | 0.0000 | 0.0045 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9087 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0913 |
| CW | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0011 | 0.0000 | 0.9058 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0931 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6667 | 0.3333 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2084 | 0.0000 | 0.0000 | 0.7916 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1638 | 0.2296 | 0.6066 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0845 | 0.3089 | 0.6066 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0407 | 0.0000 | 0.7350 | 0.2243 | 0.0000 |
| OF | 0.0076 | 0.0000 | 0.0000 | 0.0000 | 0.2570 | 0.2011 | 0.0422 | 0.2566 | 0.2355 | 0.0000 | 0.0000 | 0.0016 | 0.0000 | 0.0124 | 0.0000 | 0.0357 | 0.4965 | 0.4538 |
| NAS | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0084 | 0.0000 | 0.0397 | 0.1283 | 0.8237 | 0.0084 | 0.0088 | 0.0016 | 0.0397 | 0.0144 | 0.0000 | 0.0069 | 0.2715 | 0.6486 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8733 | 0.0000 | 0.0029 | 0.0471 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0766 |
| BU | 0.0000 | 0.9875 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0125 | 0.0077 | 0.9800 | 0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0120 |
| NA | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0042 | 0.0000 | 0.9619 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0338 |
| CW | 0.0000 | 0.0020 | 0.0000 | 0.9624 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0354 | 0.0017 | 0.0059 | 0.0007 | 0.9913 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0091 | 0.9909 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9316 | 0.0684 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0009 | 0.0000 | 0.0444 | 0.0000 | 0.0443 | 0.8923 | 0.0000 | 0.0181 | 0.0018 | 0.0162 | 0.0000 | 0.0040 | 0.0000 | 0.0000 | 0.9561 | 0.0218 | 0.0000 |
| OF | 0.0000 | 0.0099 | 0.0000 | 0.0172 | 0.0000 | 0.0000 | 0.0000 | 0.9527 | 0.0202 | 0.0027 | 0.0026 | 0.0009 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9938 | 0.0000 |
| NAS | 0.0000 | 0.0056 | 0.0000 | 0.0000 | 0.0000 | 0.0048 | 0.0000 | 0.0115 | 0.9780 | 0.0006 | 0.0115 | 0.0019 | 0.0000 | 0.0001 | 0.0000 | 0.0050 | 0.0016 | 0.9794 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.37 Transitional probability matrix for land use categories Pune and Solapur districts

| Particulars | Pune | | | | | | | | | Solapur | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.6330 | 0.0722 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2947 | 0.9564 | 0.0000 | 0.0000 | 0.0000 | 0.0436 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.9165 | 0.0140 | 0.0000 | 0.0000 | 0.0000 | 0.0457 | 0.0237 | 0.0000 | 0.0000 | 0.7308 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2692 |
| NA | 0.0000 | 0.0000 | 0.8129 | 0.0670 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1201 | 0.0000 | 0.0000 | 0.8321 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1679 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0464 | 0.8806 | 0.0730 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0060 | 0.0000 | 0.0000 | 0.6190 | 0.0783 | 0.0000 | 0.2967 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0453 | 0.0023 | 0.9523 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.5482 | 0.0000 | 0.0000 | 0.0000 | 0.4488 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.1147 | 0.0000 | 0.8853 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0312 | 0.0000 | 0.0000 | 0.3719 | 0.0000 | 0.5969 | 0.0000 |
| CF | 0.1080 | 0.0029 | 0.0000 | 0.0213 | 0.0000 | 0.0000 | 0.5987 | 0.0000 | 0.2691 | 0.0000 | 0.0172 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9828 |
| OF | 0.0246 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 | 0.9139 | 0.0611 | 0.0038 | 0.0000 | 0.0069 | 0.0048 | 0.1014 | 0.0365 | 0.1078 | 0.7387 | 0.0000 |
| NAS | 0.0649 | 0.0000 | 0.0000 | 0.0007 | 0.0006 | 0.0000 | 0.0000 | 0.0000 | 0.9338 | 0.0007 | 0.0151 | 0.0000 | 0.0124 | 0.0156 | 0.0000 | 0.0437 | 0.0162 | 0.8964 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9060 | 0.0109 | 0.0000 | 0.0379 | 0.0453 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3465 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6535 |
| BU | 0.0000 | 0.9823 | 0.0088 | 0.0089 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0151 | 0.5319 | 0.0000 | 0.4471 | 0.0059 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0043 | 0.0075 | 0.9548 | 0.0045 | 0.0000 | 0.0054 | 0.0235 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0521 | 0.7917 | 0.1236 | 0.0000 | 0.0327 | 0.0000 | 0.0000 | 0.0872 | 0.1462 | 0.0000 | 0.1096 | 0.0000 | 0.0474 | 0.6096 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8313 | 0.0000 | 0.0000 | 0.1687 | 0.0000 | 0.0070 | 0.0000 | 0.0000 | 0.0000 | 0.9244 | 0.0000 | 0.0000 | 0.0600 | 0.0087 |
| MT | 0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9577 | 0.0000 | 0.0393 | 0.0000 | 0.0122 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6387 | 0.0000 | 0.0000 | 0.3491 |
| CF | 0.0000 | 0.0000 | 0.1116 | 0.0000 | 0.0053 | 0.0000 | 0.8830 | 0.0000 | 0.0000 | 0.0140 | 0.0072 | 0.0000 | 0.0394 | 0.0000 | 0.0029 | 0.8032 | 0.0000 | 0.1332 |
| OF | 0.0720 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5615 | 0.3665 | 0.0279 | 0.0287 | 0.0000 | 0.0194 | 0.0262 | 0.0000 | 0.0000 | 0.8105 | 0.0872 |
| NAS | 0.0134 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9866 | 0.0125 | 0.0188 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0200 | 0.9487 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9667 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0333 | 0.9588 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0142 | 0.0000 | 0.0270 | 0.0000 |
| BU | 0.0000 | 0.9710 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0131 | 0.0159 | 0.0000 | 0.0000 | 0.6372 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3628 |
| NA | 0.0000 | 0.0000 | 0.9996 | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9781 | 0.0136 | 0.0000 | 0.0000 | 0.0083 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0079 | 0.9499 | 0.0423 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0037 | 0.0000 | 0.0000 | 0.8727 | 0.0000 | 0.0021 | 0.1215 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9695 | 0.0000 | 0.0000 | 0.0000 | 0.0305 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9603 | 0.0000 | 0.0000 | 0.0000 | 0.0397 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0184 | 0.0000 | 0.0000 | 0.8287 | 0.0000 | 0.1529 | 0.0000 |
| CF | 0.0000 | 0.0094 | 0.0109 | 0.0000 | 0.0005 | 0.0000 | 0.8991 | 0.0000 | 0.0801 | 0.0010 | 0.0237 | 0.0016 | 0.0000 | 0.0000 | 0.0023 | 0.8047 | 0.0000 | 0.1667 |
| OF | 0.0073 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0096 | 0.9333 | 0.0498 | 0.0014 | 0.0000 | 0.0000 | 0.0017 | 0.0000 | 0.0013 | 0.0723 | 0.9234 | 0.0000 |
| NAS | 0.0056 | 0.0045 | 0.0000 | 0.0020 | 0.0006 | 0.0000 | 0.0000 | 0.0000 | 0.9873 | 0.0010 | 0.0197 | 0.0000 | 0.0046 | 0.0022 | 0.0000 | 0.0064 | 0.0066 | 0.9595 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.38. Transitional probability matrix for land use categories in Satara and Sangli districts

| Particulars | Satara | | | | | | | | | Sangli | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9689 | 0.0311 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9644 | 0.0000 | 0.0000 | 0.0000 | 0.0356 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0122 | 0.9319 | 0.0000 | 0.0015 | 0.0018 | 0.0000 | 0.0000 | 0.0000 | 0.0526 | 0.0167 | 0.2830 | 0.0000 | 0.0716 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6287 |
| NA | 0.0017 | 0.0165 | 0.9818 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9754 | 0.0000 | 0.0000 | 0.0000 | 0.0246 | 0.0000 | 0.0000 |
| CW | 0.0098 | 0.0000 | 0.0000 | 0.9398 | 0.0497 | 0.0000 | 0.0000 | 0.0007 | 0.0000 | 0.0000 | 0.1414 | 0.0000 | 0.0907 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7679 |
| PP | 0.0000 | 0.0052 | 0.0074 | 0.0235 | 0.9639 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0151 | 0.0108 | 0.0000 | 0.7759 | 0.0277 | 0.0626 | 0.0000 | 0.1079 |
| MT | 0.0000 | 0.0159 | 0.0000 | 0.0000 | 0.0000 | 0.9841 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0410 | 0.0000 | 0.0000 | 0.8312 | 0.1278 | 0.0000 | 0.0000 |
| CF | 0.0024 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0003 | 0.9101 | 0.0000 | 0.0873 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0032 | 0.0000 | 0.9117 | 0.0000 | 0.0851 |
| OF | 0.0000 | 0.0109 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8876 | 0.1015 | 0.0000 | 0.0940 | 0.0000 | 0.0047 | 0.0119 | 0.0053 | 0.0000 | 0.6504 | 0.2337 |
| NAS | 0.0047 | 0.0033 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0046 | 0.0085 | 0.9788 | 0.0017 | 0.0367 | 0.0000 | 0.0088 | 0.0023 | 0.0023 | 0.0000 | 0.0381 | 0.9102 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9904 | 0.0000 | 0.0000 | 0.0064 | 0.0000 | 0.0033 | 0.0000 | 0.0000 | 0.0000 | 0.8936 | 0.0515 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0548 | 0.0000 | 0.0000 |
| BU | 0.0046 | 0.9421 | 0.0147 | 0.0000 | 0.0295 | 0.0000 | 0.0090 | 0.0000 | 0.0000 | 0.0785 | 0.9215 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.8539 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1461 | 0.0000 | 0.0000 | 0.0000 | 0.9702 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0298 | 0.0000 |
| CW | 0.0020 | 0.0074 | 0.0000 | 0.6134 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3771 | 0.0000 | 0.0000 | 0.0000 | 0.8232 | 0.0000 | 0.0000 | 0.0000 | 0.1768 | 0.0000 |
| PP | 0.0022 | 0.0838 | 0.0004 | 0.0000 | 0.8903 | 0.0207 | 0.0000 | 0.0000 | 0.0027 | 0.0024 | 0.0000 | 0.0000 | 0.0000 | 0.9976 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0086 | 0.0000 | 0.3155 | 0.0000 | 0.0000 | 0.6759 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0053 | 0.0000 | 0.0000 | 0.8977 | 0.0000 | 0.0970 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0063 | 0.0000 | 0.0220 | 0.0000 | 0.9591 | 0.0126 | 0.0000 | 0.0035 | 0.0055 | 0.0025 | 0.0028 | 0.0007 | 0.0000 | 0.9217 | 0.0000 | 0.0633 |
| OF | 0.0004 | 0.0000 | 0.0025 | 0.0747 | 0.0000 | 0.0000 | 0.0000 | 0.9225 | 0.0000 | 0.0000 | 0.0000 | 0.0032 | 0.0000 | 0.0000 | 0.0285 | 0.0000 | 0.7405 | 0.2278 |
| NAS | 0.0009 | 0.0003 | 0.0000 | 0.0180 | 0.0077 | 0.0005 | 0.0000 | 0.0000 | 0.9727 | 0.0026 | 0.0007 | 0.0019 | 0.0041 | 0.0000 | 0.0000 | 0.0000 | 0.0148 | 0.9758 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9677 | 0.0000 | 0.0040 | 0.0000 | 0.0067 | 0.0000 | 0.0216 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.9735 | 0.0018 | 0.0000 | 0.0008 | 0.0000 | 0.0000 | 0.0233 | 0.0007 | 0.0306 | 0.8795 | 0.0000 | 0.0000 | 0.0174 | 0.0000 | 0.0000 | 0.0000 | 0.0726 |
| NA | 0.0000 | 0.0218 | 0.9740 | 0.0042 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9955 | 0.0011 | 0.0000 | 0.0033 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0021 | 0.0000 | 0.9762 | 0.0217 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8505 | 0.0000 | 0.0010 | 0.0000 | 0.0000 | 0.1485 |
| PP | 0.0000 | 0.0000 | 0.0071 | 0.0087 | 0.9842 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0687 | 0.0000 | 0.0000 | 0.9313 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0032 | 0.0000 | 0.0000 | 0.8673 | 0.1295 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0019 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9565 | 0.0000 | 0.0416 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.9113 | 0.0000 | 0.0886 |
| OF | 0.0000 | 0.0050 | 0.0000 | 0.0016 | 0.0000 | 0.0000 | 0.0000 | 0.9448 | 0.0486 | 0.0000 | 0.0228 | 0.0000 | 0.0000 | 0.0025 | 0.0040 | 0.0000 | 0.8254 | 0.1452 |
| NAS | 0.0000 | 0.0038 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0020 | 0.0011 | 0.9931 | 0.0005 | 0.0037 | 0.0000 | 0.0034 | 0.0000 | 0.0023 | 0.0000 | 0.0173 | 0.9728 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.39. Transitional probability matrix for land use categories in Kolhapur and Ahmednagar districts

| Particulars | Kolhapur | | | | | | | | | Ahmednagar | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9818 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0126 | 0.0000 | 0.0000 | 0.0055 | 0.9125 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0875 |
| BU | 0.0373 | 0.0724 | 0.0000 | 0.0000 | 0.0585 | 0.0011 | 0.0000 | 0.0000 | 0.8307 | 0.0000 | 0.7146 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2854 |
| NA | 0.0113 | 0.0000 | 0.9779 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0109 | 0.0000 | 0.0000 | 0.6501 | 0.0000 | 0.0517 | 0.0000 | 0.2982 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0202 | 0.0000 | 0.9478 | 0.0000 | 0.0009 | 0.0000 | 0.0310 | 0.0000 | 0.0000 | 0.0000 | 0.0046 | 0.0010 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9945 |
| PP | 0.0000 | 0.1913 | 0.0000 | 0.0000 | 0.8080 | 0.0006 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3037 | 0.6963 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.6707 | 0.0000 | 0.0000 | 0.0418 | 0.2875 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 |
| CF | 0.0047 | 0.0000 | 0.0211 | 0.0000 | 0.0000 | 0.0000 | 0.7474 | 0.1499 | 0.0769 | 0.0039 | 0.0000 | 0.0563 | 0.0086 | 0.0434 | 0.0000 | 0.8878 | 0.0000 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1333 | 0.4134 | 0.4533 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0208 | 0.9792 | 0.0000 |
| NAS | 0.0014 | 0.0635 | 0.0006 | 0.0096 | 0.0134 | 0.0062 | 0.0055 | 0.0306 | 0.8692 | 0.0130 | 0.0357 | 0.0000 | 0.0000 | 0.0075 | 0.0000 | 0.0019 | 0.0022 | 0.9397 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.6429 | 0.1956 | 0.0000 | 0.0000 | 0.0282 | 0.0000 | 0.0000 | 0.0000 | 0.1333 | 0.4019 | 0.1999 | 0.0052 | 0.0086 | 0.0331 | 0.0000 | 0.0000 | 0.0000 | 0.3513 |
| BU | 0.3947 | 0.2802 | 0.0000 | 0.1455 | 0.1152 | 0.0000 | 0.0038 | 0.0606 | 0.0000 | 0.0000 | 0.5644 | 0.0000 | 0.0000 | 0.0021 | 0.0000 | 0.0000 | 0.0000 | 0.4335 |
| NA | 0.0000 | 0.0000 | 0.8808 | 0.0866 | 0.0244 | 0.0000 | 0.0000 | 0.0000 | 0.0082 | 0.0000 | 0.0000 | 0.1598 | 0.0228 | 0.0000 | 0.0797 | 0.7376 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0168 | 0.0588 | 0.6796 | 0.0856 | 0.0000 | 0.0000 | 0.0000 | 0.1591 | 0.0000 | 0.0000 | 0.4503 | 0.2754 | 0.0000 | 0.0376 | 0.1368 | 0.0999 | 0.0000 |
| PP | 0.0000 | 0.0349 | 0.0147 | 0.0000 | 0.1031 | 0.0000 | 0.0000 | 0.0000 | 0.8472 | 0.1474 | 0.2585 | 0.0000 | 0.0101 | 0.1522 | 0.0013 | 0.0000 | 0.1750 | 0.2556 |
| MT | 0.0161 | 0.0000 | 0.2125 | 0.0000 | 0.0000 | 0.7700 | 0.0000 | 0.0000 | 0.0014 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 |
| CF | 0.0917 | 0.0246 | 0.0000 | 0.1403 | 0.0000 | 0.0000 | 0.6372 | 0.1063 | 0.0000 | 0.0855 | 0.0000 | 0.0162 | 0.0202 | 0.0000 | 0.0025 | 0.8756 | 0.0000 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1823 | 0.8177 | 0.0000 | 0.0253 | 0.0000 | 0.0090 | 0.0078 | 0.0000 | 0.0000 | 0.0000 | 0.8983 | 0.0596 |
| NAS | 0.0795 | 0.0000 | 0.0000 | 0.0000 | 0.0586 | 0.0047 | 0.0000 | 0.0000 | 0.8572 | 0.0712 | 0.0117 | 0.0000 | 0.0081 | 0.0258 | 0.0012 | 0.0000 | 0.0000 | 0.8820 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9764 | 0.0236 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9275 | 0.0037 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0689 |
| BU | 0.0365 | 0.7061 | 0.0000 | 0.0000 | 0.0583 | 0.0000 | 0.0000 | 0.0000 | 0.1991 | 0.0053 | 0.8979 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0968 |
| NA | 0.0000 | 0.0000 | 0.9911 | 0.0000 | 0.0000 | 0.0024 | 0.0000 | 0.0000 | 0.0065 | 0.0000 | 0.0000 | 0.9415 | 0.0047 | 0.0000 | 0.0000 | 0.0538 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.9814 | 0.0000 | 0.0000 | 0.0000 | 0.0186 | 0.0000 | 0.0000 | 0.0000 | 0.0209 | 0.9138 | 0.0283 | 0.0000 | 0.0000 | 0.0000 | 0.0370 |
| PP | 0.0000 | 0.1611 | 0.0000 | 0.0000 | 0.8389 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0225 | 0.8979 | 0.0000 | 0.0000 | 0.0000 | 0.0797 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9751 | 0.0000 | 0.0000 | 0.0249 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0052 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9166 | 0.0782 | 0.0000 | 0.0000 | 0.0000 | 0.0047 | 0.0035 | 0.0028 | 0.0000 | 0.9663 | 0.0000 | 0.0227 |
| OF | 0.0000 | 0.0220 | 0.0045 | 0.0283 | 0.0239 | 0.0000 | 0.0497 | 0.8716 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0035 | 0.0000 | 0.0000 | 0.0442 | 0.9523 | 0.0000 |
| NAS | 0.0043 | 0.0043 | 0.0006 | 0.0000 | 0.0088 | 0.0003 | 0.0000 | 0.0026 | 0.9792 | 0.0101 | 0.0114 | 0.0000 | 0.0000 | 0.0029 | 0.0000 | 0.0007 | 0.0036 | 0.9714 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.40. Transitional probability matrix for land use categories in Nashik and Jalgaon districts

| Particulars | Nashik | | | | | | | | | Jalgaon | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.8934 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1066 | 0.8698 | 0.0000 | 0.0000 | 0.0000 | 0.0013 | 0.0004 | 0.0000 | 0.0000 | 0.1284 |
| BU | 0.1335 | 0.3574 | 0.0010 | 0.0000 | 0.0249 | 0.0014 | 0.0000 | 0.1052 | 0.3767 | 0.0627 | 0.0920 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1070 | 0.7383 |
| NA | 0.0000 | 0.0393 | 0.9607 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0328 | 0.0000 | 0.0000 | 0.6252 | 0.1380 | 0.0046 | 0.0000 | 0.0000 | 0.1993 | 0.1396 | 0.0390 | 0.0000 | 0.6647 | 0.0000 | 0.0091 | 0.0000 | 0.0000 | 0.1476 |
| PP | 0.0856 | 0.0000 | 0.0000 | 0.0000 | 0.7008 | 0.0000 | 0.0000 | 0.0684 | 0.1452 | 0.0641 | 0.0000 | 0.0000 | 0.0280 | 0.9024 | 0.0055 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.5583 | 0.0000 | 0.0000 | 0.0000 | 0.4417 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7933 | 0.0000 | 0.2067 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0119 | 0.1168 | 0.0006 | 0.0000 | 0.0001 | 0.0005 | 0.8149 | 0.0417 | 0.0136 | 0.0000 | 0.0350 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4595 | 0.0003 | 0.5051 |
| OF | 0.0000 | 0.1339 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2459 | 0.3685 | 0.2517 | 0.0236 | 0.2122 | 0.0005 | 0.0000 | 0.0092 | 0.0000 | 0.1212 | 0.1091 | 0.5243 |
| NAS | 0.0094 | 0.1146 | 0.0000 | 0.0081 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8679 | 0.0140 | 0.0869 | 0.0001 | 0.0000 | 0.0069 | 0.0000 | 0.0079 | 0.0000 | 0.8840 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9769 | 0.0097 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0054 | 0.0080 | 0.0000 | 0.9713 | 0.0271 | 0.0000 | 0.0000 | 0.0000 | 0.0016 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.9359 | 0.0000 | 0.0000 | 0.0200 | 0.0000 | 0.0000 | 0.0000 | 0.0442 | 0.0323 | 0.5903 | 0.0000 | 0.0000 | 0.0091 | 0.0032 | 0.0000 | 0.0158 | 0.3494 |
| NA | 0.0000 | 0.0000 | 0.9613 | 0.0053 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0333 | 0.0000 | 0.0000 | 0.7998 | 0.0000 | 0.0029 | 0.0026 | 0.1934 | 0.0013 | 0.0000 |
| CW | 0.0499 | 0.0000 | 0.0000 | 0.3610 | 0.0000 | 0.0073 | 0.0000 | 0.0000 | 0.5818 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0283 | 0.0000 | 0.0000 | 0.7647 | 0.0000 | 0.0000 | 0.0000 | 0.2069 | 0.0000 | 0.0235 | 0.0070 | 0.0000 | 0.9591 | 0.0029 | 0.0000 | 0.0076 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0270 | 0.0000 | 0.0000 | 0.9730 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0578 | 0.0000 | 0.0000 | 0.9422 |
| CF | 0.0000 | 0.0000 | 0.0195 | 0.0050 | 0.0000 | 0.0014 | 0.9198 | 0.0087 | 0.0457 | 0.0009 | 0.0306 | 0.1684 | 0.0000 | 0.0023 | 0.0018 | 0.6722 | 0.0000 | 0.1238 |
| OF | 0.0227 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0017 | 0.0000 | 0.8901 | 0.0855 | 0.0000 | 0.3224 | 0.0000 | 0.0000 | 0.0000 | 0.0021 | 0.0000 | 0.6755 | 0.0000 |
| NAS | 0.0062 | 0.0082 | 0.0001 | 0.0139 | 0.0022 | 0.0017 | 0.0062 | 0.0000 | 0.9613 | 0.0022 | 0.0306 | 0.0016 | 0.0000 | 0.0009 | 0.0023 | 0.0000 | 0.0000 | 0.9624 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9804 | 0.0196 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9567 | 0.0333 | 0.0000 | 0.0051 | 0.0049 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.8293 | 0.0000 | 0.0000 | 0.0206 | 0.0000 | 0.0000 | 0.0533 | 0.0968 | 0.0784 | 0.7326 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0541 | 0.0064 | 0.1286 |
| NA | 0.0000 | 0.0000 | 0.9948 | 0.0052 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9907 | 0.0000 | 0.0000 | 0.0093 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.6212 | 0.1036 | 0.0000 | 0.0000 | 0.0000 | 0.2752 | 0.0000 | 0.0000 | 0.0000 | 0.8736 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1264 |
| PP | 0.0138 | 0.0000 | 0.0000 | 0.0000 | 0.7549 | 0.0000 | 0.0000 | 0.1309 | 0.1005 | 0.0088 | 0.0021 | 0.0000 | 0.0000 | 0.9736 | 0.0000 | 0.0000 | 0.0155 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9392 | 0.0000 | 0.0000 | 0.0608 |
| CF | 0.0000 | 0.0000 | 0.0003 | 0.0000 | 0.0000 | 0.0000 | 0.9414 | 0.0000 | 0.0583 | 0.0000 | 0.0000 | 0.0074 | 0.0000 | 0.0000 | 0.0000 | 0.4900 | 0.0000 | 0.5026 |
| OF | 0.0000 | 0.0762 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1661 | 0.5882 | 0.1695 | 0.0215 | 0.0504 | 0.0015 | 0.0000 | 0.0553 | 0.0000 | 0.0990 | 0.7724 | 0.0000 |
| NAS | 0.0067 | 0.0236 | 0.0002 | 0.0083 | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.9609 | 0.0000 | 0.0188 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9811 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.41. Transitional probability matrix for land use categories in Dhule and Aurangabad districts

| Particulars | Dhule | | | | | | | | | Aurangabad | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9800 | 0.0069 | 0.0011 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0071 | 0.0049 | 0.9336 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0664 |
| BU | 0.0000 | 0.8441 | 0.0000 | 0.0000 | 0.0779 | 0.0000 | 0.0000 | 0.0000 | 0.0780 | 0.0000 | 0.9443 | 0.0000 | 0.0000 | 0.0000 | 0.0557 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.9417 | 0.0000 | 0.0000 | 0.0007 | 0.0000 | 0.0000 | 0.0576 | 0.0000 | 0.0000 | 0.9655 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0345 | 0.0000 |
| CW | 0.0000 | 0.0364 | 0.0000 | 0.9636 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9257 | 0.0000 | 0.0000 | 0.0000 | 0.0743 | 0.0000 |
| PP | 0.0230 | 0.0578 | 0.0000 | 0.0000 | 0.8449 | 0.0000 | 0.0000 | 0.0743 | 0.0000 | 0.0133 | 0.0000 | 0.0000 | 0.0000 | 0.9423 | 0.0000 | 0.0000 | 0.0000 | 0.0444 |
| MT | 0.0000 | 0.0000 | 0.2705 | 0.0000 | 0.0000 | 0.7295 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0429 | 0.0810 | 0.0000 | 0.8761 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0210 | 0.0000 | 0.0163 | 0.0000 | 0.0253 | 0.0046 | 0.4998 | 0.0104 | 0.4226 | 0.0041 | 0.0019 | 0.0000 | 0.0004 | 0.0002 | 0.0006 | 0.6012 | 0.0000 | 0.3916 |
| OF | 0.0446 | 0.0432 | 0.0072 | 0.0084 | 0.1714 | 0.0000 | 0.1775 | 0.4668 | 0.0809 | 0.0000 | 0.0000 | 0.0294 | 0.0000 | 0.0059 | 0.0011 | 0.1002 | 0.4377 | 0.4257 |
| NAS | 0.0130 | 0.0019 | 0.0000 | 0.0001 | 0.0008 | 0.0003 | 0.0000 | 0.0000 | 0.9840 | 0.0033 | 0.0010 | 0.0006 | 0.0004 | 0.0032 | 0.0000 | 0.0128 | 0.0064 | 0.9722 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.8068 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0016 | 0.0000 | 0.0000 | 0.1916 | 0.9266 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0048 | 0.0000 | 0.0686 |
| BU | 0.0000 | 0.8576 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1424 | 0.0000 | 0.6279 | 0.1048 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2673 |
| NA | 0.0232 | 0.0000 | 0.9587 | 0.0000 | 0.0000 | 0.0006 | 0.0175 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8832 | 0.0000 | 0.0000 | 0.0308 | 0.0000 | 0.0628 | 0.0232 |
| CW | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0015 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1846 | 0.8138 |
| PP | 0.0000 | 0.0000 | 0.0069 | 0.0000 | 0.9318 | 0.0003 | 0.0042 | 0.0568 | 0.0000 | 0.0000 | 0.0165 | 0.0032 | 0.0000 | 0.9802 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.4219 | 0.0000 | 0.2597 | 0.0000 | 0.0000 | 0.0017 | 0.0000 | 0.3166 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1017 | 0.0000 | 0.6626 | 0.0000 | 0.2357 | 0.0000 |
| CF | 0.0269 | 0.0000 | 0.0177 | 0.0000 | 0.0025 | 0.0020 | 0.9509 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0389 | 0.0000 | 0.0074 | 0.8617 | 0.0538 | 0.0383 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0006 | 0.0000 | 0.7887 | 0.2106 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2754 | 0.7246 | 0.0000 |
| NAS | 0.1428 | 0.0107 | 0.0001 | 0.0000 | 0.0046 | 0.0013 | 0.0000 | 0.0000 | 0.8406 | 0.0043 | 0.0060 | 0.0059 | 0.0208 | 0.0010 | 0.0000 | 0.0000 | 0.0000 | 0.9621 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9773 | 0.0069 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0071 | 0.0086 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0250 | 0.8579 | 0.0000 | 0.0000 | 0.0601 | 0.0000 | 0.0000 | 0.0000 | 0.0570 | 0.0000 | 0.9633 | 0.0000 | 0.0000 | 0.0000 | 0.0367 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.9814 | 0.0000 | 0.0000 | 0.0000 | 0.0186 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9885 | 0.0083 | 0.0000 | 0.0000 | 0.0000 | 0.0031 | 0.0000 |
| CW | 0.0000 | 0.0299 | 0.0000 | 0.9651 | 0.0050 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0053 | 0.9336 | 0.0000 | 0.0000 | 0.0000 | 0.0611 | 0.0000 |
| PP | 0.0558 | 0.0682 | 0.0000 | 0.0000 | 0.8569 | 0.0000 | 0.0000 | 0.0191 | 0.0000 | 0.0000 | 0.0082 | 0.0000 | 0.0000 | 0.9918 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0459 | 0.0000 | 0.9067 | 0.0000 | 0.0474 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0179 | 0.0000 | 0.0244 | 0.0000 | 0.8442 | 0.0455 | 0.0679 | 0.0000 | 0.0007 | 0.0000 | 0.0060 | 0.0000 | 0.0005 | 0.9661 | 0.0000 | 0.0267 |
| OF | 0.0485 | 0.0284 | 0.0000 | 0.0038 | 0.1770 | 0.0000 | 0.0581 | 0.6252 | 0.0590 | 0.0000 | 0.0000 | 0.0030 | 0.0000 | 0.0000 | 0.0002 | 0.0250 | 0.9718 | 0.0000 |
| NAS | 0.0104 | 0.0000 | 0.0005 | 0.0001 | 0.0012 | 0.0000 | 0.0000 | 0.0010 | 0.9868 | 0.0000 | 0.0002 | 0.0005 | 0.0001 | 0.0004 | 0.0001 | 0.0035 | 0.0000 | 0.9953 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.42. Transitional probability matrix for land use categories in Nanded and Osmanabad districts

