# AGRICULTURAL GROWTH AND DIVERSIFICATION IN INDIA: A STATE LEVEL ANALYSIS

*Dissertation submitted to the Jawaharlal Nehru University*
*in partial fulfillment of the requirements*
*for the award of the degree of*

## MASTER OF PHILOSOPHY


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## DECLARATION

I, Nikkita Gupta, hereby declare that the M.Phil. dissertation entitled "**Agricultural Growth and Diversification in India: A State level Analysis**" submitted by me to Jawaharlal Nehru University in partial fulfillment of the requirements for the award of the degree of **MASTER OF PHILOSOPHY** embodies the result of bonafide research work carried out by me and that it has not been submitted so far in part or full, for the award of any other degree of this university or any other university.

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## CERTIFICATE

It is hereby recommended that this dissertation may be placed before the examiners for evaluation.

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DEDICATED TO MY PARENTS

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**Date:** 02 September 2022

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## ABBREVIATIONS

| | | |
|---|---|---|
| APY | - | Area, Production and Yield |
| ADF test | - | Augmented Dickey-Fuller test |
| CAGR | - | Compound Annual Growth Rate |
| CDI | - | Crop Diversification Index |
| CV | - | Coefficient of Variation |
| GCA | - | Gross Cropped Area |
| GDP | - | Gross Domestic Product |
| GDPA | - | Gross Domestic Product from Agriculture |
| GSDPA | - | Gross State Domestic Product from Agriculture |
| GSDP | - | Gross State Domestic Product |
| HHI | - | Herfindahl-Hirschman Index |
| KCC | - | Kisan Credit Card |
| NSA | - | Net Sown Area |
| TAGR | - | Trend Annual Growth Rate |
| TOT | - | Terms of Trade |

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# CHAPTER-I

# INTRODUCTION

# CHAPTER 1

# INTRODUCTION

## 1.1 Background

"Crop diversification has emerged as an important alternative to attain the objectives of output growth, employment generation, and natural resources sustainability in the developing countries. The recent experience in Asia, particularly Southeast Asia, Middle East, and North Africa indicates that policymakers and planners are increasingly focusing on crop diversification to promote agricultural development."

Petit and Barghouti (1972)

Indian economy has undergone a significant structural change overtime. The contribution of agriculture in gross domestic product has declined from 59 percent in 1950-51 to 34.9 percent in 1990-91 and further to 18.4 percent in 2019-20. The share of industry and service sector in the gross domestic product has increased from 13 percent and 28 percent in 1950-51 to 26.7 percent and 55 percent in 2019-20 respectively (Government of India, various years). Although the share of agriculture in overall GDP has declined, agriculture still employs about 54.6 percent of rural workforce (Population Census, 2011) and contributes to income generation in rural households. Despite the transformation of agricultural sector from traditional to modern agriculture, for majority of the rural population agriculture remains a way of life. Thus, sustained and broad-based growth in the agriculture sector is essential for poverty alleviation, generation of income and employment, assurance of food security, containing the rural-urban disparity, and for sustaining a buoyant domestic market for industry and services (Johnston et al. 1961; De Janvry et al. 2010)

The attempts to modernize India's agriculture started in the British colonial period. But these efforts were mainly confined to increasing the production of non-food crops particularly to meet export demand, while the foodgrain production remained stagnant. As a whole, the agricultural growth remained less than 0.1 percent on average from 1891 to 1947 (Blyn1966) and was less than 0.5 percent during the first half of the 20$^{th}$ century (Mukherjee 1960). The seriousness of food shortage and the importance of agricultural growth first came to light with the Bengal

famine of 1943, since when efforts to increase agricultural production were started through schemes such as Grow More Food Campaign in 1943 which covered both intensive and extensive cultivation. Post-independence, the Integrated Crop Production Program of 1950-51 was started in response to adverse seasonal conditions and high imports as India was not self-reliant on cereal crops at that time. Such schemes resulted in an increase in production of foodgrains (Shetty et al. 2014).

One of the key achievements of the agriculture sector in India is the introduction of the Green Revolution technology or new seed-fertilizer-irrigation technology in 1966-67. While the policy emphasis during the pre-green revolution was on the institutional factors such as land reforms, large scale investment in irrigation, power, and creation of other infrastructures such as roads and credit market, the focus during the post-green revolution was on technological factors such as the provision of new seeds and fertilizers, water, power, credit at chapter prices, and provision of higher prices of output through a new system of procurement prices for farmers. All these effortsled to an increase in the production of foodgrains, and India could successfully achieve self-sufficiency in foodgrain production since the 1970s in quantitative terms with excess stocks and overflowing granaries of wheat and rice (Radhakrishnan 2005). India could garner buffer stock of foodgrains worth 25.4 million tons for the first time in 1986, and thus could meet the country's food requirements much more easily despite facing the worst drought during 1987-88(Gulati 2003). The compound annual growth rate of major foodgrains increased steadily from 2.12 percent during 1950-51 to 1967-68 to 2.62 percent from 1967-68 to 1983-84 (Bhalla 2007).

The period of 1980swas significant not only for the Indian economy as a whole which could overcome the Hindu rate of growth (Kumar 1992) but also for the agriculture sector, which transformed the status of the country from food-deficit to self-sufficiency in food production. During this period, the green revolution had become mature and the new seed-fertilizer technology had spread to new areas of eastern India including the states like Bihar and West Bengal. But in the north-western states where the Green Revolution technology was originally introduced lost its steam by 1985 as the adoption technology reached a state of near saturation. According to Thamrajakshi (2000), foodgrains production augmented at the rate of 3.5 percent during 1980-to 90. Kannan (2012) argues that besides decline in area, all the major crops had a comparatively higher yield growth during this decade, that is, the crops other than rice and wheat also shared the technological benefits during the mature green revolution phase.

However, it is criticized in various studies that the strategy of growth from the Green Revolution technology was not sustainable, due to its adverse effects on the environment such as soil salinity and alkalinity, water logging, declining water table from increased use of fertilizers, and monoculture wheat-rice cropping pattern in most parts of India (Pimentel et al. 1990, Chand et al. 1997). Thus, the need for diversification of agriculture was realized during the 1980's when the dominance of cereal cultivation (mainly wheat and rice) came out to be one of the major side effects of the Green Revolution leading to unsustainable growth patterns in agriculture. Various policies and strategies were introduced at different points in time by the government for diversification. Johl Committee Reports (1986, 2002) recommended a shift from wheat-rice cropping pattern to wheat-maize one (Sarkar et al 2014). A few of these strategies included Technology Mission on Oilseeds in 1986, National Agriculture Insurance Scheme 1999, Technology Mission on Cotton in 2000 and Technology Mission for integrated development of horticulture in 2014.

The monoculture cropping pattern is prominent in most parts of India, especially in northwest India which was the largest beneficiary of the agricultural technology interventions. The eastern and northern regions follow a specialised cropping pattern whereas southern, western, and central regions have relatively diversified cropping pattern (Behera et al. 2007).

Overall in India, as pointed out by Gulati et al. (2004), the government still encourages cereal production, which is undesirable in a country like India which has already achieved self-sufficiency in cereal production. Diversification of agriculture from wheat-rice monoculture towards high-value commodities is considered a key strategy to augment farm income, agricultural growth by as much as 30 percent, and conservation of soil and water resources with other benefits (Joshi et al 2003 and 2007). Further, being a leguminous crop, pulses cultivation helps in addressing the key issue of decreasing soil organic carbon and helps in increasing yield in other crops grown after its harvest.

With the above background, this study examines the trends and patterns in agricultural growth and crop diversification at state level in India from 1981-82 to 2019-20. This time period is chosen to analyze whether Indian agriculture experienced a smooth transition or still faces ups and downs after the effects of the Green Revolution realized to their maximum extent in the 1980s.It is important to understand if the crop diversification and agricultural growth are going

hand in hand or are still moving in opposition to each other over time. This study also analyzes the determinants of crop diversification in India at the macro and micro levels using state level and agricultural household data, respectively. The study results will be useful to address the challenges to the crop diversification and future policy implications.

### 1.2 Motivation for the Study/ Research Gap

The present study fills the research gap of analyzing India's agricultural growth performance by identifying the structural break points and changes in crop diversification at state level. This is done by analysing agricultural growth performance and crop diversification in India for nearly four decades, i.e., from 1981-82 to 2019-20. This research analyses the nature and timings of structural changes in India's agricultural economy endogenously and examines the trends and patterns in crop agricultural growth and crop diversification at state level. The present research also analyses the determinants of crop diversification at both state-level and household-level. There are not many comprehensive studies available on analysis of impact of various institutions and policies on crop diversification. The present study analyses the effect on crop diversification of access to credit, registered farmers' organisation, crop insurance, Mahatma Gandhi Rural Employment Guarantee Scheme (MNREGS), Soil Health Card Scheme and leasing institutional arrangement.

Further, the impact of change in demand and supply-side factors is analysed. While the former is captured through income and urbanization level, the latter is captured through availability of fertilizer input, irrigation facility, loan facility, input-output ratio and cropping intensity. Market availability and market conditions are analyzed through road density, marketable surplus ratio and terms of trade. Finally, impact of various household characteristics such as household size, operational holding, income (or consumption), education and formal training status, and household irrigation status is analysed.

### 1.3 Research Questions

Following are the research questions of the study:

1. What is the changing pattern of agricultural output share and growth from 1981-82 to 2019-20 at the national and state level? Is the growth stagnant, decreasing or increasing over structural break years?
2. What are the spatial trends and patterns of horizontal[1]crop diversification in India from 1981-82 to 2019-20?
3. What are the determinants of crop diversification at the macro and micro levels in India?

### 1.4 Objectives of the study

The specific objectives of the study are as follows.

1. To analyze the trend and changing pattern of agriculture growth at state-level in India from 1981-82 to 2019-20
2. To examine the pattern and determinants of crop diversification in India
3. To analyse the factors determining the decision of agricultural households to diversify the cropping pattern at farm level

### 1.5 Data Sources

The study makes use of secondary data sources. Firstly, to analyze the agricultural growth trends, data on variables such as gross domestic product from agriculture and value of crop output were compiled mainly from(a) National Accounts Publications provided by the Central Statistical Organisation (CSO), Government of India ; (b) cropping database provided by the Directorate of Economics and Statistics, Department of Agriculture Cooperation and Farmers Welfare (DES, DAC&FW); (c) Horticulture database provided by Baseline Data on Horticulture Crops. Data from Population Census 2011 were also used.

The National Accounts Division under Central Statistical Office (CSO) is responsible, along with other publications, to publish National Accounts Statistics, which contains data on national

[1]There are basically two types of diversification- horizontal diversification (which refers to cultivation of multiple crops instead of monoculture) and vertical diversification (which relates to incorporation of various downstream activities such as industrialization to the crops is made so as to enhance its value, such as food processing).

accounts as well as on state domestic product. The present study uses information related to GDP from agriculture as well as overall sectors both at national and state levels.

The Department of Economics and Statistics (DES), Ministry of Agriculture and Farmers' Welfare publishes statistics related to the agriculture sector. From this source, data related to (a) area, production, and yield of various crops at the national and state levels; (b) various issues of its publication 'Agricultural Statistics at a Glance' were used in the study.

For the analysis of crop diversification pattern, data were compiled from the following sources: (a) Land Use Statistics and the ICRISAT data on various crops including irrigation status, area sown, and fertilizers consumption; (b) Population Census data on total population, urban population, agriculture workers, and literacy rate; and (c) National Accounts Statistics and Reserve Bank of India's data onper capita income (NSDP per capita at constant 2011-12 prices). Other data sources such as State agriculture Statistics and IndiaStat database are also used to fill up the missing values. For statistics that are available on quinquennial or decadal intervals, data were interpolated based on the linear growth worked out between the data points. For state-level analysis, the study considers 21 states/UTs. The states which got bifurcated after the year 1981-82 were merged into the parent states for uniformity and consistency; these included Andhra Pradesh and Telangana, Bihar, and Jharkhand, Madhya Pradesh, and Chattisgarh, and Uttar Pradesh and Uttarakhand.

To analyse spatial patterns and factors affecting Crop Diversification in India, data from schedule 33.1 of NSS 77$^{th}$ round is used. This schedule compiles data related to 'Land and Livestock holdings of households and Situation Assessment of Agriculture Households'. The reference period for the survey is one agricultural year i.e. from July 2018 to June 2019, divided into two visits of six months each. Thus, visit one is from July 2018 to December 2018 which pertain broadly to Kharif season, and visit two is from January 2019 to June 2019 which pertain broadly to Rabi season. Data collected from both the visits are considered for analysis. Further, the survey has covered the whole of India except the Andaman and Nicobar Islands. The same state coverage is used in the present study. Only rural households are considered for the analysis.

In the NSS 77th round database, 58,040 sample households were surveyed twice during the reference period as visit 1and visit 2. The actual survey was made possible for 58,035

households in visit 1, of which 45,714 were agricultural households. In visit 2, a total of 56,894 households could be surveyed out of whom 44,720 were agricultural households. Out of this, the present study is concerned to analyze the crop diversification pattern, so the sample confined to only those households for which the crop production details are available. Filtering reduced the dataset comprising 41,579 households in visit 1 and 31,839 households in visit 2.

The detailed methodology is discussed in the respective chapters.

**1.6 Plan of the study**

The study is divided into six chapters, including the introduction.

The second chapter provides review of the literature on issues related to agriculture growth in India, crop diversification, and its patterns and determinants in India.

The third chapter analyzes the growth trends at national and state-level from 1981-82 to 2019-20. This is done in two ways: firstly, by analyzing share and growth in GDP derived from the agriculture sector (GDPA); and secondly, by analyzing share and growth in crop output and cropping patterns. The analysis is made by dividing the whole period into sub-periods, computed through statistical techniques.

The fourth and fifth chapters discuss the trends, patterns, and determinants of crop diversification at the macro and micro levels. More specifically, chapter four discusses the trends and patterns of crop diversification in India and state level from 1981-92 to 2019-20. Afterward, it tries to analyze the determinants of crop diversification in India. Chapter five analyses the factors affecting crop diversification at agricultural household level using the NSS 77$^{th}$ round data.

The sixth chapter provides the major findings and the conclusions of the study.

# CHAPTER-II

# REVIEW OF LITERATURE

# CHAPTER 2

# REVIEW OF LITERATURE

## 2.1 Introduction

The need for increasing agricultural production was realized at a major scale with the seriousness of food shortage and the importance of agricultural growth first came to light with the Bengal famine of 1943. Since then, serious efforts to increase agricultural growth started taking place, out of which one of the key achievements was the introduction of the Green Revolution technology or new seed-fertilizer-irrigation technology in 1966-67.This could transform the status of the country from food deficit to self-sufficiency in food production (Gulati 2003).

However, it is criticized in various studies that the strategy of growth from the green revolution technology was not sustainable, with adverse effects on the environment such as soil salinity and alkalinity, water logging, declining water table from increased use of fertilizers, and monoculture (wheat-rice cropping pattern) in most parts of India. Thus, the need and importance for diversification of agriculture was realized the 1980's when the dominance of cereal cultivation (mainly wheat and rice) came out to be one of the major side effects of the Green Revolution technology leading to unsustainable growth patterns in agriculture.

This chapter provides a critical review of past studies related to agricultural growth performance, crop diversification pattern and determinants of crop diversification.

## 2.2 Agricultural Growth Performance in India

### 2.2.1 Structural breaks in India's agricultural growth

The 1991 structural reforms and their impact on the economy as a whole and at the sectoral level have been a subject of extensive research. For the economy as a whole, the structural change in Indian macroeconomic data is studied through an analysis of 'long-term trend growth in GDP'. Kumar (1992) and Dholakia (1994) use the switching regression model and allowed for the shift in slope but not in the level of the trend function taking 1980-81 as the base year, the difference being that while the former uses 1950-51 to 1989-90 dataset while the latter uses 1960-61 to

1989-90 dataset. They found breaks structural breaks in 1980-81 and 1979-80 respectively. Balakrishnan and Parameswaran (2007) use Bai and Perron (1998 and2003) models and allowed for the shift in both levels as well as the slope of trend function, on 1950-51 to 2003-04 dataset taking 1993-94 year as the base year, and finds only one structural break at 1964-65.

At the sectoral level, many studies have tried to analyze the performance of Indian agriculture concerning both known (based on some prior information about timings of significant changes) as well as unknown break dates. Concerning known breakpoints, it is argued that the adoption of new seed-fertilizer technology in the mid-1960s has led to a marked increase in agricultural output in different parts of the country, due to an increase in productivity rather than area. Moreover, the large-scale economic reforms in 1991 are expected to have a direct and indirect bearing on agriculture. This is because the 'gradual opening up of Indian agriculture to world economy, reduction of protection to industry, exchange rate depreciation are expected to significantly affect agricultural output, agricultural exports, and terms of trade. So, taking such breaks as exogenous, descriptive as well as regression analysis are carried out in some studies.

Bhalla and Singh (2001) analyze the pattern of agricultural development at the state and district level by dividing it into triennium sub-periods as 1962-65 to 1970-73, 1970-73 to 1980-83 and 1980-83 to 1990-93. Bhalla (2007) analysis the post-independence period into four parts, namely, the pre-green revolution period (1950-51 to 1964-65), an early phase of green revolution (1967-68 to 1979-80), the mature phase of green revolution (1979-80 to 1989-90) and post-reform period (1991-92 to 2003-04) to compute agriculture growth rate in terms of both agricultural GDP and crop output. Vaidyanathan (2010) studied trends in the area, output, and yields at both national (1950-2004) and sub-national (1970-2001) levels by computing the best fitting functions on all of the following known sub-period/breakpoints: pre and early phase of green revolution period (1950-70), dynamic phase of green revolution (1970-88); and the era of globalization and liberalization (1988-2004).Discussing trends in crop sector growth, Kannan (2011) computes the compound annual growth rate (using the semi-log method) for the area, production, and yield for major crops in India between 1967-68 to 2007-08, by dividing the period as early green revolution period (1967-68 to 1979-80, mature phase of green revolution (1980-81 to 1989-90), early economic reform phase (1990-91 to 1999-2000), economic reforms (2000-01 to 2007-08) and overall period (1967-68 to 2007-08). Such studies have made many

systematic efforts to examine growth in agricultural GDP/ GSDP and growth in crop area, output, and yield at both national and sub-national levels.

However, there are only a few studies tried to analyze such growth patterns in agriculture after endogenously identifying such break dates, thus freeing the researcher from preliminary assumptions regarding the structural changes that took place in the agriculture sector. For instance, some studies have also tried to identify break dates endogenously in overall GDP as well as in its components, such as primary, secondary, and tertiary sectors, or more narrowly in sub-sectors such as agriculture, fishery, mining, etc. and testing significance of such breaks by computing growth rates at both national and sub-national levels (Kumar 1992, Dholakia 1994, Balakrishnan and Parameswaran 2007). Rather than specifically concentrating on agriculture, the objectives of these studies were much more concentrated on understanding overall economic growth. Studies concentrating specifically on the agriculture sector to identify structural breaks in GDP arising from it and in output and yield of various crops at all Indian levels are very relatively very less explored with reasons mainly linked to the green revolution and 1991-economic reforms only (Ghosh 2002 and2010).

Ghosh (2002 and 2008) uses Zivot and Andrews (1992) by allowing for a shift in level and not in the slope of trend function, on 1950-51 to 1999-2000 taking 1980-81 as the base year. Structural breaks were foundin 1964-65 and 1987-88. After using the ADF test to check if the data generating process follows a difference stationary or trend stationary process, Ghosh (2010) used Zivot and Andrews (1992) allowing for a shift in both trends as well as the slope of trend function on 1960-61 to 2006-07 period taking 1993-94 as the base year, and foundtwo structural breaks at 1967-68 and 1988-89. Since the structural transformation of an economy is generally seen in terms of GDP, so the author computes growth rates in terms of GDP from agriculture (GDPA) and Net State Domestic Product (NSDPA) at constant 1993-94 prices. Moreover, the paper also attempted to see these structural changes time state-wise for 15 major states, as different states might have gone under structural changes at different periods. He found that better growth performance was achieved mainly during the 1980s with similar trends in all states. However, all the states (except Gujarat and Andhra Pradesh) experienced deceleration during the post-reform period, with wide-interstate differences.

Regarding the statistical methodology adopted by these researchers endogenously finding the break dates, the earlier studies have used a single known breakpoint and tested using the switching regression technique by Quandt (1950) and Chow (1960) by trial and error method, testing for different break dates each time and Quandt (1960) which make it possible to test multiple known structural breaks (these methods are used in Kumar 1992, Dholakia 1994). More advanced techniques are now available such as Bai and Perron (2008) which allows for multiple unknown breakpoints with no trending regressors as applied by Balakrishnan and Parameswaran (2007). Perron (1998) allows for non-stationary and trending regressors and Zivot and Andrews (1992) test is a variation of the Perron test in which the break date is estimated rather than fixed.

The foregoing review makes it clear that a very few studies focused on detailed analysis of agricultural growth through endogenous classification of the long-term trend intothe structural break periods. The present study attempts to bridge this gap by reviewing agricultural growth performance in India comprehensively for 39 years, i.e. from 1981-82 to 2019-20 by computing the nature and timings of structural changes in Indian agriculture endogenously and analyzing the reasons for such trends and patterns in growth.

### 2.2.2 Growth trends in India's agricultural GDP, crop area and yield

The literature on the analysis of agricultural growth broadly confirms that during the first half of twentieth century, India was witnessing very low/stagnant levels of growth rates as much as growth rate in national product in agriculture at 0.46 percent per annum and in agricultural output estimates varying between 0.262 to 0.41 percent per annum (food grains growth at 0.15 percent per annum, non-food grains growth at 0.77 percent), post-independence agricultural growth witnessed an increase(Bhalla 2007, Blyn 1966). During first 15 years of independence, although agriculture was assigned a secondary role to aid growth in industrial sector, but a major step was taken with the introduction of Green Revolution in 1966. Agriculture still faced initial deceleration and grew by 2.05 percent per annum. between 1967-68 to 1979-80 which was due to after-effects off severe droughts, two consecutive wars, oil crisis, drastic reduction in food aid under PL480 that resulted in huge decline in public and overall investment (Gulati 2007). However, the growth accelerated afterwards by 3.08percent per annum during 1980-81 to 1990-91 when it reached its matured stage, due to rapid spread of new seed-fertilizer technology. In

contrast to the expectation that post 1991-reforms will end policy bias against agriculture, in reality the period from 1990-91 to 2003-04 marked a significant deceleration, with agricultural growth at 2.38 percent per annum, although overall GDP rate still kept increasing. Although the share of agriculture in GDP increased initially from 1950-51 to 1965-66, it started declining after that in accordance with Engel's law as well as empirically, with the pace of deceleration increased post 1991-reforms (Bhalla 2007).