| Particulars | Nanded | | | | | | | | | Osmanabad | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.7642 | 0.0000 | 0.0000 | 0.0000 | 0.2358 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3926 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6074 | 0.0000 |
| BU | 0.0000 | 0.9196 | 0.0804 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0125 | 0.0125 | 0.2791 | 0.0000 | 0.0000 | 0.1389 | 0.0000 | 0.5570 | 0.0000 |
| NA | 0.1993 | 0.0000 | 0.2043 | 0.0947 | 0.4366 | 0.0123 | 0.0529 | 0.0000 | 0.0000 | 0.0155 | 0.0000 | 0.2826 | 0.0203 | 0.0000 | 0.1387 | 0.0000 | 0.3108 | 0.2322 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.8512 | 0.0000 | 0.0000 | 0.0000 | 0.1488 | 0.0000 | 0.0000 | 0.0000 | 0.0017 | 0.9777 | 0.0204 | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4655 | 0.0000 | 0.0000 | 0.0000 | 0.5345 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0265 | 0.0000 | 0.0000 | 0.0000 | 0.9735 |
| MT | 0.0000 | 0.0388 | 0.0000 | 0.0000 | 0.0000 | 0.9213 | 0.0399 | 0.0000 | 0.0000 | 0.0182 | 0.0489 | 0.1834 | 0.0000 | 0.0000 | 0.1379 | 0.0000 | 0.5558 | 0.0558 |
| CF | 0.0099 | 0.0000 | 0.0158 | 0.0000 | 0.0028 | 0.0002 | 0.7910 | 0.0698 | 0.1106 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0269 | 0.0000 | 0.8908 | 0.0000 | 0.0823 |
| OF | 0.0596 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0018 | 0.6229 | 0.3156 | 0.0000 | 0.0007 | 0.0685 | 0.0635 | 0.0233 | 0.0318 | 0.0052 | 0.2486 | 0.5396 | 0.0187 |
| NAS | 0.0139 | 0.0016 | 0.0374 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0010 | 0.9461 | 0.0000 | 0.0104 | 0.0079 | 0.0000 | 0.0292 | 0.0007 | 0.0000 | 0.0017 | 0.9501 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.7603 | 0.0000 | 0.0000 | 0.0857 | 0.0000 | 0.0008 | 0.1532 | 0.0000 | 0.0000 | 0.9566 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0434 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.7298 | 0.0174 | 0.1043 | 0.1485 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0032 | 0.4926 | 0.0031 | 0.0000 | 0.0000 | 0.0000 | 0.5011 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0019 | 0.9776 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0205 | 0.0005 | 0.0332 | 0.8948 | 0.0000 | 0.0403 | 0.0298 | 0.0000 | 0.0014 | 0.0000 |
| CW | 0.0000 | 0.1256 | 0.0000 | 0.4044 | 0.0000 | 0.0075 | 0.0000 | 0.0000 | 0.4625 | 0.0001 | 0.0000 | 0.0000 | 0.2333 | 0.0408 | 0.0000 | 0.0000 | 0.0000 | 0.7258 |
| PP | 0.0076 | 0.0095 | 0.0000 | 0.0206 | 0.8858 | 0.0002 | 0.0000 | 0.0000 | 0.0763 | 0.0000 | 0.0000 | 0.0000 | 0.2639 | 0.0279 | 0.0000 | 0.0000 | 0.7082 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1642 | 0.8358 | 0.0000 | 0.0000 | 0.0000 | 0.0010 | 0.0000 | 0.2203 | 0.0000 | 0.1927 | 0.5861 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0377 | 0.0000 | 0.0000 | 0.0933 | 0.0000 | 0.0015 | 0.7994 | 0.0174 | 0.0507 | 0.0004 | 0.0094 | 0.0009 | 0.0224 | 0.0210 | 0.0520 | 0.8094 | 0.0844 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0597 | 0.9403 | 0.0000 | 0.0000 | 0.0074 | 0.0000 | 0.2521 | 0.0221 | 0.0000 | 0.0497 | 0.6687 | 0.0000 |
| NAS | 0.0246 | 0.0002 | 0.0008 | 0.0061 | 0.0029 | 0.0008 | 0.0000 | 0.0000 | 0.9646 | 0.0001 | 0.0094 | 0.0000 | 0.0158 | 0.0236 | 0.0000 | 0.0081 | 0.0000 | 0.9430 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9221 | 0.0000 | 0.0000 | 0.0243 | 0.0000 | 0.0000 | 0.0536 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.9864 | 0.0000 | 0.0000 | 0.0133 | 0.0000 | 0.0000 | 0.0003 | 0.0000 | 0.0000 | 0.4346 | 0.0571 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5083 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.9823 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0177 | 0.0000 | 0.0102 | 0.9635 | 0.0098 | 0.0166 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0095 | 0.0000 | 0.0000 | 0.9262 | 0.0000 | 0.0000 | 0.0000 | 0.0643 | 0.0000 | 0.0000 | 0.0061 | 0.0013 | 0.9794 | 0.0051 | 0.0067 | 0.0000 | 0.0014 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9290 | 0.0000 | 0.0000 | 0.0000 | 0.0710 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7801 | 0.0000 | 0.2155 | 0.0044 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1142 | 0.0067 | 0.0000 | 0.0000 | 0.8791 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0037 | 0.0000 | 0.0006 | 0.0000 | 0.0000 | 0.0000 | 0.8891 | 0.0199 | 0.0868 | 0.0000 | 0.0009 | 0.0005 | 0.0010 | 0.0079 | 0.0000 | 0.8999 | 0.0000 | 0.0899 |
| OF | 0.0369 | 0.0000 | 0.0000 | 0.0237 | 0.0000 | 0.0000 | 0.1500 | 0.7894 | 0.0000 | 0.0000 | 0.0580 | 0.0000 | 0.0000 | 0.0000 | 0.0175 | 0.0307 | 0.8938 | 0.0000 |
| NAS | 0.0074 | 0.0004 | 0.0009 | 0.0000 | 0.0058 | 0.0000 | 0.0000 | 0.0000 | 0.9856 | 0.0000 | 0.0040 | 0.0000 | 0.0012 | 0.0064 | 0.0000 | 0.0014 | 0.0000 | 0.9870 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.43. Transitional probability matrix for land use categories in Parbhani and Beed districts

| Particulars | Parbhani | | | | | | | | | Beed | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9955 | 0.0000 | 0.0000 | 0.0045 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8876 | 0.0011 | 0.0419 | 0.0476 | 0.0197 | 0.0021 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0000 | 0.9401 | 0.0000 | 0.0000 | 0.0000 | 0.0064 | 0.0000 | 0.0535 | 0.0000 | 0.0000 | 0.8179 | 0.0157 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1664 |
| NA | 0.0024 | 0.0000 | 0.9402 | 0.0000 | 0.0243 | 0.0000 | 0.0000 | 0.0000 | 0.0332 | 0.0000 | 0.0000 | 0.9270 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0730 |
| CW | 0.0003 | 0.0000 | 0.0093 | 0.9904 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0024 | 0.0000 | 0.9500 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0477 |
| PP | 0.0000 | 0.0000 | 0.0366 | 0.0000 | 0.8284 | 0.0000 | 0.0000 | 0.0000 | 0.1350 | 0.0000 | 0.0000 | 0.0067 | 0.0000 | 0.5031 | 0.0000 | 0.0000 | 0.0000 | 0.4902 |
| MT | 0.0000 | 0.0195 | 0.0000 | 0.0000 | 0.0000 | 0.9732 | 0.0000 | 0.0072 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0082 | 0.0000 | 0.9164 | 0.0231 | 0.0523 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0229 | 0.0016 | 0.7801 | 0.1323 | 0.0631 |
| OF | 0.0000 | 0.0008 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0928 | 0.9064 | 0.0000 | 0.0137 | 0.0098 | 0.0004 | 0.0000 | 0.0000 | 0.0013 | 0.0536 | 0.0138 | 0.9074 |
| NAS | 0.0001 | 0.0009 | 0.0008 | 0.0000 | 0.0056 | 0.0000 | 0.0000 | 0.0005 | 0.9921 | 0.0023 | 0.0011 | 0.0012 | 0.0005 | 0.0211 | 0.0015 | 0.0261 | 0.0428 | 0.9034 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9991 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0009 | 0.0000 | 0.0000 | 0.0000 | 0.1805 | 0.2152 | 0.0000 | 0.0000 | 0.0934 | 0.0000 | 0.0000 | 0.0000 | 0.5109 |
| BU | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4561 | 0.5439 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.8987 | 0.0000 | 0.0000 | 0.0000 | 0.1013 | 0.0000 | 0.0000 | 0.0577 | 0.0598 | 0.0000 | 0.5265 | 0.0004 | 0.0033 | 0.0831 | 0.0000 | 0.2692 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.7779 | 0.0336 | 0.0012 | 0.0000 | 0.0000 | 0.1872 | 0.0000 | 0.0000 | 0.0000 | 0.0749 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9251 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6486 | 0.0000 | 0.0000 | 0.3513 | 0.0000 | 0.0331 | 0.0000 | 0.0000 | 0.0217 | 0.9439 | 0.0014 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9144 | 0.0000 | 0.0000 | 0.0856 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3145 | 0.6855 | 0.0000 | 0.0000 |
| CF | 0.0004 | 0.0000 | 0.0318 | 0.0039 | 0.0101 | 0.0000 | 0.8485 | 0.0000 | 0.1052 | 0.0102 | 0.0009 | 0.0286 | 0.0142 | 0.0000 | 0.0016 | 0.8331 | 0.1114 | 0.0000 |
| OF | 0.0001 | 0.0000 | 0.0000 | 0.0216 | 0.0278 | 0.0011 | 0.0000 | 0.6065 | 0.3431 | 0.0000 | 0.0000 | 0.0000 | 0.0323 | 0.0002 | 0.0015 | 0.2513 | 0.6401 | 0.0745 |
| NAS | 0.0000 | 0.0000 | 0.0016 | 0.0071 | 0.0088 | 0.0006 | 0.0097 | 0.0080 | 0.9641 | 0.0177 | 0.0074 | 0.0334 | 0.0142 | 0.0000 | 0.0016 | 0.0000 | 0.0089 | 0.9168 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9960 | 0.0000 | 0.0000 | 0.0040 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9670 | 0.0000 | 0.0056 | 0.0095 | 0.0179 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0013 | 0.9970 | 0.0000 | 0.0000 | 0.0000 | 0.0018 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9647 | 0.0328 | 0.0000 | 0.0000 | 0.0025 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0034 | 0.0005 | 0.9888 | 0.0074 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0015 | 0.0185 | 0.9629 | 0.0000 | 0.0000 | 0.0050 | 0.0000 | 0.0000 | 0.0122 |
| CW | 0.0000 | 0.0000 | 0.0012 | 0.9804 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0183 | 0.0000 | 0.0000 | 0.0000 | 0.9946 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0054 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9404 | 0.0000 | 0.0000 | 0.0000 | 0.0596 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4993 | 0.0000 | 0.0000 | 0.0000 | 0.5007 |
| MT | 0.0000 | 0.0041 | 0.0000 | 0.0000 | 0.0000 | 0.9936 | 0.0000 | 0.0023 | 0.0000 | 0.0000 | 0.0104 | 0.0000 | 0.0000 | 0.0000 | 0.8872 | 0.1023 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0002 | 0.0000 | 0.0061 | 0.0000 | 0.9218 | 0.0178 | 0.0541 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0231 | 0.0000 | 0.8031 | 0.1356 | 0.0383 |
| OF | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.1373 | 0.8623 | 0.0000 | 0.0036 | 0.0009 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0642 | 0.0198 | 0.9115 |
| NAS | 0.0000 | 0.0000 | 0.0004 | 0.0002 | 0.0016 | 0.0000 | 0.0000 | 0.0052 | 0.9925 | 0.0006 | 0.0000 | 0.0008 | 0.0000 | 0.0213 | 0.0000 | 0.0211 | 0.0411 | 0.9151 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.44. Transitional probability matrix for land use categories in Buldhana and Akola districts

| Particulars | Buldhana | | | | | | | | | Akola | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9713 | 0.0000 | 0.0000 | 0.0000 | 0.0287 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9480 | 0.0017 | 0.0000 | 0.0504 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| BU | 0.0052 | 0.2754 | 0.0265 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0805 | 0.6125 | 0.0516 | 0.9278 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0207 | 0.0000 |
| NA | 0.0000 | 0.0302 | 0.9698 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9794 | 0.0000 | 0.0000 | 0.0000 | 0.0206 | 0.0000 | 0.0000 |
| CW | 0.0030 | 0.0862 | 0.0000 | 0.7784 | 0.0004 | 0.0009 | 0.0000 | 0.1312 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1208 | 0.2097 | 0.0153 | 0.0504 | 0.0000 | 0.6038 |
| PP | 0.0043 | 0.0000 | 0.0000 | 0.0163 | 0.8222 | 0.0284 | 0.0000 | 0.1288 | 0.0000 | 0.0019 | 0.0160 | 0.0000 | 0.0425 | 0.8947 | 0.0216 | 0.0000 | 0.0233 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2004 | 0.0000 | 0.6806 | 0.0000 | 0.0000 | 0.0000 | 0.1190 |
| CF | 0.0000 | 0.0000 | 0.0491 | 0.0000 | 0.0125 | 0.0000 | 0.7498 | 0.0000 | 0.1887 | 0.0000 | 0.0000 | 0.0140 | 0.0376 | 0.0000 | 0.0000 | 0.8592 | 0.0892 | 0.0000 |
| OF | 0.0068 | 0.0328 | 0.0000 | 0.0181 | 0.0339 | 0.0000 | 0.0000 | 0.4952 | 0.4131 | 0.0108 | 0.0082 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8182 | 0.1628 |
| NAS | 0.0041 | 0.0226 | 0.0000 | 0.0025 | 0.0034 | 0.0000 | 0.0042 | 0.0088 | 0.9543 | 0.0026 | 0.0007 | 0.0007 | 0.0000 | 0.0046 | 0.0000 | 0.0001 | 0.0000 | 0.9915 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9843 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0157 | 0.5011 | 0.0000 | 0.0000 | 0.0043 | 0.0000 | 0.0005 | 0.0000 | 0.0282 | 0.4659 |
| BU | 0.0000 | 0.9986 | 0.0014 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.9302 | 0.0000 | 0.0568 | 0.0000 | 0.0000 | 0.0130 | 0.0000 | 0.0636 | 0.0294 | 0.4952 | 0.0019 | 0.0591 | 0.0019 | 0.0344 | 0.0086 | 0.3056 |
| CW | 0.0000 | 0.0026 | 0.0000 | 0.9833 | 0.0000 | 0.0000 | 0.0000 | 0.0141 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6147 | 0.0000 | 0.0036 | 0.0000 | 0.0000 | 0.3817 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6306 | 0.0000 | 0.0000 | 0.0000 | 0.3694 | 0.0000 | 0.0118 | 0.4849 | 0.0105 | 0.0103 | 0.0023 | 0.0000 | 0.0000 | 0.4801 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7814 | 0.0000 | 0.2186 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0312 | 0.0261 | 0.0000 | 0.0000 | 0.9427 | 0.0000 | 0.0000 | 0.0007 | 0.0070 | 0.1911 | 0.0000 | 0.1472 | 0.0000 | 0.6531 | 0.0009 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0982 | 0.0000 | 0.0000 | 0.9018 | 0.0000 | 0.1342 | 0.0000 | 0.1061 | 0.0000 | 0.0000 | 0.0000 | 0.0652 | 0.6944 | 0.0000 |
| NAS | 0.0021 | 0.0000 | 0.0047 | 0.0000 | 0.0131 | 0.0000 | 0.0015 | 0.0023 | 0.9763 | 0.0331 | 0.0249 | 0.0000 | 0.0016 | 0.0194 | 0.0012 | 0.0081 | 0.0023 | 0.9095 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9792 | 0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0178 | 0.0000 |
| BU | 0.0000 | 0.9709 | 0.0000 | 0.0240 | 0.0000 | 0.0000 | 0.0051 | 0.0000 | 0.0000 | 0.0178 | 0.9558 | 0.0000 | 0.0067 | 0.0000 | 0.0000 | 0.0000 | 0.0197 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.9734 | 0.0004 | 0.0000 | 0.0000 | 0.0262 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9734 | 0.0000 | 0.0000 | 0.0016 | 0.0171 | 0.0079 | 0.0000 |
| CW | 0.0000 | 0.0461 | 0.0003 | 0.9536 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4998 | 0.0192 | 0.0000 | 0.0000 | 0.0000 | 0.4810 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9180 | 0.0266 | 0.0000 | 0.0553 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9897 | 0.0000 | 0.0000 | 0.0000 | 0.0103 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9934 | 0.0066 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1106 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8894 |
| CF | 0.0000 | 0.0089 | 0.0485 | 0.0000 | 0.0102 | 0.0000 | 0.8670 | 0.0000 | 0.0655 | 0.0000 | 0.0000 | 0.0210 | 0.0154 | 0.0000 | 0.0011 | 0.9625 | 0.0000 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0247 | 0.0000 | 0.0000 | 0.8789 | 0.0964 | 0.0083 | 0.0132 | 0.0000 | 0.0000 | 0.0008 | 0.0000 | 0.0000 | 0.7837 | 0.1939 |
| NAS | 0.0000 | 0.0000 | 0.0009 | 0.0001 | 0.0021 | 0.0000 | 0.0009 | 0.0015 | 0.9945 | 0.0010 | 0.0008 | 0.0012 | 0.0047 | 0.0005 | 0.0018 | 0.0000 | 0.0012 | 0.9889 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.45. Transitional probability matrix for land use categories in Amravati and Yavatmal districts

| Particulars | Amravati | | | | | | | | | Yavatmal | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9482 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0113 | 0.0000 | 0.0000 | 0.0405 | 0.9586 | 0.0101 | 0.0050 | 0.0039 | 0.0000 | 0.0000 | 0.0000 | 0.0224 | 0.0000 |
| BU | 0.0000 | 0.0000 | 0.3038 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6962 | 0.0000 | 0.8098 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1902 | 0.0000 |
| NA | 0.0000 | 0.0455 | 0.7875 | 0.0000 | 0.0000 | 0.0000 | 0.1671 | 0.0000 | 0.0000 | 0.1353 | 0.0000 | 0.8647 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.2182 | 0.0000 | 0.0000 | 0.5144 | 0.0000 | 0.0791 | 0.0000 | 0.1883 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8521 | 0.0000 | 0.0000 | 0.0546 | 0.0000 | 0.0933 |
| PP | 0.1241 | 0.0000 | 0.0000 | 0.0245 | 0.5904 | 0.0000 | 0.0000 | 0.0351 | 0.2259 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9262 | 0.0000 | 0.0738 | 0.0000 | 0.0000 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3258 | 0.0000 | 0.6742 | 0.0000 | 0.0000 | 0.0123 | 0.0000 | 0.0000 | 0.0000 | 0.9877 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0700 | 0.0000 | 0.0558 | 0.0000 | 0.0000 | 0.0000 | 0.5873 | 0.0000 | 0.2869 | 0.0000 | 0.0151 | 0.0000 | 0.0404 | 0.0000 | 0.0058 | 0.1470 | 0.0252 | 0.7665 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0498 | 0.1098 | 0.0376 | 0.0000 | 0.5240 | 0.2787 | 0.0840 | 0.1490 | 0.0000 | 0.0141 | 0.0000 | 0.0000 | 0.1543 | 0.5507 | 0.0479 |
| NAS | 0.0079 | 0.0232 | 0.0024 | 0.0047 | 0.0329 | 0.0004 | 0.0000 | 0.0000 | 0.9285 | 0.0024 | 0.0000 | 0.0048 | 0.0014 | 0.0056 | 0.0000 | 0.0102 | 0.0000 | 0.9756 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.5538 | 0.0000 | 0.0000 | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4461 | 0.9406 | 0.0000 | 0.0000 | 0.0039 | 0.0340 | 0.0019 | 0.0000 | 0.0196 | 0.0000 |
| BU | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9525 | 0.0000 | 0.0062 | 0.0413 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0443 | 0.0000 | 0.9220 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0337 | 0.0000 | 0.0000 | 0.0000 | 0.9709 | 0.0000 | 0.0219 | 0.0000 | 0.0000 | 0.0000 | 0.0072 |
| CW | 0.0000 | 0.0018 | 0.0000 | 0.9982 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8411 | 0.0876 | 0.0672 | 0.0041 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1421 | 0.0280 | 0.0311 | 0.0206 | 0.0919 | 0.0094 | 0.0707 | 0.0000 | 0.6061 |
| MT | 0.3013 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6987 | 0.0000 | 0.0000 | 0.0000 | 0.1978 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8022 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0031 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8823 | 0.0000 | 0.1146 |
| OF | 0.1178 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4897 | 0.3925 | 0.1244 | 0.0030 | 0.0000 | 0.0470 | 0.0000 | 0.0000 | 0.0000 | 0.8155 | 0.0102 |
| NAS | 0.1505 | 0.0260 | 0.0047 | 0.0000 | 0.0000 | 0.0027 | 0.0000 | 0.0078 | 0.8084 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0489 | 0.0000 | 0.0000 | 0.0000 | 0.9511 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9735 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0067 | 0.0000 | 0.0000 | 0.0197 | 0.9798 | 0.0072 | 0.0000 | 0.0040 | 0.0000 | 0.0000 | 0.0000 | 0.0089 | 0.0000 |
| BU | 0.0000 | 0.0071 | 0.1530 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8399 | 0.0000 | 0.8987 | 0.0000 | 0.0138 | 0.0000 | 0.0000 | 0.0000 | 0.0875 | 0.0000 |
| NA | 0.0100 | 0.0575 | 0.9325 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9862 | 0.0000 | 0.0000 | 0.0000 | 0.0138 | 0.0000 | 0.0000 |
| CW | 0.0213 | 0.0000 | 0.0000 | 0.9157 | 0.0262 | 0.0301 | 0.0041 | 0.0025 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8443 | 0.0000 | 0.0000 | 0.0000 | 0.0159 | 0.1397 |
| PP | 0.0052 | 0.0000 | 0.0000 | 0.0044 | 0.9874 | 0.0029 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0059 | 0.0120 | 0.9783 | 0.0000 | 0.0000 | 0.0000 | 0.0038 |
| MT | 0.2734 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.4952 | 0.0000 | 0.2314 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0000 | 0.0013 | 0.0000 | 0.0000 | 0.0000 | 0.9933 | 0.0000 | 0.0055 | 0.0000 | 0.0169 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8525 | 0.0000 | 0.1305 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0153 | 0.0688 | 0.0000 | 0.8526 | 0.0633 | 0.0000 | 0.0243 | 0.0000 | 0.0047 | 0.0000 | 0.0000 | 0.0000 | 0.7728 | 0.1982 |
| NAS | 0.0073 | 0.0224 | 0.0000 | 0.0008 | 0.0000 | 0.0000 | 0.0001 | 0.0007 | 0.9686 | 0.0058 | 0.0012 | 0.0006 | 0.0014 | 0.0015 | 0.0000 | 0.0051 | 0.0000 | 0.9844 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.46. Transitional probability matrix for land use categories in Wardha and Nagpur districts

| Particulars | Wardha | | | | | | | | | Nagpur | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.4565 | 0.0000 | 0.0489 | 0.0000 | 0.0401 | 0.0247 | 0.0000 | 0.0000 | 0.4297 | 0.7418 | 0.0381 | 0.0000 | 0.0000 | 0.1583 | 0.0000 | 0.0000 | 0.0000 | 0.0618 |
| BU | 0.0909 | 0.3809 | 0.0000 | 0.0000 | 0.0000 | 0.3224 | 0.0000 | 0.2058 | 0.0000 | 0.0000 | 0.0429 | 0.0000 | 0.0000 | 0.6586 | 0.0000 | 0.0000 | 0.0000 | 0.2986 |
| NA | 0.1700 | 0.0158 | 0.7000 | 0.0000 | 0.0000 | 0.0000 | 0.0318 | 0.0000 | 0.0823 | 0.0071 | 0.0000 | 0.9694 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0235 | 0.0000 |
| CW | 0.0000 | 0.0161 | 0.0000 | 0.7373 | 0.1896 | 0.0570 | 0.0000 | 0.0000 | 0.0000 | 0.0301 | 0.0250 | 0.0000 | 0.9236 | 0.0213 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| PP | 0.0000 | 0.0203 | 0.0000 | 0.0219 | 0.7127 | 0.0000 | 0.0000 | 0.0000 | 0.2451 | 0.0573 | 0.0589 | 0.0226 | 0.0158 | 0.5973 | 0.0299 | 0.0000 | 0.0792 | 0.1390 |
| MT | 0.2445 | 0.0000 | 0.0000 | 0.3636 | 0.0000 | 0.3919 | 0.0000 | 0.0000 | 0.0000 | 0.6062 | 0.0000 | 0.0000 | 0.0000 | 0.3405 | 0.0533 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0355 | 0.0218 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.3936 | 0.5491 | 0.0000 | 0.0936 | 0.0027 | 0.0254 | 0.0000 | 0.0000 | 0.0196 | 0.6348 | 0.1659 | 0.0580 |
| OF | 0.1243 | 0.0000 | 0.0724 | 0.0000 | 0.0000 | 0.0177 | 0.3229 | 0.4626 | 0.0000 | 0.0903 | 0.0088 | 0.0000 | 0.0000 | 0.1702 | 0.0235 | 0.3827 | 0.1815 | 0.1429 |
| NAS | 0.0609 | 0.0052 | 0.0179 | 0.0000 | 0.0161 | 0.0000 | 0.0000 | 0.0000 | 0.8998 | 0.0625 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9375 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.1039 | 0.0173 | 0.0000 | 0.0000 | 0.0000 | 0.0069 | 0.0000 | 0.0000 | 0.8719 | 0.9524 | 0.0000 | 0.0000 | 0.0000 | 0.0010 | 0.0125 | 0.0153 | 0.0094 | 0.0094 |
| BU | 0.0000 | 0.0000 | 0.0000 | 0.1748 | 0.0000 | 0.0000 | 0.8252 | 0.0000 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.9859 | 0.0000 | 0.0000 | 0.0000 | 0.0141 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9884 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0116 |
| CW | 0.0000 | 0.0442 | 0.0359 | 0.8009 | 0.0000 | 0.0120 | 0.0124 | 0.0000 | 0.0947 | 0.0000 | 0.0000 | 0.0374 | 0.9238 | 0.0000 | 0.0000 | 0.0053 | 0.0203 | 0.0132 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8280 | 0.0000 | 0.0000 | 0.1720 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9939 | 0.0000 | 0.0000 | 0.0061 | 0.0000 |
| MT | 0.0000 | 0.0227 | 0.0000 | 0.0813 | 0.0000 | 0.8960 | 0.0000 | 0.0000 | 0.0000 | 0.8153 | 0.0000 | 0.0000 | 0.0000 | 0.0160 | 0.0000 | 0.1687 | 0.0000 | 0.0000 |
| CF | 0.1513 | 0.0102 | 0.0020 | 0.0000 | 0.0000 | 0.0035 | 0.7637 | 0.0000 | 0.0693 | 0.0000 | 0.0000 | 0.0000 | 0.1391 | 0.0000 | 0.0678 | 0.7465 | 0.0466 | 0.0000 |
| OF | 0.1082 | 0.0233 | 0.0000 | 0.0000 | 0.0693 | 0.0007 | 0.1662 | 0.5768 | 0.0556 | 0.0528 | 0.0000 | 0.0000 | 0.0000 | 0.0024 | 0.0632 | 0.0468 | 0.8347 | 0.0000 |
| NAS | 0.1200 | 0.0206 | 0.0000 | 0.0017 | 0.0135 | 0.0000 | 0.0047 | 0.0079 | 0.8315 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0054 | 0.0000 | 0.0000 | 0.9946 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.8306 | 0.0000 | 0.0248 | 0.0000 | 0.0204 | 0.0124 | 0.0000 | 0.0136 | 0.0981 | 0.9897 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0011 | 0.0000 | 0.0093 |
| BU | 0.0000 | 0.9740 | 0.0000 | 0.0260 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9853 | 0.0000 | 0.0147 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0191 | 0.0018 | 0.9606 | 0.0000 | 0.0000 | 0.0185 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0045 | 0.9947 | 0.0000 | 0.0000 | 0.0008 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0000 | 0.0000 | 0.0000 | 0.8288 | 0.0982 | 0.0347 | 0.0000 | 0.0000 | 0.0383 | 0.0000 | 0.0000 | 0.0000 | 0.9514 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0486 |
| PP | 0.0030 | 0.0000 | 0.0000 | 0.0098 | 0.8478 | 0.0000 | 0.0000 | 0.0000 | 0.1394 | 0.0046 | 0.0000 | 0.0000 | 0.0000 | 0.9954 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| MT | 0.0310 | 0.0000 | 0.0000 | 0.2368 | 0.0000 | 0.7322 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0643 | 0.0000 | 0.8040 | 0.0000 | 0.1317 | 0.0000 |
| CF | 0.0000 | 0.0017 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9527 | 0.0456 | 0.0000 | 0.0079 | 0.0000 | 0.0000 | 0.0190 | 0.0129 | 0.0667 | 0.6730 | 0.2205 | 0.0000 |
| OF | 0.0216 | 0.0000 | 0.0122 | 0.0036 | 0.0000 | 0.0029 | 0.1390 | 0.8208 | 0.0000 | 0.0101 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0025 | 0.2394 | 0.7479 | 0.0000 |
| NAS | 0.0241 | 0.0002 | 0.0000 | 0.0000 | 0.0082 | 0.0000 | 0.0000 | 0.0000 | 0.9675 | 0.0019 | 0.0000 | 0.0016 | 0.0005 | 0.0000 | 0.0001 | 0.0019 | 0.0000 | 0.9939 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

Table 4.47. Transitional probability matrix for land use categories in Bhandara and Chandrapur districts

| Particulars | Bhandara | | | | | | | | | Chandrapur | | | | | | | | |
|------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| | FR | BU | NA | CW | PP | MT | CF | OF | NAS | FR | BU | NA | CW | PP | MT | CF | OF | NAS |
| Period-I | | | | | | | | | | | | | | | | | | |
| FR | 0.9525 | 0.0121 | 0.0000 | 0.0000 | 0.0227 | 0.0127 | 0.0000 | 0.0000 | 0.0000 | 0.9178 | 0.0027 | 0.0000 | 0.0000 | 0.0000 | 0.0007 | 0.0000 | 0.0099 | 0.0689 |
| BU | 0.2425 | 0.1134 | 0.5283 | 0.0000 | 0.1158 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1298 | 0.8429 | 0.0000 | 0.0000 | 0.0000 | 0.0059 | 0.0000 | 0.0213 | 0.0000 |
| NA | 0.0000 | 0.1034 | 0.8966 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2187 | 0.0000 | 0.7813 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| CW | 0.0368 | 0.0000 | 0.0164 | 0.3785 | 0.0000 | 0.0000 | 0.0000 | 0.0538 | 0.5145 | 0.0000 | 0.0000 | 0.0000 | 0.6805 | 0.1443 | 0.0034 | 0.0000 | 0.0000 | 0.1717 |
| PP | 0.0028 | 0.0000 | 0.0000 | 0.0043 | 0.8302 | 0.0000 | 0.0000 | 0.0000 | 0.1627 | 0.0000 | 0.0000 | 0.0000 | 0.0860 | 0.8673 | 0.0385 | 0.0000 | 0.0000 | 0.0081 |
| MT | 0.0000 | 0.2333 | 0.0000 | 0.0000 | 0.2054 | 0.5613 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.5795 | 0.0000 | 0.4205 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0000 | 0.0824 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1265 | 0.0421 | 0.7490 | 0.0664 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.6333 | 0.2095 | 0.0908 |
| OF | 0.0196 | 0.0000 | 0.0000 | 0.0000 | 0.0823 | 0.0000 | 0.0000 | 0.4815 | 0.4166 | 0.1814 | 0.0890 | 0.1959 | 0.0000 | 0.0000 | 0.0000 | 0.3799 | 0.0017 | 0.1521 |
| NAS | 0.0173 | 0.0000 | 0.0000 | 0.0443 | 0.0334 | 0.0000 | 0.0238 | 0.0113 | 0.8698 | 0.1285 | 0.0000 | 0.0333 | 0.0000 | 0.0150 | 0.0000 | 0.0000 | 0.0000 | 0.8232 |
| Period-II | | | | | | | | | | | | | | | | | | |
| FR | 0.9379 | 0.0000 | 0.0134 | 0.0380 | 0.0108 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9709 | 0.0000 | 0.0029 | 0.0132 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0130 |
| BU | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1353 | 0.6528 | 0.0000 | 0.0000 | 0.0480 | 0.0000 | 0.1639 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0000 | 0.8824 | 0.0000 | 0.1176 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.9102 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0898 |
| CW | 0.0000 | 0.0000 | 0.1342 | 0.6250 | 0.0000 | 0.0000 | 0.2409 | 0.0000 | 0.0000 | 0.1921 | 0.0156 | 0.0966 | 0.5620 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.1337 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7773 | 0.0000 | 0.0000 | 0.0000 | 0.2227 | 0.0048 | 0.0063 | 0.0000 | 0.0000 | 0.9352 | 0.0142 | 0.0000 | 0.0395 | 0.0000 |
| MT | 0.0654 | 0.0000 | 0.0000 | 0.0000 | 0.0734 | 0.8611 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0483 | 0.7015 | 0.1633 | 0.0868 | 0.0000 |
| CF | 0.0829 | 0.0000 | 0.0000 | 0.0160 | 0.0000 | 0.0000 | 0.5233 | 0.0049 | 0.3729 | 0.0000 | 0.0000 | 0.0777 | 0.0780 | 0.0000 | 0.0000 | 0.8443 | 0.0000 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0174 | 0.0000 | 0.0000 | 0.8296 | 0.1530 | 0.0000 | 0.0697 | 0.0000 | 0.0494 | 0.0108 | 0.1247 | 0.0000 | 0.7359 | 0.0095 |
| NAS | 0.0416 | 0.0000 | 0.0091 | 0.0000 | 0.0408 | 0.0035 | 0.0000 | 0.0033 | 0.9017 | 0.0417 | 0.0173 | 0.0000 | 0.0000 | 0.0064 | 0.0000 | 0.0000 | 0.0000 | 0.9347 |
| Overall | | | | | | | | | | | | | | | | | | |
| FR | 0.9528 | 0.0282 | 0.0000 | 0.0004 | 0.0000 | 0.0013 | 0.0173 | 0.0000 | 0.0000 | 0.9578 | 0.0026 | 0.0024 | 0.0000 | 0.0000 | 0.0020 | 0.0000 | 0.0056 | 0.0297 |
| BU | 0.3991 | 0.1147 | 0.3570 | 0.0000 | 0.1242 | 0.0050 | 0.0000 | 0.0000 | 0.0000 | 0.0369 | 0.8848 | 0.0000 | 0.0772 | 0.0000 | 0.0011 | 0.0000 | 0.0000 | 0.0000 |
| NA | 0.0000 | 0.0811 | 0.9156 | 0.0000 | 0.0000 | 0.0033 | 0.0000 | 0.0000 | 0.0000 | 0.0332 | 0.0000 | 0.9637 | 0.0000 | 0.0000 | 0.0000 | 0.0031 | 0.0000 | 0.0000 |
| CW | 0.0213 | 0.0000 | 0.0503 | 0.7324 | 0.0000 | 0.0000 | 0.0189 | 0.0000 | 0.1771 | 0.0000 | 0.0000 | 0.0000 | 0.7431 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2569 |
| PP | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.8710 | 0.0000 | 0.0000 | 0.0000 | 0.1290 | 0.0000 | 0.0000 | 0.0000 | 0.0372 | 0.9535 | 0.0000 | 0.0000 | 0.0000 | 0.0093 |
| MT | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0825 | 0.9175 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.2002 | 0.0668 | 0.7330 | 0.0000 | 0.0000 | 0.0000 |
| CF | 0.0181 | 0.0535 | 0.0000 | 0.0023 | 0.0000 | 0.0000 | 0.5886 | 0.0000 | 0.3375 | 0.0251 | 0.0000 | 0.0259 | 0.0000 | 0.0000 | 0.0000 | 0.9379 | 0.0111 | 0.0000 |
| OF | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.7895 | 0.2105 | 0.1695 | 0.0348 | 0.0401 | 0.0000 | 0.0000 | 0.0404 | 0.1159 | 0.5994 | 0.0000 |
| NAS | 0.0133 | 0.0000 | 0.0000 | 0.0202 | 0.0385 | 0.0000 | 0.0000 | 0.0048 | 0.9231 | 0.0804 | 0.0000 | 0.0000 | 0.0077 | 0.0063 | 0.0000 | 0.0000 | 0.0000 | 0.9056 |

Note: FR- Area under forest, BU-Barren and uncultivable lands, NA-Land put to non-agricultural uses, CW-Cultivable wastes, PP-Permanent pastures and other grazing lands, MT-Miscellaneous tree crops and groves, CF-Current fallows, OF-Fallows other than current fallow, NAS-Net area sown.