Kannan (2012) discussed the trends in growth in crop sector at national and sub-national levels from 1967-68 to 2007-08. He found that the cropping pattern had undergone a shift from foodgrains to commercial crops. Among the foodgrains sector, the cultivation of coarse cereals declined by 13.3 percent and the performance of pulses was also not found to be impressive during the entire period of study. Out of the area and yield, the latter one is the major contributor to increase of agricultural production since 1960s. Using crop output model, he shows that the major factors which have results in crop output growth are normal rainfall, irrigation, fertilisers, and enhanced capital formation.

Bhalla (2007) analysed the performance of agriculture since 1951 at national and sub-national levels through both agricultural GDP and crop output pattern. He found that since the new technology was confined to wheat and rice, it resulted an increase in area for mainly these crops, and widened regional disparities too. There was high agricultural growth during 1980s, but it decelerated during 1990s despite higher growth in secondary and tertiary sectors, leading to serious adverse consequences for agricultural workforce.

Vaidyanathan (2010) argued that the crop production has been rising at an unprecedented rate and yield improvement has been becoming an important source of growth even as the contribution of area declined. He contended that at the national level, the trend rate of output has increased post 1971 as compared to 1950 to 1971 phase, but again decelerated post 1987 to 1951 to1971 levels. The trend yield growth remained consistently greater than output, but roughly followed the same pattern. Area growthkept declining during his entire period of study from 1950 to 2004.

Comparing the temporal agricultural performance, Bathla (2008) found that post-reforms agricultural performance was not impressive at all with yield (which is main source of agricultural growth), whichremained almost same during pre and post reform period with

marginal improvement in case of sugarcane and oilseeds, and marginally lower for cotton. In contrast to post-green revolution period when annual output and productivity growth rate of food as well as non-food crops rose significantly between 1968-69 to 1991-92, such improvement in area, output or productivity was not seen in the post-reform period. For instance, the trend growth rates of area and output in some crops (wheat, rice, sugarcane and all oilseeds) revealed a marginal decline, while other crops (such as rapeseed-mustard, pulses, and cotton) witnessed a significant decline during the post-reform period than the previous decade.

### 2.3 Crop diversification patterns in India

The term 'agricultural or crop diversification' is interpreted differently by different researchers. Vyas (1996) considered diversification as any of the following (i) shifting from farm to non-farm activities; (ii) shifting from less to more profitable crop/enterprise; or (iii) using resources in complementary and diverse activities. This is in contrast with Behera et al (2007) who considered narrow definition based on on-farm activities as 'the diversion of a sizeable acreage from the existing crop system to some alternative crops/cropping systems/farm enterprises, while maintaining a general equilibrium of meeting the 4F needs (food, fodder, fibre and fuel), and simultaneously taking care of the basic soil health and productivity of the agro-ecosystem of the area at large.' Some also interpret diversification as 'a shift from staple and low-value crops to higher value crops such as fruits and vegetables' which can help not only in stabilizing income and employment and export opportunities for poor and marginal farmers, but can also help in conserve natural resource base such as land and water (Joshi et al. 2004, Chand 1996).

There exists a general consensus among the researchers that crop diversification carries with itself huge benefits, such as increase in farmers' income, increasing exports and competitiveness in both domestic as well as foreign markets, protecting natural resources, promoting food and nutritional security, eliminating poverty, employment generation, promoting sustainable agriculture practices through judicious use of natural resources and ecological improvement(Bathla 2008; Petit et al 1972, Lin 2011, Reddy et. al 2009). Diversification may be horizontal or vertical in nature. While the former involves 'expansion of cropping base by adding or substituting more crops in the existing cropping pattern which can increase food production to over 30 tonnes per hectare and cropping intensity by 400-500percent, the latter involves 'adding more value to the existing crops into food and industrial products' by down-streaming activities

such as storing and processing through industrial sector, so as to gain more economic returns. In other words, vertical diversification reflects the extent and stage of industrialization of crops(Singh et al 2018, Thomas at. Al 2017).

There are various statistical methods available to measure magnitude of diversification such as Simpson Index, Entropy index, Herfindahl-Hirschman Index and Modified Entropy Index. Each of these methods has its own benefit and limitation in terms of data requirement, ease of computation and interpretation of results and level of sophistication. However, the results obtained from these tools are more or less similar (Singh et al 2018).

There is a vast literature analyzing the temporal dimension of shifts in cropping patterns are analyzed at national and state-level in India (Vyas 1996, Kannan 2012), South-Asian regional level (Gulati et al. 2004) and regional and district levels within India (Vaidyanathan 2010, Bathla 2008). These studies have analyzed the changes in area, output, yield and cropping pattern among major crop groups such as foodgrains and non-food grains sector like horticulture and also within major crop groups (such as shift within different food grain crops or within different oilseeds).

For instance, the literature broadly finds that the cropping pattern has undergone a shift from foodgrains to commercial crops, and decline in coarse grains even within the foodgrain sector. Thus, there is dominance of staple crops as a result of green revolution. Bhalla (2008) argued that there was high rate of growth and per capita income in 1980s which has resulted in diversification of demand, and hence cropping pattern away from foodgrain sector toward non-foodgrain sector. Such diversification was more pronounced in central and southern parts of India.

There is huge increase in regional disparity as a result of crop diversification (Behera et al. 2007). In north-western India, the excessive mono-cultivation of wheat and water-guzzling rice has resulted in overexploitation of groundwater, soil salinity, low agricultural productivity and hence low farm income (Chand et al. 1997, Sarkar et al. 2014). Further, less encouragement to the production of high-value commodities has deteriorated qualitative nutrients intake, which is reflected in serious levels of hunger index. In contrast to this, the diversification in the southern and western regions was modest during the 1980s and 1990s. Since these regions are relatively

less developed in irrigation and rely on rainfall only, crops like pulses, oilseeds, fruits and vegetables, and maize find a niche here. However, the oilseed crop is under serious threat due to the import liberalization of edible oils (like palmolein) due to their low import price. Finally, the eastern region has high staple food (rice) cultivation due to low per capita income and less infrastructure development. The rest part of gross sown area which is allocated to cultivation of crops other than rice such as vegetables is much diversified.

### 2.4 Determinants of Crop Diversification in India

The literature can be divided into following broad categories in determining whether the cropping pattern in a given area is more diversified or specialized.

Firstly, regarding demand-side factors, although literature broadly agree it to be a considerable factor which has led to diversification in India, but for whether this demand has come from domestic or foreign-led or both, there are different views. Moststudies have given prominent role to domestic demand such as 'robust economic growth' and 'rapid urbanisation' (Gulati et al. 2004, Parthasarthy et. al 2004, Ravi and Roy 2006). This is because as per capita income and urbanization increase, the living standard of consumers increase, due to which they tend to diversify their dietary patterns to include more nutritious crops such as horticulture crops in their consumption baskets, moving away from high consumption of staple crops. Ravi and Roy (2006) argues that the demand-driven factors which propelled rapid changes in food basket are 'robust economic growth' and 'rapid urbanisation'. Parthasarthy et. al (2004) confirms the role of urbanization in diversification towards HVCs (fruits, vegetables, milk, meat and fish products) using Geographic Information System (GIS) as well as they find that urban districts having population of >1.5 million have higher share of High Variety Seeds (HVCs) than urban-surrounded and other districts. Some other studies have given prominent role to global demand factor driven by post 1991-liberal external trade policies (Bathla 2008).

Secondly, from the supply side, there is a broad consensus that diversification, how so much it may be, has not come much from government efforts which still encourage cereal production (through price and credit policy, R&D policy) in order to achieve the goal of self-sufficiency) (Gulati et al. 2004). However, the limited role of supply-side factors is still recognized (such as pricing policy, adoption of HYV seeds, Mission Programme on oilseeds, technology and

restrictive trade policy). For instance: Hazra (2001) argues that sudden increase in area under oilseeds by 43 percent in just a decade (1986-87 to 1996-97) was mainly due to a protective trade environment, Technology Mission on Oilseeds (TMO) and a favorable price policy.

Literature argues that credit, an input variable may influence crop diversification positively or negatively. This is because since credit helps in increasing the risk-bearing capacity of farmers, farmers may undergo a structural change from low-value to high-value cropping pattern (Panda 2015, Jha et al. 2009, Birthal et al. 2006). However, credit may be put in non-farm uses in case existing crops are renumerative or in case market infrastructure is relatively underdeveloped, thus constraining diversification (Nayak et al. 2019).

Some other supply side factors may be exogenous in nature such as agro-climatic conditions, physical and geographic factors that affect the diversification aspect (Vyas 1996, Gulati 2004). For instance, certain soils, some geographical features (like drainage, slope and elevation) or climatic conditions (like rainfall, sunlight, humidity) are suitable only for particular crops only. In the Indian scenario, Gulati (2004) and Hazra (2001) found diversification to be more pronounced in rain-fed areas, where the former believes that the reason to be abundant labour supply in these areas. This is, say in case of oilseeds, when growing conditions are favorable in both rainfed as well as groundwater irrigated areas. However, Hazra (2001) also pointed out that institutional support is required to reduce risk in rainfed areas to encourage diversification. Vyas (1996) argued that technological changes can help in modifying these natural conditions, although such changes might be desirable or undesirable (as these could be really difficult and may prove to be economically unviable too). For instance, irrigation technology has helped remarkably in moving towards multiple cropping systems as well as gaining higher productivity and making cropping pattern more diversified. Such technology as may be embodied in fertilizers, seeds, draught power etc. can help in shifting comparative advantage of one crop vis-à-vis another. However, Vyas (1996) mentioned that these have led to specialization rather than diversification. Some other studies found its effect to be positive but insignificant in some studies as irrigation may increase choices of farmers to grow variety of crops in the field (Kumar at al 2015).

Thirdly, market structure is one of the key factors determining the cropping pattern, if not the pace of diversification (Vyas 1996; Joshi et al 2004). This is the reason behind establishment of

National Horticulture Board, 1984, amendment in Agriculture Produce Market Committee (APMC) Act to mandate sales by farmers exclusively through government's licensed mandis were some other efforts which promoted diversification towards horticulture (Birthal et al 2007). In case market structure is weak (due to inadequate information, lack of transportation and lack of communication facilities), the farmers will not be able to receive correct price signals. Also, delivery systems for inputs and credit are necessary to be taken into consideration while making cropping decisions. Here come the challenges pointed by Buhera et al. (2007) in context of India that the current extent of diversification is still much far from the desirable extent due to following market constraints, which act as key challenges**.** These include (a) infrastructure (marketing and roads) and transport issues, as the remote areas are much distant to the markets; and (b) Lack of market extension system (such as lack of tolerant varieties of seeds, lack of knowledge and expertise); (c) Industrialization, especially in sectors such as food processing will lead to an increase in diversification (Niti Aayog 2015). However, in case 'Industry-crop relationships' are well-developed, then the shift from monoculture towards diversification becomes difficult as huge investments have already been incurred in establishment of industries in a particular area. For instance, rice industry in Punjab and Haryana, sugarcane industry in Uttar Pradesh, and soybean industry in Madhya Pradesh (Kaur 2021).

Overall while access to market should increase crop diversification as farmers can grow various crops without the fear of loss due to the non-availability of the market (Nayak et al. 2019, Shamdasani 2016, Rao et al. 2004), but recent studies have found the contrary, which is probably because better road facilities encourage people to import quality products from major towns of the cities, affecting local market (Anwer et al 2019, Ashok et al. 2006; Singh et al. 2006).

Jayne et al. (2011) argues that smallholder commercialization is an important strategy to shift from a semi-subsistence agrarian society to a diversified and food secured one. However, some literature at theoretical level argues that commercialization leads to increase in diversification at national level, as well as leads to increased specialisation at the regional and farm level (Pingali et al. 1995, Timmer 1997). This is because at national level, the shift from staple food to a diversified market-oriented production system is triggered by diversity in demand pattern towards high-valued foods like fruits and vegetables, rapid technological change and improved rural infrastructure. However, at farm level, mixed farming gives way to specialized production

in response to market price, quality inputs and learning by doing effect created by economies of scale. Kurosaki 2003 also confirms this result empirically, as more specialisation was found in commercialized regions of West Punjab.

Other market side variables are the relative price, price risk and return, which find broad consensus in literature that affects crop diversification. Vyas (1996) emphasized that there is high elasticity of supply, due to which relative prices have dictated the cropping pattern in India to a large extent. For instance, the oilseeds cultivation in both Kharif and Rabi seasons is at the expense of less profitable crops. This creates a challenge to insulate domestic producers from highly fluctuating international prices as high price responsiveness leads to huge disturbance, especially in case of open economy. Here again comes the institutional challenge pointed by Behera et al. (2007) that as relative profitability and risk affects diversification pattern, hence policies such as MSP are biased in favor of few crops only and Indian farmers are generally risk-averse, leading to adverse effect on diversification. Technology adoption by farmers can also favour/ discourage crop diversification (Vyas 1996, Joshi et al (2004)). For instance, Gulati (2004) pointed that more cereal technology adoption by farmers also reduced the scope of diversification. Hence, one of the prospects to increase crop diversification is to make such policies which lead to shift in comparative advantage towards production of high-value crops.

Fourth, at micro level, the household characteristics may also impact crop diversification. For instance, education and training helps in increasing awareness of techniques, and methods for better cultivation of a different variety of crops. The literature has found that there is a positive relationship between education and crop diversification (Malaiarasan et al. 2019, Dey 2020, Aheibam et al. 2017, Birthal et al. 2015, Rahman2008, Mango et al. 2018). Literature also finds that training impact crop diversification positively and significantly (Dey 2020, Basantaray et al 2017).At macro level, some literature suggests that rural literacy helps in increasing crop diversification (Debasis et al. 2018). However, other literature finds that rural literacy rate has a negative but insignificant impact as increased literacy rate leads to better employment opportunities in other sector, leading to shift of workforce from agriculture to other sectors (Anwer et al 2019).

There is a huge debate regarding the participation of small farm holders in the promotion of diversification process. On one side, crop diversification may get constrained if small and

marginal farmers have limited choices to diversify themselves because of diseconomies of scale and input, credit, and knowledge constraints which they often face (Singh 1984, Buhera et al. 2007, Gunasekera et al. 2017, Malaiarasan et al. 2019).For instance, Singh (1984) study on dry land regions found larger land holdings and bullock availability to stimulate plot diversification across farm households within the region.On the other hand, researchers such as Birthal et al. (2007) rejects this point by providing empirical evidence from India using NSS 54$^{th}$ round data that diversification towards high-value crops essentially exhibits a pro-smallholder approach (especially in case of vegetables). Also, the share of area allocated to vegetables by them was significantly higher in case of large family size and vice-versa.These findings are explained by Joshi et al (2002), Weinberger at al (2005), Bargouti et al (2005) and Birthal et al (2007) stating that the most of high value commodities are labour intensive in nature, with low gestation period and high returns. These are perfect conditions for small shareholders who can utilize their surplus labour to augment their incomes. Further, they would also like to avoid allocating land to a commercial crop as then they would have to make purchase from the market in order to meet their own food requirements, thus adding to an additional source of risk.

Finally, the institutional factors also impact crop diversification. For instance, using NSSO 70$^{th}$ round data for the year 2012-13, Malaiarasan et al. (2019) argues that tenancy farming discourages crop diversification because tenants are reluctant to diversify compared to their counterpart farmers with own land.

Besides, there are various farmers' producer organization which are formal rural producer organizations that provide supporting services to farmers such as marketing of farm products, supply chain activities (vertical integration) improvement production and local processing activities in order to improve farm income (Rondot and Collion 2001, Shylendra 2009). For instance, cooperatives, unions, associations, federations and groups are some of the farmers' organizations. The literature recognizes the contribution of such organizations in demand-diversification towards high-value crops, through integration of small holders with domestic and export markets of high-value commodities (Pathania 2021, Birthal et al. 2014, Roy et al. 2008).

PM Fasal Bima Yojana was launched by the government of India stating crop diversification to be one of its objectives (Government of India 2020). However, literature argues that since only a limited number of crops are notified by states for provision of crop insurance under this scheme,

it acts as impediment to crop diversification (Bhushan et al. 2017). A study in Odisha argues that the MNREGA card holders are able to diversify better because extra income is used for diversification of crops. However, such diversification is distressed in nature rather than cash-crop led because only small income is earnt through MNREGA (Basantaray et al 2017).

Crop diversification is a good strategy to improve soil quality (Ghimire et al. 2016, Kumar et al. 2021), so recommendations under soil health card scheme should automatically be in direction of adoption of diversified or multiple cropping. Chakrawarty et al. (2018) found in their primary survey in Ujjain district of Madhya Pradesh that around 77 percent of the soil health card beneficiaries were moderately or highly aware of crop diversification. Other studies on specific states such as in Assam and Punjab also argues that there is a positive role of soil health card in increasing crop diversification (Bordoloi et al. 2017, Grover et al. 2019).

**2.5 Summary**

The literature broadly confirms that structural breaks in Indian agricultural growth have taken place during the mid-1960s and 1988 for the study period from 1950s to early 2000s. No recent study on computation of structural breaks for the period after early 2000s is available.

Growth trends reveal that gross domestic product from agriculture grew by 2.05 percent per annum during early phase of green revolution till 1979-80 accompanied by severe droughts, two consecutive wars and global oil crisis. Afterwards, there was high agricultural growth of 3.08 percent during 1980s, but it decelerated during 1990s despite higher growth in secondary and tertiary sectors, leading to serious adverse consequences for agricultural workforce.

Cropping pattern has witnessed a shift from foodgrains to commercial crops from 1967-68 to 2007-08, despite increase in trend of wheat-rice monoculture. Such decline in foodgrains is due to decline in cultivation of coarse cereals and pulses. Yield has been a major contributor of agriculture production than area since 1960s. However, the increase in yield is also not much impressive in post-reform period, as was during pre-reform era. The trend growth in agricultural output has increased post green-revolution, but decelerated post 1991 reforms.

Diversification may be horizontal or vertical in nature. The former refers to the expansion in cropping base while latter refers to adding more value to the existing crops through its

integration with the industry. The eastern and northern regions follow a specialised cropping pattern whereas southern, western, and central regions have relatively diversified cropping pattern.

The literature argues that crop diversification is positively impacted by demand-side factors rather than supply side factors as government efforts still encourage specialisation much more than diversification. Under supply and market side, literature finds a significantly negative impact of fertilizer use and price ratio in favor of staple crops such as paddy, debated impact of provision of commercialization, irrigation and credit facility on crop diversification, and positive impact of cropping intensity and terms of trade. Household characteristics such as education (rural literacy at macro level) and training help in increasing the diversification. The role of small farm holders in bringing diversification is debatable, as on one side, they often face diseconomies of scale and face input, credit and knowledge constraints, while on the other side, they supply abundance labor, which is required for labor intensive cultivation like horticulture crops and pulses. The impact of industrialization on diversification is also debatable because in case the industries are biased in favor of a few staple crops such as paddy, then such forward linkage will lead to specialization rather than diversification. Literature has found positive impact of institutional factors and schemes such as being a part of registered farmers' organization, MNREGA and Soil health card scheme, while negative impact of being a part of leasing institution and PM Fasal Bima Yojana.

# CHAPTER-III

# *AGRICULTURE GROWTH IN INDIA: NATIONAL AND STATE-LEVEL ANALYSIS*

# CHAPTER 3

## *AGRICULTURE GROWTH IN INDIA: NATIONAL AND STATE-LEVEL ANALYSIS*

### 3.1 BACKGROUND

Agriculture continues to be a mainstay of the Indian economy with an employment share of 54.6 percent according to the Population Census 2011 and livelihood support to a majority of rural households, even though its share in overall GDP is declining. The trends in agricultural growth are relatively well-researched and it is argued that such performance was considerable during the 1980s, but decelerated in the 1990s owing to biased economic reforms against the agricultural sector, especially when public expenditure got stagnated (Balakrishnan 2000; Mahendradev 2000). However, the agricultural growth started reviving in the mid-2000s due to renewed government policies such as crop loans interest subvention program, Rashtriya Krishi Vikas Yojana (RKVY), National food security mission, and pulses development program (Kannan 2011).

To analyze such trends, most of the studies have divided the time period into known structural break dates assuming some prior known criteria such as the phases of spread of Green Revolution technology, domestic economic reforms/external trade liberalization policy being implemented since early 1990s (Bhalla, 2007; Vaidyanathan, 2010); or simply decadal analysis of agricultural growth pattern (Kannan, 2011; Bhalla and Singh, 2001). A few studies have computed structural break points endogenously, but their analysis have focused on overall economic growth rather than specifically examining the agricultural growth pattern (Dholakia, 1994; Balakrishnan and Parameswaran, 2007). Even those studies that have analysed the agricultural growth pattern by identifying structural breaks in agricultural GDP, confined to the periods of Green Revolution and economic reforms of 1990s (Ghosh, 2002 and 2010; Chand and Parappurathu, 2012).

The present chapter analyses the agricultural growth performance in India during the period, 1981-82 to 2019-20 by computing the nature and timings of structural changes identified endogenously. This will help in freeing the research from preliminary assumptions regarding the structural changes that took place in the agriculture sector. The trends and patterns in growth rates of agriculture are analyzed both spatially and temporally. This will help to illustrate the policy implications/ future strategy required to augment the agricultural output, reasons for a slowdown at national and sub-national levels to take correcting measures for the states lacking behind.

## 3.2 METHODOLOGY

First, it analysis the trends and status of agricultural growth in India at national and state levels from 1981-82 to 2019-20. The methods adopted in this chapter are explained below:

This chapter calculates growth in agriculture in terms of both gross domestic product and value of crop output. Agricultural GDP at the national level and agricultural GSDP at the state level at constant prices are taken by converting the series into the base year 2011-12 by using the 'splicing technique' (i.e. constant (2011-12) prices). As the base of official statistics is revised periodically, to make the whole data comparable, the data series is adjusted to 2011-12 prices to make the whole data set comparable by using the formula:

$$Y_{t(n)} = Y_{t(O)} * \frac{C_n}{C_o}$$

Where,

$$Y_{t(n)} = Value\ of\ variable\ Y\ at\ time\ t\ according\ to\ 2011-12\ prices;$$

$$Y_{t(O)} = Value\ of\ variable\ Y\ at\ time\ 0\ according\ to\ given\ base\ year;$$

$$\frac{C_n}{C_o} = Ratio\ of\ value\ of\ current\ year\ and\ base\ year\ of\ a\ common\ variable$$

### 3.2.1 Computation of Structural breaks in agricultural GDP

The growth in agricultural output and other important variables at the national and state levels are analyzed by finding structural breaks in the time series. The time period for the analysis is from 1981-82 to 2019-20.Since the structural transformation in an economy is generally seen in terms of changes in gross domestic product from different sectors, so the overall period (39 years) is divided into different sub-periods, by endogenous computation of structural breaks in in agricultural GDP data using the statistical tool 'Bai-Perron multiple breakpoint test' using e-views software.

The first step is to compute growth rate of GDP from the agriculture sector (at constant 2011-12 prices) using the formula $\left[\{{}^{Y_t - Y_{t-1}}/_{Y_t}\} * 100\right]$ for each year separately.

Afterwards, identification of series is done to estimate the univariate stationarity of agriculture GDP time series. The non-stationary series is likely to be trended, or is more likely to show structural break. Thus, the initial idea about the data generating process is obtained by looking at the shape of the graph of the univariate GDP agricultural growth series, and then by drawing the graphs for Autocorrelation functions (ACF) and Partial autocorrelation function (PACF). The stationarity/ unit root tests are applied, namely, (a) ADF test (with and without trend) assuming no breakpoint; (b) Phillips-Perron test assuming no breakpoint, and (c) Dickey-Fuller Minimum t-statistics with intercept and trend with a single unknown breakpoint. It may be noted that Bai (1997) has shown that the stationarity condition is not required for the consistency of break dates in the above procedure. Nonetheless, this chapter applies the stationarity test to better identify the properties of given series.

Bai and Perron (1998 and 2003) have formulated an approach to identify the breaks in any series using the least square principle which is commonly used in regression analysis. It is a superior method as it helps in the identification of multiple breakpoints by using global minimizers of the sum of squared residuals from OLS regression. That is, the least square estimates of breakpoints are the ones that minimize the full sample of the sum of squared residuals. This may be applied to an equation obtained by regressing the univariate series on intercept only or with the trend.

The steps are as follows:

1) Calculation of least square estimates: Let the estimated breaks be $(T_1,\ T_2, \ldots\ldots, Tm)$, where m= number of breaks. For each partition $\{T_P\}$, the associated least square estimate is $\beta_P = (a, g)_P$, which is obtained by minimizing the sum of squared residuals as:

$$\sum_{j=1}^{m+1} \sum_{t=T_{j-1}+1}^{T_j} [\ln Y_t - a_j - g_j t]^2$$

2) Computation of the sum of residual squares from the least estimated computed in Step 1. We denote such residual sum of the square as $S_T\ (T_1,\ T_2, \ldots\ldots, Tm)$, associated with the partition $\{T_P\}$.

3) Now, the estimated break dates $(\widehat{T_1}, \widehat{T_2}\ , \ldots\ldots, \widehat{T_m})$ are such that:

$$\left(\widehat{T_1}, \widehat{T_2}\ , \ldots\ldots, \widehat{T_m}\right) = argmin_{(T_1, T_2, \ldots\ldots, Tm)} S_T(T_1, T_2, \ldots\ldots, Tm);$$

Where the minimization is possible over all the probable partitions $(T_1, T_2, \ldots\ldots, Tm)$ such that $T_i - T_{i-1} \geq h$. Here, $T_i$ is the $i^{th}$ breakpoint and 'h' are the minimum lengths assigned between the two partitions. The Bai-Perron procedure considers all the probable partitions and finally, selects the one that minimizes the sum of squared residuals.

4) The number of break points and hence, the best break date(s) out of all above is chosen through Schwarz information criterion (SIC) and Liu-Wu-Zidek criterion (LWZ) criteria. However, in the present analysis, we have taken all possible break dates without choosing the best break dates to avoid any loss of information so that trend analysis may be done more comprehensively.

### 3.2.2 Compound annual growth rate (CAGR)

CAGR has been computed on GDP/GSDP from the agriculture sector, area, output, and yield of major crops atall India and state-level.

The compound growth formula is written as$Y_t = Y_0(1+r)^t$, which can be further written as: $\ln Y_t = \ln Y_0 + t.\ln(1+r)$, so a semi-log regression is run as:

$$\mathbf{\ln Y_t = \beta_1 + \beta_2.t + u_t}$$

where $Y_t Time\ series\ data\ (of\ agricultural\ GDP\ or\ GSDP, or\ APY\ data\ of\ major\ crops)$

$$t = time or trend term$$

$\beta_1 = ln\, Y_0$and $\beta_2 = \ln(1+r)$

CAGR (r) = (antilog ($\beta_2$)-1)*100.

### 3.2.3 Instability Index

Coefficient of Variation (CV) is computed to analyse the volatility in growth in agricultural GDP,area, production and yield of major crops at both all India and State-level. It is computed using the following formula:

CV= Standard deviation/Mean*100.

CV is a relative measure of dispersion, which is considered to be a better measure than any absolute measure (such as standard deviation) which depends upon units of measurement.

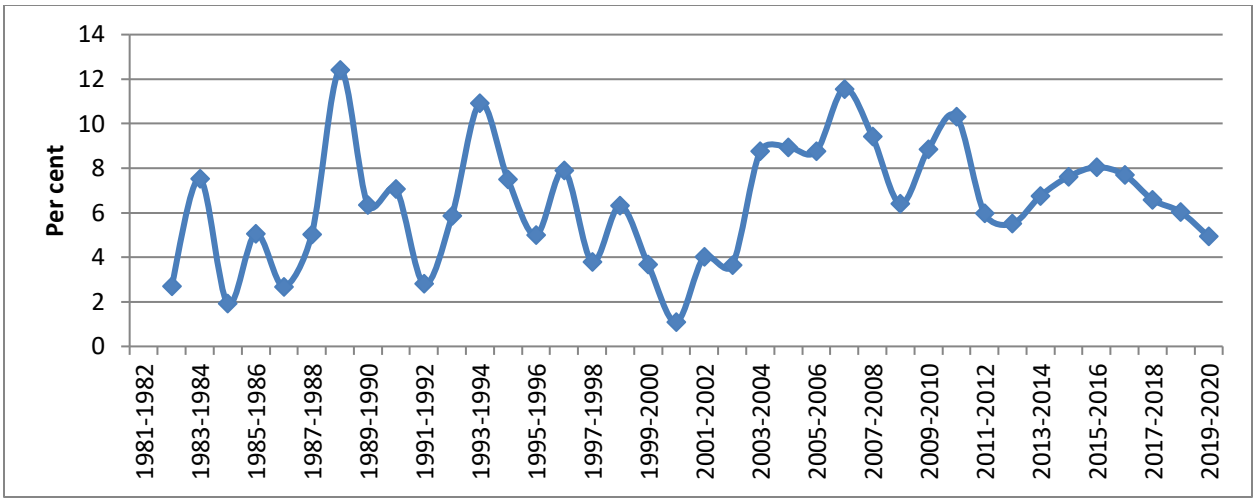
## 3.3 GROWTH PERFORMANCE OF AGRICULTURAL SECTOR IN INDIA

### 3.3.1 Structural breaks in agricultural GDP-All India

To find structural breaks, the following steps are involved: first, graphs of Gross Domestic Product from Agriculture (GDPA) and GDPA growth rate on a year-on-year (y-o-y) (i.e. first difference of logarithmic GDPA series) basis are drawn to get an approximate idea of what the data-generating process looks like. The graph reveals that while GDPA follows a smooth trending line, the graph of GDPA growth rate shows fluctuation around its meandepicting a stationary process. So, GDPA growth rate is considered so that trend in the series may not be present. Second, the ACF and PACF graphs are drawn for the GDPA growth rate. These reveal that the stochastic series is stationary and the lag might be present at t=6. Now, assuming AR(1) model i.e. $Y_t = aY_{t-1} + u_t$, and that no structural break has taken place, various unit root/ stationary tests are done where the null hypothesis is H0: a=1 (i.e. non-stationarity).Augmented Dicky-Fuller (ADF) unit root test (with intercept only) rejects the null hypothesis implying that series is stationary, ADF unit root test (with intercept and trend), Phillips-Perron test, and D-F minimum t-statistics also shows the same result, with the trend being insignificant.

Although the first differenced GDPA series is stationary, its fluctuations over time imply possibility of structural breaks in the series. Applying Bai-Perron multiple breakpoint stability diagnostics, five structural breaks have been identified endogenously at 1987-88, 1992-93, 1997-98, 2003-04, and 2011-12. The break date year is included in the upper limit of each period, to analyze if there are any noteworthy effects in upcoming years after such structural break years broke out. Although we will be using all the break dates in the study, finding the best break date is desirable to be used at specific points. Using Schwarz information criterion (SIC) and Liu-Wu-Zidek criterion (LWZ) criteria, the year 2003-04 is identified as the best break-date, where both criteria are showing minimum value. Both SIC and LWZ criteria work reasonably well in absence of serial correlation in the errors but tend to choose a higher than the true value in presence of serial correlation. So, Lagrange Multiplier (LM) test is performed to check if there is serial correlation present or not, taking null hypothesis as ‘no serial correlation up to lags four’. The result came out as p=0.4821. Hence, the null hypothesis is not rejected and there is no serial correlation present. Hence, the SIC and LWZ tests depict reasonably good results.

**Figure 3.1: Year-on-year growth of Gross Domestic Product from agriculture in India**




Source: National Accounts Statistics, Central Statistics Office.

**Table 3.1: Stationarity test results of univariate year-on-year GDPA growth data series**

| | t-ratio | p-value | Result |
|---|---|---|---|
| ADF test statistic-intercept only | -4.573844 | 0.0008*** | Stationary |
| ADF test statistic-intercept and trend | -4.592355 | 0.0039*** | Stationary, the trend is insignificant. |
| Phillips-Perron test- intercept only | -4.578085 | 0.0008*** | Stationary |
| ADF min. t-statistics | -4.593232 | 0.0043*** | Stationary, the trend is insignificant. |

Note: Null Hypothesis in all above tests is H0: GDP Agriculture growth rate has a unit root
Source: National Accounts Statistics, Central Statistics Office.

### 3.3.2 Structural breaks in agricultural GDP growth by states

Structural breaks in agricultural GDP computed at state level are given in Table 3.2. It shows that 1987-88, 1988-89, 1993-94, 1998-99, 2004-05, 2014-15, and 2015-16 are the structural breakpoints for most of the states. These dates broadly resemble the national-level structural breaks. Moreover, different states show some level of variability too, which might point to the fact that some state-specific policies are required to be implemented according to the specific situation prevailing in each state.

**Table 3.2: Potential structural breaks in state GSDPA for various states since 1981-82**

| States/ UTs | Potential structural breakpoints in | | | |
|---|---|---|---|---|
| | 1980s | 1990s | 2000s | 2010s |
| Assam | 1987-88 | 1992-93 | 2002-03, 2009-10 | 2015-16 |
| Gujarat | 1988-89 | 1997-98 | 2002-03, 2008-09 | 2015-16 |
| Haryana | | 1991-92, 1996-97 | 2004-05 | 2010-11, 2015-16 |
| Himachal Pradesh | 1988-89 | 1994-95 | 2004-05 | 2010-11, 2015-17 |
| Jammu &Kashmir | 1988-89 | 1993-94, 1999-2000 | 2004-05 | 2014-15 |
| Karnataka | 1987-88 | 1992-93, 1998-99 | 2008-09 | 2014-15 |
| Kerala | | 1991-92, 1998-99 | 2004-05, 2009-10 | 2015-16 |
| Maharashtra | 1987-88 | 1996-97 | 2004-05, 2008-09 | 2015-16 |
| Odisha | | 1990-91, 1997-98 | 2004-05, 2008-09 | 2015-16 |
| Punjab | | 1990-91, 1995-96 | 2000-01, 2005-06 | 2015-16 |
| Rajasthan | 1988-89 | 1993-94, 1998-99 | 2004-05 | 2015-16 |
| Tamil Nadu | 1987-88 | 1993-94, 1998-99 | 2004-05 | 2015-16 |
| West Bengal | | 1993-94, 1998-99 | 2004-05, 2009-10 | 2014-15 |
| Bihar &Jharkhand | 1987-88 | 1993-94, 1998-100 | 2006-07 | 2014-15 |
| Madhya Pradesh & Chhattisgarh | 1987-88 | 1994-95 | 2004-05 | 2010-11, 2015-16 |
| Uttar Pradesh &Uttarakhand | 1987-88 | 1992-93, 1997-98 | 2004-05 | 2015-16 |
| Andhra Pradesh & Telangana | 1987-88 | 1992-93 | 2004-05, 2008-09 | 2014-15 |

Source: computed based on National Accounts Statistics, Central Statistics Office.

### 3.3.3 Contribution of agriculture to National Income and Employment- All India

Table 3.3 shows that the share of agriculture in overall GDP has declined considerably overtime. There is a consistent structural transformation occurring in the economy and the rate of such transformation has increased since the mid-1990s leading to fall in share of agricultural income. Growth in agriculture averaged at 2.82 per cent during the overall period, 1981-82 to 2019-20 and the instability in year-on-year growth was as high as 41.6 per cent. Agricultural growth during the sub-period 1981-82 to 1987-88 was 1.77 percent. This was the time when India was successfully able to overcome the Hindu rate of growth for the whole economy well as in the agricultural sector, combined with the mature phase of the Green Revolution technology with improved seeds, irrigation and fertilisers made available across various regions of India (Kumar 1992; Bhalla 2007).

**Table 3.3: Share of Agricultural GDP and its Growth Rate**

| Years | % Share of GSDPA in total GDP | Growth rate (CAGR) of agricultural GDP | CV in agricultural GDP growth (%) |
|---|---|---|---|
| 1981-82 to 1987-88 | 33.27 | 1.77*** | 50.78 |
| 1988-89 to 1992-93 | 29.64 | 2.31*** | 50.45 |
| 1993-94 to 1997-98 | 26.49 | 2.61*** | 39.42 |
| 1998-99 to 2003-04 | 22.14 | 1.66*** | 57.43 |
| 2004-05 to 2011-12 | 16.36 | 3.74*** | 21.13 |
| 2012-13 to 2019-20 | 12.46 | 2.98*** | 16.72 |
| 1981-82 to 2019-20 | 22.48 | 2.82*** | 41.64 |

Note: * p<0.1 and **p<0.05 and ***p<0.01; CV stands for Coefficient of Variation.
Source: National Accounts Statistics, Central Statistics Office, Government of India

Moreover, Table 3.3 shows that even after the green revolution had come to its mature stage, the agricultural GDP grew at 2.82 percent per annum, i.e. during the overall period, 1981-82 to 2019-20.Sub-period-wise, the growth performance of Indian agriculture kept improving from the 1980s till the mid-1990s but started declining afterward, except in the sub-period 2004-05 to 2011-12, when the growth was really impressive (grew sharply by more than 3.5 percent per annum).

Specifically, the growth during sub-period 1981-82 to 1987-88 was 1.77 percent. This was the time when India was successfully able to overcome the Hindu rate of growth for the whole economy well as in the agricultural sector, combined with the mature phase of the Green

Revolution technology with improved seeds, irrigation and fertilizer made available widespread across various regions of India, so the 1980's decade registered a significantly higher growth rate (Kumar 1992, Bhalla 2007). Such paradox of relatively low growth could potentially be explained by the three consecutive droughts that took place in the year 1985, 1986 and 1987, out of which the last one was one of the four major national-scale meteorological drought events[2]that took place in India, so the overall CAGR declined rather than increasing.

The agricultural growth recovered gracefully in the following sub-period when the growth rate increased substantially to 2.31 percent per annum in 1988-89 to 1992-93. This is also confirmed by other studies which have found break date at 1987-88 or 1988-89 after which the GDP from the agriculture sector increased substantially (Ghosh 2002, 2008 and 2010). This not only implies the recovery of the sector from droughts but may include the base effect, where the low base superficially led to a higher growth rate during the year 1988-99.

The next break date1992-93 can be best regarded as having occurred due to policy changes which again led to significant improvement in growth to 2.61 percent per annum.Theeconomic reforms of 1991 implemented in off-farm sectors, had one direct impact on agriculture too which is 'reduction in fertilizer subsidy and decontrol of fertilizers' (Chand et al 2010). The sector was also indirectly affected in at least the following vital ways which led to an increase in agricultural growth during the initial phase: First, the increase higher growth rate of overall GDP (and hence, in per capita income) led to the significant rise in food demand, especially in non-foodgrain/ high-value agricultural commodities such as fruits, vegetables, dairy, and poultry; secondly, by an increase in terms of trade[3] in favor of agriculture because of decrease in industrial protection, thus creating incentives for private investment, especially in high-value agricultural products; and third, substantial rise in minimum support prices by the government to lessen the gap between international and domestic prices which resulted from devaluation to counter the earlier overvaluation in exchange rates (Landes and Gulati, 2003, Chand 2005).

[2]There is broad consensus among various studies that four major national-scale meteorological drought[2] events that took place between 1980 and 2020, namely in 1987, 2002, 2009 and 2012 (Udmale et. al. 2020, Kumar at. Al. 2013).

[3]The Terms of Trade (TOT) measures the relative prices between two sectors or two countries. Here, TOT refers to relative price of agriculture with respect to prices in other sectors, such as industry.

The sub-period 1998-99 to 2003-04 was indeed worst for agriculture where the growth rate slashed by around 1 percent of agricultural GDP to just 1.66 percent. This is possibly due to the huge agrarian crisis taken place from 1998 to 2003 led by the collapse of agricultural prices (for instance, fell in cotton prices by half), a sharp deceleration in agricultural wages, rise in power tariff, and decline in public expenditure on agriculture as Government had entered into 'State-level Structural Adjustment Programme (SAP) with World Bank' (Himanshu 2019, Biru et. al 2007).The result was shifting of terms of trade against agriculture; the agricultural sector grew just by 1.76 percent per annum during 1998-2004 and drastic suicide rates. For instance, according to Patnaik (2005), nine thousand suicides and kidney sales took place between 1998 and 2005. Moreover, the Asian Financial Crisis that took place in 1997 might have led to a more or less adverse impact on the Indian economy. The nationwide drought in 2002 might also have accelerated the pace of such a crisis.

Eventually, the economy started recovering, showing an impressive growth of 3.74 percent per annum during 2004-05 to 2011-12. This is possibly due to the renewed policy interest such as National agriculture development program, pulses development program, etc. led to somewhat improvement in agricultural growth afterward (Kannan 2011), accompanied by somewhat the base year effect too as the agriculture crisis in the previous sub-period kept the overall growth rate figure high. It is crucial to note here that the growth accelerated despite the occurrence of a nationwide drought in 2009, which may suggest the increased resilience to droughts. One more crucial point to note is that there is no separate breakpoint revealed by the breakpoint test for the Global Financial Crisis, 2008 which is supposed to be one of the major events that had brought the world down. This can be well explained as various studies have a broad consensus that although there was an unprecedented rise in food prices (much lesser rise than in the case of other countries), there was not much effect of the global financial crisis on the agriculture sector (Chand and Pandey 2010; Deepak 2012).

The question that now arises is whether this growth acceleration of at least 3 percent per annum since 2004-05 could sustain overtime. Table 3.2 shows that although the growth during 2012-13 to 2019-20 decelerated to 2.98 percent per annum of agricultural GDP, there is a clear decline in variability in growth during the whole period, as shown by the decline in value of the coefficient of variation (CV) from around 50 percent in early periods to just 20 percent during the recent

period. In this sense, it can be claimed with more certainty that agricultural growth has started hovering around 3 percent of agricultural GDP since around 2004-05. However, there are concerns as the deceleration from 3.74 percent to 2.98 percent may not only be due to a major nation-wide drought that took place in 2012 and two consecutive droughts again in 2014-15 but there are also collapse in agricultural prices and slash in agricultural wages, leading to demand deflation and hence, shift in terms of trade against agriculture (Himanshu 2019).

**Table 3.4: Workforce in the agriculture sector and its rate of change**

| Years | Total agriculture sector workforce (%) | Rate of decline in workers p.a. (%) |
|---|---|---|
| 1981 | 68.4 | - |
| 1991 | 67.1 | -1.90 |
| 2001 | 58.4 | -12.97 |
| 2011 | 54.6 | -6.51 |

Source: Census of India, various years.

Table 3.4 depicts the changes in share of workforce in agriculture sector and its rate of change. Various studies reveal that the pace of decline of agricultural workforce has quickened during the post-1991 reforms period along with a consistent fall in share of agriculture sector's income in total income. But with a rapid change in income from agriculture to non-agricultural sectors, workers have not shifted in the same proportion as that of reduction in agricultural share in national income. The agricultural workforce has declined only by one-third of the decline in its income share. This has led to a widening of income disparity between the agricultural sector and non-agricultural one (Chand and Chauhan 1999).