During overall Period, all the districts of Maharashtra were manifested some retention within 1.98 and 99.82 per cent of its previous years' share in current year of fallow other than current fallow land. Where, Beed district showed least stability with 1.98 per cent of previous years' in current year. Here, most of the districts lost its per cent shares of previous years' in current year to current fallow land, net area sown, barren and uncultivable land, area under forest, cultivable waste and land put to non-agricultural uses, respectively during Overall Period. Thane district (99.82 %) was the top most stable district in fallow other than current fallow land followed by Ratnagiri, Aurangabad, Raigad and Ahmednagar that showed higher retention per cent of its previous years' share in current year during Overall Period.

It can be observed that during Period-I, among all the land use categories, net area sown was the most stable land category with the retention of more than 80.00 per cent of previous years' share in current year in all the districts of Maharashtra. Parbhani district was topmost stable district among all the districts with 99.21 per cent of its previous years' share in current year in net area sown followed by Akola, Dhule, Satara, Yavatmal and Aurangabad with the tune of 99.15, 98.40, 97.88, 97.56 and 97.22 per cent of previous years' share in current year, respectively during Period-I.

In case of Period-II, net area sown in all the districts, except Greater Bombay showed retention of previous years' share in current year with the magnitude ranging between 64.86 to 99.46 per cent during different periods under study. However, Greater Bombay was failed to maintained its per cent share of previous years' in net area sown during Period-II. On the flip side, Nagpur was more stable district in net area sown having retention of 99.46 per cent share followed by Pune (98.66%), Buldhana (97.63%), Sangli (97.58%) and Satara (97.27%). Most of the districts of Maharashtra are inclining towards lower stability in net area sown during Period-II as compared to Period-I.

It was noted during Overall Period that all districts of Maharashtra have higher stability in net area sown with the retention of more than 90.00 per cent share and ranged from 90.56 to 99.94 per cent of previous years' share in current year. Thane (99.94%) was the most stable district followed by Aurangabad, Buldhana, Nagpur, Satara and Parbhani with the tune of 99.53, 99.45, 99.39, 99.31 and 99.25 per cent of previous years' share in current year in net area sown during the Overall Period. In most of the districts, net area sown was the major gainer among all the land use categories during the

study period. Net area sown was gained mainly from current fallow, fallow other than current fallow, cultivable waste and permanent pastures and other grazing land. The initiatives taken by the government to make the highest utilization of land under farming was the main reason of gaining of net sown area from fallow lands and cultivable waste land. On the other hand, net area sown was likely to lose their major share to barren and uncultivable land, permanent pastures and other grazing land, area under forest, cultivable waste and fallow other than current fallow during Overall Period.

In a nutshell, the results of the districtwise transitional probability matrix for the aforesaid three periods showed that the land use category of net area sown and land put to non-agricultural uses 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. Current fallow land was the most unstable land use category in majority of the districts of Maharashtra during all the periods under study.

4.2.2 Projected land use pattern of India

The area under different land use categories in India are predicted for next thirty years (2020-21 to 2050-51) using transition probabilities and the results are presented in Table 4.48.

It is evident that the land use categories *viz*; forest, barren and uncultivable land, permanent pastures and other grazing, current fallow and fallow other than current fallow are likely to lose their area in coming years. On the other hand, the land put to non-agricultural uses and cultivable waste are likely to increase in the future. However, land under miscellaneous tree, crops and groves is expected to increase in first 15 years but it is to decrease in the later years. Net area sown may increase in first few years i.e. up to year 2025-26, but it is expected to decline in later years. Land use dynamics is likely to remain stable subject to non-intervention of any developmental activities in the study area. The unfavorable trend of forest area, cultivable waste land, permanent pastures and other grazing lands and net area sown implies the need of efficient and effective management of the land use with efforts from all the stakeholders through suitable perspective land use planning.

Table 4.48. Projections of land use dynamics in India**(Area in '00' ha)**

| Sr. No. | Period | Land use categories | | | | | | | | |
|---------|------------------|---------------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
| 1 | 2016-17 (Actual) | 722945.13 | 165074.26 | 280424.85 | 122113.98 | 102909.60 | 31254.47 | 152982.40 | 112879.71 | 1389995.34 |
| 2 | 2020-21 | 717090.35 | 164698.30 | 286688.69 | 123411.00 | 101442.21 | 32473.87 | 146746.52 | 104321.45 | 1403706.99 |
| 3 | 2025-26 | 711348.81 | 164152.75 | 292156.32 | 124515.31 | 101072.38 | 32630.11 | 146077.52 | 102938.01 | 1405687.80 |
| 4 | 2030-31 | 708198.67 | 163740.25 | 296981.52 | 125338.04 | 101036.29 | 32668.73 | 145595.53 | 102593.41 | 1404426.22 |
| 5 | 2035-36 | 706375.01 | 163467.25 | 301300.41 | 125901.20 | 101066.93 | 32672.97 | 145254.10 | 102412.19 | 1402128.22 |
| 6 | 2040-41 | 705137.90 | 163282.19 | 305194.56 | 126259.26 | 101084.33 | 32660.81 | 144989.43 | 102270.08 | 1399699.36 |
| 7 | 2045-46 | 704188.56 | 163140.68 | 308717.38 | 126466.63 | 101072.48 | 32640.43 | 144771.08 | 102148.93 | 1397431.38 |
| 8 | 2050-51 | 703411.17 | 163015.44 | 311909.39 | 126567.68 | 101034.41 | 32615.93 | 144585.40 | 102044.59 | 1395393.17 |

Table 4.49. Projections of land use dynamics in Maharashtra**(Area in '00' ha)**

| Sr. No. | Period | Land use categories | | | | | | | | |
|---------|------------------|---------------------|------------------------------|-----------------------------------|------------------|---|---|----------------|----------------------------------|---------------|
| | | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Cultivable waste | Permanent pastures and other grazing land | Land under miscellaneous tree, crops and groves | Current fallow | Fallow other than current fallow | Net area sown |
| 1 | 2016-17 (Actual) | 51946.00 | 17350.00 | 16419.00 | 9248.00 | 12490.00 | 2539.00 | 14015.00 | 12575.00 | 171001.00 |
| 2 | 2020-21 | 51854.41 | 17099.31 | 16609.52 | 9206.04 | 12476.29 | 2556.65 | 13880.00 | 12298.71 | 171602.03 |
| 3 | 2025-26 | 51790.27 | 17056.05 | 16786.83 | 9188.16 | 12464.47 | 2552.02 | 13724.34 | 12148.60 | 171872.21 |
| 4 | 2030-31 | 51738.36 | 17043.47 | 16953.67 | 9182.59 | 12455.40 | 2543.12 | 13598.53 | 12051.89 | 172015.86 |
| 5 | 2035-36 | 51693.73 | 17034.74 | 17111.66 | 9183.46 | 12449.22 | 2535.55 | 13504.16 | 11984.53 | 172085.81 |
| 6 | 2040-41 | 51653.93 | 17026.16 | 17261.82 | 9187.47 | 12445.50 | 2530.29 | 13435.18 | 11936.06 | 172106.42 |
| 7 | 2045-46 | 51617.55 | 17017.46 | 17404.80 | 9192.77 | 12443.64 | 2527.08 | 13385.39 | 11900.66 | 172093.46 |
| 8 | 2050-51 | 51583.72 | 17008.80 | 17541.06 | 9198.34 | 12443.05 | 2525.46 | 13349.75 | 11874.55 | 172058.06 |

4.2.3 Projected land use pattern of Maharashtra

An analysis of projections of different land use categories in Maharashtra for next thirty years (2020-21 to 2050-51) using transition probabilities made and the outcomes are presented in Table 4.49.

It is obvious that the land use categories *viz*; area under forest, barren and uncultivable land, permanent pastures and other grazing land, land under miscellaneous tree, crops and groves, current fallow and fallow other than current fallow are expected to fail to retain their area in forthcoming years. On the other hand, the land put to non-agricultural uses is probably to rise in the future. However, mixed trend seen in case of cultivable waste land, which is likely to be increase during first 10 years then may decrease from the year 2035-36 till 2050-51. On the flip side, net area sown is expected to rise up to year 2040-41, but in the subsequent years it is prone to decreases. If no developmental activities are undertaken in the study area, land use dynamics are likely to remain stable. The unfavorable trend of forest, permanent pastures and other grazing lands and net area sown in later years, efficient and effective land use management with contributions from all stakeholders through appropriate land use planning is necessary.

These results are in conformity with the findings of Harish (2006), Aravind (2010), Gairhe *et al.* (2011), Singh (2012), Adhikari and Sekhon (2014) and Tirlapur and Mundinamani (2015) in various states/districts for different time periods.

The hypothesis state that there are no structural variations in land use pattern has not been proved i.e. null hypothesis has been rejected.

4.3 Factors responsible for temporal changes in land use pattern

In this section, an attempt has been made to analyses the factors that influence the land use across the Maharashtra. It is hypothesized that status of land use at any given point of time is reflection of cumulative influence of climatic, social, economic and institutional factors. In order to examine the influence of above factors on land use status in Maharashtra, multiple linear regression model was fitted considering the Overall Period from 1960-61 to 2016-17 for state and regional level. The area under land use was regressed on several causal factors *viz*; rainfall, net irrigated area, road length, population, number of factories and number of land holders.

4.3.1 Factors responsible for temporal changes in land use pattern in Maharashtra

The influence of selected explanatory variables on land use pattern has been analyzed for the Maharashtra state as a whole and the results are presented in Table 4.50. The results of multiple regression analysis revealed that the regression equation could explain 74 per cent of the overall variation in area under forest at Maharashtra state as a whole. Area under forest was negatively and significant influenced by population density with regression coefficient of -0.07 in Maharashtra during the period 1960-61 to 2016-17. Gairhe (2011) and Amale (2018) observed that the area under forest was negatively influenced by the population density.

As far as the barren and uncultivable land is concerned, it was negatively influenced by the net irrigated area and road length in the state. The regression coefficients were equivalent -0.03 for the both factors and it was statistically significant. However, population density showed significant and positive impact on barren and uncultivable land in Maharashtra, which might be due to the carelessness and unethical land practices of a growing population.

Land put to non-agricultural uses was positively influenced by road length and population density. It is noteworthy that corresponding regression coefficients for road length (0.19) and population density (0.35) were statistically significant. As roads are the part of non-agricultural land, it is obvious to have the positive impact on this land use category; while increasing population encroaches the cultivable land for housing and other mercantile purposes in the state which ultimately increase the land under non-agricultural use.

At the level of Maharashtra state as a whole, area under permanent pastures and other grazing land was positively influenced by the road length with the regression coefficient of 0.27. Whereas, number of land holders was negatively influenced on area under permanent pastures and other grazing land. With regard to area under miscellaneous tree crops and groves, population in the state has showed significantly positive, on the other hand, road length and number of factories influence significantly negative with the regression coefficient of 0.11 and 0.39, respectively.

Table 4.50. Causes for land use shift in Maharashtra (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Permanent pastures and other grazing lands | Miscellaneous tree crops and groves | Cultivable waste | Current fallow | Fallow other than current fallow | Net area sown |
|---------|------------------------|-------------------|------------------------------|-----------------------------------|--|-------------------------------------|-------------------|-----------------|----------------------------------|------------------|
| 1 | Intercept | 11.16 (0.21) | 10.10 (0.17) | 3.12 (1.30) | 13.21 (1.32) | 3.83 (1.80) | 11.04 (2.40) | 1.25 (6.31) | 0.19 (2.78) | 12.48 (0.46) |
| 2 | Rainfall | -0.003 (0.01) | -0.003 (0.01) | 0.01 (0.04) | -0.04 (0.05) | -0.01 (0.06) | -0.02 (0.08) | -0.26 (0.22) | -0.01 (0.10) | 0.02 (0.02) |
| 3 | Net irrigated area | 0.002 (0.02) | -0.03** (0.01) | 0.04 (0.09) | -0.11 (0.10) | 0.22 (0.13) | -0.39** (0.17) | -0.23 (0.45) | -0.04 (0.20) | 0.09** (0.03) |
| 4 | Road length | -0.01 (0.01) | -0.03** (0.01) | 0.19** (0.04) | 0.27** (0.05) | -0.11* (0.06) | 0.36** (0.08) | -0.37 (0.22) | -0.45** (0.10) | -0.01 (0.02) |
| 5 | Population density | -0.07** (0.02) | 0.05** (0.02) | 0.35** (0.13) | -0.06 (0.13) | 0.54** (0.18) | 0.26 (0.24) | 0.92 (0.64) | -0.43 (0.28) | -0.13* (0.05) |
| 6 | Number of factories | 0.03 (0.02) | -0.02 (0.01) | -0.06 (0.10) | -0.01 (0.10) | -0.39** (0.14) | -0.11 (0.19) | -0.89 (0.50) | -0.03 (0.22) | 0.07 (0.05) |
| 7 | Number of land holders | -0.01 (0.03) | 0.01 (0.02) | 0.14 (0.16) | -0.32* (0.16) | 0.25 (0.22) | -0.15 (0.30) | 1.29 (0.78) | 1.10** (0.34) | -0.08 (0.06) |
| 8 | F-value | 23.97** | 49.99** | 243.75** | 24.98** | 24.40** | 5.14** | 4.19** | 11.38** | 10.65** |
| 9 | R ² | 0.74 | 0.86 | 0.97 | 0.75 | 0.75 | 0.38 | 0.33 | 0.58 | 0.56 |

Note : Figures in parentheses indicate standard errors, ** and * shows significant level at 1 % and 5 % level, respectively.

In respect of the equation that attempts to examine the variables influencing the area under cultivable waste, the explanatory variables included in the regression equation could explain 38 per cent of variation in the dependent variable. Among which, road length was positively influencing on extent of cultivable waste at the state level during the aforesaid period. Whereas, net irrigated area was negatively influencing on cultivable waste in the state.

Selected explanatory variables accounted for 33 per cent of total variation in current fallow and none of them have significant influence on it particularly in Maharashtra during the study period. In respect of the area under fallow other than current fallow showed a significantly negative response to road length with regression coefficient of 0.45. The length of the roads was found negative effect on the extent of other fallows mainly because the extension of road facilities in rural areas facilitate better access to markets and provide impetus to agricultural development. Conversely, the number of land holder with regression coefficient of 1.10, had positive and significant impact on area under fallow other than current fallow. As far as the net area sown is considered, extent of net irrigated area showed positive influence on the net area sown in Maharashtra with a significant regression coefficient of 0.09, while on the contrary population density was observed negative impact on net area sown during study period in Maharashtra state. The R^2 varied between 0.33 to 0.97, which testified to the adequacy of the model. Ramasamy *et al.* (2005), Gairhe (2011), Pushpa (2012) and Amale (2018) also found similar results in their studies in different regions.

4.3.2 Regionwise factors responsible for temporal changes in land use pattern in Maharashtra

4.3.2.1 Konkan region

The causes for change in land use pattern in Konkan region have been analyzed with the use of multiple regression analysis and the results are presented in Table 4.51. A perusal of table revealed that the area under forest was positively and significantly influenced by the net irrigated area and road length. The population density and number of factories in the region of Konkan has showed negative influence on the area under forest during the period 1960-61 to 2016-17. The significance level of road length, population density and number of factories was at 5 per cent in area under forest.

Table 4.51. Causes for land use shift in Konkan region (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Permanent pastures and other grazing lands | Miscellaneous tree crops and groves | Cultivable waste | Current fallow | Fallow other than current fallow | Net area sown |
|---------|------------------------|------------------|------------------------------|-----------------------------------|--|-------------------------------------|------------------|-----------------|----------------------------------|-------------------|
| 1 | Intercept | 7.16 (1.15) | 9.18 (0.58) | 8.96 (9.06) | 12.55 (8.18) | 12.28 (7.06) | 12.86 (6.28) | 9.03 (8.31) | -4.10 (7.42) | 9.41 (1.22) |
| 2 | Rainfall | 0.03 (0.02) | -0.01 (0.01) | -0.29* (0.13) | 0.31** (0.12) | 0.20* (0.10) | -0.17 (0.09) | 0.16 (0.12) | 0.17 (0.11) | 0.03 (0.02) |
| 3 | Net irrigated area | 0.08** (0.03) | -0.06** (0.02) | 0.08 (0.24) | -0.36 (0.22) | -0.32* (0.19) | -0.31* (0.17) | -0.14 (0.22) | 0.50** (0.20) | 0.03 (0.03) |
| 4 | Road length | 0.12* (0.06) | 0.04 (0.03) | 1.40** (0.45) | 0.97* (0.40) | 0.65* (0.35) | 0.19 (0.31) | -0.34 (0.41) | -0.79* (0.37) | -0.17** (0.06) |
| 5 | Population density | -0.17* (0.10) | -0.04 (0.05) | 0.35 (0.80) | -0.02 (0.72) | 0.79 (0.62) | -0.04 (0.56) | 0.14 (0.74) | -0.03 (0.66) | -0.07 (0.11) |
| 6 | Number of factories | -0.16 (0.08) | 0.01 (0.04) | 1.05* (0.61) | 0.85 (0.55) | -0.21 (0.47) | 0.55 (0.42) | -0.72 (0.56) | -0.96* (0.50) | 0.08 (0.08) |
| 7 | Number of land holders | 0.15 (0.13) | -0.03 (0.07) | -1.83 (1.06) | -1.31 (0.96) | -1.04 (0.83) | -0.61 (0.73) | 0.46 (0.97) | 1.76* (0.87) | 0.04 (0.14) |
| 8 | F-value | 5.65** | 35.20** | 58.06** | 12.69** | 2.69* | 4.08** | 17.87** | 9.41** | 10.97** |
| 9 | R ² | 0.40 | 0.81 | 0.87 | 0.60 | 0.24 | 0.33 | 0.68 | 0.53 | 0.57 |

Note : Figures in parentheses indicate standard errors, ** and * shows significant level at 1 % and 5 % level, respectively.

The notable observation was that the number of factories in Konkan region had negative influence on forest area indicating that there may be use of forest land for establishment of new factories. As far as the barren and uncultivable land is concerned, it was negatively influenced by the net irrigated area with regression coefficient of 0.06 in the Konkan region.

Land put to non-agricultural uses was positively influenced by the road length and number of factories with the regression coefficients of 1.40 and 1.05, respectively and they were statistically significant. However, rainfall has the negative impact on land put to non-agricultural uses. In Konkan region, area under permanent pastures and other grazing land was positively influenced by the rainfall and road length during the period under study. The rainfall and road length have a positive effect on miscellaneous tree crops and groves with regression coefficient of 0.20 and 0.65, respectively. However, miscellaneous tree crops and groves influenced negatively by net irrigated area. The cultivable waste was negatively influenced by both rainfall and net irrigated area with regression coefficient of 0.17 and 0.31, respectively in Konkan region.

None of the explanatory factors influence the area under current fallow land in this region even with 68 per cent variation in regression equation during the period of 1960-61 to 2016-17. In respect of the area under fallow other than current fallow, the selected explanatory variables could explain 53 per cent of variation in the extent of other fallow land. Among which, net irrigated area and number of land holders had positive influence on area under fallow other than current fallow, while road length has negative influence on it with statistically significant regression coefficient of 0.79 during the period of study. Road length has showed significant and negative influence on the net area sown in Konkan region with regression coefficient of 0.17 during the study period indicating that the land put to non-agricultural use.

4.3.2.2 Western Maharashtra region

Influence of the selected causal factors to land use pattern in Western Maharashtra region has been analyzed and the results are presented in Table 4.52. It can be observed from the results that population density in the region put negative and significant influence on area under forest during the period of 1960-61 to 2016-17. In Western Maharashtra, the barren and uncultivable land was negatively influenced by the

rainfall, population density number of factories and number of land holders with regression coefficient of 0.03, 0.06, 0.03, and 0.07, respectively. As far as land put to non-agricultural uses is concerned, obviously, it was positively influenced by the road length with the regression coefficient of 0.42.

The area under permanent pastures and other grazing land was negatively influenced by the number of factories, however, it was positive influenced by road length in the region of Western Maharashtra. None of the selected explanatory variables significantly influence the area under miscellaneous tree crops and groves in Western Maharashtra during entire study period. In case of cultivable waste in the Western Maharashtra, net irrigated area and number of factories showed significant and negative influence with the regression coefficients of 0.52 and 0.26, respectively, however, it was positively influenced by road length during the period under study.

Negative but significant influence of net irrigated area was noticed on current fallows with the regression coefficient of 0.79 in Western Maharashtra during study period. Whereas, current fallow was significantly and positively influence by population density with regression coefficient of 0.78. In respect of the area under fallow other than current fallow, road length and number of land holders had negative influence with statistically significant regression coefficients of 0.24 and 0.57, respectively during the period of study. Net irrigated area showed positive and significant influence on the net area sown with the regression coefficient of 0.11. Conversely, road length, population density and number of factories put negative impact on net area sown with the statistically significant regression coefficient of 0.05 0.16 and 0.06, respectively during the study period in Western Maharashtra. The study identified a correlation between irrigated land and net area sown. This suggests that expanding irrigation facilities through farm ponds and micro-irrigation systems could be a crucial strategy for increasing cultivated land.

Table 4.52. Causes for land use shift in Western Maharashtra region (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Permanent pastures and other grazing lands | Miscellaneous tree crops and groves | Cultivable waste | Current fallow | Fallow other than current fallow | Net area sown |
|---------|------------------------|-------------------|------------------------------|-----------------------------------|--|-------------------------------------|------------------|-------------------|----------------------------------|-------------------|
| 1 | Intercept | 10.68 (0.17) | 10.02 (0.26) | -9.46 (3.23) | 5.58 (1.75) | -7.91 (3.95) | 5.32 (2.40) | 11.49 (4.34) | 4.79 (1.91) | 11.71 (0.43) |
| 2 | Rainfall | -0.01 (0.01) | -0.03** (0.01) | 0.04 (0.15) | -0.04 (0.08) | -0.10 (0.19) | -0.04 (0.11) | -0.21 (0.14) | -0.09 (0.09) | 0.03 (0.02) |
| 3 | Net irrigated area | -0.005 (0.02) | 0.02 (0.03) | -0.23 (0.38) | -0.10 (0.21) | 0.64 (0.47) | -0.52* (0.28) | -0.79** (0.23) | -0.07 (0.23) | 0.11* (0.05) |
| 4 | Road length | 0.01 (0.01) | 0.002 (0.01) | 0.42** (0.13) | 0.38** (0.07) | 0.11 (0.16) | 0.17* (0.10) | -0.17 (0.14) | -0.24** (0.08) | -0.05** (0.02) |
| 5 | Population density | -0.05** (0.02) | -0.06* (0.03) | 0.31 (0.43) | -0.17 (0.23) | 0.20 (0.52) | 0.23 (0.32) | 0.78* (0.42) | -0.14 (0.25) | -0.16** (0.06) |
| 6 | Number of factories | 0.01 (0.01) | -0.03** (0.01) | -0.11 (0.17) | -0.18* (0.09) | -0.17 (0.21) | -0.26* (0.13) | 0.13 (0.24) | -0.05 (0.10) | -0.06** (0.02) |
| 7 | Number of land holders | -0.05* (0.03) | -0.07* (0.04) | 0.90 (0.58) | 0.15 (0.26) | 0.51 (0.59) | 0.45 (0.35) | 0.14 (0.53) | 0.57* (0.28) | -0.05 (0.06) |
| 8 | F-value | 94.92** | 28.15** | 97.05** | 9.89** | 45.04** | 2.87* | 13.35** | 4.94** | 13.11** |
| 9 | R ² | 0.92 | 0.77 | 0.92 | 0.54 | 0.84 | 0.26 | 0.62 | 0.37 | 0.61 |

Note : Figures in parentheses indicate standard errors, ** and * shows significant level at 1 % and 5 % level, respectively.

4.3.2.3 Marathwada region

The factors influencing land use pattern in Marathwada region have been analyzed by employing multiple regression analysis and the results are presented in Table 4.53. It is evident from the results that the road length had a significant and negative influence on area under forest in Marathwada region during the period 1960-61 to 2016-17. With regard to barren and uncultivable land, the population density has showed negative influence during the study period. It is noteworthy to record that the population density showed negative influence on area under barren and uncultivable land indicating that there may be pressure of population to convert barren land into non-agricultural uses and or agricultural land during study period.

Land put to non-agricultural uses was positively influenced by the net irrigated area with the statistically significant regression coefficients of 0.10. The selected explanatory variables accounted for 88 per cent of total variation in area under permanent pastures and other grazing land, population density had a significant and negative influence on it during the study period.

The miscellaneous tree crops and groves influenced by population density positively and significantly, with the regression coefficients of 0.55 in Marathwada region of Maharashtra. The road length showed positive and significant impact on cultivable waste with regression coefficient of 0.54. Rainfall, net irrigated area and number of factories put negative and significant influence on current fallow in Marathwada region during study period. The corresponding regression coefficients of rainfall, net irrigated area and number of factories were 0.19, 0.57 and 0.24, respectively. Conversely, area under current fallow was positively influenced by the population density and number of land holders with the statistically significant regression coefficient of 0.68 and 0.78, respectively in Marathwada region during the investigation period. The road length showed significant and negative influence on area under fallow other than current fallow with the regression coefficients of 0.24 during the period of study. However, number of land holders had significant and positive impact on area under fallow other than current fallow in Marathwada region.

Table 4.53. Causes for land use shift in Marathwada region (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Permanent pastures and other grazing lands | Miscellaneous tree crops and groves | Cultivable waste | Current fallow | Fallow other than current fallow | Net area sown |
|---------|------------------------|-------------------|------------------------------|-----------------------------------|--|-------------------------------------|------------------|------------------|----------------------------------|------------------|
| 1 | Intercept | 7.84 (0.44) | 5.77 (0.72) | 4.82 (0.81) | 9.34 (0.61) | 1.50 (1.45) | 4.45 (4.40) | -7.30 (2.94) | -0.09 (3.62) | 10.60 (0.58) |
| 2 | Rainfall | 0.01 (0.01) | 0.02 (0.02) | -0.01 (0.03) | -0.004 (0.02) | -0.01 (0.05) | -0.04 (0.14) | -0.19* (0.11) | 0.08 (0.11) | 0.01 (0.02) |
| 3 | Net irrigated area | 0.03 (0.02) | 0.04 (0.04) | 0.10** (0.04) | 0.03 (0.03) | 0.02 (0.08) | 0.08 (0.23) | -0.57* (0.24) | -0.24 (0.19) | 0.12** (0.03) |
| 4 | Road length | -0.05** (0.01) | -0.004 (0.02) | 0.04 (0.03) | 0.02 (0.02) | 0.03 (0.05) | 0.54** (0.14) | -0.15 (0.11) | -0.24* (0.11) | -0.02 (0.02) |
| 5 | Population density | -0.01 (0.04) | -0.21** (0.07) | 0.03 (0.08) | -0.11* (0.06) | 0.55** (0.14) | 0.22 (0.42) | 0.68* (0.31) | -0.26 (0.35) | -0.10* (0.06) |
| 6 | Number of factories | 0.003 (0.02) | 0.04 (0.04) | -0.03 (0.04) | -0.01 (0.03) | -0.09 (0.08) | -0.25 (0.24) | -0.24* (0.11) | 0.21 (0.20) | -0.03 (0.03) |
| 7 | Number of land holders | -0.07 (0.05) | -0.05 (0.09) | 0.13 (0.10) | -0.10 (0.07) | 0.13 (0.18) | -0.16 (0.54) | 0.78** (0.29) | 0.82* (0.44) | -0.01 (0.07) |
| 8 | F-value | 16.12** | 85.00** | 120.68** | 61.20** | 107.17** | 23.20** | 66.52** | 22.97** | 11.28** |
| 9 | R ² | 0.66 | 0.91 | 0.94 | 0.88 | 0.93 | 0.74 | 0.89 | 0.73 | 0.56 |

Note : Figures in parentheses indicate standard errors, ** and * shows significant level at 1 % and 5 % level, respectively.