**Table 3.5. Average agriculture output-immediate input ratio and Average terms of trade**

| Years | Average agriculture output-immediate input ratio | Average TOT (2011-12=100) |
|---|---|---|
| 1981-82 to 1987-88 | 3.09 | 75.74 |
| 1988-89 to 1992-93 | 3.17 | 82.76 |
| 1993-94 to 1997-98 | 3.35 | 85.21 |
| 1998-99 to 2003-04 | 3.31 | 83.47 |
| 2004-05 to 2011-12 | 3.23 | 90.60 |
| 2012-13 to 2019-20 | 3.12 | 106.82 |
| Overall period | 3.20 | 88.47 |

Source: Agricultural Statistics at a Glance (various issues)
Note: Terms of Trade (TOT)= GDP deflator in agriculture sector/ GDP deflator in non-agriculture sector.

Table 3.5 shows the agricultural output-immediate inputs ratio in agriculture production and average Terms of trade in agriculture vis-à-vis other sectors of the economy. The terms of trade seem to be a key factor that influenced accelerations during the early 1990s, as well as decelerations during the 1998-99 crises. Moreover, it shows that the agriculture output increased relative to immediate inputs used for the same till 1997-98 sub-periods, hence, agriculture was becoming increasingly profitable to the farmers. However, such trend changed afterward when a major agriculture crisis took place around 1998-99 and this trend has continued during the recent period. This may prove to be a source for long-term stagnancy in agricultural growth (as CAGR in agriculture had declined compared to its previous sub-period during 1998-99 to 2003-04 and 2012-13 to 2019-20) and hence require immediate corrective steps. The prices or cost of inputs which are required more in production such as livestock feed, seeds, market charges, and chemical fertilizers (Table 3.6) are required to be paid greater attention by the government through regulation of their costs, to ensure that adequate input-output ratio, and hence adequate returns to the farmers are taken care of. Moreover, the public investment, which was the main driver during 1980s acceleration, became the reason for deceleration post-mid-1990s (Sivagnanam et al. 2016).

**Table 3.6. Average percentage/composition of inputs used in agriculture and allied sector**

| | 1981-82 to 1987-88 | 1988-89 to 1992-93 | 1993-94 to 1997-98 | 1998-99 to 2003-04 | 2004-05 to 2011-12 | 2012-13 to 2019-20 | Overall period |
|---|---|---|---|---|---|---|---|
| Seed | 12.05 | 11.94 | 11.49 | 10.24 | 8.78 | 7.29 | 10.11 |
| Organic manure | 7.79 | 6.88 | 6.33 | 5.86 | 5.99 | 5.71 | 6.41 |
| Chemical fertilizers | 6.77 | 9.31 | 9.48 | 9.92 | 10.83 | 10.47 | 9.50 |
| Current repairs, maintenance of fixed assets & other operational costs | 1.43 | 1.66 | 2.03 | 2.08 | 2.46 | 4.13 | 2.36 |
| Feed of livestock | 73.39 | 64.62 | 61.67 | 61.94 | 55.97 | 49.89 | 60.89 |
| Irrigation charges | 1.05 | 1.19 | 1.12 | 1.22 | 1.02 | 0.99 | 1.08 |
| Market charges | 10.11 | 10.75 | 10.85 | 10.69 | 10.54 | 10.10 | 10.47 |
| Electricity | 0.73 | 1.44 | 2.56 | 2.18 | 2.00 | 2.89 | 1.96 |
| Pesticides &insecticides | 0.65 | 0.58 | 0.49 | 0.47 | 0.51 | 0.51 | 0.54 |
| Diesel oil | 2.76 | 3.81 | 4.36 | 5.00 | 5.93 | 8.03 | 5.10 |
| Financial intermediation services indirectly measured | 0.77 | 1.75 | 2.54 | 2.40 | 6.15 | 12.12 | 4.61 |
| Total Inputs | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

Source: National accounts statistics (various issues), MOSPI, Government of India.

Overall, out of the five break dates, three breaks viz. 1987-88, 2003-04, and 2011-12 in the agricultural GDP series occurred are due to major national-scale meteorological drought events[4], implying that Indian agriculture is still heavily monsoon-dependent even after gaining food self-sufficiency. For instance, the percentage area irrigated has increased from an average 30.41 percent during 1981-82 to 1987-88 subperiod to just around 50 percent during 2012-13 to 2019-20 subperiod (Table 3.7). Increased irrigation cover has helped in building resilience to droughts in the past (Gulati et al (2013).

**Table 3.7: Percentage of area irrigated to gross cropped area**

| Years | % Area Irrigated |
|---|---|
| 1981-82 to 1987-88 | 30.41 |
| 1988-89 to 1992-93 | 34.65 |
| 1993-94 to 1997-98 | 38.43 |
| 1998-99 to 2003-04 | 41.51 |
| 2004-05 to 2011-12 | 44.59 |
| 2012-13 to 2019-20 | 49.09 |
| Overall period | 40.43 |

Source: ICRISAT database.

### 3.3.4 Relative contribution of agriculture in the state economy

Table 3.8 provides share of agricultural gross state domestic product (GSDP) and its growth rate. It reveals that states such as the undivided state of Madhya Pradesh, the undivided state of Bihar, and Punjab have more than 25 percent contribution of their GSDP arising from the agricultural sector. This is followed by the undivided state of Uttar Pradesh, Haryana, the undivided state of Andhra Pradesh, and West Bengal, whose agriculture contribution in GSDP ranges from 20 percent to 25 percent. States such as Jammu and Kashmir, Tamil Nadu, Gujarat, and Maharashtra have relatively less contribution of their GSDP arising from the agriculture sector. So, agriculture contributes the most to state income in North-western and Eastern regions.

Temporally, there is a huge decline in the share of agriculture in state income in every state of study. This is in agreement with the fact that as an economy grows, the share of the industry and

[4]There is broad consensus that four major national-scale meteorological drought[4] events that took place between 1980 and 2020, namely in 1987, 2002, 2009 and 2012 (Udmale et. al. 2020, Kumar et. al. 2013), out of which three break dates coincide.

service sector grows relatively faster than the agriculture sector, due to which its share in GSDP declines.In the first subperiod, the undivided states of Madhya Pradesh, Uttar Pradesh and Bihar were the most agriculturally- dependent with agricultural shares of 53.61 percent, 49.86 percent, and 41.29 percent. The relative share of Madhya Pradesh in agricultural activity has remained huge in the latest sub-period with 26.90 percent share, while for all the other states, the contribution of agriculture in state income in the latest sub-period is less than 15 percent only. Overall, the relative ranking of various states in their contribution to agriculture has remained more or less same during the entire sub-period. For instance, the contribution of agriculture in state income of Maharashtra and Tamil Nadu are still among the least of all, standing at 5.58 and 3.83 percent, respectively.

**Table 3.8: Average percentage share and CAGR of agricultural GDP across states in India**

| S.No | States | Agriculture share in GSDP (%) | CAGR (%) | S.No | States | Agriculture share in GSDP (%) | CAGR (%) |
|---|---|---|---|---|---|---|---|
| | **North-Western region** | | | | **Central region** | | |
| 1 | Haryana | | | 10 | Gujarat | | |
| | 1981-82 to 1991-92 | 28.63 | 2.012*** | | 1981-82 to 1988-89 | 21.36 | -1.83 |
| | 1992-93 to 1997-98 | 27.27 | 1.32 | | 1989-90 to 1997-98 | 19.40 | 4.10*** |
| | 1998-99 to 2002-03 | 22.08 | 0.68 | | 1998-99 to 2002-03 | 15.33 | -1.76 |
| | 2003-04 to 2008-09 | 17.50 | 1.96*** | | 2003-04 to 2008-09 | 15.14 | 2.24* |
| | 2009-10 to 2015-16 | 11.90 | -0.14 | | 2009-10 to 2015-16 | 11.04 | 1.77 |
| | 2016-17 to 2019-20 | 8.40 | 0.92** | | 2016-17 to 2019-20 | 8.06 | 2.73 |
| | Overall period | 22.88 | | | Overall period | 12.08 | |
| 2 | Himachal Pradesh | | | 11 | Maharashtra | | |
| | 1981-82 to 1988-89 | 24.13 | 0.79 | | 1981-82 to 1987-88 | 17.54 | 0.05 |
| | 1989-90 to 1994-95 | 20.86 | -0.48 | | 1988-89 to 1996-97 | 14.86 | 1.80** |
| | 1995-96 to 2004-05 | 15.54 | 2.31*** | | 1997-98 to 2004-05 | 17.49 | 1.55*** |
| | 2005-06 to 2010-11 | 11.96 | 0.20 | | 2005-06 to 2008-09 | 9.57 | 1.71 |
| | 2011-12 to 2015-16 | 9.48 | 2.64* | | 2009-10 to 2015-16 | 7.41 | 0.31 |
| | 2016-17 to 2019-20 | 6.62 | -0.08 | | 2016-17 to 2019-20 | 5.58 | -0.61 |
| | Overall period | 15.91 | | | Overall period | 12.08 | |
| 3 | Jammu &Kashmir | | | 12 | Madhya Pradesh &Chhattisgarh | | |
| | 1981-82 to 1988-89 | 13.80 | 0.20 | | 1981-82 to 1987-88 | 53.61 | 1.16* |
| | 1989-90 to 1993-94 | 12.63 | 1.74*** | | 1988-89 to 1994-95 | 48.40 | 1.76** |
| | 1994-95 to 1999-2000 | 13.44 | 1.13** | | 1995-96 to 2004-05 | 36.85 | -0.19 |
| | 2000-01 to 2004-05 | 12.67 | 2.27*** | | 2005-06 to 2010-11 | 30.10 | 1.99*** |
| | 2005-06 to 2014-15 | 10.13 | 0.27 | | 2007-08 to 2015-16 | 29.20 | 1.60 |
| | 2015-16 to 2019-20 | 8.43 | 25.55 | | 2016-17 to 2019-20 | 26.90 | 0.11 |
| | Overall period | 10.62 | | | Overall period | 32.61 | |

Continued...

| S.No | States | Agriculture share in GSDP (%) | CAGR (%) | S.No | States | Agriculture share in GSDP (%) | CAGR (%) |
|---|---|---|---|---|---|---|---|
| 4 | Punjab | | | 13 | Rajasthan | | |
| | 1981-82 to 1990-91 | 35.28 | 1.99*** | | 1981-82 to 1988-89 | 23.68 | 0.65 |
| | 1991-92 to 1995-96 | 34.34 | 1.23** | | 1989-90 to 1993-94 | 21.99 | 2.56 |
| | 1996-97 to 2000-01 | 30.53 | 0.99 | | 1994-95 to 1998-99 | 25.02 | 2.72* |
| | 2001-02 to 2005-06 | 27.54 | 0.96** | | 1999-2000 to 2004-05 | 19.91 | 2.36 |
| | 2006-07 to 2015-16 | 19.31 | 0.22 | | 2005-06 to 2015-16 | 16.52 | 2.51*** |
| | 2016-17 to 2019-20 | 13.66 | 0.35 | | 2016-17 to 2019-20 | 12.14 | 1.30 |
| | Overall period | 28.43 | | | Overall period | 20.55 | |
| 5 | Uttar Pradesh & Uttarakhand | | | | **Southern region** | | |
| | 1981-82 to 1987-88 | 49.86 | 0.91*** | 14 | Andhra Pradesh & Telangana | | |
| | 1988-89 to 1992-93 | 44.40 | 0.97* | | 1981-82 to 1987-88 | 34.59 | -0.78 |
| | 1993-94 to 1997-98 | 43.36 | 1.26* | | 1988-89 to 1992-93 | 28.52 | 0.00 |
| | 1998-99 to 2004-05 | 29.62 | -2.38* | | 1993-94 to 2004-05 | 20.86 | 1.15*** |
| | 2005-06 to 2015-16 | 18.59 | 0.98*** | | 2004-05 to 2008-09 | 9.35 | 3.18 |
| | 2016-17 to 2019-20 | 13.84 | 1.25 | | 2009-10 to 2014-15 | 7.52 | 1.33* |
| | Overall period | 23.69 | | | 2015-16 to 2019-20 | 6.07 | 3.13* |
| | **Eastern region** | | | | Overall period | 21.81 | |
| 6 | Assam | | | 15 | Karnataka | | |
| | 1981-82 to 1987-88 | 27.44 | 0.92** | | 1981-82 to 1987-88 | 25.75 | 0.89 |
| | 1988-89 to 1992-93 | 26.07 | 1.36** | | 1988-89 to 1992-93 | 21.94 | 1.91 |
| | 1993-94 to 2002-03 | 22.93 | -0.12 | | 1993-94 to 1998-99 | 19.24 | 1.09* |
| | 2003-04 to 2009-10 | 16.59 | 0.91*** | | 1999-2000 to 2008-09 | 11.77 | 0.46 |
| | 2010-11 to 2015-16 | 14.96 | 1.99** | | 2009-10 to 2014-15 | 8.51 | 0.37 |
| | 2016-17 to 2019-20 | 12.04 | 0.43** | | 2015-16 to 2019-20 | 5.54 | 2.59 |
| | Overall period | 19.50 | | | Overall period | 13.79 | |

Continued...

| S.No | States | Agriculture share in GSDP (%) | CAGR (%) | S.No | States | Agriculture share in GSDP (%) | CAGR (%) |
|---|---|---|---|---|---|---|---|
| 7 | Bihar &Jharkhand | | | 16 | Kerala | | |
| | 1981-82 to 1987-88 | 41.29 | 1.90* | | 1981-82 to 1991-92 | 23.34 | 1.61*** |
| | 1988-89 to 1993-94 | 33.64 | -0.89 | | 1992-93 to 1998-99 | 21.74 | 1.27* |
| | 1994-95 to 1998-99 | 26.80 | 0.45 | | 1999-2000 to 2004-05 | 16.68 | 0.64** |
| | 1999-2000 to 2006-07 | 22.72 | 1.85** | | 2005-06 to 2009-10 | 11.26 | -1.03* |
| | 2007-08 to 2014-15 | 16.42 | 3.56** | | 2010-11 to 2015-16 | 6.80 | -1.87** |
| | 2015-16 to 2019-20 | 10.59 | 0.86 | | 2016-17 to 2019-20 | 8.21 | 22.44 |
| | Overall period | 25.41 | | | Overall period | 12.87 | |
| 8 | Odisha | | | 17 | Tamil Nadu | | |
| | 1981-82 to 1990-91 | 30.30 | 0.62 | | 1981-82 to 1987-88 | 16.36 | 1.26 |
| | 1991-92 to 1997-98 | 22.09 | 0.32 | | 1988-89 to 1993-94 | 14.86 | 3.80*** |
| | 1999-2000 to 2004-05 | 15.95 | 0.28 | | 1994-95 to 1998-99 | 13.85 | 0.58 |
| | 2005-06 to 2008-09 | 12.95 | 1.34** | | 1999-2000 to 2004-05 | 10.32 | -1.86 |
| | 2009-10 to 2015-16 | 11.25 | 0.66 | | 2005-06 to 2015-16 | 7.06 | 0.95** |
| | 2016-17 to 2019-20 | 7.33 | -0.61 | | 2016-17 to 2019-20 | 3.83 | 5.29* |
| | Overall period | 19.00 | | | Overall period | 11.96 | |
| 9 | West Bengal | | | | | | |
| | 1981-82 to 1993-94 | 25.90 | 2.59*** | | | | |
| | 1994-95 to 1998-99 | 27.97 | 1.74** | | | | |
| | 1999-2000 to 2004-05 | 21.96 | 0.95** | | | | |
| | 2005-06 to 2009-10 | 16.84 | 1.09* | | | | |
| | 2010-11 to 2014-15 | 13.88 | 0.88* | | | | |
| | 2015-16 to 2019-20 | 12.27 | 1.95*** | | | | |
| | Overall period | 22.22 | | | | | |

Note: * p<0.1 and **p<0.05 and ***p<0.01
Source: National Accounts Publications, MOSPI.

In terms of growth rate, West Bengal has registered the highest growth in agriculture followed by the Gujarat, Maharashtra, Tamil Nadu, and Haryana during the overall period of study. During the crisis period of 1998-99 to 2003-04,many states had registered very low growth rates. Some of these states included Haryana, Himachal Pradesh, Jammu and Kashmir, Punjab, Bihar, Odisha, West Bengal, Gujarat, Rajasthan, Madhya Pradesh, Maharashtra, Kerala and Karnataka. Recovery led to an increase in the growth rates in the subsequent period 2004-05 to 2012-13. The recent slowdown in growth rates since 2012-13 was witnessed in a few states with exceptions. The southern states such as Karnataka, Andhra Pradesh, Kerala and Tamil Nadu have shown a remarkable growth performance in the recent most period. Similarly, Gujarat and Jammu and Kashmir have also registered robust average growth rate in the recent period.

## 3.4 AREA, YIELD AND PRODUCTION IN MAJOR CROPS AND CROPPING PATTERN

### 3.4.1 Cropping pattern- Share of APY of major crop groups in India

Table 3.9 shows that the share of the area under food grains constituted around two-thirds of the total gross cropped area on average since 1981-82. However, its share in cropping pattern has declined consistently (by around 0.27 percent per annum during the whole period). Such decline is more due to cereals and millets whose share has declined by 0.30 percent per annum. The share of pulses has also diminished, but at a much slower pace, and overall hovers around 12 percent of the gross cropped area. It is important to note that while the cereals and millets have declined at a consistent pace of at least 0.49 percent per annum during each sub-period (except during 1998-99 to 2003-04 sub-period), the share of pulses was initially declining and has started to increase as much as by 1.53 percent per annum during the last sub-period from its previous one, reflecting the increasing focus given on pulses.

The decrease in share of area under food grain has led to an increase in share of area under almost all sub-categories of non-food grains, especially horticulture, sugarcane, and oilseeds crops. One of the key factors for the shift in the area was commodity price, which increased

proportionately more for horticulture crops than for cereals (Chand et al 2011). The share of area under plantation crops has also increased in the overall cropping pattern, pointing towards overall increased diversification. Again, the decline in pace in case of sugarcane and plantation crops suddenly during 1998-99 to 2003-04 period shows that the increase in area under cereals were at the cost of these two crops. Moreover, the rate of increase in area under sugarcane is consistently declining during the period of study.

Tables 3.9 and 3.10 simultaneously show that although the share of foodgrain in total area is two-thirds on average during the entire year of study, its share in production is just 30 percent for the same period. This shows that foodgrains have comparatively lower yield as compared to other crops. On the other hand, sugarcane is grown on just around 2 percent of the area, but has a share of around 40 percent of the production, which shows that the yield from sugarcane is very high. The yield from horticulture crops is also very high, as it is grown on just around 9 percent of the area but have a share of 22.76 percent in total output. Pulses, oilseeds, and plantation crops have comparatively much lower yields, as these have an average of 2-4 percent share in total production.

Temporally, the share of total food grains in production has declined mainly due to a decline in cereals and millets rather than pulses. In the non-food grain category, the share of horticulture is increasing at an increasing rate each year on average, again due to commodity prices comparatively in favor of them than other crops. The share of cotton and oilseeds is also consistently increasing especially since 2002-03 but at a decreasing rate each year on average. The increase in production under cotton has shown the most expansion since 2002-03. Such increase is due to the widespread cultivation of Bt cotton, as its productivity and profitability are substantially higher than the earlier conventional hybrid varieties of cotton (Kannan 2011). However, the share under sugarcane is declining at a decreasing rate each year on average.

**Table 3.9: Average share of area of major crops groups in GCA in India (%)**

| Years | Cereals & millets | Total pulses | Total foodgrains | Nine oilseeds | Cotton, Jute & Mesta | Sugarcane | Horticulture crops | Other crops | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1981-82 to 1987-88 | 58.87 | 13.15 | 72.02 | 10.22 | 4.86 | 1.77 | 5.88 | 5.25 | 100 |
| 1988-89 to 1992-93 | 55.46 | 12.62 | 68.07 | 13.04 | 4.64 | 1.93 | 6.77 | 5.54 | 100 |
| 1993-94 to 1997-98 | 53.32 | 11.98 | 65.3 | 13.86 | 5.01 | 2.07 | 7.32 | 6.44 | 100 |
| 1998-99 to 2003-04 | 53.47 | 11.69 | 65.17 | 12.59 | 5.1 | 2.28 | 8.78 | 6.09 | 100 |
| 2004-05 to 2011-12 | 51.43 | 12.14 | 63.57 | 13.92 | 5.57 | 2.36 | 10.7 | 3.88 | 100 |
| 2012-13 to 2019-20 | 49.66 | 13.45 | 63.11 | 13.14 | 6.59 | 2.44 | 12.43 | 2.29 | 100 |
| Overall period | 53.48 | 12.56 | 66.04 | 12.77 | 5.39 | 2.17 | 8.96 | 4.67 | 100 |

Source: Agriculture Statistics at a Glance (various issues) and Baseline Data on Horticulture Crops

**Table 3.10: Average share of production of major crops groups in total output of major crops in India (%)**

| Years | Cereals & millets | Total pulses | Total foodgrains | Nine oilseeds | Cotton, Jute & Mesta | Sugarcane | Horticulture crops | Other crops | Total |
|---|---|---|---|---|---|---|---|---|---|
| 1981-82 to 1987-88 | 29.46 | 2.82 | 32.28 | 2.76 | 3.73 | 41.32 | 17.6 | 2.31 | 100 |
| 1988-89 to 1992-93 | 28.78 | 2.46 | 31.23 | 3.43 | 3.55 | 41.18 | 17.98 | 2.62 | 100 |
| 1993-94 to 1997-98 | 27.21 | 2.14 | 29.35 | 3.54 | 3.48 | 40.39 | 19.7 | 3.54 | 100 |
| 1998-99 to 2003-04 | 26.89 | 1.94 | 28.84 | 3.07 | 3.23 | 39.77 | 21.94 | 3.16 | 100 |
| 2004-05 to 2011-12 | 25.07 | 1.85 | 26.91 | 3.41 | 4.36 | 38.51 | 25.96 | 0.84 | 100 |
| 2012-13 to 2019-20 | 24.13 | 2.06 | 26.2 | 3.06 | 4.4 | 36.04 | 29.59 | 0.71 | 100 |
| Overall period | 26.7 | 2.2 | 28.89 | 3.19 | 3.86 | 39.62 | 22.76 | 1.67 | 100 |

Source: Agriculture Statistics at a Glance (various issues) and Baseline Data on Horticulture Crops

The yield for all crop groups has been consistently increasing since 1980-81, especially of horticulture, plantation crops, food grains, and oilseeds. However, the yield from oilseeds andpulses is very much fluctuating. Table 3.11 compares the yield levels of select crops grown in India with the highest yield of the top 10 producing countries This shows that yield level in India is very low as compared to other countries. For instance, in the case of food grain crops, the productivity of maize in India is just 25.4 percent of that in the USA. Moreover, although India produces paddy and pulses on more than 25 percent and more than 35 percent of the world's area allocated for these crops, still paddy's yield is around half of China's, and pulses yield is less than half of that of the USA. Similar results hold in the case of non-food grain crops also, whose yield is much lesser than in the case of other countries. So, there is a need to find the gap between the potential and actual yield and means to achieve the same.

**Table 3.11: International Comparison of Productivity of select crops in 2018**

| | India | | Highest yielding country (out of top 10 producing ones) | | |
|---|---|---|---|---|---|
| | Area (% of world) | Yield (in Kg/ha) | Area (% of world) | Yield (in Kg/ha) | Country |
| **Foodgrain crops** | | | | | |
| Paddy | 26.63 | 3878 | 18.23 | 6964 | China |
| Wheat | 13.80 | 3371 | 2.44 | 6843 | France |
| Maize | 4.75 | 3024 | 17.07 | 11864 | USA |
| Pulses | 36.42 | 739 | 17.07 | 1958 | USA |
| **Non-foodgrain crops** | | | | | |
| Sugarcane | 18.01 | 79683 | 1.14 | 118464 | Guatemala |
| Groundnut | 16.46 | 1893 | 1.49 | 2075 | Argentina |
| Tobacco | 12.41 | 1795 | 1.37 | 2304 | Pakistan |

Source: Government of India. (2020). Agricultural statistics at a glance. Table 7.1, pp 141-2.

### 3.4.2 State-wise cropping pattern in production of major crops

Table 3.12 shows the state-wise changes in cropping pattern by structural breaks of each state from 1981-82 to 2019-20. At an all-India level, although the share of foodgrain is still predominant, its share has consistently declined from an average of 73.95 percent during 1981-81 to 1987-88 sub-period to 63.52 percent during 2012-13 to 2019-20 sub-period. Within the foodgrains category, the share of coarse grain has declined alarmingly, reaching from 23.40 percent during 1981-81 to

1987-88 sub-period to 12.25 percent during 2012-13 to 2019-20 sub-period. The share of wheat is increasing, and of rice is declining slightly except during the crisis period of 1998-99 to 2003-04 when the cultivation of staple crops increased. The share of pulses has more or less remained the same during the whole period of study. At the state level also, the trend for foodgrain cultivation has declined in most of the states except in the case of Punjab and Odisha where the area under foodgrains cultivation has consistently increased from 75.57 and 75.49 percent during the first sub-period to 87.31percent and 77.37 percent respectively during the last sub-period. Moreover, the area under the foodgrain category is more or less constant in Haryana and Karnataka. While the trend of wheat cultivation has increased or constant in almost all the states, the trend of rice cultivation has declined in overall India, mainly due to states like Maharashtra, undivided state of Madhya Pradesh, Kerala, West Bengal, and Assam, where the rice cultivation has declined. However, in most of the northwestern states, rice cultivation has still increased consistently. The trend for coarse cereals and pulses cultivation has declined in most of the states.

However, pulses cultivation has increased remarkably in the central states of Maharashtra, Rajasthan, and the undivided state of Madhya Pradesh, as well as in the Southern states of Karnataka and Tamil Nadu. Coming to the non-foodgrain category, there is a clear-cut movement towards the cultivation of fruits and vegetables which is termed as a "silent revolution" Gulati (2004). There is a slight and consistent increase in the temporal cultivation of condiments and spices in India. This is mainly due to the increased cultivation in the central region such as in Gujarat, Rajasthan, and the undivided state of Madhya Pradesh, some Southern and Eastern states such as Karnataka, Assam, and West Bengal. There is a very much fluctuating trend in oilseeds and fiber production in various states in various years, but still, there is an overall increase in the production of these two crop groups in India as a whole. For instance, oilseeds production shows a clear-cut increase in states like West Bengal, Maharashtra, and the undivided state of Madhya Pradesh, while its production has declined in most of the northern region. In almost all southern states, the cultivation of oilseeds increased in initial sub-periods but started declining afterward. Similarly, there is a clear increase of fiber cultivating area in states such as Rajasthan, Gujarat, and the undivided state of Andhra Pradesh, but there is a clear decline in other states such as Assam, Karnataka, and Punjab.

**Table 3.12: Average share of major crop groups in total area under cultivation from 1981-82 to 2019-20 (%)**

| States | Rice | Wheat | Coarse cereals | Total Pulses | Total Foodgrains | Total Condiments and Spices | Total Fruits & Vegetables | Total Oilseeds | Total Fibres | Other crops | Gross cropped area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **North-west region** | | | | | | | | | | | |
| Haryana | | | | | | | | | | | |
| 1981-82 to 1991-92 | 10.52 | 31.48 | 16.99 | 12.04 | 71.03 | 0.22 | 1.05 | 6.95 | 6.77 | 13.98 | 100.00 |
| 1992-93 to 1997-98 | 13.50 | 33.50 | 12.78 | 7.58 | 67.37 | 0.09 | 0.99 | 10.34 | 10.08 | 11.12 | 100.00 |
| 1998-99 to 2002-03 | 16.75 | 37.09 | 12.14 | 3.32 | 69.30 | 0.08 | 1.01 | 8.34 | 9.24 | 12.04 | 100.00 |
| 2003-04 to 2008-09 | 16.53 | 36.83 | 11.72 | 2.83 | 67.91 | 0.09 | 1.03 | 9.68 | 8.32 | 12.98 | 100.00 |
| 2009-10 to 2015-16 | 19.39 | 39.19 | 9.19 | 1.67 | 69.45 | 0.08 | 1.07 | 8.25 | 8.91 | 12.24 | 100.00 |
| 2016-17 to 2019-20 | 22.04 | 38.55 | 8.74 | 0.90 | 70.23 | 0.09 | 1.24 | 8.57 | 10.03 | 9.84 | 100.00 |
| Himachal Pradesh | | | | | | | | | | | |
| 1981-82 to 1988-89 | 9.59 | 38.70 | 37.05 | 4.60 | 89.93 | 0.37 | 5.88 | 2.24 | 0.08 | 1.49 | 100.00 |
| 1989-90 to 1994-95 | 8.71 | 38.62 | 36.93 | 4.11 | 88.37 | 0.31 | 7.47 | 2.24 | 0.01 | 1.60 | 100.00 |
| 1995-96 to 2004-05 | 8.54 | 38.54 | 35.69 | 3.38 | 86.14 | 0.51 | 9.70 | 1.98 | 0.00 | 1.67 | 100.00 |
| 2005-06 to 2010-11 | 8.23 | 37.99 | 34.92 | 3.35 | 84.51 | 0.74 | 11.37 | 1.74 | 0.00 | 1.64 | 100.00 |
| 2011-12 to 2015-16 | 8.38 | 37.48 | 34.27 | 2.57 | 82.70 | 0.83 | 13.50 | 1.56 | 0.01 | 1.40 | 100.00 |
| 2016-17 to 2019-20 | 10.99 | 36.14 | 31.64 | 2.83 | 79.77 | 1.06 | 16.11 | 1.26 | 0.01 | 1.78 | 100.00 |
| Jammu and Kashmir | | | | | | | | | | | |
| 1981-82 to 1988-89 | 26.12 | 22.28 | 31.76 | 4.52 | 84.68 | 0.13 | 5.21 | 6.28 | 0.12 | 3.59 | 100.00 |
| 1989-90 to 1993-94 | 25.60 | 22.90 | 31.02 | 3.47 | 82.99 | 0.17 | 5.80 | 6.66 | 0.08 | 4.30 | 100.00 |
| 1994-95 to 1999-2000 | 25.07 | 22.78 | 31.81 | 2.99 | 82.65 | 0.20 | 5.99 | 6.50 | 0.05 | 4.61 | 100.00 |
| 2000-01 to 2004-05 | 22.72 | 23.18 | 33.31 | 2.72 | 81.79 | 0.21 | 6.89 | 6.18 | 0.00 | 4.93 | 100.00 |
| 2005-06 to 2014-15 | 22.94 | 24.96 | 30.68 | 2.50 | 80.93 | 0.23 | 8.03 | 5.59 | 0.01 | 5.21 | 100.00 |
| 2015-16 to 2019-20 | 24.34 | 24.70 | 28.68 | 1.47 | 79.18 | 0.23 | 10.84 | 4.44 | 0.07 | 5.23 | 100.00 |
| Punjab | | | | | | | | | | | |
| 1981-82 to 1990-91 | 24.11 | 43.73 | 4.88 | 2.85 | 75.57 | 0.09 | 1.35 | 2.62 | 7.75 | 12.61 | 100.00 |
| 1991-92 to 1995-96 | 28.25 | 42.97 | 3.20 | 1.38 | 75.81 | 0.05 | 1.24 | 2.16 | 8.79 | 11.95 | 100.00 |
| 1996-97 to 2000-01 | 30.93 | 42.33 | 2.91 | 1.03 | 77.20 | 0.06 | 1.80 | 1.76 | 7.58 | 11.60 | 100.00 |
| 2001-02 to 2005-06 | 32.80 | 43.61 | 2.41 | 0.57 | 79.39 | 0.04 | 2.00 | 1.13 | 6.55 | 10.89 | 100.00 |
| 2006-07 to 2015-16 | 35.58 | 44.63 | 2.02 | 0.29 | 82.52 | 0.02 | 2.22 | 0.73 | 6.29 | 8.22 | 100.00 |
| 2016-17 to 2019-20 | 40.15 | 45.42 | 1.56 | 0.18 | 87.31 | 0.02 | 2.07 | 0.43 | 3.49 | 6.67 | 100.00 |

Continued...

| States | Rice | Wheat | Coarse cereals | Total Pulses | Total Foodgrains | Total Condiments and Spices | Total Fruits & Vegetables | Total Oilseeds | Total Fibres | Other crops | Gross cropped area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Uttar Pradesh & Uttarakhand | | | | | | | | | | | |
| 1981-82 to 1987-88 | 21.81 | 33.11 | 15.13 | 12.44 | 82.49 | 0.22 | 3.17 | 3.36 | 0.24 | 10.52 | 100.00 |
| 1988-89 to 1992-93 | 21.53 | 34.25 | 12.82 | 11.82 | 80.42 | 0.26 | 3.48 | 4.09 | 0.14 | 11.60 | 100.00 |
| 1993-94 to 1997-98 | 21.59 | 35.08 | 11.69 | 11.08 | 79.46 | 0.25 | 3.68 | 4.70 | 0.09 | 11.82 | 100.00 |
| 1998-99 to 2004-05 | 23.01 | 36.59 | 10.07 | 10.66 | 80.33 | 0.29 | 3.83 | 3.45 | 0.05 | 12.05 | 100.00 |
| 2005-06 to 2015-16 | 23.27 | 37.75 | 8.73 | 9.20 | 78.95 | 0.28 | 4.27 | 4.37 | 0.03 | 12.10 | 100.00 |
| 2016-17 to 2019-20 | 25.05 | 37.45 | 8.07 | 7.79 | 78.36 | 0.28 | 4.58 | 5.04 | 0.04 | 11.71 | 100.00 |
| **Central region** | | | | | | | | | | | |
| Gujarat | | | | | | | | | | | |
| 1981-82 to 1988-89 | 5.57 | 5.08 | 29.65 | 8.39 | 48.69 | 1.23 | 1.53 | 24.21 | 13.54 | 10.79 | 100.00 |
| 1989-90 to 1997-98 | 6.31 | 5.74 | 22.37 | 8.38 | 42.80 | 1.53 | 2.13 | 26.80 | 12.20 | 14.54 | 100.00 |
| 1998-99 to 2002-03 | 6.41 | 4.49 | 18.27 | 7.34 | 36.51 | 1.87 | 2.88 | 27.00 | 15.76 | 15.98 | 100.00 |
| 2003-04 to 2008-09 | 6.25 | 8.56 | 14.19 | 7.30 | 36.30 | 2.43 | 3.59 | 25.72 | 18.24 | 13.72 | 100.00 |
| 2009-10 to 2015-16 | 6.48 | 9.54 | 12.33 | 6.62 | 34.97 | 3.18 | 8.52 | 24.59 | 21.87 | 11.42 | 100.00 |
| 2016-17 to 2019-20 | 7.37 | 8.12 | 6.34 | 7.97 | 29.80 | 5.09 | 6.94 | 23.14 | 21.73 | 11.90 | 100.00 |
| Maharashtra | | | | | | | | | | | |
| 1981-82 to 1987-88 | 7.43 | 4.74 | 43.01 | 13.79 | 68.98 | 0.89 | 1.35 | 11.08 | 13.46 | 4.24 | 100.00 |
| 1988-89 to 1996-97 | 7.37 | 3.56 | 38.91 | 15.39 | 65.24 | 0.77 | 2.39 | 11.98 | 13.36 | 6.27 | 100.00 |
| 1997-98 to 2004-05 | 6.97 | 3.86 | 32.98 | 16.33 | 60.14 | 0.80 | 4.29 | 12.92 | 14.70 | 7.15 | 100.00 |
| 2005-06 to 2008-09 | 6.70 | 4.92 | 28.62 | 16.50 | 56.74 | 0.66 | 4.99 | 16.25 | 13.79 | 7.57 | 100.00 |
| 2009-10 to 2015-16 | 6.72 | 4.43 | 23.76 | 15.28 | 50.20 | 0.60 | 5.04 | 17.83 | 17.74 | 8.59 | 100.00 |
| 2016-17 to 2019-20 | 6.25 | 4.88 | 18.55 | 19.50 | 49.19 | 0.01 | 7.75 | 17.96 | 17.72 | 7.38 | 100.00 |
| Madhya Pradesh & Chattisgarh | | | | | | | | | | | |
| 1981-82 to 1987-88 | 22.03 | 16.11 | 20.35 | 21.92 | 80.41 | 0.66 | 0.80 | 11.35 | 2.36 | 4.42 | 100.00 |
| 1988-89 to 1994-95 | 21.60 | 15.90 | 15.73 | 20.25 | 73.49 | 0.87 | 0.93 | 18.52 | 2.33 | 3.86 | 100.00 |
| 1995-96 to 2004-05 | 21.73 | 16.48 | 10.69 | 20.13 | 69.03 | 1.02 | 1.18 | 23.56 | 2.14 | 3.08 | 100.00 |
| 2005-06 to 2010-11 | 21.01 | 16.31 | 8.40 | 20.89 | 66.60 | 1.09 | 1.46 | 26.12 | 2.35 | 2.37 | 100.00 |
| 2011-12 to 2015-16 | 20.17 | 20.56 | 6.50 | 18.86 | 66.09 | 1.32 | 1.78 | 26.97 | 1.99 | 1.85 | 100.00 |
| 2016-17 to 2019-20 | 20.57 | 21.08 | 6.31 | 22.13 | 70.09 | 1.48 | 1.95 | 23.43 | 1.63 | 1.42 | 100.00 |

Continued…

| States | Rice | Wheat | Coarse cereals | Total Pulses | Total Foodgrains | Total Condiments and Spices | Total Fruits & Vegetables | Total Oilseeds | Total Fibres | Other crops | Gross cropped area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rajasthan | | | | | | | | | | | |
| 1981-82 to 1988-89 | 0.87 | 10.31 | 39.78 | 19.67 | 70.63 | 1.56 | 0.38 | 10.54 | 1.97 | 14.91 | 100.00 |
| 1989-90 to 1993-94 | 0.70 | 10.06 | 35.64 | 17.17 | 63.57 | 1.92 | 0.39 | 17.10 | 2.54 | 14.49 | 100.00 |
| 1994-95 to 1998-99 | 0.75 | 11.95 | 30.48 | 19.19 | 62.37 | 2.11 | 0.42 | 19.17 | 2.96 | 12.98 | 100.00 |
| 1999-2000 to 2004-05 | 0.69 | 11.48 | 33.46 | 15.22 | 60.86 | 2.74 | 0.56 | 17.64 | 2.48 | 15.73 | 100.00 |
| 2005-06 to 2015-16 | 0.59 | 11.90 | 28.73 | 16.13 | 57.35 | 2.97 | 0.69 | 20.32 | 1.88 | 16.79 | 100.00 |
| 2016-17 to 2019-20 | 0.79 | 12.27 | 23.33 | 26.20 | 62.60 | 3.86 | 0.76 | 17.25 | 2.25 | 13.28 | 100.00 |
| **Southern region** | | | | | | | | | | | |
| Andhra Pradesh & Telangana | | | | | | | | | | | |
| 1981-82 to 1987-88 | 27.73 | 0.13 | 27.51 | 11.34 | 66.71 | 2.96 | 2.92 | 17.63 | 5.28 | 4.50 | 100.00 |
| 1988-89 to 1992-93 | 30.58 | 0.08 | 15.73 | 12.12 | 58.50 | 2.68 | 4.05 | 24.15 | 5.93 | 4.69 | 100.00 |
| 1993-94 to 2004-05 | 28.60 | 0.09 | 11.79 | 13.80 | 54.28 | 2.88 | 6.13 | 22.62 | 8.35 | 5.73 | 100.00 |
| 2004-05 to 2008-09 | 29.45 | 0.08 | 10.03 | 14.34 | 53.91 | 2.42 | 7.18 | 21.15 | 9.11 | 6.23 | 100.00 |
| 2009-10 to 2014-15 | 29.72 | 0.06 | 9.60 | 13.52 | 52.91 | 2.36 | 7.58 | 15.60 | 15.62 | 5.93 | 100.00 |
| 2015-16 to 2019-20 | 29.90 | 0.03 | 9.69 | 16.16 | 55.77 | 2.61 | 7.95 | 11.50 | 16.96 | 5.21 | 100.00 |
| Karnataka | | | | | | | | | | | |
| 1981-82 to 1987-88 | 9.68 | 2.62 | 39.00 | 14.32 | 65.62 | 2.25 | 2.04 | 19.19 | 5.79 | 5.10 | 100.00 |
| 1988-89 to 1992-93 | 10.22 | 1.83 | 34.46 | 13.74 | 60.26 | 2.28 | 2.34 | 23.23 | 5.39 | 6.50 | 100.00 |
| 1993-94 to 1998-99 | 11.05 | 2.02 | 31.73 | 13.62 | 58.43 | 2.71 | 2.85 | 23.90 | 5.08 | 7.02 | 100.00 |
| 1999-2000 to 2008-09 | 11.09 | 2.10 | 30.22 | 16.73 | 60.14 | 3.10 | 4.40 | 21.11 | 3.69 | 7.55 | 100.00 |
| 2009-10 to 2014-15 | 11.05 | 2.11 | 29.73 | 17.09 | 59.99 | 3.17 | 4.54 | 21.09 | 3.60 | 7.62 | 100.00 |
| 2015-16 to 2019-20 | 11.03 | 2.08 | 29.23 | 17.58 | 59.93 | 3.22 | 4.67 | 20.82 | 3.57 | 7.80 | 100.00 |
| Kerala | | | | | | | | | | | |
| 1981-82 to 1991-92 | 22.89 | 0.00 | 0.23 | 0.95 | 24.07 | 9.91 | 20.59 | 26.48 | 0.22 | 18.74 | 100.00 |
| 1992-93 to 1998-99 | 15.17 | 0.00 | 0.29 | 0.62 | 16.08 | 11.27 | 18.95 | 30.40 | 0.41 | 22.89 | 100.00 |
| 1999-2000 to 2004-05 | 10.67 | 0.00 | 0.19 | 0.26 | 11.11 | 13.12 | 20.10 | 30.75 | 0.11 | 24.81 | 100.00 |
| 2005-06 to 2009-10 | 8.86 | 0.00 | 0.11 | 0.22 | 9.19 | 13.61 | 18.76 | 29.95 | 0.05 | 28.44 | 100.00 |
| 2010-11 to 2015-16 | 7.73 | 0.00 | 0.03 | 0.13 | 7.90 | 10.86 | 18.78 | 30.57 | 0.02 | 31.88 | 100.00 |
| 2016-17 to 2019-20 | 7.21 | 0.00 | 0.01 | 0.04 | 7.27 | 10.24 | 18.87 | 29.81 | 0.00 | 33.81 | 100.00 |