It is clear from the result that fallow other than current fallow was negatively influenced by road length, implying that road facilities helped to revamp the culturable land from these fallow lands. Net irrigated area showed positive influence on the net area sown with the significant regression coefficients of 0.12 and conversely, population density put negative influence to net area sown in Marathwada during the period under study.

4.3.2.4 Vidarbha region

The causes for change in land use shift in Vidarbha region have been analyzed and the results are presented in Table 4.54. The results revealed that the area under forest was negatively influenced by net irrigated area, road length, number of factories and number of land holders with the regression coefficients of 0.03, 0.02, 0.06 and 0.05, respectively in the region during the period of 1960-61 to 2016-17. The barren and uncultivable land was negatively influenced by road length, number of factories and number of land holders with the statistically significant regression coefficient of 0.33, 0.09 and 0.58, respectively during the period under study.

As far as land put to non-agricultural uses is concerned, it was positively influenced by the population density and number of factories with the regression coefficients of 0.34 and 0.10, respectively during the period under study. Whereas, number of land holders was observed to influence land put to non-agricultural uses negatively in Vidarbha region during study period.

The area under permanent pastures and other grazing land was negatively influenced by the net irrigated area, population density, road length, number of factories and number of land holders indicating that the pressure on common land may be severe in days to come. In Vidarbha region, the miscellaneous tree crops and groves negatively influenced by road length (0.29) and number of factories (0.13). On the other hand, net irrigated area (0.24) was positively significant on this land use category in Vidarbha during the study period.

The road length, population density and number of factories of Vidarbha has showed significant and negative influence on area under cultivable waste with the regression coefficient of 0.38, 0.39 and 0.15, respectively during the period under study. Current fallows land also influenced significantly and negatively by road length and

number of factories with regression coefficients of 0.29 and 0.78, respectively during the period of 1960-61 to 2016-17. Though the decline of area under current fallow is expected to capture the increasing pressure of population, but contradictory results were observed in case of Vidarbha region where population has showed positive influence on current fallow with the regression coefficient of 1.56. The road length and population density showed negative influence on area under fallow other than current fallow with statistically significant regression coefficient of 0.19 and 0.68, respectively during the period of study. Whereas, number of land holders observed significant and positive relation with area under fallow other than current fallow during study period. The road length had put positive influence on the net area sown in Vidarbha with the significant regression coefficient of 0.05. Conversely, net area sown was negatively influenced by the number of land holders in Vidarbha region. This implies that agricultural land might have converted to other land use categories for housing and other development purposes in the region. Appropriate policy measures and awareness campaign for the same need to be initiated to save the agricultural land.

The summary of regression analysis on causes for change in land use shift in Maharashtra state are presented here as, net irrigated area had a significant and positive influence on the net area sown, while it had a negative and significant impact on barren and uncultivable land and cultivable waste land during the study period. In case of cultivable waste land, road length affected significantly and positively in entire study period. Same observations were noticed by Ramasamy *et al.* (2005) in Tamil Nadu, Aravind (2010) in Karnataka, Bardhan and Tewari (2010) in India, Gairhe (2011) in Karnataka, Pushpa (2012) in Karnataka and Amale (2018) in Gujarat.

Based on the above results, the hypothesis state that land use pattern does not influenced by number of factors has not been proved i.e. null hypothesis has been rejected.

Table 4.54. Causes for land use shift in Vidarbha region (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Forest | Barren and uncultivable land | Land put to non-agricultural uses | Permanent pastures and other grazing lands | Miscellaneous tree crops and groves | Cultivable waste | Current fallow | Fallow other than current fallow | Net area sown |
|---------|------------------------|-------------------|------------------------------|-----------------------------------|--|-------------------------------------|-------------------|------------------|----------------------------------|-------------------|
| 1 | Intercept | 11.03 (0.15) | 1.47 (1.33) | 3.14 (0.56) | 14.83 (0.92) | 5.39 (1.46) | 5.21 (1.82) | 7.16 (4.72) | 2.24 (2.14) | 11.40 (0.21) |
| 2 | Rainfall | 0.01 (0.01) | -0.01 (0.05) | -0.02 (0.02) | -0.01 (0.03) | 0.05 (0.06) | -0.05 (0.07) | -0.29 (0.16) | 0.10 (0.08) | 0.005 (0.01) |
| 3 | Net irrigated area | -0.03** (0.01) | 0.12 (0.11) | -0.004 (0.05) | -0.26** (0.07) | 0.24* (0.12) | 0.17 (0.15) | -0.46 (0.34) | -0.01 (0.17) | 0.01 (0.02) |
| 4 | Road length | -0.02* (0.01) | -0.33** (0.05) | 0.003 (0.02) | -0.12** (0.03) | -0.29** (0.05) | -0.38** (0.07) | -0.29* (0.16) | -0.19* (0.08) | 0.05** (0.01) |
| 5 | Population density | -0.02 (0.02) | 0.20 (0.14) | 0.34** (0.06) | -0.27** (0.10) | 0.05 (0.15) | -0.39* (0.19) | 1.56** (0.47) | -0.68** (0.23) | -0.03 (0.02) |
| 6 | Number of factories | -0.06** (0.01) | -0.09* (0.05) | 0.10** (0.02) | -0.06* (0.03) | -0.13* (0.05) | -0.15* (0.07) | -0.78* (0.37) | 0.05 (0.08) | -0.004 (0.01) |
| 7 | Number of land holders | -0.05** (0.01) | 0.58** (0.13) | -0.32** (0.05) | -0.29** (0.09) | 0.04 (0.14) | 0.31 (0.18) | 0.73 (0.58) | 0.67** (0.21) | -0.07** (0.02) |
| 8 | F-value | 39.36** | 17.03** | 274.82** | 90.26** | 7.65** | 15.04** | 7.61** | 13.56** | 15.03** |
| 9 | R ² | 0.83 | 0.67 | 0.97 | 0.92 | 0.48 | 0.64 | 0.48 | 0.62 | 0.64 |

Note : Figures in parentheses indicate standard errors, ** and * shows significant level at 1 % and 5 % level, respectively.

4.4 Impact of changes in land use pattern on cropping intensity and crop diversification

This section is precisely an attempt to identify the impact of land use shift on cropping intensity and crop diversification for period of the 57 years using multiple regression of double log form where, the cropping intensity was regressed with all the nine land use categories i.e. forest, barren and uncultivable land, land put to non-agricultural use, permanent pasture and other grazing lands, miscellaneous tree crops and groves, cultivable waste, current fallow, fallow other than current fallow and net area sown.

4.4.1 Impact of changes in land use pattern on cropping intensity

The response of cropping intensity to nine land use categories has been analyzed for the state, regional and district wise and the results are elaborated as under.

Table 4.55. Impact of land use shift on cropping intensity and crop diversification in Maharashtra (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Regression Coefficient | |
|---------|--------------------------------------|------------------------|----------------------|
| | | Cropping Intensity | Crop Diversification |
| 1 | Intercept | 17.03 (12.70) | -7.21 (12.04) |
| 2 | Forest | 0.35 (0.40) | 1.10** (0.40) |
| 3 | Barren and uncultivable land | 0.41** (0.13) | 0.08 (0.14) |
| 4 | Land put to non-agricultural uses | 0.24** (0.03) | 0.12** (0.03) |
| 5 | Cultivable waste | -0.22** (0.06) | -0.13* (0.06) |
| 6 | Permanent pastures and other grazing | -0.31** (0.10) | -0.18* (0.09) |
| 7 | Miscellaneous tree crops and groves | 0.06 (0.04) | 0.11** (0.03) |
| 8 | Current fallow | -0.05 (0.05) | 0.03 (0.05) |
| 9 | Fallow other than current fallow | -0.15* (0.08) | -0.05 (0.07) |
| 10 | Net area sown | -1.32* (0.73) | -0.39 (0.68) |
| 11 | F-value | 126.96** | 30.24** |
| 12 | R ² | 0.96 | 0.89 |

Note: Figures in parentheses indicate standard errors,
** and * shows significant level at 1 % and 5 % level, respectively

4.4.1.1 Impact of land use shift on cropping intensity in Maharashtra

A perusal of Table 4.55 indicates that for the Maharashtra state as a whole, the R^2 value was found to be 0.96, which indicated that the variables specified in the model could together explain more than 96 per cent of the variation in the cropping intensity. Cropping intensity was influenced positively significant by changes in the barren and uncultivable land and area put to non- agricultural uses. The regression coefficient of barren and uncultivable land (0.41) and land put to non-agricultural uses (0.24) signified that the increases in barren and uncultivable land and area land under non-agricultural uses will also compel to increase the cropping intensity at the Maharashtra state as a whole.

Whereas, cultivable wastes land (-0.22), permanent pasture and other grazing lands (-0.31), fallow other than current fallow (-0.15) and net area sown (-1.32) were showed significantly negative relationship with the cropping intensity in Maharashtra during the study period. All other land use categories viz, forest, miscellaneous tree crops and groves and area under current fallow were not showed significant relationship with cropping intensity in Maharashtra.

4.4.1.2 Regionwise impact of land use shift on cropping intensity

As far as the regional analysis is concerned, though the selected explanatory variables i.e. all the land use categories explain 81, 94, 95 and 95 per cent of variation in cropping intensity, respectively in Konkan, Marathwada, Western Maharashtra and Vidarbha regions of Maharashtra during the period of 1960-61 to 2016-17 which is presented in Table 4.56.

In Konkan region, cropping intensity was negatively influenced by the permanent pastures and other grazing land and net area sown with regression coefficient of 0.09 and 0.18, respectively, which were statistically significant. On the other hand, land put to non-agricultural uses had shown significantly positive impact on cropping intensity during said study period in Maharashtra state as a whole.

The significant and negative influence of land use categories viz, forest and cultivable waste on cropping intensity whereas, barren and uncultivable land and land put to non-agricultural uses were showed significantly positive in the case of Western Maharashtra and Marathwada regions of Maharashtra during the study period.

However, Marathwada region was positively influenced by miscellaneous tree crops and groves with regression coefficient of 0.15.

The land put to non-agricultural uses was positively and significantly, on the contrary, cultivable waste land was negatively impact on cropping intensity in Vidarbha region during study period.

Table 4.56. Regionwise impact of land use shift on cropping intensity in Maharashtra (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Regions | | | |
|---------|--------------------------------------|-------------------|---------------------|------------------|------------------|
| | | Konkan | Western Maharashtra | Marathwada | Vidarbha |
| 1 | Intercept | 6.45 (2.82) | 15.36 (6.02) | 7.66 (7.53) | 14.21 (12.14) |
| 2 | Forest | 0.13 (0.09) | -1.14** (0.25) | -0.60* (0.31) | -0.36 (0.58) |
| 3 | Barren and uncultivable land | -0.07 (0.07) | 0.30** (0.08) | 0.79** (0.17) | 0.08 (0.08) |
| 4 | Land put to non-agricultural use | 0.04** (0.01) | 0.07** (0.02) | 0.19* (0.11) | 0.26** (0.07) |
| 5 | Cultivable waste | -0.01 (0.05) | -0.07** (0.02) | -0.09* (0.04) | -0.08 (0.04) |
| 6 | Permanent pastures and other grazing | -0.09** (0.03) | -0.05 (0.04) | -0.26 (0.14) | -0.14 (0.10) |
| 7 | Miscellaneous tree crops and groves | 0.01 (0.01) | 0.01 (0.01) | 0.15** (0.05) | -0.04 (0.06) |
| 8 | Current fallow | 0.01 (0.01) | -0.01 (0.03) | -0.01 (0.06) | 0.01 (0.02) |
| 9 | Fallow other than current fallow | -0.04 (0.03) | -0.02 (0.04) | -0.03 (0.05) | -0.04 (0.03) |
| 10 | Net area sown | -0.18* (0.10) | -0.14 (0.33) | -0.29 (0.55) | -0.59 (0.52) |
| 11 | F-value | 22.24** | 90.95** | 83.70** | 108.60** |
| 12 | R ² | 0.81 | 0.95 | 0.94 | 0.95 |

Note: Figures in parentheses indicate standard errors,

** and * shows significant level at 1 % and 5 % level, respectively

All regions were observed significant and positive impact of land put to non-agricultural uses on cropping intensity during the study period. The corresponding regression coefficients of land put to non-agricultural use was 0.04, 0.07, 0.19 and 0.26 in Konkan, Western Maharashtra, Marathwada and Vidarbha, respectively, which were statistically significant which indicates the pressure on agricultural land for increasing production through higher cropping intensity with limited agricultural land. The

surprising relationship between net area sown and the cropping intensity was observed in the region of Konkan, where the regression coefficient of net area sown (0.18) was negative and significant in relation with cropping intensity. The reason for that unexpected impact of net area sown might be due to the fact that, Konkan region leading in the area under fruit orchards and these annual crops are not replicated in enhancing the cropping intensity but added in the net area sown.

In sum up, at an overall level, it has been seen that almost in all the regions and at state level, change in land use categories did not show considerable impact on cropping intensity in Maharashtra, except in few cases.

4.4.1.3 Districtwise impact of changes in land use pattern on cropping intensity

To identify the impact of land use shift on cropping intensity in different districts, multiple regression of double log form was used where; the cropping intensity was regressed with all the nine land use categories and the results are presented in Table 4.57.

The results indicated that area under forest showed significant influence on the cropping intensity in the sixteen districts during the period of 1960-61 to 2016-17. Among these districts, Ratnagiri, Satara, Sangli, Ahmednagar, Nashik, Jalgaon, Dhule, Aurangabad, Nanded, Buldhana, Akola and Amravati districts were significantly and negatively influenced by forest, while it was positively and significantly influenced in Thane, Osmanabad, Wardha and Chandrapur. The twelve of the districts experienced the significant influence of barren and uncultivable land on cropping intensity in Maharashtra during aforesaid period. Out of which, Raigad, Pune, Sangli, Dhule, Buldhana and Bhandara were manifested significantly negative effect whereas, Ratnagiri, Satara, Kolhapur, Nanded, Beed and Wardha districts showed significantly positive impact of barren and uncultivable land on cropping intensity.

As far as the impact of change in area under non-agricultural use on cropping intensity is concerned, cropping intensity was positively influenced in the districts of Nanded, Wardha, Kolhapur, Buldhana, Osmanabad, Aurangabad, Yavatmal, Dhule, Amravati, Beed, Pune and Ratnagiri by land put under non-agricultural uses with the statistically significant regression coefficients of 0.86, 0.65, 0.44, 0.43, 0.43, 0.21, 0.18, 0.17, 0.15, 0.12, 0.08 and 0.06, 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.

During the study period, only just ten districts of Maharashtra viz; Thane, Raigad, Kolhapur, Ahmednagar, Jalgaon, Dhule, Nanded, Beed, Bhandara and Chandrapur were observed significantly negative influence on the cropping intensity by area under permanent pastures and grazing lands.

The cropping intensity was positively and significantly influenced by cultivable waste in Thane Satara and Kolhapur but it was negatively influenced in Raigad, Pune, Nashik, Jalgaon, Parbhani, Beed, Akola, Amravati and Bhandara during study period. The area under miscellaneous tree crops and groves was noticed to have negative and significant impact on cropping intensity in Thane, Raigad, Dhule, Nanded, Parbhani, Akola and Chandrapur districts, while, in Ratnagiri, Satara, Osmanabad, Amravati, Yavatmal and Wardha districts of Maharashtra positive and significant impact was observed during study period.

The cropping intensity in Maharashtra's districts, except for Ratnagiri, Kolhapur, Ahmednagar, Parbhani, Yavatmal, Nagpur, and Bhandara, was not affected by the current fallow land. Cropping intensity was negatively influenced by current fallow land in the district of Kolhapur, Ahmednagar and Bhandara, while it was positively influenced in Ratnagiri, Parbhani, Yavatmal and Nagpur. The fallow other than current fallow land was observed to have significantly positive influence on cropping intensity in Thane and Ratnagiri districts, however, it put negative influence in Raigad, Pune, Sangli, Ahmednagar, Dhule, Nanded, Osmanabad and Akola districts. In case of Ahmednagar and Akola districts, the cropping intensity was negatively influenced by area under fallow other than current fallow, because of the degradation of land especially from the area where intensive agriculture is practiced. The Ratnagiri was the only district, which showed significantly positive impact of net area sown on cropping intensity, but it was negatively impact in Raigad, Pune, Sangli, Kolhapur, Ahmednagar, Dhule, Akola Bhandara and Chandrapur districts of Maharashtra during study period. The land use shift was unable to exert any significant impact on cropping intensity in Solapur district of the Maharashtra.

Table 4.57. Districtwise impact of land use shift on cropping intensity (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Thane | Raigad | Ratnagiri | Pune | Solapur | Satara | Sangli | Kolhapur | Ahmednagar |
|---------|--------------------------------------|-------------------|-------------------|------------------|--------------------|-----------------|-------------------|--------------------|-------------------|--------------------|
| 1 | Intercept | 2.10 (1.84) | 10.20 (1.74) | 1.16 (1.05) | 10.82 (2.96) | 3.73 (4.16) | 10.95 (2.66) | 15.84 (2.80) | 18.30 (10.86) | 30.39 (3.52) |
| 2 | Forest | 0.20* (0.11) | -0.04 (0.10) | -0.05* (0.03) | 0.31 (0.33) | 0.10 (0.18) | -1.02** (0.18) | -0.73** (0.30) | 0.09 (0.53) | -1.60** (0.24) |
| 3 | Barren and uncultivable land | -0.04 (0.04) | -0.13* (0.07) | 0.16* (0.07) | -0.33** (0.07) | -0.24 (0.31) | 0.09* (0.04) | -0.50** (0.14) | 0.81** (0.18) | -0.05 (0.07) |
| 4 | Land put to non-agricultural use | 0.01* (0.005) | -0.005 (0.01) | 0.06** (0.02) | 0.08* (0.04) | 0.02 (0.03) | 0.01 (0.01) | -0.01 (0.01) | 0.44** (0.10) | 0.01 (0.01) |
| 5 | Permanent pastures and other grazing | -0.03** (0.01) | -0.06* (0.03) | 0.04 (0.04) | -0.02 (0.02) | 0.01 (0.04) | -0.02 (0.02) | -0.01 (0.02) | -0.47** (0.09) | -0.05** (0.02) |
| 6 | Cultivable waste | 0.08** (0.03) | -0.04* (0.02) | 0.01 (0.01) | -0.07* (0.03) | 0.01 (0.09) | 0.03* (0.02) | -0.002 (0.12) | 0.30* (0.16) | -0.04 (0.04) |
| 7 | Miscellaneous tree crops and groves | -0.02* (0.01) | -0.20** (0.02) | 0.03** (0.01) | -0.0002 (0.001) | -0.01 (0.04) | 0.002* (0.001) | -0.0002 (0.002) | -0.09 (0.08) | -0.0003 (0.001) |
| 8 | Current fallow | 0.001 (0.001) | -0.01 (0.01) | 0.02* (0.01) | -0.01 (0.01) | 0.03 (0.04) | 0.002 (0.01) | 0.003 (0.002) | -0.12** (0.05) | -0.04* (0.02) |
| 9 | Fallow other than current fallow | 0.02* (0.01) | -0.07** (0.03) | 0.07* (0.03) | -0.07** (0.02) | 0.01 (0.07) | 0.01 (0.02) | -0.08* (0.04) | -0.10 (0.08) | -0.10** (0.03) |
| 10 | Net area sown | 0.10 (0.09) | -0.26** (0.09) | 0.12* (0.07) | -0.60** (0.15) | 0.17 (0.27) | 0.04 (0.17) | -0.35* (0.21) | -2.27* (1.04) | -1.28** (0.31) |
| 11 | F-value | 3.62** | 33.32** | 7.19** | 24.76** | 1.28 | 33.56** | 13.06** | 35.88** | 48.97** |
| 12 | R ² | 0.41 | 0.86 | 0.58 | 0.83 | 0.20 | 0.87 | 0.71 | 0.87 | 0.90 |

Note: Figures in parentheses indicate standard errors, ** Significant at 1 % level, * Significant at 5 % level

Due to non-unavailability of data for some variables, analysis was not done for Grater Bombay district.

Table 4.57 contd.....

| Sr. No. | Explanatory variables | Nashik | Jalgaon | Dhule | Aurangabad | Nanded | Osmanabad | Parbhani | Beed |
|---------|--------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 1 | Intercept | 8.16 (1.91) | 21.23 (10.76) | 31.88 (7.09) | 18.06 (3.55) | 13.84 (8.36) | 6.37 (4.44) | 12.27 (3.80) | 7.75 (2.75) |
| 2 | Forest | -0.31** (0.10) | -0.58* (0.31) | -1.64** (0.31) | -1.95** (0.25) | -0.74** (0.21) | 0.08* (0.04) | -0.29 (0.26) | -0.02 (0.05) |
| 3 | Barren and uncultivable land | -0.12 (0.08) | 0.13 (0.15) | -0.17* (0.08) | -0.37 (0.35) | 0.32** (0.08) | 0.03 (0.10) | -0.11 (0.25) | 0.19* (0.08) |
| 4 | Land put to non-agricultural use | -0.002 (0.01) | -0.01 (0.02) | 0.17** (0.04) | 0.21** (0.05) | 0.86** (0.08) | 0.43** (0.09) | -0.07 (0.24) | 0.12* (0.06) |
| 5 | Permanent pastures and other grazing | 0.02 (0.02) | -0.07* (0.04) | -0.04* (0.02) | 0.03 (0.04) | -0.16** (0.06) | 0.002 (0.02) | 0.02 (0.03) | -0.05* (0.03) |
| 6 | Cultivable waste | -0.09** (0.03) | -0.55** (0.09) | -0.01 (0.02) | -0.18 (0.12) | -0.08 (0.06) | 0.20 (0.25) | -0.39** (0.09) | -0.27** (0.11) |
| 7 | Miscellaneous tree crops and groves | 0.01 (0.01) | 0.01 (0.02) | -0.04* (0.02) | 0.03 (0.04) | -0.12** (0.05) | 0.04* (0.02) | -0.32** (0.04) | -0.01 (0.03) |
| 8 | Current fallow | 0.01 (0.01) | -0.02 (0.02) | -0.02 (0.01) | 0.02 (0.02) | -0.03 (0.06) | -0.06 (0.04) | 0.04* (0.02) | -0.07 (0.05) |
| 9 | Fallow other than current fallow | -0.02 (0.02) | -0.02 (0.03) | -0.06** (0.02) | -0.01 (0.02) | -0.06* (0.03) | -0.10** (0.04) | -0.02 (0.03) | -0.02 (0.03) |
| 10 | Net area sown | 0.04 (0.16) | -1.01 (0.90) | -1.37** (0.47) | 0.14 (0.23) | -0.98 (0.78) | -0.52 (0.39) | -0.18 (0.34) | -0.24 (0.22) |
| 11 | F-value | 17.32** | 43.74** | 10.07** | 40.27** | 34.27** | 102.63** | 51.17** | 17.30** |
| 12 | R ² | 0.77 | 0.89 | 0.66 | 0.89 | 0.87 | 0.95 | 0.91 | 0.77 |

Note: Figures in parentheses indicate standard errors, ** Significant at 1 % level, * Significant at 5 % level

Table 4.57 contd.....

| Sr. No. | Explanatory variables | Buldhana | Akola | Amravati | Yavatmal | Wardha | Nagpur | Bhandara | Chandrapur |
|---------|--------------------------------------|-------------------|-------------------|-------------------|------------------|------------------|------------------|-------------------|-------------------|
| 1 | Intercept | 15.25 (8.80) | 56.50 (11.21) | 9.17 (10.86) | -5.23 (6.20) | -8.66 (6.57) | 7.01 (5.23) | 26.99 (7.11) | -7.55 (5.60) |
| 2 | Forest | -0.48** (0.16) | -0.97** (0.16) | -1.52** (0.39) | 0.22 (0.21) | 0.43** (0.15) | -0.27 (0.20) | -0.77 (0.54) | 1.69** (0.43) |
| 3 | Barren and uncultivable land | -0.26** (0.10) | -0.14 (0.12) | 0.15 (0.12) | 0.02 (0.04) | 0.18** (0.05) | 0.10 (0.08) | -0.25** (0.10) | 0.003 (0.04) |
| 4 | Land put to non-agricultural use | 0.43** (0.07) | -0.002 (0.07) | 0.15* (0.09) | 0.18** (0.04) | 0.65** (0.14) | 0.08 (0.09) | 0.04 (0.19) | -0.02 (0.05) |
| 5 | Permanent pastures and other grazing | -0.03 (0.04) | -0.01 (0.03) | -0.02 (0.04) | 0.03 (0.03) | 0.01 (0.06) | -0.05 (0.04) | -0.20** (0.08) | -0.05* (0.03) |
| 6 | Cultivable waste | 0.11 (0.08) | -0.36** (0.06) | -0.17** (0.05) | 0.04 (0.04) | 0.06 (0.09) | 0.05 (0.11) | -0.62* (0.26) | -0.05 (0.04) |
| 7 | Miscellaneous tree crops and groves | 0.01 (0.02) | -0.12** (0.04) | 0.15** (0.03) | 0.07** (0.02) | 0.17** (0.06) | -0.004 (0.05) | 0.02 (0.04) | -0.08** (0.03) |
| 8 | Current fallow | 0.04 (0.03) | -0.01 (0.02) | -0.03 (0.03) | 0.05* (0.02) | 0.03 (0.04) | 0.04* (0.02) | -0.09** (0.02) | -0.01 (0.01) |
| 9 | Fallow other than current fallow | -0.06 (0.04) | -0.16** (0.05) | -0.03 (0.03) | -0.03 (0.02) | -0.02 (0.02) | 0.01 (0.03) | -0.01 (0.03) | -0.01 (0.01) |
| 10 | Net area sown | -0.97 (0.78) | -4.57** (1.09) | 0.78 (0.90) | 0.68 (0.42) | 0.56 (0.56) | -0.19 (0.43) | -1.10** (0.28) | -0.31* (0.17) |
| 11 | F-value | 43.52** | 46.72** | 62.13** | 104.85** | 10.30** | 16.06** | 6.65** | 52.21** |
| 12 | R ² | 0.89 | 0.90 | 0.92 | 0.95 | 0.66 | 0.75 | 0.56 | 0.91 |

Note: Figures in parentheses indicate standard errors, ** Significant at 1 % level, * Significant at 5 % level

The major explanatory variable that put impact on cropping intensity was land put to non-agricultural uses in state, regions as well as in districts also. The increasing demand of land for urbanization and infrastructural development due to increasing population may increase pressure on area left for cultivation and improve cropping intensity.

It has been observed that almost in all the districts, regions and at the state level, changes in land use categories did reflect marginally impact on cropping intensity in Maharashtra.

4.4.2 Impact of changes in land use pattern on crop diversification

The impact of crop diversification on nine land use categories has been analyzed for the state, regional and districtwise level and the results are presented as under.

4.4.2.1 Impact on crop diversification in Maharashtra

The analysis of impact of change in land use categories on the crop diversification is presented in Table 4.55, though the selected explanatory variables *i.e.* all the land use categories explain 89 per cent of variation in crop diversification in Maharashtra. Area under forest, land put to non-agricultural uses and area under miscellaneous tree crops and groves has showed positive and significant impact on crop diversification during whole study period. The regression coefficients were 1.10, 0.12 and 0.11 of the area under forest, land put to non-agricultural uses and area under miscellaneous tree crops and groves, respectively.

The impact of change in area under cultivable waste and permanent pastures and other grazing land on crop diversification was negatively influenced with the statistically significant regression coefficient of 0.13 and 0.18, respectively during the study period in Maharashtra as a State.

4.4.2.2 Regionwise impact of land use shift on crop diversification

In the context of impact of land use change on crop diversification at regional level, results are presented in Table 4.58, which indicated that all the land use categories explain 66, 83, 89 and 95 per cent of variation in crop diversification in Western Maharashtra, Marathwada, Konkan and Vidarbha regions, respectively. In Konkan region of Maharashtra, area under land put to non-agricultural uses showed

significant and positive impact on crop diversification whereas, it was significantly negative impact of permanent pastures and other grazing and fallow other than current fallow on crop diversification during the study period.

Table 4.58. Regionwise impact of land use shift on crop diversification in Maharashtra

(1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Regions | | | |
|---------|--------------------------------------|-------------------|---------------------|-------------------|-------------------|
| | | Konkan | Western Maharashtra | Marathwada | Vidarbha |
| 1. | Intercept | 11.61 (12.19) | 0.11 (10.28) | 0.79 (3.34) | 4.37 (10.80) |
| 2. | Forest | 0.19 (0.37) | -1.09** (0.40) | 0.08 (0.14) | -0.02 (0.52) |
| 3. | Barren and uncultivable land | -0.37 (0.27) | 0.28* (0.14) | 0.20** (0.07) | 0.09 (0.07) |
| 4. | Land put to non-agricultural use | 0.22** (0.05) | 0.01 (0.03) | -0.01 (0.05) | 0.24** (0.06) |
| 5. | Cultivable waste | -0.21 (0.20) | -0.07* (0.04) | -0.05** (0.02) | -0.05* (0.03) |
| 6. | Permanent pastures and other grazing | -0.56** (0.13) | 0.04 (0.07) | -0.21** (0.07) | -0.15* (0.09) |
| 7. | Miscellaneous tree crops and groves | 0.04 (0.06) | -0.02 (0.02) | 0.03 (0.03) | -0.01 (0.05) |
| 8. | Current fallow | -0.06 (0.06) | 0.07* (0.04) | 0.02 (0.03) | 0.02 (0.02) |
| 9. | Fallow other than current fallow | -0.22* (0.12) | 0.10 (0.07) | -0.03 (0.02) | -0.06** (0.02) |
| 10. | Net area sown | -0.54 (0.46) | 0.57 (0.57) | -0.11 (0.25) | -0.48 (0.47) |
| 11. | F-value | 28.03** | 6.99** | 17.75** | 62.21** |
| 12. | R ² | 0.89 | 0.66 | 0.83 | 0.95 |

Note : Figures in parentheses indicate standard errors,

** and * shows significant level at 1 % and 5 % level, respectively

In the case of Western Maharashtra region, forest and cultivable waste were showed to have significant and negative impact on crop diversification with regression coefficient of 1.09 and 0.07, respectively, however, barren and uncultivable land and current fallow showed significantly positive impact on crop diversification during the study period. As far as Marathwada region concerned, cultivable waste land and permanent pastures and other grazing land were showed significantly negative influence on crop diversification with regression coefficient of 0.05 and 0.21,

respectively during aforesaid period. On the other hand, barren and uncultivable land put positive influence on crop diversification in Marathwada region of Maharashtra. The area under cultivable waste (0.05), permanent pastures and other grazing land (0.15) and fallow other than current fallow (0.06) in Vidarbha region were having significantly negative influence on crop diversification while, crop diversification was positively influenced by the land put to non-agricultural uses in Vidarbha region with regression coefficient of 0.24 during same study period.