Continued…

| States | Rice | Wheat | Coarse cereals | Total Pulses | Total Foodgrains | Total Condiments and Spices | Total Fruits & Vegetables | Total Oilseeds | Total Fibres | Other crops | Gross cropped area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Tamil Nadu | | | | | | | | | | | |
| 1981-82 to 1987-88 | 34.15 | 0.01 | 22.74 | 8.49 | 65.41 | 2.57 | 4.23 | 17.57 | 3.36 | 6.87 | 100.00 |
| 1988-89 to 1993-94 | 29.97 | 0.00 | 16.57 | 10.95 | 57.49 | 2.29 | 5.46 | 21.09 | 3.78 | 9.89 | 100.00 |
| 1994-95 to 1998-99 | 33.09 | 0.00 | 12.45 | 9.35 | 54.89 | 2.46 | 6.96 | 20.54 | 3.75 | 11.41 | 100.00 |
| 1999-2000 to 2004-05 | 31.29 | 0.00 | 13.14 | 10.60 | 55.02 | 2.76 | 8.81 | 18.60 | 2.34 | 12.46 | 100.00 |
| 2005-06 to 2015-16 | 32.09 | 0.00 | 12.84 | 11.26 | 56.19 | 2.41 | 10.39 | 15.90 | 2.21 | 12.90 | 100.00 |
| 2016-17 to 2019-20 | 30.53 | 0.00 | 14.66 | 14.64 | 59.82 | 2.11 | 10.21 | 14.61 | 3.05 | 10.19 | 100.00 |
| **Eastern region** | | | | | | | | | | | |
| Assam | | | | | | | | | | | |
| 1981-82 to 1987-88 | 63.39 | 3.42 | 1.03 | 3.22 | 71.05 | 2.31 | 5.17 | 9.10 | 3.59 | 8.76 | 100.00 |
| 1988-89 to 1992-93 | 64.86 | 2.29 | 1.00 | 3.04 | 71.19 | 2.71 | 5.53 | 8.97 | 2.84 | 8.76 | 100.00 |
| 1993-94 to 2002-03 | 63.86 | 2.00 | 0.73 | 2.89 | 69.48 | 3.09 | 7.36 | 8.48 | 2.61 | 8.98 | 100.00 |
| 2003-04 to 2009-10 | 61.47 | 1.50 | 0.66 | 2.80 | 66.42 | 3.39 | 10.32 | 7.53 | 2.07 | 10.26 | 100.00 |
| 2010-11 to 2015-16 | 61.22 | 0.79 | 0.76 | 3.44 | 66.21 | 3.68 | 9.65 | 7.81 | 2.05 | 10.59 | 100.00 |
| 2016-17 to 2019-20 | 59.94 | 0.39 | 0.98 | 3.77 | 65.07 | 3.65 | 8.75 | 8.43 | 1.97 | 12.13 | 100.00 |
| Bihar & Jharkhand | | | | | | | | | | | |
| 1981-82 to 1987-88 | 50.50 | 17.74 | 9.69 | 11.86 | 89.79 | 0.24 | 4.16 | 2.30 | 2.06 | 1.44 | 100.00 |
| 1988-89 to 1993-94 | 49.95 | 19.94 | 9.09 | 10.85 | 89.83 | 0.17 | 4.44 | 2.29 | 1.59 | 1.67 | 100.00 |
| 1994-95 to 1998-99 | 50.24 | 20.97 | 9.05 | 9.21 | 89.47 | 0.16 | 4.82 | 2.34 | 1.66 | 1.56 | 100.00 |
| 1999-2000 to 2006-07 | 49.56 | 21.87 | 8.99 | 8.78 | 89.21 | 0.14 | 5.20 | 2.19 | 1.74 | 1.53 | 100.00 |
| 2007-08 to 2014-15 | 47.38 | 23.90 | 9.22 | 7.40 | 87.90 | 0.12 | 5.71 | 2.09 | 1.56 | 2.61 | 100.00 |
| 2015-16 to 2019-20 | 49.17 | 22.75 | 9.12 | 6.77 | 87.82 | 0.11 | 5.87 | 2.16 | 1.11 | 2.94 | 100.00 |
| Odisha | | | | | | | | | | | |
| 1981-82 to 1990-91 | 47.53 | 0.55 | 6.76 | 20.65 | 75.49 | 1.71 | 9.83 | 11.21 | 1.07 | 0.69 | 100.00 |
| 1991-92 to 1997-98 | 48.28 | 0.23 | 5.11 | 21.03 | 74.66 | 1.75 | 10.35 | 11.80 | 0.85 | 0.60 | 100.00 |
| 1999-2000 to 2004-05 | 53.17 | 0.21 | 4.95 | 18.58 | 76.91 | 1.75 | 10.12 | 9.72 | 1.09 | 0.42 | 100.00 |
| 2005-06 to 2008-09 | 49.58 | 0.20 | 4.74 | 21.72 | 76.23 | 1.62 | 10.75 | 9.82 | 1.09 | 0.47 | 100.00 |
| 2009-10 to 2015-16 | 49.06 | 0.16 | 5.02 | 22.38 | 76.61 | 1.72 | 10.90 | 8.85 | 1.45 | 0.46 | 100.00 |
| 2016-17 to 2019-20 | 50.38 | 0.11 | 4.63 | 22.25 | 77.37 | 1.70 | 11.16 | 7.41 | 1.88 | 0.47 | 100.00 |

Continued…

| States | Rice | Wheat | Coarse cereals | Total Pulses | Total Foodgrains | Total Condiments and Spices | Total Fruits & Vegetables | Total Oilseeds | Total Fibres | Other crops | Gross cropped area |
|---|---|---|---|---|---|---|---|---|---|---|---|
| West Bengal | | | | | | | | | | | |
| 1981-82 to 1993-94 | 65.82 | 3.93 | 1.20 | 4.29 | 75.23 | 0.80 | 9.31 | 5.73 | 7.07 | 1.85 | 100.00 |
| 1994-95 to 1998-99 | 64.84 | 3.87 | 0.74 | 2.43 | 71.87 | 1.09 | 12.47 | 5.87 | 6.53 | 2.16 | 100.00 |
| 1999-2000 to 2004-05 | 61.57 | 4.30 | 0.67 | 2.55 | 69.09 | 1.08 | 13.76 | 6.62 | 6.62 | 2.82 | 100.00 |
| 2005-06 to 2009-10 | 59.70 | 3.52 | 1.07 | 2.10 | 66.39 | 1.45 | 15.67 | 7.42 | 6.29 | 2.78 | 100.00 |
| 2010-11 to 2014-15 | 58.83 | 3.46 | 1.12 | 2.07 | 65.48 | 1.54 | 16.16 | 7.60 | 6.39 | 2.84 | 100.00 |
| 2015-16 to 2019-20 | 58.64 | 3.41 | 1.14 | 2.04 | 65.23 | 1.53 | 16.34 | 7.60 | 6.42 | 2.89 | 100.00 |
| **All India** | | | | | | | | | | | |
| 1981-82 to 1987-88 | 23.59 | 13.55 | 23.40 | 13.41 | 73.95 | 1.30 | 3.27 | 10.70 | 4.95 | 5.84 | 100.00 |
| 1988-89 to 1992-93 | 23.50 | 13.28 | 20.15 | 13.00 | 69.94 | 1.37 | 3.70 | 13.73 | 4.87 | 6.38 | 100.00 |
| 1993-94 to 1997-98 | 22.95 | 13.72 | 17.21 | 12.62 | 66.49 | 1.49 | 3.99 | 14.86 | 5.11 | 8.05 | 100.00 |
| 1998-99 to 2003-04 | 23.61 | 14.28 | 16.04 | 12.27 | 66.20 | 1.61 | 4.65 | 13.76 | 5.26 | 8.51 | 100.00 |
| 2004-05 to 2011-12 | 22.58 | 14.68 | 14.62 | 12.39 | 64.27 | 1.64 | 5.04 | 15.04 | 5.60 | 8.41 | 100.00 |
| 2012-13 to 2019-20 | 22.38 | 15.78 | 12.25 | 13.11 | 63.52 | 1.84 | 5.54 | 14.10 | 6.32 | 8.68 | 100.00 |

Source: Land use statistics

### 3.4.3 CAGR of agricultural output:

The agriculture production is increasing at a CAGR of 0.89 percent per annum, out of which the growth in the area contributed just around 0.10 percent per annum, while the yield contributed to 0.77 percent per annum (Table 3.13). Period-wise, 1998-99 to 2003-04 seems to be the only period where the agricultural production growth decelerated, which may be the effect of the Asian Financial Crisis 1997. The growth in both area and yield are highly fluctuating in different sub-periods, with the growth in the area turning positive and negative very frequently, while yield is remaining positive most of the time, except during 1997-98.

**Table 3.13: CAGR of Area, Production, and Yield of major crops in India (%)**

| Years | Area | Production | Yield |
|---|---|---|---|
| 1981-82 to 1987-88 | -0.31 | 0.29** | 0.6** |
| 1988-89 to 1992-93 | -0.12 | 1.03 | 1.15** |
| 1993-94 to 1997-98 | 0.2* | 1.2 | 0.99 |
| 1998-99 to 2003-04 | -0.46 | (-)0.83* | -0.37 |
| 2004-05 to 2011-12 | 0.32** | 1.6** | 1.28** |
| 2012-13 to 2019-20 | 0.35** | 0.72** | 0.23 |
| **Overall period** | 0.1*** | 0.89*** | 0.78*** |

Source: Directorate of Economics & Statistics, DAC&FW
Note: *, ** and *** depicts significance at 10, 5 and 1 percent respectively.

### 3.4.4 CAGR of Area, Production, and Yield of major crop groups in India

Table 3.14 shows the CAGR in area, production, and yield of major crops in India, segregated by break dates. It shows the increased relative importance of non-foodgrain crops, especially horticulture crops whose increase in area (1.22 percent) and production (1.96 percent) is the maximum. Even all other non-foodgrain crops have also shown an increase in area by 0.60 percent, 0.58 percent, and 0.43 percent in the case of sugarcane, plantation crops, and oilseeds, respectively. The growth in area under the foodgrains has declined by 0.02 percent, although there is a marginal increase in area under its pulses sub-category.However, owing to technology, irrigation, and other possible factors, the increase in yield is still highest in the case of plantation crops (0.88 percent), followed by foodgrains(0.85 percent) and oilseeds (0.82 percent), while

such an increase was relatively less in case of horticulture (0.66 percent) and pulses (0.48 percent). The lowest increase in yield was found in sugarcane (just 0.27 percent).

Overall, while the highest increase in production (1.90 percent) in the case of horticulture was relatively high due to area expansion, the second-highest increase in oilseeds production (1.19 percent) was relatively high due to yield growth than area growth, i.e. it was more intensively cultivated during the overall period. All other groups have also shown an increase in production by more than 0.65 percent.

By sub-periods, the biggest change is seen in pulses in terms of both area and yield, whose growth declined till 2003-04, but after this best break date, has turned positive, leading to overall increase in production of pulses. Another drastic change is seen in how India can intensely cultivate oilseeds by turning the growth in oilseeds yield from negative (-0.12 percent during 1981-82 to 1987-88 period) to positive of 0.82 percent during 2012-13 to 2019-20, and also from earlier positive CAGR in oilseeds area (1.43 percent during 1981-82 to 1987-88 period) to negative of -0.31 percent during 2012-13 to 2019-20. Also, the CAGR of area for most of the crops was negative during 1981-82 to 1987-88 and 1998-99 to 2003-04.

**Table 3.14: CAGR of Area, Production, and Yield of major crop groups in India (%)**

| Years | Particulars | Cereals & millets | Total pulses | Total food grains | Oilseeds | Cotton, Jute & Mesta | Sugarcane | Horticulture crops |
|---|---|---|---|---|---|---|---|---|
| | Area | -0.27 | -0.42 | -0.30 | 1.43 | -1.27 | -0.44 | 1.51 |
| | Production | 0.61 | -0.21 | 0.54 | 0.34 | -0.17 | 0.16 | 1.9 |
| **1981-82 to 1987-88** | Yield | 0.88 | 0.22 | 0.88 | -0.12 | 0.54 | 0.45 | 0.38 |
| | Area | -0.41 | -0.37 | -0.40 | 1.94 | 0.3 | 1.29 | 0.97 |
| | Production | 0.52 | -0.96 | 0.41 | 1.37 | 1.69 | 1.54 | 1.79 |
| **1988-89 to 1992-93** | Yield | 0.93 | -0.5 | 0.89 | -0.43 | 0.78 | 0.43 | 0.81 |
| | Area | 0.07 | 0.13 | 0.08 | -0.1 | 2.37 | 1.54 | 1.55 |
| | Production | 0.6 | -0.18 | 0.54 | 0.51 | 1.99 | 1.75 | 1.36 |
| **1993-94 to 1997-98** | Yield | 0.53 | -0.32 | 0.48 | 0.61 | 0.31 | 0.2 | -0.19 |
| | Area | 0.07 | -0.02 | -0.36 | -0.1 | -1.49 | 0.09 | 1.81 |
| | Production | -0.28 | -0.46 | -0.30 | -0.99 | 0.45 | -1.44 | 0.14 |
| **1998-99 to 2003-04** | Yield | 0.15 | -0.44 | 0.06 | 0.1 | 1.33 | -1.54 | -1.65 |
| | Area | -0.43 | 1.56 | 0.21 | -0.24 | 1.84 | 1.16 | 0.87 |
| | Production | 1.37 | 1.81 | 1.40 | 1.12 | 3.11 | 1.64 | 2.46 |
| **2004-05 to 2011-12** | Yield | 1.27 | 1.15 | 1.19 | 1.37 | 0.85 | 0.48 | 1.58 |
| | Area | 0.1 | 1.56 | 0.26 | -0.31 | 0.34 | -0.45 | 0.53 |
| | Production | 0.86 | 2.01 | 0.95 | 0.5 | -0.6 | 0.52 | 1.01 |
| **2012-13 to 2019-20** | Yield | 0.95 | 0.44 | 0.69 | 0.81 | 0.21 | 0.98 | 0.48 |
| | Area | -0.06 | 0.18 | -0.02 | 0.43 | 0.58 | 0.6 | 1.22 |
| | Production | 0.85 | 0.66 | 0.83 | 1.19 | 1.43 | 0.86 | 1.9 |
| **Overall period** | Yield | 0.91 | 0.48 | 0.85 | 0.82 | 0.88 | 0.27 | 0.66 |

Source: Agriculture Statistics at a Glance (various issues) and Baseline Data on Horticulture Crops

### 3.4.5 Instability in the agricultural area, production, and yield

Instability index in area, production, and yield is provided in Table 3.15. Most of the instability in agricultural output (23.44 percent) is coming from yield (20.30 percent), rather than in area (just 1.31 percent). The instability in yield was much high during the sub-period 2004-05 to 2011-12, which may again point to the best break date that occurred in agricultural production at 2003-04.

**Table 3.15: Instability in Area, Production, and Yield of major crops in India**

| Years | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| | SD | Mean | CV (%) | SD | Mean | CV (%) | SD | Mean | CV (%) |
| 1981-82 to 1987-88 | 4.62 | 180.36 | 2.56 | 6.63 | 363.83 | 1.82 | 74.94 | 2018.73 | 3.71 |
| 1988-89 to 1992-93 | 2.44 | 184.77 | 1.32 | 20.98 | 454.07 | 4.62 | 114.52 | 2457.73 | 4.66 |
| 1993-94 to 1997-98 | 1.7 | 185.09 | 0.92 | 27.97 | 515.53 | 5.42 | 135.06 | 2784.75 | 4.85 |
| 1998-99 to 2003-04 | 6.73 | 180.66 | 3.73 | 25.71 | 541.27 | 4.75 | 118.52 | 2996.92 | 3.95 |
| 2004-05 to 2011-12 | 4.53 | 188.97 | 2.4 | 70.35 | 617.64 | 11.39 | 307.48 | 3263.33 | 9.42 |
| 2012-13 to 2019-20 | 4.84 | 196.04 | 2.47 | 41.13 | 723.48 | 5.68 | 148.47 | 3666.82 | 4.05 |
| Overall period | 7.2 | 186.56 | 3.86 | 128.47 | 547.98 | 23.44 | 592.31 | 2917.08 | 20.3 |

Source: Directorate of Economics & Statistics, DAC&FW

### 3.5 Summary of major findings

The present study has analysed India's agricultural growth pattern by endogenously identified structural break dates over four decades. Five national level structural breaks in crop agricultural GDP were identified: they included 1987-88, 1992-93, 1997-98, 2003-04, and 2011-12. Although there are variations at the state-level, the major structural breakpoints identified include 1987-88, 1988-89, 1993-94, 1998-99, 2004-05, 2014-15, and 2015-16. The major reasons for occurrence of such structural breaks at national level were identified to be (a) droughts (which led to break points at 1987-88, 2003-04, and 2011-12), implying that Indian agriculture is still heavily monsoon-dependent and thus, there is policy requirement towards investment in irrigation infrastructure; (b) terms of trade (which is one of the reasons for

structural breaks at 1993-94, 1998-99, and 2014-15); and (c) public investment (leading to a major structural break during 1998-99).

The agricultural GDP has grown at an average rate of 2.82 percent per annum during 1981-82 to 2019-20. So far, the highest growth in agricultural GDP was registered at 3.74 per cent during 2004-05 to 2011-12 followed by 2.98 per cent during 2012-13 to 2019-20. These growth rates even much higher than those registered during the 1980s during which the Green Revolution technology spread to a wider geographical area in the country. Agriculture in the states such as Madhya Pradesh, Bihar and Punjab still contributes to more than 25 percent of their respective state income. The states such as Punjab, Haryana and West Bengal registered a higher agricultural growth during the 1980s, but have witnessed deceleration in growth rates during the recent periods. The states that have registered a higher agricultural growth in the recent periods included Bihar, Rajasthan, Andhra Pradesh and Gujarat.

Cropping pattern of Indian agriculture depicts that while foodgrains are grown on around an average two-third of gross cropped area from 1980-81 to 2019-20, its share in production is just around 30 percent. So, foodgrains are grown on majority of the area on average in all states, except for Kerala and Gujarat. Sub-category wise, there is huge rice cultivation in eastern states, a mix of wheat and rice cultivation in the north-western states, while southern states are comparatively diversified towards the production of coarse cereals and pulses too. The share of area under foodgrains has consistently declined since 1981-82 due to decline in coarse cereals, millets and pulses. This has led to increase in area under almost all sub-categories of non-food grains, especially horticulture, sugarcane, spices and oilseeds crops. Due to high yielding nature of horticulture and sugarcane, their share in production has increased at even a greater pace. Horticulture is grown principally in Kerala, West Bengal, Odisha, and Himachal Pradesh, fiber crops are grown in Kerala and Gujarat, and spices and condiments are the major crops of Kerala only.

Agriculture production has increased at a CAGR of 0.89 percent per annum, out of which the growth in the area has contributed just around 0.10 per center annum, while the yield has contributed hugely amounting to 0.77 per cent per annum. Horticulture production has grown the highest due to relative more increase in area, while oilseeds production has grown second-highest whose source is relatively more increase in yield. State-wise, West Bengal has registered the highest growth, followed by Gujarat, Maharashtra, Tamil Nadu, and Haryana, all of which

have registered a growth rate of at least 3 percent on average during the overall period of study. Assam and Jammu & Kashmir have grown the least, by less than 2 percent during the same period. The recent slowdown since 2012-13 has affected growth in almost every state except southern states such as Karnataka, undivided Andhra Pradesh and Tamil Nadu. However, most of the instability in output has come from yield, rather than area.

## APPENDIX

### A.3.1 Structural changes in time-series data: Critical analysis of various tests

There are various tests available for testing for structural changes. Most of the literature concentrates on cases involving stationary regressors and stationary errors. The early works are Quandt (1958) and Chow (1960) which consider tests for a single known breakpoint. For instance, Quandt (1958) suggests firstly estimating the switch point by direct examination of the maximum likelihood function and then testingthe hypothesis that no switch occurred against the alternative that one switching took place (i.e. through switching regression model). Likewise, taking two regressions equations for the same variables, Chow uses F-statistics to test whether the coefficients in both equations are the same or not. The research started progressing by taking the breakpoints as an unknown variable. Quandt (1960) extends the Chow test by proposing a large Chow test over all possible breakpoints. The work on non-stationary time series and trending regressors started with Perron (1989). It points out that a series might well appear to be a non-stationary I(1) process, but could be stationary with one or more structural breaks. So, such unmodelled structural breaks need to be accounted for. Peron (1989) carries a 'unit-root hypothesis' against 'trend alternatives with a break taking place at 1929 Great Depression period or 1973 oil price shock'. The test results rejected the unit root null hypothesis for most of the series if the data generating process had 'stationary fluctuations around a trend function with one structural break' in reality.

Zivot and Andrews (1992) further modified Perron's tests by estimating the break date rather than fixing it. The research interest further grew to consider the case for multiple structural changes. Some studies consider Bayesian Information Criterion to estimate the number of mean multiple shifts/changes in variable sequence (such as Yao 1988, Yin 1988 and Yao and Au 1989)

while some other studies use the Schwartz criterion to estimate the number of changes after estimating multiple changes in the linear model by OLS (Liu et al. 1997). In the case of a linear model with no trending[5] regressors estimated by OLS, Bai and Perron (1998) proposed some tests and selection procedures based on the sequence of tests to estimate multiple structural shifts/ breakpoints in the model. Bai and Perron (2004) tried to assess the adequacy of these methods by studying the power and size of these tests, relative merits of the model selection procedure and convergence rates for confidence intervals.

[5] Non-trending variable are the ones which show no persistent trend with time. E.g.- Inflation, interest rates etc.

# CHAPTER-IV

# *CROP DIVERSIFICATION IN INDIA: NATIONAL AND STATE-LEVEL ANALYSIS*

# CHAPTER 4

## *CROP DIVERSIFICATION IN INDIA: NATIONAL AND STATE-LEVEL ANALYSIS*

### 4.1 BACKGROUND

One of the key achievements of the agriculture sector in India is the introduction of the Green Revolution technology or new seed-fertilizer-irrigation technology which led to an increase in production of foodgrains. However, it is argued that the growth strategy led by the Green Revolution technology is losing its steam and it is not sustainable due to its adverse effects on the environment such as soil salinity and alkalinity, water logging, declining water table from increased use of fertilisers and mono-cropping pattern (Pingali 2012).

Crop diversification from cereals particularly rice-wheat cropping system to high-value commodities is considered to be a key strategy to overcome some of these sustainability issues confronting the India's agricultural sector. Further, crop diversification has huge potential as an important source of crop output growth, employment generation, and nutrition security (Joshi et al., 2003 and 2007; Mishra et al., 2020). In India, its need has been realized since 1980s due to which various policies and strategies have been introduced by the government for diversification, such as the technology mission on oilseeds in 1986, the national agriculture insurance scheme in 1999, the technology mission on cotton in 2000, and the Technology Mission for integrated development of horticulture year in 2014.

In light of the above background, the present chapter looks into the trends and status of crop diversification at the national and state level, and analyses its relationship with the agricultural growth pattern. This chapter also analyzes the factors affecting crop diversification in India.

### 4.2 METHODOLOGY

The descriptive analysis intends to analyze the trend in crop diversification patterns at the national and state level, as well as to analyze its relationship with agricultural growth. The regression analysis is also used to analyze the determinants of crop diversification using state-level database.

The methods adopted in this chapter are explained below:

### 4.2.1 Measurement of Crop Diversification Index

There are various statistical methods available to measure the magnitude of diversification such as Simpson Index, Entropy index, Herfindahl-Hirschman Index and Modified Entropy Index(Appendix A.4.1). Each of these methods has some merits and demerits in terms of data requirement, ease of computation and interpretation of results and level of sophistication. However, the results obtained from these methods are more or less similar. This study uses Crop Diversification Index (CDI) worked out from Herfindahl-Hirschman Index (HHI). Firstly, HHI is computed as a sum of squares of individual crop share in a portfolio'. Secondly, as HHI is a measure of concentration (or inverse measure of diversification) and its value lies between zero (complete diversification) and one (complete specialization). The formula for computing CDI is given below.

***Crop Diversification Index (CDI) = 1- HHI***

$$=\mathbf{1}-\sum_{i=1}^{n}\boldsymbol{P_i^2}=\mathbf{1}-\{\boldsymbol{A_i}/(\sum_{i=1}^{n}\boldsymbol{A_i})\}^{\mathbf{2}};$$

where

$A_i$= proportion of area under i$^{th}$cro

$\sum_{i=1}^{n} A_i$= Total cropped area

So, CDI varies from zero to one, where larger the value, the more diversified the state is.

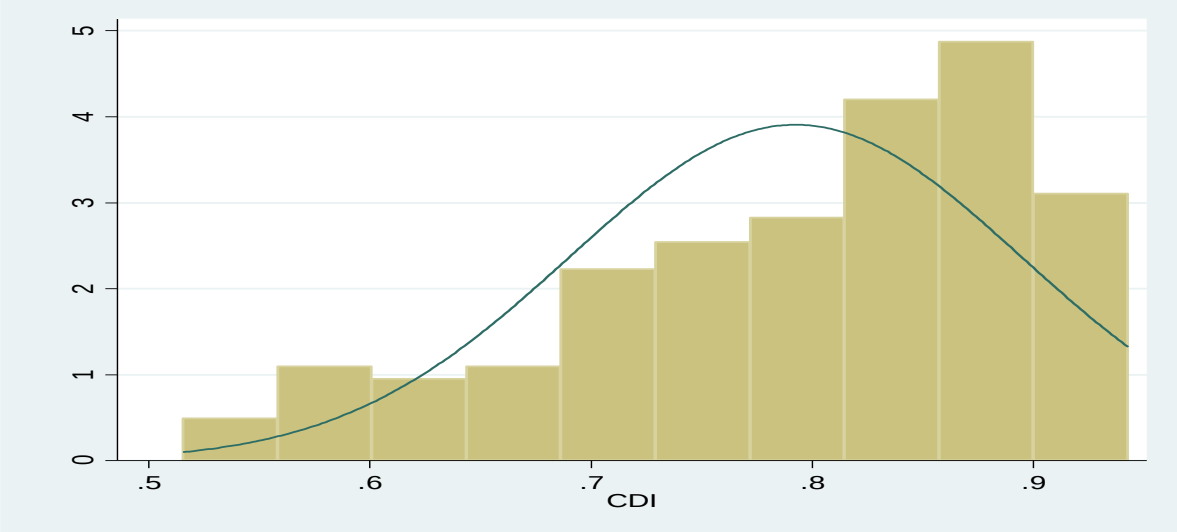
### 4.2.2 Panel Data regression analysis on factors affecting Crop Diversification

For panel regression analysis, 17 cross-section units (states) and 39 years from 1981-81 to 2019-20 are used. The panel structure is a balanced one. STATA software is used to conduct the analysis.

The values of the dependent variable i.e. crop diversification index (CDI) lie between zero and one. So, OLS estimates cannot be used as these provide predicted value to lie outside these intervals. The maximum and minimum values of CDI are found to be 0.9445992 and 0.5156099. The histogram of CDI drawn in Graph 4.1 depicts that it is skewed towards the upper extremity towards one, and it is a non-linear continuous variable. So, a beta regression under fractional

outcomes model[6] is applied in the study, which captures the non-linear relationships especially when the outcome (i.e. dependent) variable is near zero or one.

**Graph 4.1: Histogram of CDI for 17 states from 1981-82 to 2019-20**




**Selection of variables for the panel regression**

The dependent variable is Crop Diversification Index. The independent variables are chosen based on existing literature and availability of data.

The beta regression model is:

$Y_i = \alpha + \beta_i X_i + u_i$; where

Y= Crop Diversification Index

$\beta$= Slope Coefficient

[6] The fractional outcome model is used for fractions, indices, proportions, rates and probabilities. There are two types of fractional outcome models namely fractional response regression and beta regression. The former is applied when the continuous dependent variable lies is in [0,1] while the latter is applied when the dependent variable lies in (0,1). In the present regression, it is almost impossible that values will be 0 or 1 where all farms in the states can't be completely specialized or diversified to achieve such extreme values. It may be noted that the Tobin model could not be applied in the present study because the CDI variable is bounded between zero and one rather than being censored. Tobit model may not be suitable for dealing with such data because the CDI variable is bounded between 0 and 1 rather than being censored. However, the Tobit model is applied where the data is unbounded otherwise if censoring is not done, which is not the case with the CDI variable.

$X_i$= Vector containing various independent variables

The conditional mean of dependent variable Y for beta regression is as follows:

$E(Y|X) = \mu_x$; where $\mu_x$ must lie in (0,1). The model is estimated by maximum likelihood procedure.

The beta regression makes use of the logit link function[7]:

$g(\mu_x) = x\beta$, so that $\mu_x = g^{-1}(x\beta)$ is in (0,1).

This can be written as,

$$\ln\left[\frac{\mu_x}{1-\mu_x}\right] = x\beta$$

$$\mu_x = \exp[\frac{x\beta}{1+\exp(x\beta)}]$$

The log link function for conditional scaling is also applied to condition the dependent variable to be greater than zero. The independent variables are as follows:

Firstly, from the demand side, per-capita income and urbanization rate are considered. Demand side variables included per-capita income, measured as Net State Domestic Product per unit of population and urbanization rate. These are hypothesized to have a positive impact on crop diversification (Gulati et al. 2004, Parthasarthy et. al 2004, Ravi and Roy 2006).

Secondly, inputs such as irrigation, NPK consumption, cropping intensity and percentage of agricultural workers are taken from the supply side. The percentage of area covered under irrigation is computed by dividing gross irrigated area by gross cropped area and multiplying by 100. The fertilizer consumption is captured by dividing the consumption of Nitrogen, Phosphorus, and Potassium (NPK) by net sown area and multiplying by 100. The cropping intensity is computed as the ratio of gross sown area to net sown area. The impact of irrigation on crop diversification is debatable as some studies argues its impact to be negative because traditional crops require more water than high value crops (Vyas 1996, Kumar 2017, Anwer et al

[7] Link function refers to the Generalised Linear Model (GLM) that maps non-linear relationships to the linear one. In other words, it connects the regressors with the expected value of dependent variable in a linear wayin a model.

2019), while some other literature found its effect to be positive as irrigation reduces risk and increase choices of farmers to grow variety of crops in the field (Hazra 2001, Kumar at al 2015). More fertilizers' consumption is expected to discourage multiple cropping, which is otherwise the alternative method to let soil regain its fertility (Singh 2001). It is expected that as the cropping intensity increases, farmers tend to grow different crops in alternative seasons, so diversification will increase (Kumar et al 2015, Joshi et al 2004). The proportion of agricultural workers to total workforce is hypothesized to have positive impact on crop diversification (Utpal et al. 2010).

From the market side, terms of trade and road density are taken into consideration. Market related variables included price and access to market. The proxy variable 'road density' is used to capture market accessibility. To calculate the price, gross terms of trade[8]between agriculture and non-agriculture sectors is calculated as per the methodology adopted in Hazell and Mishra (1995) as follows:

$$TOT = \frac{GDP\ deflator^{9}\ in\ agriculture\ sector}{GDP\ deflator\ in\ non-agriculture\ sector}$$

The impact of this variable on crop diversification is also debatable. Traditional wisdom argues that access to market increases crop diversification, as farmers can grow various crops without the fear of loss due to the non-availability of the market (Nayak et al. 2019, Shamdasani 2016, Rao et al. 2004). However, recent studies have found the contrary, which is probably because better road facilities encourage people to import quality products from major towns of the cities, affecting local market (Anwer et al 2019, Ashok et al. 2006; Singh et al. 2006). Moreover, the higher the terms of trade in favor of agriculture, the diversification is expected to increase as the traditional wisdom argues.

The socio-economic characteristics of farmers are captured through literacy rate, small and marginal holdings. Higher rural literacy is expected to improve diversification as per the literature (Debasis et al. 2018), as it helps in increasing awareness of techniques, and methods for

[8] Note: There is an alternative TOT measurement provided by Commission for Agricultural Costs and Prices (CACP), computed by taking weighted price ratio of basket of various agricultural commodities purchased by agricultural households. The problem is that such official estimate is available only at national level, but the state level estimates are required in the present study.

[9] GDP deflator is computed as the ratio of nominal GDP to real GDP.

better cultivation of a different variety of crops. The impact of small farms on crop diversification is debatable as diversification may get constrained in case small farmholders face diseconomies of scale and input and credit and knowledge constraints (Singh 1984, Buhera et al. 2007, Gunasekera et al. 2017, Malaiarasan et al. 2019), but may aid diversification as most of high value commodities are labour intensive in nature, with low gestation period and high returns (Joshi et al 2002, Weinberger at al. 2005, Bargouti et al. 2005 and Birthal et al 2007)..

Finally, the industrialization rate, captured as share of industry GSDP in total GSDP is taken as a variable to capture the possible impact of backward and forward linkages on crop diversification. It is expected that the impact of industrialization will be negative on crop diversification in India due to the development of Industry-crop relationships in favor of few crops such as rice and sugarcane (Kaur 2021).

## 4.3 TRENDS AND PATTERNS OF CROP DIVERSIFICATION

### 4.3.1Crop Diversification at All India Level

Table 4.1 shows the extent of horizontal crop diversification in India, measured using the HHI Index. It shows that India is a country with a highly diversified cropping pattern with a score of 0.9041. Sub-period-wise, the overall extent of diversification has increased in the first three sub-periods. However, as discussed in Chapter 3,a huge crisis that took place during 1998-99 to 2003-04, the diversification at that time declined sharply. This is due to the huge insecurity and risk that forced farmers to grow staple crops such as rice, whose production increased proportionately more in overall crops. With the recovery in the economy, crop diversification again got a boost and it recovered to its previous level. However, the present deceleration in agriculture since 2012-13, as was evident from the decline in agricultural growth which is apparent here also, as the diversification has again declined during the last sub-period.The coefficient of variation in the crop diversification index depicts that the variability in diversification has declined since 1981-82 but suddenly increased during the 1998-99 to 2003-04 sub-period which is also likely to be the result of crisis only.

**Table 4.1 Crop Diversification and GDP growth rate in India, 1981-82 to 2019-20**

| Years | Crop Diversification Index (CDI) | Growth rate (CAGR) of agricultural GDP | Coefficient of Variation (CV) in CDI |
|---|---|---|---|
| 1981-82 to 1987-88 | 0.9045 | 1.77*** | 0.518 |
| 1988-89 to 1992-93 | 0.9048 | 2.31*** | 0.120 |
| 1993-94 to 1997-98 | 0.9051 | 2.61*** | 0.044 |
| 1998-99 to 2003-04 | 0.9019 | 1.66*** | 0.310 |
| 2004-05 to 2011-12 | 0.9054 | 3.74*** | 0.137 |
| 2012-13 to 2019-20 | 0.903 | 2.98*** | 0.128 |
| Overall period | 0.9041 | 2.82*** | 0.287 |

Note: * p<0.1 and **p<0.05 and ***p<0.01

Source: Computed based on Land Use Statistics, DES, MA&FW, and National Accounts Statistics, CSO, GOI.

Looking at the relationship between the compound annual growth in agricultural GDP and crop diversification, it emerges that there is a positive relationship between them. The correlation between agricultural GDP growth and crop diversification index for the overall period is 0.4054 and it is statistically significant at 5 percent level. A significant positive relationship between agricultural growth and crop diversification was evident during 1998-99 to 2003-04 and such a relationship was also seen during the subsequent period as well. But there seems to be some divergence between agricultural growth and crop diversification in the recent most period though the correlation coefficient is not statistically significant.

### 4.3.2 Crop Diversification at State Level

Table 4.2 reveals status of crop diversification on average in different states of India. For instance, the southern, western, and central regions are the most diversified ones in terms of cropping patterns, and state-wise, Karnataka tops the list in terms of diversification. Assam, the northeastern state, has a highly concentrated cropping pattern. Eastern and northern are yet other regions that are highly specialized (except for Rajasthan where temperature and precipitation probably do not permit diversification (Vinita et al. 2018).

**Table 4.2: Average CDI in various states from 1981-82 to 2019-20**

| Regions | States | Average CDI |
|---|---|---|
| Southern | Karnataka | 0.925 |
| | Andhra Pradesh and Telangana | 0.862 |
| | Tamil Nadu | 0.859 |
| | Kerala | 0.835 |
| Western | Gujarat | 0.904 |
| | Maharashtra | 0.888 |
| Central | Madhya Pradesh and Chattisgarh | 0.873 |
| | Uttar Pradesh and Uttarakhand | 0.805 |
| Northern | Rajasthan | 0.877 |
| | Haryana | 0.809 |
| | Jammu and Kashmir | 0.795 |
| | Himachal Pradesh | 0.738 |
| | Punjab | 0.697 |
| Eastern | Odisha | 0.720 |
| | Bihar & Jharkhand | 0.699 |
| | West Bengal | 0.595 |
| North-east | Assam | 0.591 |
| **All India** | | **0.904** |

Source: Computed based on Land Use Statistics, DES, MA&FW.

Temporally, Table 4.3 depicts that out of southern regions, Karnataka does not only top in diversification but has also shown a remarkable and consistent increase in diversification in each sub-period, from an average CDI of 0.910 in 1981-81 to 1987-88 to 0.938 during 2015-16 to 2019-20. In Tamil Nadu, the diversification has increased overall but not that consistently while it is almost stagnant in undivided Andhra Pradesh and is consistently declining in the state of Kerala. Unfortunately, the central regions, namely in undivided Madhya Pradesh and undivided Uttar Pradesh, have shown consistent movement towards specialization; while diversification in the western region has remained almost stagnant during the whole period of study. The scenario in the northern region is also the same, with some states such as Punjab and Haryana being moving towards specialization, while diversification is almost stagnant in Himachal Pradesh and Jammu& Kashmir. The state of Rajasthan is the only exception where the diversification is not only high (unlike all other states in the Northern region) but is also getting more and more diversified over time. On the other hand, the most specialized states of eastern and north-eastern regions such as Assam, West Bengal and undivided Bihar are gaining more and more crop diversification during each successive sub-period. Odisha has also gained diversification during recent sub-periods.

**Table 4.3 Structural break- wise Crop Diversification in various states in India**

| S.No | States | Crop Diversification Index (CDI) | S.No | States | Crop Diversification Index (CDI) |
|---|---|---|---|---|---|
| | **Southern region** | | 10 | Haryana | |
| 1 | Karnataka | | | 1981-82 to 1991-92 | 0.840 |
| | 1981-82 to 1987-88 | 0.910 | | 1992-93 to 1997-98 | 0.829 |
| | 1988-89 to 1992-93 | 0.916 | | 1998-99 to 2002-03 | 0.799 |
| | 1993-94 to 1998-99 | 0.922 | | 2003-04 to 2008-09 | 0.800 |
| | 1999-2000 to 2008-09 | 0.931 | | 2009-10 to 2015-16 | 0.781 |
| | 2009-10 to 2014-15 | 0.936 | | 2016-17 to 2019-20 | 0.769 |
| | 2015-16 to 2019-20 | 0.938 | 11 | J&K | |
| 2 | AP & Telangana | | | 1981-82 to 1988-89 | 0.795 |
| | 1981-82 to 1987-88 | 0.861 | | 1989-90 to 1993-94 | 0.796 |
| | 1988-89 to 1992-93 | 0.850 | | 1994-95 to 1999-2000 | 0.792 |
| | 1993-94 to 2004-05 | 0.869 | | 2000-01 to 2004-05 | 0.790 |
| | 2004-05 to 2008-09 | 0.869 | | 2005-06 to 2014-15 | 0.796 |
| | 2009-10 to 2014-15 | 0.860 | | 2015-16 to 2019-20 | 0.797 |
| | 2015-16 to 2019-20 | 0.862 | 12 | HP | |
| 3 | Tamil Nadu | | | 1981-82 to 1988-89 | 0.739 |
| | 1981-82 to 1987-88 | 0.853 | | 1989-90 to 1994-95 | 0.734 |
| | 1988-89 to 1993-94 | 0.862 | | 1995-96 to 2004-05 | 0.737 |
| | 1994-95 to 1998-99 | 0.850 | | 2005-06 to 2010-11 | 0.737 |
| | 1999-2000 to 2004-05 | 0.864 | | 2011-12 to 2015-16 | 0.738 |
| | 2005-06 to 2015-16 | 0.859 | | 2016-17 to 2019-20 | 0.746 |
| | 2016-17 to 2019-20 | 0.864 | 13 | Punjab | |
| 4 | Kerala | | | 1981-82 to 1990-91 | 0.735 |
| | 1981-82 to 1991-92 | 0.842 | | 1991-92 to 1995-96 | 0.717 |
| | 1992-93 to 1998-99 | 0.838 | | 1996-97 to 2000-01 | 0.710 |
| | 1999-2000 to 2004-05 | 0.835 | | 2001-02 to 2005-06 | 0.691 |
| | 2005-06 to 2009-10 | 0.837 | | 2006-07 to 2015-16 | 0.666 |
| | 2010-11 to 2015-16 | 0.826 | | 2016-17 to 2019-20 | 0.641 |
| | 2016-17 to 2019-20 | 0.825 | | **Eastern region** | |
| | **Western region** | | 14 | Odisha | |
| 5 | Gujarat | | | 1981-82 to 1990-91 | 0.727 |
| | 1981-82 to 1988-89 | 0.901 | | 1991-92 to 1997-98 | 0.718 |
| | 1989-90 to 1997-98 | 0.907 | | 1999-2000 to 2004-05 | 0.680 |
| | 1998-99 to 2002-03 | 0.905 | | 2005-06 to 2008-09 | 0.706 |
| | 2003-04 to 2008-09 | 0.906 | | 2009-10 to 2015-16 | 0.743 |
| | 2009-10 to 2015-16 | 0.900 | | 2016-17 to 2019-20 | 0.748 |
| | 2016-17 to 2019-20 | 0.906 | 15 | Bih&Jhar | |
| 6 | Maharashtra | | | 1981-82 to 1987-88 | 0.694 |
| | 1981-82 to 1987-88 | 0.856 | | 1988-89 to 1993-94 | 0.697 |
| | 1988-89 to 1996-97 | 0.875 | | 1994-95 to 1998-99 | 0.692 |
| | 1997-98 to 2004-05 | 0.836 | | 1999-2000 to 2006-07 | 0.694 |

| | | |
|---|---|---|
| | 2005-06 to 2008-09 | 0.906 |
| | 2009-10 to 2015-16 | 0.902 |
| | 2016-17 to 2019-20 | 0.911 |
| | **Central region** | |
| 7 | MP&Chattisgarh | |
| | 1981-82 to 1987-88 | 0.892 |
| | 1988-89 to 1994-95 | 0.887 |
| | 1995-96 to 2004-05 | 0.872 |
| | 2005-06 to 2010-11 | 0.867 |
| | 2007-08 to 2015-16 | 0.858 |
| | 2016-17 to 2019-20 | 0.851 |
| 8 | UP&Uttarakhand | |
| | 1981-82 to 1987-88 | 0.827 |
| | 1988-89 to 1992-93 | 0.820 |
| | 1993-94 to 1997-98 | 0.815 |
| | 1998-99 to 2004-05 | 0.799 |
| | 2005-06 to 2015-16 | 0.791 |
| | 2016-17 to 2019-20 | 0.782 |
| | **Northern region** | |
| 9 | Rajasthan | |
| | 1981-82 to 1988-89 | 0.864 |
| | 1989-90 to 1993-94 | 0.873 |
| | 1994-95 to 1998-99 | 0.882 |
| | 1999-2000 to 2004-05 | 0.873 |
| | 2005-06 to 2015-16 | 0.882 |
| | 2016-17 to 2019-20 | 0.889 |
| | 2007-08 to 2014-15 | 0.706 |
| | 2015-16 to 2019-20 | 0.714 |
| 16 | West Bengal | |
| | 1981-82 to 1993-94 | 0.542 |
| | 1994-95 to 1998-99 | 0.565 |
| | 1999-2000 to 2004-05 | 0.603 |
| | 2005-06 to 2009-10 | 0.625 |
| | 2010-11 to 2014-15 | 0.651 |
| | 2015-16 to 2019-20 | 0.670 |
| | **North-eastern region** | |
| 17 | Assam | |
| | 1981-82 to 1987-88 | 0.576 |
| | 1988-89 to 1992-93 | 0.566 |
| | 1993-94 to 2002-03 | 0.580 |
| | 2003-04 to 2009-10 | 0.607 |
| | 2010-11 to 2015-16 | 0.610 |
| | 2016-17 to 2019-20 | 0.619 |

Source: Computed based on Land Use Statistics, DES, MA&FW.

### 4.4 Regression analysis on factors affecting crop diversification in India

Table 4.4 shows the results of the fractional outcome regression to find out the determinants of crop diversification in India. Summary statistics of variables is provided in Appendix A.4.2.

**Demand side characteristics**

From the demand side, Table 4.4 shows that there is more crop diversification in India where there is more demand in terms of both per capita income and urbanization, which is in agreement with the expected hypothesis. One percent increase in per capita income and urbanization lead to an increase in diversification by around 60 per cent and 8.3 per cent, respectively implying that crop diversification is basically demand-driven.

**Supply side characteristics**

From the supply side, the regression results prove that more engagement of agricultural workers in agriculture leads to better diversification, which is in agreement with the hypothesis. Regression results show that more engagement of agricultural workers is positively related to crop diversification with one per cent increase in share of agricultural workers enhances crop diversification around 9.4 per cent.