It is noted that crop diversification negatively influenced by cultivable waste land in state and regions of Maharashtra state. The presence of cultivable wasteland in Maharashtra acts as a barrier to crop diversification. With less usable land available, farmers have limited options and are less likely to switch between different crops.

4.4.2.3 Districtwise impact of changes in land use pattern on crop diversification

The impact of land use shift on crop diversification in different districts of Maharashtra was analyzed by using multiple regression of double log form where, the crop diversification was regressed with all the nine land use categories and the results are presented in Table 4.59.

The results revealed that Raigad, Sangli, Ahmednagar, Nashik, Jalgaon, Dhule, Buldhana, Akola Amravati and Bhandara districts showed significantly negative influence of area under forest on the crop diversification, while, it was positively influenced by forest in Thane, Osmanabad, Beed, Nagpur and Chandrapur districts during entire study period. The Kolhapur, Jalgaon, Beed, Buldhana, Wardha and Bhandara districts of Maharashtra experienced the negatively significant influence of barren and uncultivable land on crop diversification, whereas, Thane, Ratnagiri and Parbhani district was shown positive and significant impact on crop diversification.

As far as the impact of change in area under non-agricultural use on crop diversification is concerned, crop diversification was positively influenced in the districts of Thane, Ratnagiri Nanded, Buldhana, Amravati and Chandrapur by land put under non-agricultural uses with the statistically significant regression coefficients of 0.04, 0.17, 0.21, 0.16, 0.14 and 0.30, respectively during the study period. However, negative and significant effect of area under non-agricultural uses on crop diversification in Raigad,

Kolhapur, Jalgaon, Beed and Bhandara districts during study period. The area under permanent pastures and other grazing land regressed and observed positive and significant impact on crop diversification in Pune, Kolhapur, Beed, Wardha and Nagpur. However, Raigad, Sangli and Ahmednagar were having negatively significant effect on crop diversification during entire study period.

Except in the districts of Thane, Parbhani, Akola, Amravati and Nagpur, in other districts of Maharashtra, cultivable wasteland did not significantly influence the crop diversification. The area under miscellaneous tree crops and groves was noticed negative and significant impact on crop diversification in Raigad, Parbhani and Akola districts while, in Ratnagiri, Satara, Sangli, Kolhapur and Amravati districts of Maharashtra, positive and significant impact was observed during study period.

Among all the districts, Thane and Bhandara districts of Maharashtra were having significant and negative influence of shift in area under current fallow on the crop diversification. Whereas, Solapur, Kolhapur, Dhule, Aurangabad, Beed, Nagpur and Chandrapur were observed positively significant impact of current fallow land on crop diversification. In case of Raigad, Sangli, Ahmednagar, Nanded, Osmanabad, Parbhani, Buldhana, Akola and Yavatmal, the crop diversification was negatively influenced by area under fallow other than current fallow. While, in Solapur, Kolhapur, Beed, Wardha and Nagpur districts, crop diversification influenced positively and significant by area under fallow other than current fallow.

During entire study period, net area sown has showed positive influence on crop diversification in Thane, Ratnagiri, Solapur, Kolhapur, Aurangabad, Beed, Amravati, Wardha and Nagpur district. Though, the Raigad, Sangli, Jalgaon, Buldhana, Akola and Bhandara significant negative impact of net sown area on crop diversification was observed.

The results on impact of land use shift on cropping intensity and crop diversification have shown that the land put to non-agricultural uses would compel to increase the cropping intensity and crop diversification in some districts, regions as well as at the Maharashtra state as a whole. This might be due to the pressure of this land use category on agricultural land to maintain or even increasing the agricultural income from the same piece of land.

Table 4.59. Districtwise impact of land use shift on crop diversification (1960-61 to 2016-17)

| Sr. No. | Explanatory variables | Thane | Raigad | Ratnagiri | Pune | Solapur | Satara | Sangli | Kolhapur | Ahmednagar |
|---------|--------------------------------------|-------------------|-------------------|------------------|-------------------|------------------|--------------------|--------------------|-------------------|-------------------|
| 1 | Intercept | -9.64 (3.59) | 69.50 (17.93) | -14.90 (3.13) | 3.76 (3.93) | -14.35 (3.60) | -0.47 (5.64) | 9.17 (2.91) | -9.62 (6.01) | 24.35 (9.65) |
| 2 | Forest | 0.73** (0.21) | -5.67** (1.30) | -0.09 (0.07) | -0.53 (0.35) | -0.03 (0.17) | -0.37 (0.38) | -0.81** (0.31) | -0.28 (0.29) | -1.86** (0.41) |
| 3 | Barren and uncultivable land | 0.12* (0.07) | 0.03 (0.65) | 0.56** (0.19) | 0.10 (0.10) | -0.07 (0.27) | 0.09 (0.09) | -0.01 (0.12) | -0.54** (0.11) | -0.03 (0.11) |
| 4 | Land put to non-agricultural use | 0.04** (0.01) | -0.35** (0.09) | 0.17** (0.04) | 0.02 (0.04) | 0.002 (0.03) | 0.01 (0.02) | -0.01 (0.01) | -0.15* (0.07) | -0.01 (0.02) |
| 5 | Permanent pastures and other grazing | 0.02 (0.02) | -0.78** (0.25) | -0.03 (0.11) | 0.04* (0.02) | 0.01 (0.04) | -0.06 (0.04) | -0.06** (0.02) | 0.31** (0.05) | -0.07* (0.03) |
| 6 | Cultivable waste | -0.24** (0.06) | -0.05 (0.15) | 0.02 (0.02) | -0.03 (0.03) | -0.01 (0.08) | 0.01 (0.03) | 0.03 (0.13) | 0.24 (0.10) | -0.08 (0.07) |
| 7 | Miscellaneous tree crops and groves | 0.01 (0.03) | -0.60** (0.23) | 0.09** (0.02) | -0.001 (0.001) | 0.01 (0.03) | 0.003** (0.001) | 0.003** (0.001) | 0.08* (0.04) | -0.003 (0.002) |
| 8 | Current fallow | -0.03** (0.01) | -0.03 (0.08) | 0.003 (0.03) | 0.003 (0.01) | 0.16** (0.04) | 0.02 (0.02) | -0.002 (0.002) | 0.07* (0.03) | -0.03 (0.03) |
| 9 | Fallow other than current fallow | 0.03 (0.02) | -0.49* (0.24) | 0.14 (0.09) | 0.03 (0.03) | 0.14* (0.06) | 0.04 (0.04) | -0.08* (0.04) | 0.08* (0.04) | -0.11* (0.07) |
| 10 | Net area sown | 0.42** (0.17) | -2.03* (0.86) | 0.97** (0.21) | -0.16 (0.34) | 1.30** (0.23) | 0.21 (0.38) | -0.46** (0.18) | 1.19* (0.57) | -0.98 (0.85) |
| 11 | F-value | 45.94** | 8.79** | 16.48** | 3.66** | 6.31** | 7.91** | 2.93* | 28.82** | 4.43** |
| 12 | R ² | 0.93 | 0.71 | 0.82 | 0.51 | 0.64 | 0.69 | 0.45 | 0.89 | 0.56 |

Note: Figures in parentheses indicate standard errors, ** Significant at 1 % level, * Significant at 5 % level

Due to non-unavailability of data for some variables, analysis was not done for Grater Bombay district.

Table 4.59 contd . . .

| Sr. No. | Explanatory variables | Nashik | Jalgaon | Dhule | Aurangabad | Nanded | Osmanabad | Parbhani | Beed |
|---------|--------------------------------------|-------------------|--------------------|------------------|------------------|------------------|------------------|-------------------|-------------------|
| 1 | Intercept | 8.14 (5.08) | 7.62 (3.12) | 10.18 (11.36) | 0.31 (1.66) | -3.51 (6.17) | -0.60 (3.80) | -0.24 (0.83) | -10.90 (3.15) |
| 2 | Forest | -1.18** (0.27) | -0.32** (0.09) | -1.09* (0.56) | -0.22 (0.14) | 0.18 (0.17) | 0.05* (0.03) | -0.07 (0.06) | 0.14* (0.06) |
| 3 | Barren and uncultivable land | 0.17 (0.19) | -0.08* (0.04) | -0.12 (0.13) | -0.04 (0.16) | 0.02 (0.08) | 0.03 (0.09) | 0.10* (0.05) | -0.19* (0.10) |
| 4 | Land put to non-agricultural use | -0.004 (0.01) | -0.01** (0.005) | -0.07 (0.07) | -0.004 (0.03) | 0.21** (0.08) | -0.08 (0.10) | 0.01 (0.05) | -0.18* (0.09) |
| 5 | Permanent pastures and other grazing | 0.03 (0.04) | -0.003 (0.01) | 0.002 (0.03) | -0.02 (0.02) | -0.02 (0.05) | -0.03 (0.02) | 0.003 (0.01) | 0.22** (0.03) |
| 6 | Cultivable waste | -0.08 (0.09) | 0.01 (0.03) | -0.02 (0.03) | -0.08 (0.10) | -0.06 (0.06) | 0.12 (0.22) | -0.06** (0.02) | -0.08 (0.16) |
| 7 | Miscellaneous tree crops and groves | 0.01 (0.02) | -0.01 (0.01) | 0.02 (0.02) | -0.02 (0.02) | -0.01 (0.04) | 0.02 (0.02) | -0.04** (0.01) | -0.0007 (0.04) |
| 8 | Current fallow | 0.02 (0.03) | -0.002 (0.01) | 0.02* (0.01) | 0.02* (0.01) | 0.02 (0.04) | 0.03 (0.04) | 0.004 (0.005) | 0.14** (0.05) |
| 9 | Fallow other than current fallow | -0.04 (0.04) | -0.01 (0.01) | -0.003 (0.03) | 0.01 (0.01) | -0.05* (0.02) | -0.07* (0.03) | -0.02* (0.01) | 0.21** (0.04) |
| 10 | Net area sown | 0.0003 (0.38) | -0.55* (0.26) | -0.01 (0.71) | 0.17* (0.10) | 0.14 (0.58) | 0.002 (0.35) | 0.02 (0.07) | 0.91** (0.26) |
| 11 | F-value | 7.27** | 5.21** | 3.82** | 4.63** | 8.86** | 4.92** | 20.61** | 19.05** |
| 12 | R ² | 0.67 | 0.59 | 0.52 | 0.57 | 0.71 | 0.58 | 0.85 | 0.84 |

Note: Figures in parentheses indicate standard errors, ** Significant at 1 % level, * Significant at 5 % level

Table 4.59 contd

| Sr. No. | Explanatory variables | Buldhana | Akola | Amravati | Yavatmal | Wardha | Nagpur | Bhandara | Chandrapur |
|---------|--------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|-------------------|-------------------|
| 1 | Intercept | 2.50 (2.97) | 14.57 (3.46) | -5.58 (6.11) | 0.95 (5.74) | -23.14 (6.73) | -17.12 (4.25) | 22.46 (6.81) | -27.69 (11.03) |
| 2 | Forest | -0.13** (0.05) | -0.41** (0.05) | -0.51* (0.22) | 0.02 (0.20) | -0.12 (0.15) | 0.40* (0.17) | -1.10* (0.54) | 2.38** (0.86) |
| 3 | Barren and uncultivable land | -0.08** (0.03) | -0.02 (0.04) | -0.05 (0.07) | 0.04 (0.03) | -0.20** (0.05) | -0.03 (0.07) | -0.25** (0.09) | 0.13 (0.08) |
| 4 | Land put to non-agricultural use | 0.16** (0.02) | -0.01 (0.02) | 0.14** (0.05) | 0.06 (0.04) | 0.23 (0.14) | 0.07 (0.08) | -0.37* (0.17) | 0.30** (0.12) |
| 5 | Permanent pastures and other grazing | -0.02 (0.01) | 0.0009 (0.01) | -0.005 (0.02) | -0.03 (0.03) | 0.18* (0.08) | 0.09** (0.03) | -0.11 (0.07) | 0.02 (0.07) |
| 6 | Cultivable waste | -0.06* (0.03) | -0.12** (0.02) | -0.09** (0.03) | 0.03 (0.03) | 0.18 (0.22) | -0.22* (0.10) | -0.22 (0.24) | -0.01 (0.08) |
| 7 | Miscellaneous tree crops and groves | 0.01 (0.01) | -0.04** (0.01) | 0.04* (0.02) | -0.0005 (0.01) | -0.01 (0.06) | -0.06 (0.04) | -0.06 (0.04) | -0.02 (0.07) |
| 8 | Current fallow | 0.01 (0.01) | -0.01 (0.01) | 0.003 (0.02) | 0.02 (0.02) | 0.03 (0.03) | 0.08** (0.02) | -0.08** (0.02) | 0.05** (0.02) |
| 9 | Fallow other than current fallow | -0.03** (0.01) | -0.04* (0.02) | -0.01 (0.02) | -0.09** (0.02) | 0.10** (0.02) | 0.08** (0.03) | 0.01 (0.03) | -0.03 (0.03) |
| 10 | Net area sown | -0.22* (0.27) | -1.22** (0.34) | 1.04* (0.50) | -0.19 (0.39) | 2.37** (0.65) | 1.61** (0.35) | -0.98** (0.26) | 0.15 (0.33) |
| 11 | F-value | 53.16** | 46.12** | 47.39** | 23.71** | 45.36** | 35.75** | 13.46** | 29.08** |
| 12 | R ² | 0.94 | 0.93 | 0.93 | 0.87 | 0.93 | 0.91 | 0.79 | 0.89 |

Note: Figures in parentheses indicate standard errors, ** Significant at 1 % level, * Significant at 5 % level

Similar results on impact of land use shift on cropping intensity were reported by Wani *et al.* (2009) in Jammu and Kashmir, Gairhe *et al.* (2011) in Karnataka and Amale (2018) in Gujarat but references of impact of land use shift on crop diversification were not found. Except in some cases, it has been observed that almost in all the districts, regions and at the state level, changes in land use categories were reflect minute impact on cropping intensity and crop diversification in Maharashtra.

The hypothesis state that the cropping intensity and crop diversification does not change with changes in land use pattern has not been proved i.e null hypothesis has been rejected.

4.5 Ecological implications of land use dynamics

As per the methodology suggested by Pandey and Tewari (1987), Wani *et al.* (2009), Bardhan and Tewari (2010), Pushpa and Akashraj (2014) and Amale (2018), the total land endowment was conveniently grouped into three broad sectors, viz., (i) Ecological sector comprising of forest, permanent pastures and other grazing lands, miscellaneous trees and groves which is not included in the net area sown and barren and uncultivable land (ii) Non-agricultural sector comprising of area under non-agricultural uses, (iii) Agricultural sector comprising of cultivable wastes, net area sown, current fallow and fallows land other than current fallow. From this, the possible directions of major inter-sectoral as well as intra-sectoral land use shift were studied.

4.5.1 Intra-sectoral dynamics of land use

In the first objective of this study, percentage changes between Period-I and Period-II were worked out for land use categories under study. In this section, an attempt has been made to examine the absolute average annual changes in hectares terms in respect of each of the land use category for further budgeting of inter-sectoral land use shift.

4.5.1.1 Intra-sectoral dynamics of land use in India

A perusal of Table 4.60 and Figure 4.23 indicates the annual rate of change in land use categories at All India level. The results revealed that the land put to non-agricultural uses increased during Period-I as well as Period-II by more than 2,100 hundred hectares per annum. This could be attributed mainly to rapid industrialization, infrastructural development and population pressure.

As far as the ecological sector is concerned, forest area showed an annual increase of 4,550, 1,766 and 3,258 hundred hectares during the Period-I, Period-II and Overall Period, respectively; on the flip side, miscellaneous tree crops and groves, permanent pastures and other grazing lands and barren and uncultivable land showed decline during all the study periods. As permanent pastures and other grazing lands is a part of desirable land use category of ecological sector, it is noteworthy to mention that the rate of its annual decline was lower in Period-II over the Period-I, which in turn, can be considered as favorable situation. On the other hand, barren and uncultivable land is an undesirable land use category and the rate of decline in this category is of considerably low magnitude during the Period-II as compared to Period-I, which in turn, is a situation of concern for the policy makers.

In respect of agricultural sector, it is noteworthy to record here that the area under cultivable waste has showed annual decline of 1,404, 1,073 and 1,250 hundred hectares during the Period-I, Period-II and Overall Period, respectively at aggregate level of India. Fallow lands are also the undesirable land use categories. In India, area under fallows other than current fallow has showed decline by 506 hundred hecters annually during Period-I, however, this land use category was increased by 625 hundred hecters annually during Period-II, which is an unfavourable situation.

Table 4.60. Intra-sectoral dynamics of land use in India

(Annual rate of change in '00' ha)

| Sr. No. | Land use sector | Land use category | Period-I | Period-II | Overall |
|---------|-------------------|---|----------|-----------|----------|
| 1 | Non- agricultural | Land put to non-agricultural uses | 2126.60 | 2624.11 | 2357.59 |
| 2 | Ecological | Forest | 4550.07 | 1766.27 | 3257.59 |
| | | Miscellaneous tree crops and groves | -215.20 | -264.60 | -238.13 |
| | | Permanent pastures and other grazing land | -853.50 | -428.67 | -656.26 |
| | | Barren and uncultivable land | -5467.47 | -1154.30 | -3464.92 |
| 3 | Agricultural | Cultivable waste | -1403.90 | -1072.65 | -1250.11 |
| | | Current fallow | 733.77 | 560.75 | 653.44 |
| | | Fallow other than current fallow | -505.57 | 624.87 | 19.28 |
| | | Net area sown | 3223.53 | -1488.49 | 1035.81 |

Though, the area under current fallow in India increased in both the study periods, the annual rate of increase has lowered to 561 hundred hectares in Period-II from 734 hundred hectares in Period-I, which might be due to increasing irrigation facilities in the country.

In a nut shell, though the current fallow, cultivable waste land as well as the fallow other than current fallows are undesirable categories, among them area under cultivable waste land has declined during Period-II but on the same time, area under current fallow and fallow other than current fallow increased in India. It is interesting to note that India's efforts to expand cultivated land through wasteland reclamation are being hampered by a concurrent increase in fallow land.

As a desirable land use category, net area sown is expected to increase and it has showed an increase of 3,224 and 1,036 hundred hectares in Period-I and Overall Period, while it declined by 1,488 hundred hectares during Period-II in India. The decrease in net sown area might be caused by land conversion, either to fallow land or for non-agricultural purposes.

4.5.1.2 Intra-sectoral dynamics of land use in Maharashtra

It could be ascertained from Table 4.61 that during Period-I, land shifts have taken place from the forest, area under miscellaneous tree crops and groves, as well as barren and uncultivable lands as an ecological sector to other sectors. The permanent pastures and other grazing land was increased at an annual rate of 2,590 hectares, on the other hand, forest, area under miscellaneous tree crops and groves as well as barren and uncultivable lands declined annually by 30, 180 and 2,593 hectares, respectively. In the agricultural sector, there was a shift in land from current fallow and fallow other than current fallow to other sub-sectors during Period-I. Here current fallow and fallow other than current fallow showed an annual decline by 10,737 and 7,833 hectares, respectively. The cultivable waste and net sown area increased at an annual rate of 3,197 and 2,063 hectares. However, in case of non-agricultural sector, there was substantial increase in the area with the annual rate of 13,693 hectares, at aggregate of Maharashtra state.

The results furnished in Table 4.61 and Figure 4.24 revealed that, during the Period-II, land shifts have taken place from permanent pastures and other grazing land and forest land as an ecological sector by 10,381 and 8,292 hectares to other sectors,

respectively. However, barren and uncultivable lands and miscellaneous tree crops and groves have increased at an annual rate of 704 and 2,846 hectares, respectively. Earlier analysis (Table 4.1) revealed a decrease in forest area in Period-II over Period-I on average change basis, which was 53,738.13 and 52,540.06 hundred hectares for Period I and II, respectively. Also, we consider annual rate of change, forest area declined within both the study periods and it is a sign of ecological degradation as the proportion of forest area to the total reporting area of state is much lower (17.08%) to that of the national aggregate (22.96%) during Period-II. To maintain ecological balance and sustainability, the recommended share of forest to total geographical area is 33 per cent. To keep pace with the recommended level, the state has to initiate stiff actions and necessary policy provisions to restrain ecological imbalance.

Table 4.61. Intra-sectoral dynamics of land use in Maharashtra

(Annual rate of change in '00' ha)

| Sr. No. | Land use sector | Land use category | Period-I | Period-II | Overall |
|---------|-------------------|---|----------|-----------|---------|
| 1 | Non- agricultural | Land put to non-agricultural uses | 136.93 | 204.19 | 168.16 |
| 2 | Ecological | Forest | -0.30 | -82.92 | -38.66 |
| | | Miscellaneous tree crops and groves | -1.80 | 28.46 | 12.25 |
| | | Permanent pastures and other grazing land | 25.90 | -103.81 | -34.32 |
| | | Barren and uncultivable land | -25.93 | 7.04 | -10.63 |
| 3 | Agricultural | Cultivable waste | 31.97 | -39.92 | -1.41 |
| | | Current fallow | -107.37 | 202.69 | 36.59 |
| | | Fallow other than current fallow | -78.33 | 105.50 | 7.02 |
| | | Net area sown | 20.63 | -323.27 | -139.04 |

In agricultural sector, there was a shift in area towards fallow other than current fallow and current fallow from the net area sown and cultivable waste land. The net area sown and cultivable waste land were decreased by 32,327 and 3,992 hectares per annum, however, current fallow and fallow other than current fallow lands has increased by 20,269 and 10,550 hectares per annum, respectively during Period-II. The non-agricultural sector showed an increase in its area by 20,419 hectares annually during this

period against the annual increase of 13,693 hectares during Period-I. A relatively more increase in non-agricultural sector is unfavourable situation of land use. Since the land is limited to feed the millions of people in the country, its efficient use is utmost important.

A comparative land use shift between Period-I and II indicated that the shifting rate of barren and uncultivable land to other land use categories has annually declined in Period-I (2,593 hectares) but it has increased in Period-II (704 hectares) in ecological sector. Similar observation was made in respect of current fallow and fallow other than current fallow in agricultural sector. Within agricultural sector, area under current fallow and fallow other than current fallow observed to be decreased by 10,737 and 7,833 hectares per annum, respectively during Period-I and it tilted towards increased by 20,269 and 10,550 hectares per annum, respectively during Period-II. On the contrary, cultivable waste and net area sown increased by annual change of 3,197 and 2,063 hectares, respectively during Period-I, however, this land use categories were decreased by 3,992 and 32,327 hectares per annum, respectively in Period-II. This decline in net area sown is to be prime concern to researchers and policy makers.

For the Overall Period, it can be observed that land shift has taken place from the forest (3,866 hectares/annum), permanent pastures and other grazing lands (3,432 hectares/annum) and barren and uncultivable lands (1,063 hectares/annum) to another sector. Contrary, the area under miscellaneous tree crops and groves has increased at annual rate of 1,225 hectares. In agricultural sector, current fallow and fallow other than current fallow showed an annual increase of 3,659 and 702 hectares, respectively. At the level of Maharashtra state as a whole, cultivable waste land and net area sown have decreased substantially at the annual rate of 141 and 13,904 hectares, respectively at Overall Period. However, area under non-agricultural sector showed a considerable increase in its area to the extent of 16,816 hectares per annum at an aggregate of Maharashtra state.

An attempt has been made to analyse the district and regionwise intra-sectoral land use shift separately for each period under study and the results are depicted in Appendix-II and III. The results for the same are not discussed in this section but it was used for the next section *i.e.* budgeting of land use shift in different regions as well as at state level.

4.5.2 Budgeting of inter-sectoral land use shift

An attempt has been made in this section to estimate the land use shift in-between the major land use sectors. In inter-sectoral land use dynamics, the net change in the agricultural sector, if positive ($+\Delta A$), will be at the cost of the ecological sector, since there is little chance of land shift from the non-agricultural sector to the agricultural sector. If however, the net change in agricultural sector is negative ($-\Delta A$), the land use shift may occur due to either ecological (desirable and/or undesirable sub-sector) or non-agricultural sectors or both. Land use dynamics within the agricultural sector will also have important implications. If there is a positive net change to the agricultural sector ($+\Delta A$) and also an increase in the net sown area, the situation would be favorable for agricultural growth. But, if there is no addition to the net sown area, it would imply a situation where there is addition to cultivated area, on the one hand and depletion in cultivated area by means of land use shifts to current fallow, fallows other than current fallow and cultivable waste, on the other hand, thereby leaving the net sown area constant. This situation connotes a very adverse situation as an increase in the agricultural sector could occur at the cost of the desirable ecological sector. Further, this situation would require larger investments and efforts to reclaim waste lands.

4.5.2.1 Budgeting of inter-sectoral land use shift in India

The inter-sectoral budgeting analysis was carried out to find the pattern and extent of dynamics in land-use shifts at All India level and the results are given in Table 4.62 and Figure 4.25.

The results evoked that, during the Period-I, area under ecological sector has declined substantially at an annual rate of 198,610 hectares. Among various changes, the desirable ecology sector increased by 348,137 hectares and undesirable ecology sector decreased by 546,747 hectares implying the favourable land use shift in both the sub-sectors of ecology sector. Agricultural sector and non-agricultural sector showed a sizable growth in area at the annual rate of 204,783 hectares and 212,660 hectares, respectively during the Period-I.

An ecological sector was decreased by 8,129 hectares annually during Period-II. This decline happened even though the desirable ecology sector increased by 107,301 hectares per year. The reason for the overall decrease is that the undesirable

ecology sector shrank at a much faster rate, declined by 115,430 hectares annually. This highlights a favourable shift in land use within the ecological sectors. Agricultural sector showed a decline of 137,552 hectares per annum while, non-agricultural sector showed a notable growth in area at the annual rate of 262,411 hectares. As compared to Period-I, inter-sectoral budgeting in ecological sector was favourable in Period-II. As the area under the ecological sector declined by 198,610 hectares per annum in Period-I and by 8,129 hectares per annum in Period-II. There was a positive shift (204,783 hectares/annum) of land towards the agricultural sector during the Period-I, which tilted unfavourably during Period-II, where it declined by 137,552 hectares per annum at an aggregate of India. The shift of land from the agricultural sector to other sector may have serious implications towards agricultural growth and requires an immediate check. In order to achieve the doubling the farmers' income, the Government needs to initiate intensive efforts for minimizing the land shift from agriculture to non-agricultural sectors. Inter-sectoral budgeting estimates for non-agricultural sector at All India level have indicated less annual increase in Period-I (212,660 ha) as compare to Period-II (262411 ha). It is a fact that urbanization is unavoidable with increasing rate of development and to meet the tempo of urbanization, land investment in road infrastructure and industries is an unavoidable phenomenon. Hence, steadily growing population and shrinking net sown area, demand urgent evolution and adoption of technologies that augment land productivity. These agricultural land shifts towards non-agricultural uses pointed out towards a tremendous pressure of urban and industrial expansion on land use, which calls for a more rational approach in urbanisation and industrialisation policies.

Table 4.62. Budgeting of inter-sectoral land use shifts in India
(Annual rate of change in '00' ha)

| Sr. No. | Land use sector | Period-I | Period-II | Overall |
|---------|---|----------|-----------|----------|
| 1 | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | -1986.10 | -81.29 | -1101.72 |
| a. | Desirable ecological (ΔE_1) | 3481.37 | 1073.01 | 2363.20 |
| b. | Undesirable ecological (ΔE_2) | -5467.47 | -1154.30 | -3464.92 |
| 2 | Agricultural (ΔA) | 2047.83 | -1375.52 | 458.42 |
| 3 | Non-agricultural (ΔN) | 2126.60 | 26324.11 | 2357.59 |
| 4 | Net sectoral changes | 2188.33 | 1167.30 | 1714.28 |

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

During the Overall Period, at an aggregate of country level, ecological sector has annually declined by 110172 hectares. Among which, area under undesirable ecological sector has declined by 346492 hectares per annum while, the area under desirable ecological sector increased at an annual rate of 236320 hectares. The area under agricultural and non-agricultural sectors showed an annual increase of 45842 and 235759 hectares, respectively, during the Overall Period in India.

4.5.2.2 Budgeting of inter-sectoral land use shift in Maharashtra

The sectoral annual rate of change, as given in Table 4.63 and Figure 4.25, reveals that during the Period-I, at the Maharashtra state as a whole, area under ecological sector declined minimal at an annual rate of 213 hectares. At aggregate of Maharashtra, the desirable ecology sector annually increased by 2,380 hectares while, the undesirable ecology sector decreased by 2,593 hectares indicating the favourable land use shift in both the sub-sectors of ecology sector. Agricultural sector showed a substantial decline of 13,310 hectares per annum. On the other hand, non-agricultural sector showed a sizable growth in area at the annual rate of 13,693 hectares.

During the Period-II, the area under ecological sector has substantially decreased at an annual rate of 15,123 hectares, of which, the desirable ecology was declined by 15,827 hectares, whereas, the undesirable ecological sector was increased by 704 hectares. This change was due to increase in barren and uncultivable land in recent years. Decline of desirable ecological sector during this period was due to the decline of permanent pastures and other grazing land and forest area in Maharashtra. The agricultural sector showed decline in area by 5,500 hectares annually, which was due to extremely decline in net area sown and cultivable waste land. On the other hand, non-agricultural sector showed an annual growth of 20,419 hectares during the Period-II.

During the Overall Period, the area under ecological sector has decreased at an annual rate of 7,136 hectares, of which, the share of desirable ecology was 6,073 hectares (85.10%) and the share of undesirable ecological sector was 1,063 hectares (14.90%). Decline of undesirable ecological sector during this period was due to the decline of area barren and uncultivable land in Maharashtra. The area under agricultural sector showed an annual decrease of 9,684 hectares while, non-agricultural sector was annually increased by 16,816 hectares in the aforesaid period.

The comparative evaluation of land use shift between Period-I and Period-II indicates that, the area under ecological sector declined in both the periods, the rate of decline was more (15,123 hectares/annum) in Period-II over Period-I (213 hectares/annum). It is undesirable that the decline in area under ecological sector should be on account of tremendously decline in desirable ecology sector and the same was imitated during the Period-II. However, it is interesting to note that the scenario of area shifts under desirable ecology (E1) compared to undesirable ecology (E2) has not been favourable during Period-II and Overall Period, where land-use shift has been occurring from the desirable ecology towards either undesirable ecology and or non-agricultural sectors.

Table 4.63. Budgeting of inter-sectoral land use shifts in Maharashtra
(Annual rate of change in '00' ha)

| Sr. No. | Land use sector | Period-I | Period-II | Overall |
|---------|---|----------|-----------|---------|
| 1 | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | -2.13 | -151.23 | -71.36 |
| | a. Desirable ecological (ΔE_1) | 23.80 | -158.27 | -60.73 |
| | b. Undesirable ecological (ΔE_2) | -25.93 | 7.04 | -10.63 |
| 2 | Agricultural (ΔA) | -133.10 | -55.00 | -96.84 |
| 3 | Non-agricultural (ΔN) | 136.93 | 204.19 | 168.16 |
| 4 | Net sectoral changes | 1.70 | -2.04 | -0.04 |

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

At the state level, inter-sectoral budgeting for Period-I and Period-II indicates that, though the area under agricultural sector declined in both the periods, it is desired that the rate of decline was less (55,00 hectares/annum) in Period-II over Period-I (13,310 hectares/annum). It is noticed that the decline in area under agricultural sector should be on account of equal or relatively more increased in area under non-agricultural sector and the same was reflected during the all three study periods. It is noteworthy to mention here that the land shift from the agricultural sector is due to decrease in either net area sown or fallow lands. This can be confirmed from the earlier discussion, perusal of Table 4.61, clearly depicted that agricultural sector showed declining trend throughout all study periods. This may be due to the undesirable land use categories of agricultural sector, which were declined during Period-I, eventually sole decrease in agriculture

sector that was only due to the decrease in net area sown during Period-II and Overall Period. Against the constant growth of area under non-agricultural sector at the national level, the Maharashtra has experienced one-and-a-half times more annual increase in area under non-agricultural sector during Period-II (20,419 hectares/annum) over Period-I (13,693 hectares/annum). This was reflected that prominently agricultural land converted into non-agricultural uses during post liberalization period in Maharashtra. It may be noted from the analysis that at the national level, the net sectoral change during all the periods considered for the analysis has turned out to be positive. This type of phenomenon is not unique to present study.

4.5.2.3 Regionwise budgeting of inter-sectoral land use shifts in Maharashtra

The regionwise inter-sectoral land use shift experienced in Maharashtra during the periods under study has been estimated and the results are presented in Table 4.64, which are discussed in this section from ecological implications point of view.

During the Period-I, except Vidarbha region, all regions of Maharashtra showed an increase in the area under ecological sector among which, Marathwada region witnessed highest magnitude of annual increase to the extent of 1,983 hectares in area under ecology sector due to the result of increase in the area under desirable ecological sector (1,317 hectares/annum) and undesirable ecological sector (667 hectares/annum). Area under ecological sector has declined substantially in the Vidarbha region of Maharashtra at an annual rate of 5,797 hectares, out of which the share of desirable ecology was 3,637 hectares (62.74%) and the share of undesirable ecological sector was 2,160 hectares (37.26%). The declining rate in case of Vidarbha region may be due to the fact that area under permanent pasture and other grazing land (desirable ecological sector) and barren and uncultivable land (undesirable ecological sector) decreased by very high magnitude with tune of 2,300 and 2,160 hectares per annum, respectively in this region. This may be converted to agricultural purposes or non-agricultural uses also, during the Period-I.

During Period-II, all the regions of Maharashtra experienced the decline in area under ecological sector. The annual rate of decline was the highest in Vidarbha region with the magnitude of 8,069 hectares per annum, followed by Western Maharashtra, Marathwada and Konkan regions of Maharashtra. For the Overall Period,

mixed trend observed, where Konkan and Marathwada regions of Maharashtra showed an increase in area under ecological sector, whereas, Western Maharashtra and Vidarbha regions showed a decline in area under ecological sector indicating the need of efforts to check decline in desirable ecological sector i.e., forest, permanent pastures and other grazing lands and area under miscellaneous trees and groves. Policy makers should pay due attention for restructuring of land acquisition policies to bring more of the undesirable ecological sectors' land for development, sparing desirable ecological sector.

If we consider the sub-sectors of the ecological sector of land use i.e., desirable and undesirable ecological sectors separately during all periods of study, it has been seen that area under undesirable ecological sector declined in Konkan and Western Maharashtra regions, whereas, Marathwada region of Maharashtra showed an increase in undesirable ecology. On the other hand, the desirable ecological sector was increased in Konkan region, while, Vidarbha region was showed decline in desirable ecology sector. The favorable situation from ecological point of view was observed in case of Konkan region during all the three study periods, where area under desirable ecological sector increased by 2,490, 615 and 1,620 hectares per annum and undesirable ecological sector was decreased by 740, 850 and 791 hectares per annum during the Period-I, Period-II and Overall Period, respectively.

Also, in case of Western Maharashtra region, favorable situation with outlook of the ecological point was observed during Period-I. Where, area under desirable ecological sector increased by 2,210 hectares per annum, however, undesirable ecological sector was decreased by 360 hectares per annum during the Period-I. On the flip side, unfavorable ecological situation in Vidarbha region was noticed during Period-II, in which area under desirable ecological sector declined by 9,681 hectares per annum and area under undesirable ecological sector increased was by 1,612 hectares per annum and in Marathwada region area under desirable ecological sector declined by 1,785 and 123 hectares per annum and area under undesirable ecological sector increased was by 396 and 541 hectares per annum during Period-II and Overall Period, respectively.

The unfavorable 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 efforts from all

the stakeholders, particularly policy makers in changing agro-ecological situations to minimize the effects of climate change.

Area under agricultural sector has decreased in all regions except, Vidarbha region during all the three study periods. Agricultural sector was increased by 2,243, 3,254 and 2,713 hectares per annum during Period-I, Period-II and Overall Period, respectively in Vidarbha region of Maharashtra. This very high rate of increase in Vidarbha region was due to the fact that agricultural sector includes cultivable waste and fallow lands also. Contrary, the regions of Konkan, Western Maharashtra and Marathwada experienced the shift of land from agricultural sector to the other sectors during all study periods. The highest magnitude of decline in agricultural sector was to be found in Western Maharashtra region with the tune of 6,240, 5,873 and 6,070 hectares per annum during Period-I, Period-II and Overall Period, respectively. Further, it may be noted from the results that during Period-II, Western Maharashtra and Marathwada regions have showed decrease in area under agricultural sector which might be the impact of low rainfall in the respective regions of Maharashtra.

Table 4.64. Regionwise budgeting of inter-sectoral land use shifts in Maharashtra

| Sr. No. | Land use sector | Annual rate of change ('00' ha) | | | | | |
|---------|--|---------------------------------|-----------|---------|---------------------|-----------|---------|
| | | Konkan | | | Western Maharashtra | | |
| | | Period-I | Period-II | Overall | Period-I | Period-II | Overall |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | 17.50 | -2.35 | 8.29 | 18.50 | -54.31 | -15.30 |
| a. | Desirable ecological (ΔE_1) | 24.90 | 6.15 | 16.20 | 22.10 | -49.77 | -11.27 |
| b. | Undesirable ecological (ΔE_2) | -7.40 | -8.50 | -7.91 | -3.60 | -4.54 | -4.04 |
| 2. | Agricultural(ΔA) | -57.37 | -18.85 | -39.48 | -62.40 | -58.73 | -60.70 |
| 3. | Non-agricultural(ΔN) | 41.53 | 21.15 | 32.07 | 45.03 | 112.92 | 76.55 |
| 4. | Net sectoral changes | 1.67 | -0.04 | 0.88 | 1.13 | -0.12 | 0.55 |
| | | Marathwada | | | Vidarbha | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | 19.83 | -13.88 | 4.18 | -57.97 | -80.69 | -68.52 |
| a. | Desirable ecological (ΔE_1) | 13.17 | -17.85 | -1.23 | -36.37 | -96.81 | -64.43 |
| b. | Undesirable ecological (ΔE_2) | 6.67 | 3.96 | 5.41 | -21.60 | 16.12 | -4.09 |
| 2. | Agricultural(ΔA) | -35.77 | -9.96 | -23.79 | 22.43 | 32.54 | 27.13 |
| 3. | Non-agricultural(ΔN) | 15.83 | 23.83 | 19.55 | 34.53 | 46.27 | 39.98 |
| 4. | Net sectoral changes | -0.10 | 0.00 | -0.05 | -1.00 | -1.88 | -1.41 |

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

Area under non-agricultural sector has showed an increase in all the regions and during all three study periods. Where, the magnitude of annual rate of increase was the highest in Period-II as compared to Period-I in all regions of Maharashtra, except Konkan region, because of the fact that the most of the infrastructural developments were planned in the Period-II like major irrigation dams, power projects, national as well as state highways, etc. It was concluded that in all regions of Maharashtra state, area under non-agricultural use has increased.

It is a paradoxical situation that on the one hand, more production is required from the scarce soil resources for meeting the demand of ever-expanding population, while on the other, cultivable areas or area from ecological sector are being shifted towards non-agricultural uses. Changes in net sectoral changes has been seen in all the regions that were due to the changes in reporting areas in respective regions which is not unique for this study, as Wani *et al.* (2009), Bardhan and Tewari (2010), Gairhe (2011) and Baba *et al.* (2015) also observed the net sectoral changes in their study areas for different time periods.

4.5.2.4 Districtwise budgeting of inter-sectoral land use shift in Maharashtra

Districtwise budgeting of inter-sectoral land use shift in Maharashtra is given in Table 4.65. It is desired that the decline in area under ecological sector should be on account of equal or more decline in undesirable ecology sector, however, it is interesting to note that the scenario of area shifts under desirable ecology compared to undesirable ecology has not been found favorable across different districts. During Period-I, the unfavorable condition was observed from the ecological point of view in Greater Bombay, Nashik, Aurangabad, Buldhana and Amravati district, where, the area under undesirable ecological sector has increased with the tune of 93, 390, 13, 3 and 93 hectares per annum, respectively. However, the area under desirable ecological sector in these districts has declined by 107, 547, 477, 713 and 537 hectares per annum, respectively. The favorable situation was to be seen in Thane, Ratnagiri, Pune and Solapur districts of Maharashtra where, the area under undesirable ecological sector has decreased; on the contrast, area under desirable ecological sector has increased in these districts during Period-I.

As far as the Period-II is concerned, the unfavorable condition regarding ecological view was observed in Raigad, Pune, Solapur, Satara, Nanded, Buldhana,

Amravati, Yavatmal, Nagpur and Bhandara districts of Maharashtra. In these districts, area under the desirable ecological class was declined with the magnitude of 704, 696, 1,342, 242, 1,808, 1,196, 1,950, 1,138, 3,188 and 127 hectares per annum, respectively while area under undesirable ecological sector was increased with the tune of 212, 450, 81, 146, 296, 827, 27, 19, 777 and 4 hectares per annum, respectively. The notable observation that except Thane, Ratnagiri, Kolhapur, Dhule, Aurangabad, Osmanabad and Wardha districts, remaining all districts showed a decline in the area under the desirable ecological sector which may have serious implications in the long-run. There was no change in ecological sector within Greater Bombay district of Maharashtra. The Thane, Ratnagiri, Dhule and Aurangabad districts of Maharashtra were found in ecologically favorable condition, in which the area under undesirable ecological sector has decreased; on other hand, area under desirable ecological sector in these districts has increased during Period-II.

At the Overall Period, the unfavorable situation in ecological point of view was seen in Greater Bombay, Raigad, Nashik, Buldhana, Amravati and Nagpur districts of Maharashtra in which area under the desirable ecological class was declined with the magnitude of 57, 79, 784, 938, 1193 and 1564 hectares per annum, respectively; whereas area under undesirable ecological sector was increased in these districts with the tune of 50, 241, 5, 386, 63 and 300 hectares per annum, respectively. The favorable situation was to be seen in Thane, Ratnagiri, Sangli and Kolhapur districts of Maharashtra, where undesirable ecological sector has decreased with the tune of 614, 468, 109 and 48 hectares per annum, respectively. Conversely, the area under desirable ecological sector has increased in these districts with 1211, 545, 138, 4 hectares per annum, respectively during Overall Period.

The noted observation that, undesirable ecological sector has declined less than the decline of area under desirable ecological sector in Solapur, Jalgaon, Dhule, Aurangabad, Akola, Yavatmal and Chandrapur districts. This clearly implies that the area has shifted from desirable to undesirable ecological sector in these districts which may have long term negative environmental implications. It is worth noting that, from an ecological perspective, a favorable situation was observed in just two districts namely Thane and Ratnagiri districts. However, an unfavorable situation was identified in two other districts specially Buldhana and Amravati districts, across all three study periods.

Districtwise budgeting of inter-sectoral land use shift regarding the agricultural sector reveals that except the Ahmednagar, Jalgaon, Dhule, Akola, Amravati, Yavatmal, Wardha and Chandrapur, all other districts experienced the decline in area under agricultural sector within the range of 17 hectares per annum in Ratnagiri to 3380 hectares per annum in Satara during the Period-I. It is important to note here that more decline in Satara may be due to decline in current fallow land during this period. On the flip side, half of the districts of the Maharashtra state, experienced an increase in area under agricultural sector, during Period-II. It is a fact that agricultural sector of land use is sum total of net area sown along with the area under fallows and cultivable waste. 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.

Area under non-agricultural sector has increased in all the districts, during all the three periods except Nanded in Period-I and Aurangabad and Bhandara in Period-II, due to increasing population pressure, urban migration and industrialization. It is important to note here that the rate of expansion for the non-agricultural sector was slowed down in most districts during Period-II compared to Period-I. To sum up, the depletion in the desirable part of ecological sector has occurred through decline in forest cover in some districts. Moreover, the decline in area under permanent pasture and other grazing lands adversely affect the local village economy, where livestock enterprise is a major income contributor. This calls for consensus on policy to balance urbanization and growth of non-agricultural sector by blending state of technology, limited natural resource base and ecological concerns.

Similar results on budgeting of inter-sectoral land use shift in different areas for various time periods were reported by Pandey and Tewari (1987) in Uttar Pradesh, Sharma and Pandey (1992) in India, Ramasamy *et al.* (2005) in Tamil Nadu, Wani *et al.* (2009) in Jammu and Kashmir, Bardhan and Tewari (2010) in India, Gairhe (2011) in Karnataka, Sharma (2015) in India and Amale (2018) in Gujarat.

Based on the above results, the hypothesis state that the there is no land shift from one ecological sub-sector to the other sectors has not been proved i.e. null hypothesis has been rejected.

Table 4.65. Districtwise budgeting of inter-sectoral land use shifts in Maharashtra

| Sr. No. | Land use sector | Annual rate of change ('00' ha) | | | | | | | | | | | |
|---------|---|---------------------------------|--------|--------|----------------|--------|--------|---------------|-------|--------|---------------|-------|-------|
| | | P-I | P-II | OV | P-I | P-II | OV | P-I | P-II | OV | P-I | P-II | OV |
| | | Greater Bombay | | | Thane | | | Raigad | | | Ratnagiri | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | -0.13 | 0.00 | -0.07 | 12.30 | -1.35 | 5.96 | 7.30 | -4.92 | 1.63 | -1.97 | 3.92 | 0.77 |
| a. | Desirable ecological (ΔE_1) | -1.07 | 0.00 | -0.57 | 15.80 | 7.85 | 12.11 | 4.63 | -7.04 | -0.79 | 5.53 | 5.35 | 5.45 |
| b. | Undesirable ecological (ΔE_2) | 0.93 | 0.00 | 0.50 | -3.50 | -9.19 | -6.14 | 2.67 | 2.12 | 2.41 | -7.50 | -1.42 | -4.68 |
| 2. | Agricultural (ΔA) | -3.73 | -2.88 | -3.34 | -31.33 | -11.69 | -22.21 | -22.13 | 0.15 | -11.79 | -0.17 | -4.42 | -2.14 |
| 3. | Non-agricultural (ΔN) | 3.87 | 2.88 | 3.41 | 19.63 | 13.00 | 16.55 | 14.83 | 4.73 | 10.14 | 3.20 | 0.54 | 1.96 |
| 4. | Net sectoral changes | 0.00 | 0.00 | 0.00 | 0.60 | -0.04 | 0.30 | 0.00 | -0.04 | -0.02 | 1.07 | 0.04 | 0.59 |
| | | Pune | | | Solapur | | | Satara | | | Sangli | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | 7.03 | -2.46 | 2.63 | 4.63 | -12.62 | -3.38 | 30.80 | -0.96 | 16.05 | 5.50 | -5.73 | 0.29 |
| a. | Desirable ecological (ΔE_1) | 10.33 | -6.96 | 2.30 | 7.73 | -13.42 | -2.09 | 18.80 | -2.42 | 8.95 | 5.50 | -3.38 | 1.38 |
| b. | Undesirable ecological (ΔE_2) | -3.30 | 4.50 | 0.32 | -3.10 | 0.81 | -1.29 | 12.00 | 1.46 | 7.11 | 0.00 | -2.35 | -1.09 |
| 2. | Agricultural (ΔA) | -15.57 | -81.96 | -46.39 | -5.27 | 8.46 | 1.11 | -33.80 | -1.62 | -18.86 | -19.73 | 3.27 | -9.05 |
| 3. | Non-agricultural (ΔN) | 6.63 | 84.42 | 42.75 | 1.30 | 4.15 | 2.63 | 2.63 | 2.50 | 2.57 | 14.20 | 2.42 | 8.73 |
| 4. | Net sectoral changes | -1.90 | 0.00 | -1.02 | 0.67 | 0.00 | 0.36 | -0.37 | -0.08 | -0.23 | -0.03 | -0.04 | -0.04 |

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

P-I, P-II and OV indicate the Period-I, Period-II, Overall Period, respectively.

Table 4.65 contd.....

| Sr. No. | Land use sector | Annual rate of change ('00' ha) | | | | | | | | | | | |
|---------|--|---------------------------------|-------|-------|------------|-------|-------|--------|--------|-------|-----------|--------|-------|
| | | P-I | P-II | OV | P-I | P-II | OV | P-I | P-II | OV | P-I | P-II | OV |
| | | Kolhapur | | | Ahmednagar | | | Nashik | | | Jalgaon | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | -1.30 | 0.54 | -0.45 | -9.53 | -7.96 | -8.80 | -1.57 | -14.96 | -7.79 | -7.73 | -11.08 | -9.29 |
| a. | Desirable ecological (ΔE_1) | -0.20 | 0.31 | 0.04 | -4.67 | -4.04 | -4.38 | -5.47 | -10.58 | -7.84 | -7.63 | -10.92 | -9.16 |
| b. | Undesirable ecological (ΔE_2) | -1.10 | 0.23 | -0.48 | -4.87 | -3.92 | -4.43 | 3.90 | -4.38 | 0.05 | -0.10 | -0.15 | -0.13 |
| 2. | Agricultural (ΔA) | -3.50 | -1.77 | -2.70 | 5.50 | 5.73 | 5.61 | -3.67 | 4.73 | 0.23 | 3.53 | 10.12 | 6.59 |
| 3. | Non-agricultural (ΔN) | 4.80 | 1.35 | 3.20 | 4.07 | 2.15 | 3.18 | 5.00 | 10.19 | 7.41 | 4.20 | 0.96 | 2.70 |
| 4. | Net sectoral changes | 0.00 | 0.12 | 0.05 | 0.03 | -0.08 | -0.02 | -0.23 | -0.04 | -0.14 | 0.00 | 0.00 | 0.00 |
| | | Dhule | | | Aurangabad | | | Nanded | | | Osmanabad | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | -9.33 | 0.92 | -4.57 | -4.63 | 2.00 | -1.55 | 2.93 | -15.12 | -5.45 | 6.80 | 5.08 | 6.00 |
| a. | Desirable ecological (ΔE_1) | -2.30 | 1.65 | -0.46 | -4.77 | 2.62 | -1.34 | 4.83 | -18.08 | -5.80 | 5.67 | 2.58 | 4.23 |
| b. | Undesirable ecological (ΔE_2) | -7.03 | -0.73 | -4.11 | 0.13 | -0.62 | -0.21 | -1.90 | 2.96 | 0.36 | 1.13 | 2.50 | 1.77 |
| 2. | Agricultural (ΔA) | 10.10 | -5.69 | 2.77 | -6.87 | -1.73 | -4.48 | -1.77 | 9.15 | 3.30 | -6.97 | -11.69 | -9.16 |
| 3. | Non-agricultural (ΔN) | 2.20 | 4.77 | 3.39 | 11.50 | -0.23 | 6.05 | -1.23 | 5.96 | 2.11 | 0.13 | 6.58 | 3.13 |
| 4. | Net sectoral changes | 2.97 | 0.00 | 1.59 | 0.00 | 0.04 | 0.02 | -0.07 | 0.00 | -0.04 | -0.03 | -0.04 | -0.04 |

Note : The net sectoral change is equal to algebraic sum of $\Delta N + \Delta E_1 + \Delta E_2 + \Delta A$
P-I, P-II and OV indicate the Period-I, Period-II, Overall Period, respectively.

Table 4.65 contd.....

| Sr. No. | Land use sector | Annual rate of change ('00' ha) | | | | | | | | | | | |
|---------|--|---------------------------------|--------|--------|----------|--------|--------|----------|--------|-------|--------|--------|--------|
| | | P-I | P-II | OV | P-I | P-II | OV | P-I | P-II | OV | P-I | P-II | OV |
| | | Parbhani | | | Beed | | | Buldhana | | | Akola | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | 6.97 | -1.77 | 2.91 | 7.77 | -4.08 | 2.27 | -7.10 | -3.69 | -5.52 | -11.77 | -9.27 | -10.61 |
| a. | Desirable ecological (ΔE_1) | 3.83 | -1.31 | 1.45 | 3.60 | -3.65 | 0.23 | -7.13 | -11.96 | -9.38 | -5.70 | -7.81 | -6.68 |
| b. | Undesirable ecological (ΔE_2) | 3.13 | -0.46 | 1.46 | 4.17 | -0.42 | 2.04 | 0.03 | 8.27 | 3.86 | -6.07 | -1.46 | -3.93 |
| 2. | Agricultural (ΔA) | -7.00 | -2.85 | -5.07 | -13.17 | -2.85 | -8.38 | -1.83 | -0.65 | -1.29 | 6.57 | 4.77 | 5.73 |
| 3. | Non-agricultural (ΔN) | 0.00 | 4.62 | 2.14 | 5.43 | 6.92 | 6.13 | 5.53 | 4.38 | 5.00 | 5.20 | 4.50 | 4.88 |
| 4. | Net sectoral changes | -0.03 | 0.00 | -0.02 | 0.03 | 0.00 | 0.02 | -3.40 | 0.04 | -1.80 | 0.00 | 0.00 | 0.00 |
| | | Amravati | | | Yavatmal | | | Wardha | | | Nagpur | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | -4.43 | -19.23 | -11.30 | -22.83 | -11.19 | -17.43 | -3.63 | 7.65 | 1.61 | -2.70 | -24.12 | -12.64 |
| a. | Desirable ecological (ΔE_1) | -5.37 | -19.50 | -11.93 | -9.63 | -11.38 | -10.45 | -3.03 | 5.92 | 1.13 | -1.57 | -31.88 | -15.64 |
| b. | Undesirable ecological (ΔE_2) | 0.93 | 0.27 | 0.63 | -13.20 | 0.19 | -6.98 | -0.60 | 1.73 | 0.48 | -1.13 | 7.77 | 3.00 |
| 2. | Agricultural (ΔA) | 1.90 | 16.04 | 8.46 | 21.73 | 3.69 | 13.36 | 0.83 | -9.23 | -3.84 | -1.63 | 12.38 | 4.88 |
| 3. | Non-agricultural (ΔN) | 4.70 | 1.31 | 3.13 | 1.13 | 7.54 | 4.11 | 2.90 | 1.50 | 2.25 | 4.40 | 11.73 | 7.80 |
| 4. | Net sectoral changes | 2.17 | -1.88 | 0.29 | 0.03 | 0.04 | 0.04 | 0.10 | -0.08 | 0.02 | 0.07 | 0.00 | 0.04 |

Note : The net sectoral change is equal to algebraic sum of $\Delta N + \Delta E_1 + \Delta E_2 + \Delta A$
P-I, P-II and OV indicate the Period-I, Period-II, Overall Period, respectively.

Table 4.65 contd.....

| Sr. No. | Land use sector | Annual rate of change ('00' ha) | | | | | |
|---------|--|---------------------------------|-------|-------|------------|--------|--------|
| | | P-I | P-II | OV | P-I | P-II | OV |
| | | Bhandara | | | Chandrapur | | |
| 1. | Ecological ($\Delta E = \Delta E_1 + \Delta E_2$) | 4.07 | -1.23 | 1.61 | -9.57 | -19.62 | -14.23 |
| a. | Desirable ecological (ΔE_1) | 3.50 | -1.27 | 1.29 | -7.43 | -18.92 | -12.77 |
| b. | Undesirable ecological (ΔE_2) | 0.57 | 0.04 | 0.32 | -2.13 | -0.69 | -1.46 |
| 2. | Agricultural (ΔA) | -10.17 | 1.92 | -4.55 | 5.03 | 3.62 | 4.38 |
| 3. | Non-agricultural (ΔN) | 6.07 | -0.62 | 2.96 | 4.60 | 15.92 | 9.86 |
| 4. | Net sectoral changes | -0.03 | 0.08 | 0.02 | 0.07 | -0.08 | 0.00 |

Note : The net sectoral change is equal to algebraic sum of $\Delta N + \Delta E_1 + \Delta E_2 + \Delta A$
P-I, P-II and OV indicate the Period-I, Period-II, Overall Period, respectively.

5. SUMMARY AND CONCLUSIONS

A significant global challenge confronting agricultural policymakers revolves around ensuring food security for a growing population while simultaneously promoting sustainable natural resource management within the agricultural sector. This issue is particularly complex in developing countries like India, where land serves not only as a critical production factor but also as the fundamental means of livelihood for the majority of the population. The magnitude of the natural resource management challenge becomes evident when considering that India possesses a mere 2.4 per cent of the world's land and only 4.0 per cent of the world's freshwater resources, yet it must support 17.5 per cent of the global population (Anonymous, 2022b).

Land and water stand as paramount natural resources crucial for the developmental activities of any state or nation. However, land serves a dual purpose, being essential for both agricultural and non-agricultural endeavors, including housing, industries, road construction, parks, railway lines and various commercial enterprises. Unplanned diversification and urbanization often lead to unsustainable development patterns. While market-driven land uses may generate short-term profits, they can give rise to intractable problems for future generations due to the unregulated exploitation of these natural resources.

In general, development activities demand more land, raising concerns about potential encroachments on agricultural land, particularly fertile rural areas, due to the conflict between decreasing agricultural land availability and population growth, along with the increasing need for land in industrial and infrastructure development. This issue has garnered significant attention from political systems, academics, industry players, civil society and other stakeholders. It is widely perceived that large-scale conversions of agricultural land into non-agricultural uses have taken place and the acquisition of substantial portions of fertile land by corporate entities, resulting in the displacement of farmers, agricultural laborers and rural communities, has become a predominant political issue rather than merely a socio-economic one. It is imperative to ascertain whether these perceptions align with empirical evidence on land use competition and to identify the primary drivers contributing to the loss of agricultural land.

Understanding the patterns of land use is imperative for shaping future research strategies related to land use planning and policies. Economic rationality necessitates the efficient utilization of land to enhance societal welfare by addressing diverse needs. The configuration of land use is ultimately influenced by factors such as human settlement, socio-economic conditions, political dynamics, technological advancements and institutional changes. An examination of how the land use pattern evolves over time offers an opportunity for organized and prudent land management. Regrettably, there has been limited focus on a comprehensive study of land use dynamics in various districts and regions of Maharashtra. To address this gap, the study titled "An Economic Analysis of Land Use Dynamics in Maharashtra" was initiated with the following objectives.

1. To study temporal changes in land use pattern in Maharashtra.
2. To find out nature and extent of structural variations 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 crop diversification and cropping intensity.
5. To analyze the ecological implications of land use dynamics in Maharashtra.

The present study was based on the secondary data on land use for the period from 1960-61 to 2016-17, 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 Maharashtra State, Handbook of Basic Statistics of Maharashtra State published by the Directorate of Economics and Statistics (DES), Government of Maharashtra, Mumbai. The entire period of 1960-61 to 2016-17 was decomposed into three periods, viz; Pre-liberalization, Post- liberalization and Overall Period.

To achieve the specific objectives of the study, various appropriate analytical tools and techniques were employed. To assess the temporal changes in land use patterns, the study utilized methods such as calculating percentage changes, compound growth rates, instability indices and location coefficients. Markov Chain analysis was applied to examine the nature and extent of shifts in land use among land

use categories. Multiple regression analysis was utilized to identify the key factors responsible for driving changes in land use dynamics.

Furthermore, to assess the impact of land use shifts on cropping intensity and crop diversification, a multiple regression analysis in double log form was employed. Crop diversification was assessed using the Herfindahl Index (HI) method. To investigate both intra-sectoral and inter-sectoral shifts in land use, the land classes were grouped into three broad sectors: (i) Ecological sector, (ii) Non-agricultural sector and (iii) Agricultural sector. An annual rate of change was calculated to examine intra and inter-sectoral shifts.

5.1 Summary

1. The temporal changes in land use pattern of Maharashtra state as a whole envisaged that land put to non-agricultural uses, land under miscellaneous tree crops and groves, current fallow and fallow other than current fallow land have increased by 51.46, 23.78, 21.91 and 17.35 per cent, respectively. However, permanent pastures and other grazing lands, cultivable waste land, net area sown, area under forest and barren and uncultivable land have declined by 14.17, 4.24, 2.75, 2.23 and 1.91 per cent, respectively during Period-II over Period-I.
2. The noteworthy observations were that the area under forest and net area sown have been increased by 8.62 and 1.02 per cent at the national level, while in Maharashtra state, it decreased by 2.23 and 2.75 per cent, respectively during Period-II over the Period-I. At aggregate level of India, area under non-agricultural uses has increased by 36.52 per cent, while it has been increased by 51.46 per cent in case of Maharashtra between Period-I and Period-II, implying thereby almost one and a half times more increase in Maharashtra compared to that of India. The area under cultivable waste declined by 19.99 per cent in India during Period-II over the Period-I, while a decline was only 4.24 per cent for the Maharashtra state as a whole. The increase in area under current fallow and fallow other than current fallow was observed at Maharashtra state as well as at aggregate level of India, but the increase in case of Maharashtra was as high as 21.91 and 17.35 per cent, respectively, while it was only 13.32 and 7.25 per cent, respectively, at national level. Notable results of the comparative analysis of change in area sown more than once at India and Maharashtra is that it increased

by 74.08 per cent at country level, while it was 207.60 per cent in case of Maharashtra state during Period-II over the Period-I. Net irrigated area and gross irrigated area were increased at National as well as at State level but percentage change during the Period-II over the Period-I in both areas were found more at State level as compared to National level.

3. For Maharashtra state as a whole, area under forest has declined by 2.23 per cent during Period-II over period-I and the regionwise analysis revealed that the forest area increased in Konkan (3.48%) and Marathwada (1.65%), while it has declined in Western Maharashtra and Vidarbha by 5.38 and 1.62 per cent, respectively, during the Period-II over the Period-I. The area under forest has declined in 16 districts of Maharashtra, which ranged from 0.64 to 18.06 per cent in the Period-II over the Period-I. However, it increased in ten districts, among which, the highest increase was observed in Osmanabad (246.31%), followed by Parbhani (16.38%), Beed (10.52%), Thane (7.51%), Nanded (5.14%), etc. 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 tribal 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 Maharashtra.
4. Though at state level, barren and uncultivable land has declined by 1.91 per cent during the period of investigation, the area under barren and uncultivable land has declined in Konkan and Western Maharashtra by 5.49 and 4.17 per cent, respectively. On the other hand, it has increased by 21.35 and 7.26 per cent in Marathwada and Vidarbha, respectively during Period-II over the Period-I. The results revealed that the area under barren and uncultivable land showed notable increase in 14 districts with the highest increase in Nagpur (79.33%), followed Buldhana (57.29%), Osmanabad (52.94%), Wardha (52.20%), Beed (46.96%), Parbhani (35.29%), *etc.* Uncultivated land area increased mostly due to deforestation, overgrazing, over-cultivation and inadequate irrigation in these districts. The remaining districts of Maharashtra registered the decline (within the range of 0.32 to 26.27%) in the aforesaid land use category during Period-II over the Period-I.

5. The land put to non-agricultural uses has increased in all the districts and ultimately in all the regions of Maharashtra. It was the highest in Western Maharashtra (130.54%), followed by Konkan (83.26%), Vidarbha (29.82%) and Marathwada (23.48%) during Period-II over the Period-I. It is evident from the results that among all the districts, Nashik district showed the highest (455.24%) increase in area under non-agricultural uses during Period-II over the Period-I, which was followed by Solapur (285.77%), Pune (249.23%) Ahmednagar (150.59%), Sangli (140.38%), Thane (122.19%), Jalgaon (117.38%), Raigad (108.68%), etc., while the district of Parbhani recorded the lowest (5.88%) increase in area under non-agricultural uses during Period-II over the Period-I.
6. The area under permanent pastures and other grazing lands has decreased in all the regions of Maharashtra except Konkan region during Period-II over the Period-I. Moreover, it has also declined in 20 districts out of 26 districts of Maharashtra in the range of 2.77 to 48.33 per cent in the Period-II over the Period-I. The percentage decline in area under permanent pastures and other grazing lands was the highest in Greater Bombay (48.33%), followed by Nagpur (38.79%), Jalgaon (35.67%), Chandrapur (34.67%), Amravati (32.67%), etc. However, it has been increased in the Raigad, Satara, Ahmednagar, Ratnagiri, Pune and Kolhapur districts by 53.75, 27.51, 11.32, 11.27, 6.41 and 0.93 per cent, respectively during the Period-II over the Period-I.
7. It is revealed that, area under miscellaneous tree, crops and groves increased by 23.78 per cent during Period-II over period-I in Maharashtra. All regions of Maharashtra showed an increase in area under miscellaneous tree, crops and groves except Konkan region. The maximum increase was observed in Western Maharashtra (116.33%) followed by Marathwada (49.46%) and Vidarbha region (0.13%) whereas, it was declined in Konkan region by 1.26 per cent during Period-II over Period-I. The area under miscellaneous tree, crops and groves has observed to be increased in 18 districts in the range of 2.02 to 2880.77 per cent during the Period-II over the Period-I. The maximum change in area was recorded in Ahmednagar followed by Pune, Satara, Jalgaon, Osmanabad and Thane by 2880.77, 2446.43, 319.52, 216.01, 139.59 and 119.66 per cent, respectively.

8. All the regions of Maharashtra, except the Marathwada, experienced remarkable decline in cultivable waste. An alarming increase (41,667 hectares) in area under cultivable waste was experienced in Marathwada region during Period-II over the Period-I. The probability for increased cultivable waste area in Marathwada region might be prolong drought condition. Though the per cent increase was higher in Buldhana (54.92%) district in absolute term, an increase in area under cultivable waste was the highest in Osmanabad (19,232 hectares), followed by Satara (8,480 hectares), Nanded (8,063 hectares), Buldhana (7,836 hectares), Aurangabad (7,071 hectares), Ahmednagar (6,571 hectares), Pune (6,440 hectares), Nagpur (5,968 hectares) and Solapur (5,757 hectares) during aforesaid period.
9. It was observed from the results that the in area under fallow other than current fallow increased remarkable by 58.22, 15.79 and 13.55 per cent in Marathwada, Konkan and Western Maharashtra, respectively, while in Vidarbha it was decreased by 14.75 per cent in Period-II over the Period-I. The area under fallow other than current fallow increased in 12 districts of Maharashtra during Period-II over Period-I, where the changes were ranging from 6.01 to 118.83 per cent. During the aforesaid period, per cent increase was highest in Osmanabad (118.83%) followed by Wardha (118.16%), Aurangabad (118.11%), Ahmednagar (93.82%), Solapur (70.66%), Nagpur (37.54%), Parbhani (37.29%), *etc.*
10. The results revealed that the Vidarbha (103.68%), Western Maharashtra (38.34%) and Marathwada (2.48%) regions registered an increase in area under current fallow during Period-II over the Period-I. While Konkan region of Maharashtra showed decline in area under current fallow by 37.71 per cent during aforesaid period, which might have been caused by rapid urbanization in and around metropolitan cities. Area under current fallow declined in 17 districts of Maharashtra within the range of 8.30 to 684.88 per cent. The increased in area under current fallow was higher in Wardha (684.88%), followed by Ahmednagar (203.07%), Chandrapur (151.00%), Akola (127.91%), *etc.* It is notable observed that, Vidarbha region showed highest increase in area under current fallow by 103.68 per cent while area under fallow other than current fallow was declined by 14.75 per cent during Period-II over the Period-I.

11. The results of analysis in the Maharashtra state showed that net sown area was declined by 2.75 per cent during the Period- II over the Period-I. Also, all the regions in Maharashtra recorded decrease in net area sown during the aforesaid period. The conversion to non-agricultural uses and or fallow categories might have caused such decline in net sown area. It is explicitly observed that net area sown decreased in majority of the districts (17 out of 26) of Maharashtra within the range of 0.81 to 92.79 per cent during the Period- II over the Period-I.
12. Area sown more than once was increased by 207.60 per cent during the Period- II over the Period-I and reasons might be change in cropping pattern, availability of irrigation facilities, *etc.* The changes in area sown more than once at regional level indicates that Marathwada recorded the highest increase (290.74%), followed by Vidarbha (206.39%), Western Maharashtra (159.95%) and Konkan (39.88%). Almost in all the districts of Maharashtra, area sown more than once has increased in the range of 0.99 to 1078.86 per cent during Period-II over the Period-I, except Greater Bombay and Bhandara districts.
13. All the regions recorded positive changes in gross cropped area and cropping intensity during the aforesaid time period. The results revealed that area under gross cropped area increased in majority of districts (19 out of 26) of Maharashtra within the range of 2.27 to 56.98 per cent. Whereas, all the districts of Maharashtra recorded a remarkable increase in cropping intensity, except Greater Bombay, Bhandara, Thane, Wardha, Solapur, Satara and Raigad districts during Period-II over the Period-I.
14. In Maharashtra, results revealed that net irrigated area and gross irrigated area was increased by 87.78 and 96.75 per cent, respectively, during the Period- II over the Period-I. All the regions and districts of Maharashtra experienced increase in net as well as gross irrigated areas during Period-II over Period-I.
15. Land use trends in Maharashtra were identified through estimated growth rates in different land-use categories. During the Period-I, it was observed that land under permanent pastures and other grazing, area under culturable waste and land put to non-agricultural use significantly increased by 0.38, 0.75 and 1.95 per cent per annum, respectively. In contrast, under forest, barren and uncultivable land, fallow other than current fallow and current fallow and in Maharashtra

significantly declined by 0.05, 0.17, 0.79 and 1.62 per cent per annum, respectively during the Period-I. The results of instability indices showed that current fallow was more unstable (27.35%) while area under forest land was most stable (0.71%) as compared to other land use categories in Maharashtra state as a whole.

16. During the Period-II, barren and uncultivable land, area under fallow other than current fallow, land under miscellaneous tree crops and groves, land put to non-agricultural uses and current fallow in Maharashtra state as a whole increased significantly by 0.05, 0.61, 1.17, 1.18 and 1.75 per cent per annum, respectively. However, area under forest, net sown area, cultivable waste and permanent pastures and other grazing land significantly declined by 0.13, 0.18, 0.20 and 0.56 per cent per annum. The results of instability indices revealed that among all land use categories, land under miscellaneous tree crops and groves (5.28%) was more unstable followed by current fallow (5.05%), but at aggregate of fallow land (fallow other than current fallow and current fallow), it was to be found more unstable (7.91%). On the other hand, barren and uncultivable land (0.46%) and net sown area (0.46%) were least unstable in Maharashtra state as a whole. During all the three study periods, area sown more than once, net irrigated area and gross irrigated area increased significantly in Maharashtra state.
17. The results showed that during the Overall Period, area under fallow other than current fallow, current fallow, land under miscellaneous tree crops and groves and land put to non-agricultural uses increased significantly by 0.38, 0.49, 0.66 and 1.55 per cent per annum, respectively. In contrast, barren and uncultivable land, area under forest, net area sown and permanent pastures and other grazing land in Maharashtra state significantly declined by 0.07, 0.08, 0.09 and 0.39 per cent per annum, respectively during the Overall Period. The results of instability indices showed that the current fallow was more unstable (31.47%), while area under forest was most stable (0.43%) as compared to other land use categories in Maharashtra state as a whole.
18. As far as Overall Period concerned, the growth rates of gross cropped area, net irrigated area, gross irrigated area and area sown more than once increased by 0.43, 2.91, 3.07 and 4.04 per cent, respectively in Maharashtra state as a whole. It

is interesting to note that growth rates of area sown more than once, net irrigated area and gross irrigated area were low in Period-II as compared to Period-I. During all the three study periods, area sown more than once, gross cropped area, net irrigated area and gross irrigated area significantly increased in Maharashtra state.

19. The spatial distribution of forest land in Maharashtra reveals that the area under forest was more concentrated in the Vidarbha region of the state as compared to the other regions during all study periods. Districtwise location coefficient for area under forest indicate that the forest area was less concentrated in relatively dry and drought-prone regions of the state such as Osmanabad, Beed and Solapur districts of Maharashtra.
20. Region wise study of location coefficient of barren and uncultivable land revealed that Konkan region of Maharashtra was having high concentration, whereas, Marathwada region was observed lowest concentration than other regions during three study periods. The concentration of barren and uncultivable land was gradually increased in Marathwada and Vidarbha regions of Maharashtra in Period-II over Period-I.
21. During Period-II and Overall Period, among all regions of Maharashtra, Konkan region showed high concentration of land put to non-agricultural uses and Western Maharashtra was lowest. Almost all the districts from Konkan and Western Maharashtra regions witnessed increased concentration of the land put to non-agricultural uses in Period-II over Period-I. This is might be due to infrastructure development in urban area and expansion of roads in rural area.
22. The results of spatial dynamics of current fallow land in Maharashtra proclaimed that the current fallow land was more concentrated in the Marathwada region of the state as compared to the other regions of the state during all the study Periods. This is probably due to low rainfall and the limited availability of reliable sources of surface irrigation in the Marathwada region of the state.
23. The regionwise analysis manifested that Marathwada region was higher concentration in net area sown than other regions of Maharashtra with location coefficients of 1.36, 1.32 and 1.27 during Period-I, Period-II and Overall Period, respectively. The Concentration of net area sown in Marathwada region was

inclining towards lower concentration in Period-II over Period-I. This is serious problem regarding conversion of net area sown to other land use categories, which may adversely affect the agriculture production in future.

24. The results of First order Markov chain employed for analyzing the land use shift revealed that during Overall Period, land put to non-agricultural uses was more stable among all the land use categories with the retention of 98.27 per cent of its previous years' share at the national level followed by cultivable waste, barren and uncultivable land, net area sown, forest area, permanent pastures and other grazing land, fallow other than current fallow, land under miscellaneous tree, crops and groves and current fallow with retention of 94.09, 90.56, 88.00, 85.79, 85.54, 69.27, 64.68 and 4.65 per cent, respectively of its previous years' share during current year in India. As observed in Overall Period, net area sown was a major gainer among the different land use categories with the gain of 94.85, 35.32, 7.95, 3.60 and 1.71 per cent from current fallow, land under miscellaneous tree, crops and groves, barren and uncultivable land, permanent pastures and other grazing land and fallow other than current fallow, 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 4.65 per cent of its previous years' share in current year.
25. At Maharashtra state, the land put to non-agricultural uses was highly stable among all the land use categories with the retention of 98.95 per cent of its previous years' share in current year, whereas, barren and uncultivable land recorded as mostly unstable land use category during Overall Period, which experienced the retention of 71.88 per cent of its previous years share. Among the different land use categories in the overall period, net area sown was a major gainer among the different land use categories with the gain of 0.72, 28.12, 5.81, 5.92 and 6.53 per cent from forest land, barren and uncultivable land, permanent pastures and other grazing land, current fallow and fallow other than current fallow, respectively. The area under forest, land put to non-agricultural uses, cultivable waste land, permanent pastures and other grazing land, fallow other than current fallow and net area sown showed lower retention of its own previous

- years' share in current year during Period-II over the Period-I, indicating inclination of these land use categories towards the instability in recent years.
26. The area under different land use categories in Maharashtra were predicted for next thirty years (2020-21 to 2050-51) using TPM. The projected land use dynamics implying that the land use categories *viz*; area under forest, barren and uncultivable land, permanent pastures and other grazing land, land under miscellaneous tree, crops and groves, current fallow and fallow other than current fallow are expected to fail to retain their area in forthcoming years. On the other hand, the land put to non-agricultural uses is expected to rise in the future. However, mixed trend seen in cultivable waste land, which is likely to increase during first 10 years, then it is seen to be decrease from the year 2035-36 till 2050-51. On the flip side, net area sown is expected to rise up to year 2040-41, but in the subsequent years it is likely to decreases.
 27. Regionwise Markov chain analysis of land use pattern in Maharashtra during all study periods revealed that all regions showed probability of retention of its previous years' share in current year in case of net sown area. All regions of Maharashtra showed that net area sown was major gainer land use category from previous years' share of other land use categories during all the three study periods, except Konkan in Period-I and Marathwada in Overall Period.
 28. The results of the districtwise transitional probability matrix for the aforesaid three periods showed that the land use category of net area sown and land put to non-agricultural uses 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. The current fallow land was the most unstable land use category in majority of the districts of Maharashtra during all the periods under study.
 29. The results of multiple regression of double log analysis to study the causes for land use shift in Maharashtra during the period 1960-61 to 2016-17 indicated that the population has showed significantly negative influence on the area under forest. As far as the barren and uncultivable land is concerned, it was negatively influenced by the net irrigated area and road length in the state. The regression coefficients for both the variables were same i.e. 0.03 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 (0.19) and population density (0.35) were statistically significant. The net irrigated area (0.39) was negatively influencing on extent of cultivable waste land, whereas, road length (0.36) was positively influencing at the state level during the aforesaid period. The road length exerted negative and statistically significant influence to the extent of area under fallow other than current fallow with regression coefficient of 0.45. Conversely, the number of land holder with regression coefficient of 1.10, had positive and significant impact other fallow land during the period of study. As far as the net area sown is concerned, extent of net irrigated area showed positive influence on the net area sown in Maharashtra with the significant regression coefficient of 0.09, while population has negative influence on net area sown during the period of study.

30. Regionwise study of factors responsible for temporal changes in land use pattern in Maharashtra during the overall period showed that net sown area was influenced positively by changes in net irrigated area in Western Maharashtra and Marathwada region with regression coefficient of 0.11 and 0.12, respectively. The notable observation that number of land holders have positive and significant impact on area under fallow other than current fallow within all regions of Maharashtra.
31. 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 barren and uncultivable land and area put to non-agricultural uses. The regression coefficient of barren and uncultivable land (0.41) and land put to non-agricultural uses (0.24) signified that the increases in these land use categories would also compel to increase the cropping intensity at the Maharashtra state as a whole. However, cultivable waste land, permanent pastures and other grazing lands, fallow other than current fallow and net area sown have significant and negative impact on cropping intensity with regression coefficients of 0.22, 0.31, 0.15 and 1.31, respectively during the study period in Maharashtra State.

32. The regionwise study exhibited that cropping intensity was positively influenced by the land put to non-agricultural uses in all regions of Maharashtra. However, cultivable waste land has significant and negative impact on cropping intensity in all regions, except Konkan region of State during study period. The surprising relationship between net area sown and the cropping intensity was observed in the region of Konkan, where the regression coefficient of net area sown (0.18) 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 Konkan region leading in the area under fruit orchards and these annual crops are not replicated in enhancing the cropping intensity but added in the net area sown.
33. As far as districtwise impact of change in area under non-agricultural use on cropping intensity is concerned, cropping intensity was positively influenced in the twelve districts *viz.*, Ratnagiri, Pune, Kolhapur, Dhule, Aurangabad, Nanded, Osmanabad, Beed, Buldhana, Amravati, Yavatmal and Wardha with the statistically significant coefficients. 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. The fallow other than current fallow land was observed to have significantly positive influence on cropping intensity in Thane and Ratnagiri districts, however, it was having negative influence in Raigad, Pune, Sangli, Ahmednagar, Dhule, Nanded, Osmanabad and Akola districts. In case of Ahmednagar and Akola district, the cropping intensity was negatively influenced by area under fallow other than current fallow because of the degradation of land especially from the area where intensive agriculture is practiced.
34. The analysis of impact of change in land use categories on the crop diversification revealed that all the land use categories explain 89 per cent of variation in crop diversification in Maharashtra. Area under forest (1.10), land put to non-agricultural uses (0.12) and area under miscellaneous tree crops and groves (0.11) has showed positive and significant impact on crop diversification during whole study period in Maharashtra State as a whole. The impact of change in area under cultivable waste and permanent pastures and other grazing lands on crop

diversification was negatively influenced with the statistically significant regression coefficient of 0.13 and 0.18, respectively during the study period in Maharashtra.

35. Area under land put to non-agricultural uses showed significant and positive impact on crop diversification in Konkan and Vidarbha regions of Maharashtra, whereas, Western Maharashtra and Marathwada regions were showed significantly positive impact of barren and uncultivable land on crop diversification during the study period. Diversifying crops might be a strategic response by farmers to the pressure from these land use categories, with the goal of maintaining or even increasing their agricultural income. On the other hand, cultivable waste land was negatively influenced on crop diversification in Western Maharashtra, Marathwada and Vidarbha regions of Maharashtra. Area under fallow other than current fallow in Konkan (0.20) and Vidarbha region (0.06), while area under forest in Western Maharashtra region (1.09) was having negative and significant influence on crop diversification in study period. Crop diversification was negatively influenced by the permanent pastures and other grazing land in Konkan, Marathwada and Vidarbha regions of Maharashtra with regression coefficient of 0.56, 0.21 and 0.15, respectively.
36. The districtwise study of impact of change in land use categories on crop diversification revealed that Raigad, Sangli, Ahmednagar, Nashik, Jalgaon, Dhule, Buldhana, Akola, Amravati and Bhandara districts showed significantly negative influence of area under forest on the crop diversification, while it was positively influenced by forest in Thane, Osmanabad, Beed, Nagpur and Chandrapur districts during entire study period. The Kolhapur, Jalgaon, Beed, Buldhana, Wardha and Bhandara districts of Maharashtra experienced the negative and significant influence of barren and uncultivable land on crop diversification, whereas, Thane, Ratnagiri and Parbhani districts were shown to have positive and significant impact on crop diversification. As far as the impact of change in area under non-agricultural use on crop diversification is concerned, crop diversification was positively influenced in the districts of Thane, Ratnagiri, Nanded, Amravati and Chandrapur by land put under non-agricultural uses with the statistically significant regression coefficients of 0.04, 0.17, 0.21, 0.14 and

- 0.30, respectively during the study period. However, negative and significant effect of area under non-agricultural uses on crop diversification in Raigad, Kolhapur, Jalgaon, Beed and Bhandara districts during study period.
37. During entire study period, net area sown has showed negative influence on crop diversification in Raigad, Sangli, Jalgaon, Buldhana. Akola and Bhandara. Though, the Thane, Ratnagiri, Solapur, Kolhapur, Aurangabad, Beed, Amravati, Wardha and Nagpur experienced significant and positive impact on crop diversification.
 38. 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 favorable in Period-II at the national level. As the area under the ecological sector declined by 198,610 hectares per annum in Period-I and by 8,129 hectares per annum in Period-II. There was a positive shift (20,4783 hectare/annum) of land towards the agricultural sector during the Period-I, which tilted unfavourably during Period-II, where it declined by 137,552 hectares per annum at an aggregate of India.
 39. For the state level, the comparative evaluation of land use shift between Period-I and Period-II indicates that the area under ecological sector declined in both the periods, the rate of decline was more (15,123 hectares/annum) in Period-II over Period-I (213 hectares/annum). It is undesired that the decline in area under ecological sector should be on account of tremendously decline in desirable ecology sector and the same was imitated during the Period-II. However, it is interesting to note that the scenario of area shifts under desirable ecology (E1) compared to undesirable ecology (E2) has not been favourable during Period-II and Overall Period, where land-use shift has been occurring from the desirable ecology towards either undesirable ecology and or non-agricultural sectors.
 40. At the state level, inter-sectoral budgeting for Period-I and Period-II indicates that though the area under agricultural sector declined in both the periods, it is desired that the rate of decline was less (5,500 hectares/annum) in Period-II over Period-I (13,310 hectares/annum). It is noticed that the decline in area under agricultural sector should be on account of equal or relatively more increased in area under non-agricultural sector and the same was reflected during the all three study

periods. Against the constant growth of area under non-agricultural sector at the national level, the Maharashtra has experience one-and-a-half times more annual increase in area under non-agricultural sector during Period-II (20,419 hectares/annum) over Period-I (13,693 hectares/annum). This was reflected that prominently agricultural land converted into non-agricultural uses during post liberalization in Maharashtra.

41. The regionwise inter-sectoral land use shift experienced in Maharashtra during the periods under study. Analysis done for the sub-sectors of the ecological sector of land use i.e. desirable and undesirable ecological sectors separately during all periods of study. The favorable situation from ecological point of view was observed in case of Konkan region during all the three periods and Western Maharashtra region during Period-I. On the flip side, Marathwada region was noticed unfavorable situation from ecological point of view in Period-II and Overall Period. As far as desirable ecology concerned, unfavorable situation was observed in Western Maharashtra and Marathwada region during Period-II and Overall Period and in Vidarbha region during all the study periods. On the other hand, undesirable ecology was increased during all three study periods in Marathwada region and Period-II in Vidarbha region. This is alarming situation in Marathwada and Vidarbha region of Maharashtra, where, unfavorable trends of desirable and undesirable ecological sectors, which lead to the degeneration of this important natural resource.
42. The area under agricultural sector has decreased in all regions during all three study periods, except Vidarbha region. Agricultural sector was increased by 2,243, 3,254 and 2,713 hectares per annum during Period-I, Period-II and Overall Period, respectively in Vidarbha region of Maharashtra. On the contrary, the regions of Konkan, Western Maharashtra and Marathwada experienced the shift of land from agricultural sector to the other sectors during all study periods. Further, it may be noted from the results that during Period-II, Western Maharashtra and Marathwada regions have showed decrease in area under agricultural sector, which might be the impact of low rainfall in the respective regions of Maharashtra.

43. The area under non-agricultural sector has showed an increase in all the regions and during all three study periods. Where, the magnitude of annual rate of increase was the highest in Period-II as compared to Period-I in all regions of Maharashtra, except Konkan region, because of the fact that the most of the infrastructural developments were planned in the Period-II.
44. District wise budgeting of inter-sectoral land use shift in Maharashtra implying that the area shifts under desirable ecology compared to undesirable ecology has not been found favorable across different districts. During Period-II, except Thane, Ratnagiri, Kolhapur, Dhule, Aurangabad, Osmanabad and Wardha, remaining all 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 majority of districts (15 out of 26 districts) viz; Raigad, Pune, Solapur, Satara, Kolhapur, Nanded, Osmanabad, Parbhani, Beed, Buldhana, Amravati, Yavatmal, Wardha, Nagpur and Bhandara during the Period-II. It is worth noting that from an ecological perspective, a favorable situation was observed in just two districts namely Thane and Ratnagiri districts. However, an unfavorable situation was identified in two other districts specially Buldhana and Amravati districts, across all three study periods.
45. Inter-sectoral land use shift in case of agricultural sector reveals that except Ahmednagar, Jalgaon, Dhule, Akola, Amravati, Yavatmal, Wardha and Chandrapur, all other districts experienced decline in area under agricultural sector during Period-I. Similarly, more than half of the districts of the Maharashtra state experienced decrease 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; from the ecological point of view, which can be considered as desirable one over the increase in undesirable ecological and non-agricultural sector. In almost all districts of Maharashtra, area under non-agricultural sector has increased during all the three periods except Nanded in Period-I and Aurangabad and Bhandara during Period-II.

5.2 Conclusions

1. The temporal changes in land use patterns of Maharashtra state as a whole showed significant shift. The forest cover in the state is about 17.08 per cent during Period-II, which is far below the minimum suggested level of at least one-third of the geographical area and it was declined by 2.23 per cent of Period- II over Period-I.
2. The growth rate for entire period was revealed that the highest positive growth rate was observed in current fallow land, however net area sown was found declined significantly during post liberational period in Maharashtra state as a whole.
3. The results of instability indices in Maharashtra state for the overall period showed that current fallow land was the most unstable land use category. Interestingly, all districts, regions and Maharashtra as a whole exhibited greater stability in current fallow land during Period-II compared to Period-I.
4. The studies on the spatial dynamics on land use in Maharashtra found that Marathwada consistently had a higher proportion of both current fallow land and net area sown compared to other regions. Marathwada has a higher concentration of current fallow land because it relies heavily on dryland agriculture. However, there's also a trend of net area sown being converted to other land use categories in this region.
5. The proportions of all land use categories remained relatively stable during the three study periods. However, the overall period revealed that net sown area showed the most significant increase in area, gaining major share from barren and uncultivable land. For Maharashtra state as a whole, barren and uncultivable land recorded as most unstable, whereas land put to non-agricultural uses has most stable land use category during the Overall Period.
6. In Maharashtra state, the projected land use dynamics imply that several land-use categories, such as forest area, barren land, pastures and fallow land, will decrease in some regions in the coming years. On the other hand, net sown area is projected to rise until around 2040-41 in many regions, but then potentially decrease.

7. The study on factors responsible for change in land use in Maharashtra stated that the area under permanent pastures and other grazing land was negatively influenced by the population especially in Marathwada and Vidarbha regions.
8. The results of multiple linear regression analysis in Maharashtra suggest that an increase in the net irrigated area during the study period has a positive influence on net sown area. This likely happens because the increase in irrigation leads to a decrease in barren and cultivable wasteland, converting it into land suitable for cultivation.
9. The study of impact of changes in land use patterns on cropping intensity and crop diversification observed that change in land put to non-agricultural uses positively influenced however, change in cultivable wasteland negatively influenced on cropping intensity and crop diversification during study period in Maharashtra.
10. At the overall level, the outcome of ecological implication in Maharashtra revealed that the ecological sector was declined due to the desirable ecology sector has been decreased, which includes area under forest and permanent pastures and other grazing lands and it is a sign of ecological degradation. While, the area under the agricultural sector annually decreased by 9,684 hectares due to a declined the net area sown and cultivable wasteland and the same situation was found in Period -II.
11. The findings of ecological study in Maharashtra exhibited that the undesirable ecological sector had increased by 704 hectares per annum during Period II, which was primarily due to the expansion of barren and uncultivable land in the state.

5.3 Policy Implications

1. The concerted efforts are needed to increase forest cover. This can be achieving by planting trees (afforestation) on barren and uncultivable lands, which comprise 5.59 per cent of the state's total geographical area. This initiative is crucial for maintaining ecological balance and achieving sustainability. To reach this goal, the forest cover needs to be increased to at least 33 per cent of the total geographical area.

2. Expanding the area under agriculture has limitations. However, there's potential to increase cultivation in other ways. This can be achieved by utilizing 6.92% of cultivable wasteland and fallows land. Providing farmers with the necessary inputs and infrastructure to improve land productivity is one way. Furthermore, implementing state land-use policies to regulate the conversion of cultivable land for non-agricultural purposes is crucial for ensuring long-term food security.
3. The livestock sector faces a significant challenge due to a decline in pastures and grazing lands. This decline is a result of a concerning trend: land use is shifting away from desirable ecological areas (forests, pastures) towards non-agricultural purposes. This shift has serious ecological implications and demands immediate attention from policymakers and all stakeholders. By working together to conserve existing pastures, create fodder banks and incorporate silage systems, we can address the fodder shortage and minimize the impact of climate change on our agro-ecological situation.
4. A major reason for land lying fallow is the scarcity of irrigation facilities. To address this, increasing irrigation access and water conservation through small-scale water harvesting structures like farm ponds and percolation tanks are crucial sources to increasing the maximum land under cultivation.
5. The unfavorable 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.
6. 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, for holistic rural development, natural resource management and eco-restoration.

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7. APPENDIX

Appendix-I

I. Definitions of land use categories

Forest area : This includes all land classified either as forest under any legal enactment, or administered as forest, whether State-owned or private and whether wooded or maintained as potential forest land. The area of crops raised in the forest and grazing lands or areas open for grazing within the forests remain included under the "forest area".

Area under non-agricultural uses : This includes all land occupied by buildings, roads and railways or under water *e.g.* rivers and canals and other land put to uses other than agriculture.

Barren and uncultivable land : This includes all land covered by mountains, deserts, *etc.* land, which cannot be brought under cultivation except at an exorbitant cost is classified as uncultivable whether such land is in isolated blocks or within cultivated holdings.

Permanent pasture and other grazing land : This include all grazing land whether it is permanent pasture/meadows or not. Village common grazing land is included under this category.

Land under miscellaneous tree crops, *etc.* : This includes all cultivable land, which is not included in 'Net area sown' but is put to some agricultural use. Land under casuarina trees, thatching grasses, bamboo bushes and other groves for fuel, *etc.* which are not included under 'Orchards' are classified under this category.

Culturable waste land : This includes land available for cultivation, whether taken up or not taken up for cultivation once, but not cultivated during the last five years or more in succession including the current year for some reason or the other. Such land may be either fallow or covered with shrubs and jungles, which are not put to any use. They may be accessible or inaccessible and may lie in isolated blocks or within cultivated holdings.

Fallow lands other than current fallows : This includes all land, which was taken up for cultivation but is temporarily out of cultivation for a period of not less than one year and not more than five years.

Current fallows : This represents cropped area, which is kept fallow during the current year.

Net area sown : This represents the total area sown with crops and orchards.

II. Definitions of some commonly used terms in land use statistics:

Geographical area : The latest figures of geographical area of the State/Union

Reporting area for land utilization statistics : The reporting area stands for the area for which data on land use classification is available. In areas where land utilization figures are based on land records, reporting area is the area according to village papers, *i.e.* the papers prepared by the village accountants. In some cases, the village papers may not be maintained in respect of the entire area of the State. For example, village papers are not prepared for the forest areas but the magnitude of such area is known. Also, there are tracts in many states for which no village paper exists. In such cases, estimates of classification of area from agriculture census, 2000-01 and 2005-06 are adopted to complete the coverage.

Gross cropped area : This represents the total area sown once and/or more than once in a particular year, *i.e.* the area is counted as many times as there are sowings in a year. This total area is also known as total cropped area or total area sown.

Area sown more than once : This represents the areas on which crops are cultivated more than once during the agricultural year. This is obtained by deducting net area sown from gross cropped area.

Irrigated area : The area is assumed to be irrigated for cultivation through such sources as canals (Govt. and Private), tanks, tube-wells, other wells and other sources.

Net irrigated area : It is the area irrigated through any source once in a year for a particular crop.

Net un-irrigated area : It is the area arrived at by deducting the net irrigated area from net sown area.

Gross irrigated area : It is the total area under crops, irrigated once and/or more than once in a year. It is counted as many times as the number of times the areas are cropped and irrigated in a year.

Gross un-irrigated area : It is the area arrived at by deducting the gross irrigated area from the gross sown area.

Cropping intensity : It is the ratio of total cropped area to net area sown.

Agricultural land/total culturable land/total arable land : This consists of net area sown, current fallows, fallow lands other than current fallows, culturable waste land and land under miscellaneous tree crops (Anon., 2019a).

Appendix-II

District wise intra- sectoral dynamics of land use in Maharashtra

(Annual rate of change in “00” hectares)

| Districts | Periods | Ecological Sector (E) | | | | | NA | Agricultural Sector | | | | |
|----------------|-----------|----------------------------------|-------|--------|-----------------|------------------------------------|-------|---------------------|--------|--------|--------|--------------|
| | | Desirable ecological Sector (E1) | | | | Undesirable ecological sector (E2) | | CW | CF | OF | NAS | CW+CF+OF+NAS |
| | | FR | MT | PP | FR + Misc. + PP | | | | | | | |
| Greater Bombay | Period-I | 0.03 | -0.13 | -0.97 | -1.07 | 0.93 | 3.87 | -0.73 | -0.43 | -0.50 | -2.07 | -3.73 |
| | Period-II | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2.88 | -1.04 | -0.08 | -0.81 | -0.96 | -2.88 |
| | Overall | 0.02 | -0.07 | -0.52 | -0.57 | 0.50 | 3.41 | -0.88 | -0.27 | -0.64 | -1.55 | -3.34 |
| Thane | Period-I | 3.10 | -0.73 | 13.43 | 15.80 | -3.50 | 19.63 | 9.50 | -18.33 | -15.00 | -7.50 | -31.33 |
| | Period-II | 10.69 | 7.31 | -10.15 | 7.85 | -9.19 | 13.00 | -2.27 | -4.23 | 3.19 | -8.38 | -11.69 |
| | Overall | 6.63 | 3.00 | 2.48 | 12.11 | -6.14 | 16.55 | 4.04 | -11.79 | -6.55 | -7.91 | -22.21 |
| Raigad | Period-I | -0.60 | -3.97 | 9.20 | 4.63 | 2.67 | 14.83 | -8.07 | -2.10 | -1.93 | -10.03 | -22.13 |
| | Period-II | -6.19 | -0.85 | 0.00 | -7.04 | 2.12 | 4.73 | -0.04 | -1.77 | 1.92 | 0.04 | 0.15 |
| | Overall | -3.20 | -2.52 | 4.93 | -0.79 | 2.41 | 10.14 | -4.34 | -1.95 | -0.14 | -5.36 | -11.79 |
| Ratnagiri | Period-I | 4.47 | -2.17 | 3.23 | 5.53 | -7.50 | 3.20 | 23.13 | -9.40 | -1.37 | -12.53 | -0.17 |
| | Period-II | -0.54 | 5.04 | 0.85 | 5.35 | -1.42 | 0.54 | -45.69 | 5.12 | 15.42 | 20.73 | -4.42 |
| | Overall | 2.14 | 1.18 | 2.13 | 5.45 | -4.68 | 1.96 | -8.82 | -2.66 | 6.43 | 2.91 | -2.14 |
| Pune | Period-I | -3.37 | 0.23 | 13.47 | 10.33 | -3.30 | 6.63 | 9.67 | 0.70 | -35.40 | 9.47 | -15.57 |
| | Period-II | -9.15 | 5.19 | -3.00 | -6.96 | 4.50 | 84.42 | 2.04 | 14.04 | -0.69 | -97.35 | -81.96 |
| | Overall | -6.05 | 2.54 | 5.82 | 2.30 | 0.32 | 42.75 | 6.13 | 6.89 | -19.29 | -40.13 | -46.39 |
| Solapur | Period-I | 0.87 | 0.37 | 6.50 | 7.73 | -3.10 | 1.30 | 3.70 | 2.23 | 14.93 | -26.13 | -5.27 |
| | Period-II | -0.69 | 1.08 | -13.81 | -13.42 | 0.81 | 4.15 | 0.35 | 22.15 | 13.92 | -27.96 | 8.46 |
| | Overall | 0.14 | 0.70 | -2.93 | -2.09 | -1.29 | 2.63 | 2.14 | 11.48 | 14.46 | -26.98 | 1.11 |
| Satara | Period-I | -0.63 | 2.27 | 17.17 | 18.80 | 12.00 | 2.63 | 10.40 | -22.53 | 11.47 | -33.13 | -33.80 |
| | Period-II | -1.54 | 0.38 | -1.27 | -2.42 | 1.46 | 2.50 | 0.35 | 5.12 | 8.85 | -15.92 | -1.62 |
| | Overall | -1.05 | 1.39 | 8.61 | 8.95 | 7.11 | 2.57 | 5.73 | -9.70 | 10.25 | -25.14 | -18.86 |
| Sangli | Period-I | 1.60 | 4.73 | -0.83 | 5.50 | 0.00 | 14.20 | -0.60 | 12.43 | -14.53 | -17.03 | -19.73 |
| | Period-II | -2.96 | 0.73 | -1.15 | -3.38 | -2.35 | 2.42 | 3.12 | -2.38 | 2.46 | 0.08 | 3.27 |
| | Overall | -0.52 | 2.88 | -0.98 | 1.38 | -1.09 | 8.73 | 1.13 | 5.55 | -6.64 | -9.09 | -9.05 |

Appendix-II contd...

| Districts | Periods | Ecological Sector (E) | | | | | NA | Agricultural Sector | | | | |
|------------|-----------|----------------------------------|-------|--------|-----------------|------------------------------------|-------|---------------------|--------|-------|--------|--------------|
| | | Desirable ecological Sector (E1) | | | | Undesirable ecological sector (E2) | | CW | CF | OF | NAS | CW+CF+OF+NAS |
| | | FR | MT | PP | FR + Misc. + PP | | | | | | | |
| Kolhapur | Period-I | 1.20 | -0.03 | -1.37 | -0.20 | -1.10 | 4.80 | -11.37 | 4.33 | -0.37 | 3.90 | -3.50 |
| | Period-II | -0.50 | 0.92 | -0.12 | 0.31 | 0.23 | 1.35 | -4.23 | -5.38 | -3.46 | 11.31 | -1.77 |
| | Overall | 0.41 | 0.41 | -0.79 | 0.04 | -0.48 | 3.20 | -8.05 | -0.18 | -1.80 | 7.34 | -2.70 |
| Ahmednagar | Period-I | -7.70 | 0.00 | 3.03 | -4.67 | -4.87 | 4.07 | 0.53 | 30.60 | 12.90 | -38.53 | 5.50 |
| | Period-II | -3.31 | 1.23 | -1.96 | -4.04 | -3.92 | 2.15 | 2.77 | 27.96 | 12.15 | -37.15 | 5.73 |
| | Overall | -5.66 | 0.57 | 0.71 | -4.38 | -4.43 | 3.18 | 1.57 | 29.38 | 12.55 | -37.89 | 5.61 |
| Nashik | Period-I | -1.23 | 0.17 | -4.40 | -5.47 | 3.90 | 5.00 | -9.97 | 8.87 | -2.00 | -0.57 | -3.67 |
| | Period-II | -10.12 | 0.04 | -0.50 | -10.58 | -4.38 | 10.19 | -0.12 | 16.62 | 0.54 | -12.31 | 4.73 |
| | Overall | -5.36 | 0.11 | -2.59 | -7.84 | 0.05 | 7.41 | -5.39 | 12.46 | -0.82 | -6.02 | 0.23 |
| Jalgaon | Period-I | -4.77 | 0.07 | -2.93 | -7.63 | -0.10 | 4.20 | -1.07 | -0.37 | -1.97 | 6.93 | 3.53 |
| | Period-II | -4.04 | 0.85 | -7.73 | -10.92 | -0.15 | 0.96 | 0.08 | 1.35 | 0.00 | 8.69 | 10.12 |
| | Overall | -4.43 | 0.43 | -5.16 | -9.16 | -0.13 | 2.70 | -0.54 | 0.43 | -1.05 | 7.75 | 6.59 |
| Dhule | Period-I | 3.57 | 0.23 | -6.10 | -2.30 | -7.03 | 2.20 | -10.73 | 0.43 | -1.93 | 22.33 | 10.10 |
| | Period-II | 0.85 | 0.27 | 0.54 | 1.65 | -0.73 | 4.77 | -0.23 | 3.46 | 0.58 | -9.50 | -5.69 |
| | Overall | 2.30 | 0.25 | -3.02 | -0.46 | -4.11 | 3.39 | -5.86 | 1.84 | -0.77 | 7.55 | 2.77 |
| Aurangabad | Period-I | -4.63 | 1.70 | -1.83 | -4.77 | 0.13 | 11.50 | 6.87 | 6.83 | -7.90 | -12.67 | -6.87 |
| | Period-II | -1.19 | 1.88 | 1.92 | 2.62 | -0.62 | -0.23 | -4.08 | 28.19 | 10.88 | -36.73 | -1.73 |
| | Overall | -3.04 | 1.79 | -0.09 | -1.34 | -0.21 | 6.05 | 1.79 | 16.75 | 0.82 | -23.84 | -4.48 |
| Nanded | Period-I | 2.90 | -0.40 | 2.33 | 4.83 | -1.90 | -1.23 | 3.27 | -13.83 | -2.57 | 11.37 | -1.77 |
| | Period-II | -2.00 | 0.42 | -16.50 | -18.08 | 2.96 | 5.96 | 1.12 | 5.31 | 1.85 | 0.88 | 9.15 |
| | Overall | 0.63 | -0.02 | -6.41 | -5.80 | 0.36 | 2.11 | 2.27 | -4.95 | -0.52 | 6.50 | 3.30 |
| Osmanabad | Period-I | 0.63 | 2.70 | 2.33 | 5.67 | 1.13 | 0.13 | 23.37 | -40.93 | 4.13 | 6.47 | -6.97 |
| | Period-II | 1.08 | 3.42 | -1.92 | 2.58 | 2.50 | 6.58 | 1.38 | 20.38 | 37.46 | -70.92 | -11.69 |
| | Overall | 0.84 | 3.04 | 0.36 | 4.23 | 1.77 | 3.13 | 13.16 | -12.46 | 19.61 | -29.46 | -9.16 |
| Parbhani | Period-I | 5.77 | 0.90 | -2.83 | 3.83 | 3.13 | 0.00 | 9.17 | -38.77 | 6.67 | 15.93 | -7.00 |
| | Period-II | 0.31 | -0.92 | -0.69 | -1.31 | -0.46 | 4.62 | -0.88 | 15.38 | -4.88 | -12.46 | -2.85 |
| | Overall | 3.23 | 0.05 | -1.84 | 1.45 | 1.46 | 2.14 | 4.50 | -13.63 | 1.30 | 2.75 | -5.07 |

Appendix-II contd...

| Districts | Periods | Ecological Sector (E) | | | | | NA | Agricultural Sector | | | | |
|------------|-----------|----------------------------------|-------|--------|-----------------|------------------------------------|-------|---------------------|--------|--------|--------|--------------|
| | | Desirable ecological Sector (E1) | | | | Undesirable ecological sector (E2) | | CW | CF | OF | NAS | CW+CF+OF+NAS |
| | | FR | MT | PP | FR + Misc. + PP | | | | | | | |
| Beed | Period-I | 4.13 | 0.00 | -0.53 | 3.60 | 4.17 | 5.43 | 9.77 | -45.17 | -2.33 | 24.57 | -13.17 |
| | Period-II | -1.19 | 0.38 | -2.85 | -3.65 | -0.42 | 6.92 | -4.46 | 10.46 | 1.81 | -10.65 | -2.85 |
| | Overall | 1.66 | 0.18 | -1.61 | 0.23 | 2.04 | 6.13 | 3.16 | -19.34 | -0.41 | 8.21 | -8.38 |
| Buldhana | Period-I | -1.90 | -0.27 | -4.97 | -7.13 | 0.03 | 5.53 | -0.90 | 1.43 | -4.47 | 2.10 | -1.83 |
| | Period-II | -9.62 | 0.27 | -2.62 | -11.96 | 8.27 | 4.38 | 4.58 | 4.88 | 1.62 | -11.73 | -0.65 |
| | Overall | -5.48 | -0.02 | -3.88 | -9.38 | 3.86 | 5.00 | 1.64 | 3.04 | -1.64 | -4.32 | -1.29 |
| Akola | Period-I | -5.77 | 0.00 | 0.07 | -5.70 | -6.07 | 5.20 | 0.73 | 1.33 | -10.63 | 15.13 | 6.57 |
| | Period-II | -1.54 | 0.08 | -6.35 | -7.81 | -1.46 | 4.50 | -0.31 | 3.54 | 0.88 | 0.65 | 4.77 |
| | Overall | -3.80 | 0.04 | -2.91 | -6.68 | -3.93 | 4.88 | 0.25 | 2.36 | -5.29 | 8.41 | 5.73 |
| Amravati | Period-I | -7.17 | -1.20 | 3.00 | -5.37 | 0.93 | 4.70 | -4.30 | 3.43 | -10.63 | 13.40 | 1.90 |
| | Period-II | -7.04 | -0.81 | -11.65 | -19.50 | 0.27 | 1.31 | -1.19 | 5.88 | 0.62 | 10.73 | 16.04 |
| | Overall | -7.11 | -1.02 | -3.80 | -11.93 | 0.63 | 3.13 | -2.86 | 4.57 | -5.41 | 12.16 | 8.46 |
| Yavatmal | Period-I | -13.50 | -3.00 | 6.87 | -9.63 | -13.20 | 1.13 | -2.33 | -3.13 | -10.83 | 38.03 | 21.73 |
| | Period-II | -10.81 | -0.81 | 0.23 | -11.38 | 0.19 | 7.54 | -0.88 | 3.96 | -1.15 | 1.77 | 3.69 |
| | Overall | -12.25 | -1.98 | 3.79 | -10.45 | -6.98 | 4.11 | -1.66 | 0.16 | -6.34 | 21.20 | 13.36 |
| Wardha | Period-I | 1.80 | -0.73 | -4.10 | -3.03 | -0.60 | 2.90 | -4.53 | 10.60 | 0.70 | -5.93 | 0.83 |
| | Period-II | -3.19 | 0.27 | 8.85 | 5.92 | 1.73 | 1.50 | 0.81 | 5.08 | 1.96 | -17.08 | -9.23 |
| | Overall | -0.52 | -0.27 | 1.91 | 1.13 | 0.48 | 2.25 | -2.05 | 8.04 | 1.29 | -11.11 | -3.84 |
| Nagpur | Period-I | 3.40 | -0.57 | -4.40 | -1.57 | -1.13 | 4.40 | -10.33 | 2.90 | -1.50 | 7.30 | -1.63 |
| | Period-II | -15.12 | 1.42 | -18.19 | -31.88 | 7.77 | 11.73 | 6.85 | 0.27 | 1.42 | 3.85 | 12.38 |
| | Overall | -5.20 | 0.36 | -10.80 | -15.64 | 3.00 | 7.80 | -2.36 | 1.68 | -0.14 | 5.70 | 4.88 |
| Bhandara | Period-I | 3.07 | 0.27 | 0.17 | 3.50 | 0.57 | 6.07 | -0.27 | 0.00 | -2.20 | -7.70 | -10.17 |
| | Period-II | 1.58 | 0.31 | -3.15 | -1.27 | 0.04 | -0.62 | 0.54 | 2.88 | -0.96 | -0.54 | 1.92 |
| | Overall | 2.38 | 0.29 | -1.38 | 1.29 | 0.32 | 2.96 | 0.11 | 1.34 | -1.63 | -4.38 | -4.55 |
| Chandrapur | Period-I | 14.43 | -2.23 | -19.63 | -7.43 | -2.13 | 4.60 | -12.93 | 1.50 | -1.07 | 17.53 | 5.03 |
| | Period-II | -6.69 | 0.35 | -12.58 | -18.92 | -0.69 | 15.92 | 1.54 | 14.50 | -0.08 | -12.35 | 3.62 |
| | Overall | 4.63 | -1.04 | -16.36 | -12.77 | -1.46 | 9.86 | -6.21 | 7.54 | -0.61 | 3.66 | 4.38 |

Where, FR-Forest, NA-Area under non-agriculture uses, BU-Barren and unculturable land, PP-Permanent pastures and other grazing lands, MT-Land under miscellaneous tree crops and groves, CW-Culturable waste land, OF-Fallow land other than current fallow, CF-Current fallow land, NAS-Net area sown.

Appendix-III

Region wise intra- sectoral dynamics of land use in Maharashtra

(Annual rate of change in “00” hectares)

| Regions/MH/ IN | Periods | Ecological Sector (E) | | | | | NA | Agricultural Sector | | | | |
|------------------------|-----------|----------------------------------|---------|---------|--------------------|--|---------|---------------------|---------|---------|----------|------------------|
| | | Desirable ecological Sector (E1) | | | | Undesirable ecological sector (E2) | | CW | CF | OF | NAS | CW+CF+ OF+NAS |
| | | FR | MT | PP | FR + Misc. + PP | | | | | | | |
| Konkan | Period-I | 7.00 | -7.00 | 24.90 | 24.90 | -7.40 | 41.53 | 23.83 | -30.27 | -18.80 | -32.13 | -57.37 |
| | Period-II | 3.96 | 11.50 | -9.31 | 6.15 | -8.50 | 21.15 | -49.04 | -0.96 | 19.73 | 11.42 | -18.85 |
| | Overall | 5.59 | 1.59 | 9.02 | 16.20 | -7.91 | 32.07 | -10.00 | -16.66 | -0.91 | -11.91 | -39.48 |
| Western Maharashtra | Period-I | -10.47 | 8.03 | 24.53 | 22.10 | -3.60 | 45.03 | -9.43 | 36.70 | -16.90 | -72.77 | -62.40 |
| | Period-II | -31.46 | 10.69 | -29.00 | -49.77 | -4.54 | 112.92 | 4.12 | 82.92 | 34.35 | -180.12 | -58.73 |
| | Overall | -20.21 | 9.27 | -0.32 | -11.27 | -4.04 | 76.55 | -3.14 | 58.16 | 6.89 | -122.61 | -60.70 |
| Marathwada | Period-I | 8.80 | 4.90 | -0.53 | 13.17 | 6.67 | 15.83 | 52.43 | -131.87 | -2.00 | 45.67 | -35.77 |
| | Period-II | -3.00 | 5.19 | -20.04 | -17.85 | 3.96 | 23.85 | -6.92 | 79.73 | 47.12 | -129.88 | -9.96 |
| | Overall | 3.32 | 5.04 | -9.59 | -1.23 | 5.41 | 19.55 | 24.88 | -33.63 | 20.80 | -35.84 | -23.79 |
| Vidarbha | Period-I | -5.63 | -7.73 | -23.00 | -36.37 | -21.60 | 34.53 | -34.87 | 18.07 | -40.63 | 79.87 | 22.43 |
| | Period-II | -52.42 | 1.08 | -45.46 | -96.81 | 16.12 | 46.27 | 11.92 | 41.00 | 4.31 | -24.69 | 32.54 |
| | Overall | -27.36 | -3.64 | -33.43 | -64.43 | -4.09 | 39.98 | -13.14 | 28.71 | -19.77 | 31.32 | 27.13 |
| Maharashtra | Period-I | -0.30 | -1.80 | 25.90 | 23.80 | -25.93 | 136.93 | 31.97 | -107.37 | -78.33 | 20.63 | -133.10 |
| | Period-II | -82.92 | 28.46 | -103.81 | -158.27 | 7.04 | 204.19 | -39.92 | 202.69 | 105.50 | -323.27 | -55.00 |
| | Overall | -38.66 | 12.25 | -34.32 | -60.73 | -10.63 | 168.16 | -1.41 | 36.59 | 7.02 | -139.04 | -96.84 |
| India | Period-I | 4550.07 | -215.20 | -853.50 | 3481.37 | -5467.47 | 2126.60 | -1403.90 | 733.77 | -505.57 | 3223.53 | 2047.83 |
| | Period-II | 1766.27 | -264.60 | -428.67 | 1073.01 | -1154.30 | 2624.11 | -1072.65 | 560.75 | 624.87 | -1488.49 | -1375.52 |
| | Overall | 3257.59 | -238.13 | -656.26 | 2363.20 | -3464.92 | 2357.59 | -1250.11 | 653.44 | 19.28 | 1035.81 | 458.42 |

Where, FR-Forest, NA-Area under non-agriculture uses, BU-Barren and unculturable land, PP-Permanent pastures and other grazing lands, MT-Land under miscellaneous tree crops and groves, CW-Culturable waste land, OF-Fallow land other than current fallow, CF-Current fallow land, NAS-Net area sown

Appendix-IV
Classification of districts based on changes in area under ecological and agricultural sectors
(Annual rate of change in '00' ha)

| Sr. No. | Land use sector | Districts having positive shift | | | | | | Districts having negative shift | | | | | |
|---------|--|---------------------------------|-------|------------|------|-----------|-------|---------------------------------|--------|------------|--------|------------|--------|
| | | Period-I | | Period-II | | Overall | | Period-I | | Period-II | | Overall | |
| | | District | Area | District | Area | District | Area | District | Area | District | Area | District | Area |
| 1. | Ecological ($\Delta E = \Delta E1 + \Delta E2$) | Thane | 12.30 | Ratnagiri | 3.92 | Thane | 5.96 | G. Bombay | -0.13 | Thane | -1.35 | G. Bombay | -0.07 |
| | | Raigad | 7.30 | Kolhapur | 0.54 | Raigad | 1.63 | Ratnagiri | -1.97 | Raigad | -4.92 | Solapur | -3.38 |
| | | Pune | 7.03 | Dhule | 0.92 | Ratnagiri | 0.77 | Kolhapur | -1.30 | Pune | -2.46 | Kolhapur | -0.45 |
| | | Solapur | 4.63 | Aurangabad | 2.00 | Pune | 2.63 | Ahmednagar | -9.53 | Solapur | -12.62 | Ahmednagar | -8.80 |
| | | Satara | 30.80 | Osmanabad | 5.08 | Satara | 16.05 | Nashik | -1.57 | Satara | -0.96 | Nashik | -7.79 |
| | | Sangli | 5.50 | Wardha | 7.65 | Sangli | 0.29 | Jalgaon | -7.73 | Sangli | -5.73 | Jalgaon | -9.29 |
| | | Nanded | 2.93 | | | Osmanabad | 6.00 | Dhule | -9.33 | Ahmednagar | -7.96 | Dhule | -4.57 |
| | | Osmanabad | 6.80 | | | Parbhani | 2.91 | Aurangabad | -4.63 | Nashik | -14.96 | Aurangabad | -1.55 |
| | | Parbhani | 6.97 | | | Beed | 2.27 | Buldhana | -7.10 | Jalgaon | -11.08 | Nanded | -5.45 |
| | | Beed | 7.77 | | | Wardha | 1.61 | Akola | -11.77 | Nanded | -15.12 | Buldhana | -3.88 |
| | | Bhandara | 4.07 | | | Bhandara | 1.61 | Amravati | -4.43 | Parbhani | -1.77 | Akola | -10.61 |
| | | | | | | | | Yavatmal | -22.83 | Beed | -4.08 | Amravati | -11.30 |
| | | | | | | | | Wardha | -3.63 | Buldhana | -3.69 | Yavatmal | -17.43 |
| | | | | | | | | Nagpur | -2.70 | Akola | -9.27 | Nagpur | -12.64 |
| | | | | | | | | Chandrapur | -9.57 | Amravati | -19.23 | Chandrapur | -14.23 |
| | | | | | | | | | | Yavatmal | -11.19 | | |
| | | | | | | | | | | Nagpur | -24.12 | | |
| | | | | | | | | | | Bhandara | -1.23 | | |
| | | | | | | | | | | Chandrapur | -19.62 | | |

Appendix-IV contd....

| Sr. No. | Land use sector | Districts having positive shift | | | | | | Districts having negative shift | | | | | |
|---------|--------------------------------------|---------------------------------|-------|------------|------|-----------|-------|---------------------------------|--------|------------|--------|------------|--------|
| | | Period-I | | Period-II | | Overall | | Period-I | | Period-II | | Overall | |
| | | District | Area | District | Area | District | Area | District | Area | District | Area | District | Area |
| a. | Desirable ecological ($\Delta E1$) | Thane | 15.80 | Thane | 7.85 | Thane | 12.11 | G. Bombay | -1.07 | Raigad | -7.04 | G. Bombay | -0.57 |
| | | Raigad | 4.63 | Ratnagiri | 5.35 | Ratnagiri | 5.45 | Kolhapur | -0.20 | Pune | -6.96 | Raigad | -0.79 |
| | | Ratnagiri | 5.53 | Kolhapur | 0.31 | Pune | 2.30 | Ahmednagar | -4.67 | Solapur | -13.42 | Solapur | -2.09 |
| | | Pune | 10.33 | Dhule | 1.65 | Satara | 8.95 | Nashik | -5.47 | Satara | -2.42 | Ahmednagar | -4.38 |
| | | Solapur | 7.73 | Aurangabad | 2.62 | Sangli | 1.38 | Jalgaon | -7.63 | Sangli | -3.38 | Nashik | -7.84 |
| | | Satara | 18.80 | Osmanabad | 2.58 | Kolhapur | 0.04 | Dhule | -2.30 | Ahmednagar | -4.04 | Jalgaon | -9.16 |
| | | Sangli | 5.50 | Wardha | 5.92 | Osmanabad | 4.23 | Aurangabad | -4.77 | Nashik | -10.58 | Dhule | -0.46 |
| | | Nanded | 4.83 | | | Parbhani | 1.45 | Buldhana | -7.13 | Jalgaon | -10.92 | Aurangabad | -1.34 |
| | | Osmanabad | 5.67 | | | Beed | 0.23 | Akola | -5.70 | Nanded | -18.08 | Nanded | -5.80 |
| | | Parbhani | 3.83 | | | Wardha | 1.13 | Amravati | -5.37 | Parbhani | -1.31 | Buldhana | -9.38 |
| | | Beed | 3.60 | | | Bhandara | 1.29 | Yavatmal | -9.63 | Beed | -3.65 | Akola | -6.68 |
| | | Bhandara | 3.50 | | | | | Wardha | -3.03 | Buldhana | -11.96 | Amravati | -11.93 |
| | | | | | | | | Nagpur | -1.57 | Akola | -7.81 | Yavatmal | -10.45 |
| | | | | | | | | Chandrapur | -7.43 | Amravati | -19.50 | Nagpur | -15.64 |
| | | | | | | | | | | Yavatmal | -11.38 | Chandrapur | -12.77 |
| | | | | | | | | | | Nagpur | -31.88 | | |
| | | | | | | | | Bhandara | -1.27 | | | | |
| | | | | | | | | Chandrapur | -18.92 | | | | |

Appendix-IV contd.....

| Sr. No. | Land use sector | Districts having positive shift | | | | | | Districts having negative shift | | | | | |
|---------|---|---------------------------------|-------|-----------|------|-----------|------|---------------------------------|--------|------------|-------|------------|-------|
| | | Period-I | | Period-II | | Overall | | Period-I | | Period-II | | Overall | |
| | | District | Area | District | Area | District | Area | District | Area | District | Area | District | Area |
| b. | Undesirable ecological (ΔE_2) | G. Bombay | 0.93 | Raigad | 2.12 | G. Bombay | 0.50 | Thane | -3.50 | Thane | -9.19 | Thane | -6.14 |
| | | Raigad | 2.67 | Pune | 4.50 | Raigad | 2.41 | Ratnagiri | -7.50 | Ratnagiri | -1.42 | Ratnagiri | -4.68 |
| | | Satara | 12.00 | Solapur | 0.81 | Pune | 0.32 | Pune | -3.30 | Sangli | -2.35 | Solapur | -1.29 |
| | | Nashik | 3.90 | Satara | 1.46 | Satara | 7.11 | Solapur | -3.10 | Ahmednagar | -3.92 | Sangli | -1.09 |
| | | Aurangabad | 0.13 | Kolhapur | 0.23 | Nashik | 0.05 | Kolhapur | -1.10 | Nashik | -4.38 | Kolhapur | -0.48 |
| | | Osmanabad | 1.13 | Nanded | 2.96 | Nanded | 0.36 | Ahmednagar | -4.87 | Jalgaon | -0.15 | Ahmednagar | -4.43 |
| | | Parbhani | 3.13 | Osmanabad | 2.50 | Osmanabad | 1.77 | Jalgaon | -0.10 | Dhule | -0.73 | Jalgaon | -0.13 |
| | | Beed | 4.17 | Buldhana | 8.27 | Parbhani | 1.46 | Dhule | -7.03 | Aurangabad | -0.62 | Dhule | -4.11 |
| | | Buldhana | 0.03 | Amravati | 0.27 | Beed | 2.04 | Nanded | -1.90 | Parbhani | -0.46 | Aurangabad | -0.21 |
| | | Amravati | 0.93 | Yavatmal | 0.19 | Buldhana | 3.86 | Akola | -6.07 | Beed | -0.42 | Akola | -3.93 |
| | | Bhandara | 0.57 | Wardha | 1.73 | Amravati | 0.63 | Yavatmal | -13.20 | Akola | -1.46 | Yavatmal | -6.98 |
| | | | | Nagpur | 7.77 | Wardha | 0.48 | Wardha | -0.60 | Chandrapur | -0.69 | Chandrapur | -1.46 |
| | | | | Bhandara | 0.04 | Nagpur | 3.00 | Nagpur | -1.13 | | | | |
| | | | | | | Bhandara | 0.32 | Chandrapur | -2.13 | | | | |

Appendix-IV contd.....

| Sr. No. | Land use sector | Districts having positive shift | | | | | | Districts having negative shift | | | | | |
|---------|-------------------|---------------------------------|-------|------------|-------|------------|-------|---------------------------------|--------|------------|--------|------------|--------|
| | | Period-I | | Period-II | | Overall | | Period-I | | Period-II | | Overall | |
| | | District | Area | District | Area | District | Area | District | Area | District | Area | District | Area |
| 2. | Agricultural (ΔA) | Ahmednagar | 5.50 | Raigad | 0.15 | Solapur | 1.11 | G. Bombay | -3.73 | G. Bombay | -2.88 | G. Bombay | -3.34 |
| | | Jalgaon | 3.53 | Solapur | 8.46 | Ahmednagar | 5.61 | Thane | -31.33 | Thane | -11.69 | Thane | -22.21 |
| | | Dhule | 10.10 | Sangli | 3.27 | Nashik | 0.23 | Raigad | -22.13 | Ratnagiri | -4.42 | Raigad | -11.79 |
| | | Akola | 6.57 | Ahmednagar | 5.73 | Jalgaon | 6.59 | Ratnagiri | -0.17 | Pune | -81.96 | Ratnagiri | -2.14 |
| | | Amravati | 1.90 | Nashik | 4.73 | Dhule | 2.77 | Pune | -15.57 | Satara | -1.62 | Pune | -46.39 |
| | | Yavatmal | 21.73 | Jalgaon | 10.12 | Nanded | 3.30 | Solapur | -5.27 | Kolhapur | -1.77 | Satara | -18.86 |
| | | Wardha | 0.83 | Nanded | 9.15 | Akola | 5.73 | Satara | -33.80 | Dhule | -5.69 | Sangli | -9.05 |
| | | Chandrapur | 5.03 | Akola | 4.77 | Amravati | 8.46 | Sangli | -19.73 | Aurangabad | -1.73 | Kolhapur | -2.70 |
| | | | | Amravati | 16.04 | Yavatmal | 13.36 | Kolhapur | -3.50 | Osmanabad | -11.69 | Aurangabad | -4.48 |
| | | | | Yavatmal | 3.69 | Nagpur | 4.88 | Nashik | -3.67 | Parbhani | -2.85 | Osmanabad | -9.16 |
| | | | | Nagpur | 12.38 | Chandrapur | 4.38 | Aurangabad | -6.87 | Beed | -2.85 | Parbhani | -5.07 |
| | | | | Bhandara | 1.92 | | | Nanded | -1.77 | Buldhana | -0.65 | Beed | -8.38 |
| | | | | Chandrapur | 3.62 | | | Osmanabad | -6.97 | Wardha | -9.23 | Buldhana | -1.29 |
| | | | | | | | | Parbhani | -7.00 | | | Wardha | -3.84 |
| | | | | | | | | Beed | -13.17 | | | Bhandara | -4.55 |
| | | | | | | | | Buldhana | -1.83 | | | | |
| | | | | | | | | Nagpur | -1.63 | | | | |
| | | | | | | | | Bhandara | -10.17 | | | | |

8. VITAE

LEMBHE JAYESH VASANTRAO
DOCTOR OF PHILOSOPHY (AGRICULTURE)
in
AGRICULTURAL ECONOMICS
2024

| | | |
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