Crop diversification increases with better irrigation facilities i.e. one percent increase in area under irrigation leads to increase in crop diversification by around 8.8 percent. Thus, irrigation technology has helped remarkably in moving towards multiple cropping systems as well as gaining higher productivity and making cropping patterns more diversified. This is also in confirmation with some of the existing literature, which points towards the need of institutional support to overcome the natural resources constraints and reduce risk in rain fed areas to encourage diversification (Hazra 2001;Vyas 1996). The use of more fertilisers has discouraged crop diversification, as the hypothesis stated. The extensive use of chemical fertilisers is likely to increase in cropping intensity is accompanied by specialization in cropping patterns instead of diversification.

**Market variables**

The table also reveals that the higher terms of trade are responsible for crop specialization in the case of India. This is possible because higher terms of trade are associated in India in favor of the

**Table 4.4: Determinants of Crop Diversification (Dependent variable= Crop Diversification Index)**

| | Fractional outcome beta model | | | Average marginal effects | | |
|---|---|---|---|---|---|---|
| **Independent variables** | **Coefficient** | **Std. error** | **P value (P>z)** | **dy/ex** | **Std. Err.** | **P value (P>z)** |
| Log Per capita income | 0.473*** | 0.079 | 0.000 | 0.592*** | 0.098 | 0.000 |
| Percent Urbanization | 0.012*** | 0.002 | 0.000 | 0.083*** | 0.012 | 0.000 |
| Percent Area Irrigated | 0.008*** | 0.001 | 0.000 | 0.088*** | 0.009 | 0.000 |
| Cropping Intensity | -0.009*** | 0.001 | 0.000 | -0.357*** | 0.027 | 0.000 |
| NPK per hectare of land | -0.002*** | 0.000 | 0.000 | -0.086*** | 0.007 | 0.000 |
| % agriculture workers in population | 0.016*** | 0.002 | 0.000 | 0.094*** | 0.011 | 0.000 |
| % rural literacy | 0.007*** | 0.001 | 0.000 | 0.098*** | 0.018 | 0.000 |
| % number under small & marginal holding | -0.002*** | 0.001 | 0.005 | -0.033*** | 0.012 | 0.005 |
| TOT between agriculture and non-agriculture | -0.001** | 0.000 | 0.025 | -0.021** | 0.009 | 0.025 |
| Percent Industrialization | -0.007*** | 0.001 | 0.000 | -0.053*** | 0.008 | 0.000 |
| Road density | -0.001*** | 0.000 | 0.000 | -0.018*** | 0.003 | 0.000 |
| Constant | -0.641** | 0.284 | 0.024 | | | |
| Number of obs: 660 | | | | | | |
| Prob> chi2: 0.0000 | | | | | | |
| Log pseudolikelihood: -322.1419 | | | | | | |
| Pseudo R^2: 0.0445 | | | | | | |

Note: Average marginal effects is the delta method, which depicts dy/ ex with respect to the independent variables.

* p<0.1 and **p<0.05 and ***p<0.01

price of only a few staple crops such as wheat and rice, due to the minimum support price (MSP) policy, which is also in agreement with the literature.

The road density is taken as a proxy variable for accessibility to market or infrastructural facilities. Regression results show that the improvement in road density has led to specialisation rather than diversification though magnitude of marginal effects is low. This is in consistent with the findings in the literature.

**Socio-economic characteristics**

Regarding the socio-economic status of farmers, a one percent increase in rural literacy leads to better awareness and hence, increases diversification by 0.0143, which is in conformity with the literature (Debasis et al. 2018). However, some literature found that rural literacy rate has a negative but insignificant impact as increased literacy rate leads to better employment opportunities in other sector, leading to shift of workforce from agriculture to other sectors (Anwer et al 2019). Contrary to the proposed hypothesis, the regression results show that small and marginal farms can diversify the cropping pattern less.

**Industry-crop relationship**

One of the institutional factors is the development of industries. In case the Industry-crop relationships are well-developed, then the shift from monoculture towards diversification becomes difficult as huge investments have already been incurred in the establishment of industries in a particular area. This research finds consensus that the increase in the rate of industrialization has decreased diversification in the case of India. This is possible because industries such as the food-processing industry encourage the cultivation of only those crops which are required by the industry. This may create the policy implication that it is required to develop industries in various crops, rather than just one or two specialized ones.

## 4.5 Summary of major findings

The present chapter looked into the trends and status of crop diversification at the national and state level, and its relationship with the agricultural growth pattern. Then, it proceeded to analyze the factors affecting crop diversification in India.

The cropping pattern is diversified as much as 0.9041 on a scale of 0 to 1. Sub-period-wise, the overall extent of diversification has increased in the first three sub-periods. The diversification declined sharply from 1998-99 to 2003-04 when the huge crisis took place. Overall, the growth and diversification have moved hand-in-hand. State-wise, there is a clear demarcation in diversification aspects in different regions on an average since 1981-82. For instance, southern, western and central regions are the most diversified ones in terms of cropping patterns while the north-eastern state of Assam is highly concentrated.

The regression analysis was carried out to analyze the factors which possibly affect the diversification in cropping patterns. The results reveal that the demand-driven factors namely, percapita income and urbanization are one of the major reasons which have led to crop diversification in India. Since per-capita income and urban population are expected to rise at a faster rate in future (United Nations 2018, Dadush et al. 2010), these demand-side factors would further fuel diversification in coming years.

Regression results show that more engagement of agricultural workers is positively related to crop diversification with one per cent increase in share of agricultural workers enhances crop diversification around 9.4 per cent. Also, crop diversification increases with better irrigation facilities i.e. one percent increase in area under irrigation leads to increase in crop diversification by around 8.8 per cent.

However, in the Indian context, the higher terms of trade have led to crop specialization, possibly because relative profitability affects diversification patterns, hence policies such as MSP are biased in favor of a few crops only leading to an adverse effect on diversification. In present model results, more road density has led to specialization rather than diversification. This research finds consensus that the increase in the rate of industrialization has decreased diversification in the case of India. This is possible because industries such as the food-

processing industry encourage the cultivation of only those crops which are required by the industry.

Regarding the socio-economic status of farmers, the effect of rural literacy on crop diversification is found to be positive and statistically significant at 1 per cent level, so should be encouraged. The regression results show that small and marginal farms are less able to diversify.

# APPENDIX

## A.4.1 Average values of Crop diversification Index and its determinants

**Table 4.5: Average values of Crop diversification Index and its determinants from 1981-82 to 2019-20 - All India**

| Variables | 1981-82 to 1987-88 | 1988-89 to 1992-93 | 1993-94 to 1997-98 | 1998-99 to 2003-04 | 2004-05 to 2011-12 | 2012-13 to 2019-20 | Overall period |
|---|---|---|---|---|---|---|---|
| Crop Diversification Index | 0.9045 | 0.9048 | 0.9051 | 0.9019 | 0.9054 | 0.9030 | 0.9041 |
| Per capita income (in Rs.) | 22306 | 26636 | 31553 | 39386 | 54907 | 80246 | 45247 |
| The growth rate in per capita income | | 0.0054 | 0.0044 | 0.0040 | 0.0035 | 0.0027 | 0.0007 |
| % urban population | 23.90 | 25.76 | 27.34 | 28.47 | 30.05 | 31.15 | 28.52 |
| % Area Irrigated | 30.41 | 34.65 | 38.43 | 41.51 | 44.59 | 49.09 | 40.43 |
| Cropping Intensity | 125.95 | 129.73 | 132.81 | 133.62 | 138.06 | 145.04 | 134.89 |
| TOT | 77.32 | 80.50 | 84.15 | 84.25 | 92.92 | 116.02 | 90.81 |
| NPK cons. per unit of land | 55.32 | 84.48 | 98.68 | 121.34 | 169.08 | 189.56 | 125.51 |
| % Agri workers | 21.73 | 21.88 | 22.23 | 22.62 | 22.08 | 21.28 | 21.93 |
| % Rural literacy rate | 38.45 | 43.81 | 49.89 | 57.66 | 65.26 | 74.23 | 56.40 |
| % Area under small and marginal holdings | 28.17 | 31.74 | 35.26 | 38.60 | 42.17 | 47.16 | 38.16 |
| % Industrialisation | 22.56 | 22.93 | 23.89 | 23.71 | 26.14 | 26.03 | 24.40 |
| Road density | 514.81 | 605.76 | 684.21 | 761.48 | 988.06 | 1445.08 | 874.04 |

Note: The terms of trade (TOT) are taken between agriculture and non-agriculture sectors, and are taken at base 2011-12=100. NPK consumption in tonnes/ha, road density in Km per '000 Km^2. The agricultural workers are measured with respect to the total population.

**Table 4.6: Average values of of CDI and its determinants from 1981-82 to 2019-20-Statewise**

| States | CDI | Per capita income (Rs.) | Growth in per capita income | % urban population | % Area Irrigated | Cropping Intensity | NPK consumption per hectare | % of Agri workers in population | % rural literacy rate | % area under S&M holdings | TOT | % Industrialisation | Road density |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Haryana | 0.8091 | 71217 | 5.05 | 30.34 | 80.60 | 172.16 | 254.88 | 17.01 | 50.23 | 21.13 | 88.65 | 29.58 | 749 |
| Himachal Pradesh | 0.7380 | 60242 | 4.68 | 9.49 | 19.22 | 171.38 | 71.37 | 29.04 | 62.69 | 49.33 | 76.73 | 35.71 | 624 |
| Jammu and Kashmir | 0.7947 | 40985 | 2.33 | 25.39 | 41.42 | 149.79 | 95.27 | 16.57 | 48.12 | 66.77 | 113.15 | 32.18 | 124 |
| Punjab | 0.6966 | 63953 | 3.34 | 34.10 | 95.57 | 183.03 | 345.61 | 14.67 | 53.30 | 9.77 | 81.80 | 18.13 | 1464 |
| UP&Uttarakhand | 0.8047 | 24784 | 2.94 | 21.30 | 67.25 | 151.49 | 182.82 | 20.84 | 42.18 | 60.03 | 81.52 | 24.92 | 859 |
| North W. region | 0.7686 | 52236 | 3.67 | 24.12 | 60.81 | 165.57 | 189.99 | 19.63 | 51.30 | 41.40 | 88.37 | 28.10 | 764 |
| Assam | 0.5907 | 33908 | 2.46 | 12.83 | 10.07 | 142.32 | 48.93 | 19.11 | 48.28 | 47.00 | 88.76 | 31.49 | 2008 |
| Bih&Jharkhand | 0.6991 | 15121 | 3.41 | 13.71 | 47.71 | 136.28 | 134.25 | 24.67 | 36.98 | 58.40 | 89.52 | 12.92 | 756 |
| Odisha | 0.7198 | 36274 | 4.10 | 15.12 | 27.32 | 154.86 | 55.95 | 24.98 | 49.28 | 55.59 | 106.39 | 38.35 | 1422 |
| West Bengal | 0.5953 | 34821 | 4.21 | 29.43 | 46.55 | 169.69 | 196.50 | 17.15 | 51.31 | 73.57 | 79.64 | 26.74 | 1705 |
| Eastern region | 0.6747 | 34472 | 3.57 | 19.04 | 38.49 | 153.74 | 125.12 | 21.11 | 47.43 | 55.19 | 90.54 | 27.52 | 1331 |
| Gujarat | 0.9041 | 58412 | 6.02 | 38.64 | 36.40 | 115.17 | 110.05 | 20.01 | 51.75 | 24.50 | 71.30 | 34.02 | 619 |
| Maharashtra | 0.8879 | 64916 | 5.12 | 42.36 | 16.76 | 123.38 | 101.20 | 23.49 | 56.43 | 35.14 | 80.37 | 34.39 | 1130 |
| MP&Chattisgarh | 0.8727 | 28719 | 3.74 | 24.91 | 26.78 | 130.65 | 71.19 | 30.52 | 41.85 | 27.56 | 93.05 | 22.59 | 518 |
| Rajasthan | 0.8765 | 38419 | 4.56 | 23.79 | 32.14 | 126.67 | 46.60 | 24.94 | 38.37 | 13.34 | 76.89 | 24.89 | 471 |
| Central region | 0.8432 | 44988 | 4.60 | 29.75 | 30.11 | 129.92 | 90.83 | 24.01 | 47.17 | 31.15 | 82.43 | 28.68 | 814 |
| AP & Telangana | 0.8622 | 47380 | 4.82 | 29.44 | 43.07 | 121.68 | 193.14 | 28.54 | 42.20 | 45.85 | 82.72 | 25.58 | 865 |
| Karnataka | 0.9255 | 63178 | 5.07 | 34.99 | 25.77 | 117.28 | 117.00 | 23.62 | 49.01 | 33.73 | 106.63 | 25.19 | 1046 |
| Kerala | 0.8354 | 62884 | 4.89 | 33.94 | 15.76 | 132.17 | 94.57 | 8.16 | 79.03 | 73.86 | 62.22 | 25.41 | 4170 |
| Tamil Nadu | 0.8580 | 57271 | 5.57 | 42.93 | 52.41 | 118.78 | 171.61 | 23.21 | 55.99 | 55.96 | 78.89 | 34.64 | 1485 |
| Southern region | 0.8648 | 55140 | 4.99 | 34.21 | 33.42 | 123.97 | 133.43 | 21.51 | 54.68 | 48.11 | 82.58 | 27.90 | 1676 |

Note: The terms of trade (TOT) are taken between agriculture and non-agriculture sectors, and are taken at base 2011-12=100. NPK consumption in tonnes/ha, road density in Km per '000 Km^2. The agricultural workers are measured with respect to the total population.

# CHAPTER-V

# *CROP DIVERSIFICATION IN INDIA: A MICRO LEVEL ANALYSIS USING NSSO DATA*

# CHAPTER 5

## *CROP DIVERSIFICATION IN INDIA: A MICRO-LEVEL ANALYSIS USING NSSO DATA*

### 5.1 BACKGROUND

In chapter four of this dissertation, the state-wise analysis of crop diversification revealed that India has a highly diversified cropping pattern with a score of 0.90. The southern, western, and central regions have highly diversified cropping pattern, whereas eastern and northern regions follow a specialized cropping pattern. Regression results on factors affecting diversification using state-level database revealed that per capita income and urbanization had positive and significant effect on crop diversification. While availability of irrigation encourages crop diversification, fertilizer use, cropping intensity and proportion marginal and small farmers are associated with specialization. Effect of rural literacy and proportion of agricultural workers on crop diversification was positive and statistically significant. However, coefficient of industry value added was negative and statistically significant implying that there exists industry-crop relationship leading to cultivation of specialized crops required as raw materials for the industry. The improvement in road density and terms of trade in favor of agriculture has led to specialization rather than diversification though magnitude of marginal effects is low.

Although the above analysis had the advantage of making analysis for whole population database, the impact of some household-specific variables on level of crop diversification could not be taken in above analysis. For instance, the impact of whether a household has actively joined various institutions and policies such as banks, Registered Farmers' Organisation, Kisan Credit Card Scheme, PM Fasal Fima Yojana, Mahatma Gandhi Rural Employment Guarantee Scheme (MNREGS), Soil Health Card Scheme and leasing institutional arrangement on crop diversification is still required to be analyzed. Further, some farm-specific variables such as such as input-output ratio, marketable surplus ratio and proportion of loan taken could not be analyzed in previous chapter. The present chapter tries to fulfill these gaps by using NSS household-level

database. Further, impact of variables such as proportionate small and marginal holdings, per-capita income, rural literacy and irrigation status were analysed in previous chapter at macro level can be analysed with more precision using household characteristics such as household and operational holding size, their income (or consumption), education and formal training status, and household irrigation status respectively. The analysis from previous chapter to analyze impact of terms of trade between agriculture vis-à-vis non-agriculture sector on level of crop diversification is made more comprehensive here to analyze impact of inter-crops terms of trade on crop diversification.

## 5.2 METHODOLOGY

The study used both descriptive and regression analysis. The methods adopted in this chapter are explained below:

### 5.2.1 Classification of CDI score for descriptive analysis

For descriptive analysis, the status of crop diversification at the households is divided into three categories, namely, low, medium and high levels of diversification. To create these categories, first distribution of CDI is analysed. After merging the two visits, mean and standard deviation of CDI found to be 0.439 and 0.2568, respectively. Its maximum value for the combined visits is 0.8968 and the minimum value is zero.

The class intervals are created by keeping the break points as mean plus-minus standard deviation, after approximating them to one decimal place. Table 5.1 shows the three categories, where the low category is the one in which the CDI value is less than or equal to 0.2, medium category covers the households whose CDI value ranges from more than 0.2 to less than or equal to 0.7 percent. Finally, the highly diversified category is the one in which households' CDI values range to more than 0.7 percent.

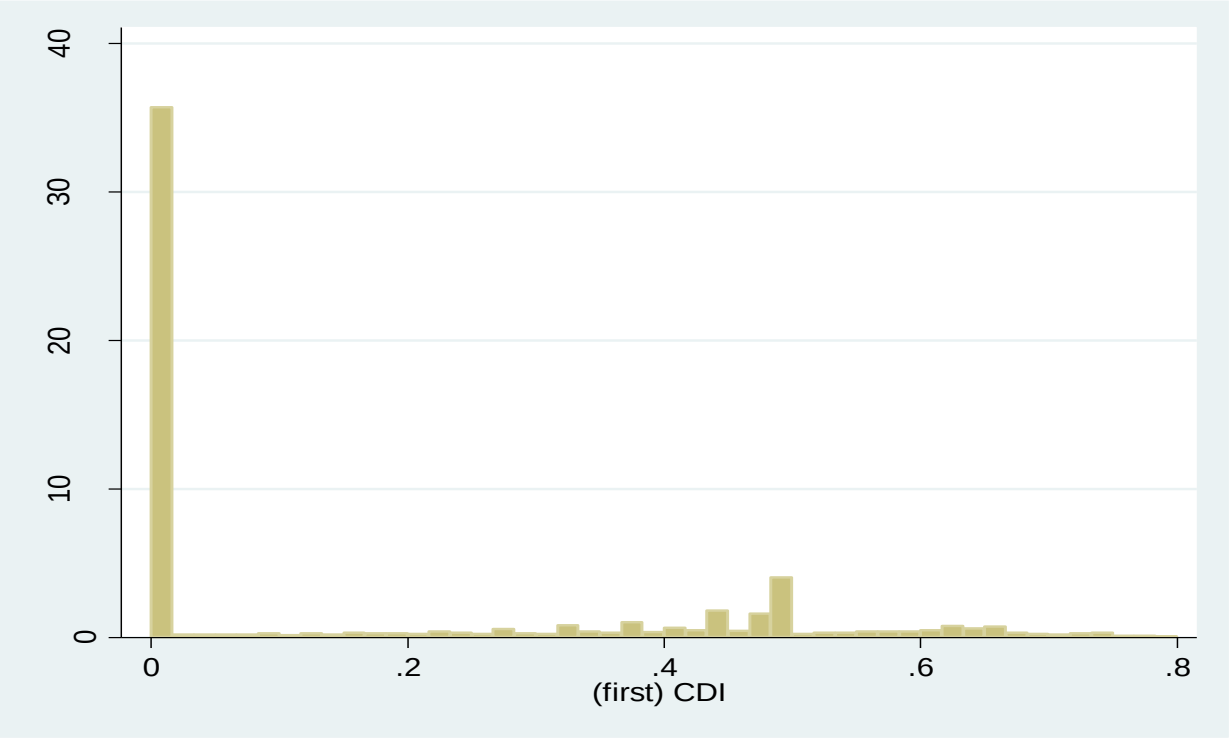
**Table 5.1: Distribution of households among various categories of CDI**

| **Categories** | **Distribution of households (%)** | | |
|---|---|---|---|
| | **Visit 1** | **Visit 2** | **Combined visits** |
| Less than 0.2 | 70.08 | 62.4 | 20.08 |
| 0.21 to 0.7 | 28.61 | 35.79 | 68.82 |
| Greater than 0.71 | 1.31 | 1.81 | 11.1 |
| **Total** | **100** | **100** | **100** |

### 5.2.2 Model specification and variables taken for descriptive and regression analysis of their impact on crop diversification

The dependent variable is Crop Diversification Index (CDI). Since the histogram of CDI is a non-linear continuous variable bounded between zero and one (both inclusive), the fractional logit response model[10] is used in the study. (Papke and Wooldridge (1996), Wooldridge 2002). This model is based on maximum likelihood estimators and has been used in various studies such as Adjimoti (2018) and Priscilla et.al. (2021).

**Graph 5.1: Graph showing histogram of CDI for sample households**




Source: Author's own calculation from unit-level NSSO 77th round.

[10] There are two types of fractional outcome models- (a) fractional response regression, which is applied in case the continuous dependent variable lies in [0,1], and (b) beta regression, which is applied in case the continuous dependent variable lies in (0,1). It may be noted that OLS regression couldn't be used as the dependent variable lies between zero and one, OLS estimates provide predicted values to lie outside these intervals. Also, Tobin model couldn't be applied in present study as the values of CDI are bounded between zero and one. Tobin model is applied in case the dependent variable is unbounded otherwise in case censoring is not done, which is not the case with CDI variable.

Papke and Wooldridge (1996) consider the conditional expectation model for the fractional response variable as$E\ (Y_i/X_i) = G(X_i\beta) + u_i; where\ i = 1,2,3, \ldots., N$. Here, $0 \leq Y_i \leq 1$ denotes the continuous dependent variable Crop Diversification Index (CDI), $\beta$ denotes slope coefficient, $X_i$denotes the k*1 vector of explanatory variables of observation i, and G(.) signifies a cumulative distribution function. The model is estimated by the maximum likelihood procedure.

*The independent variables taken are described as follows:*

Firstly, market variables include extent of commercialization (captured by marketed surplus ratio) and relative price ratios. Marketable surplus ratio is computed indirectly in the following manner, using the data of imputed value of crops grown for subsistence purpose provided by National Sample Survey:

$$\text{Marketable surplus ratio} = \left(1 - \frac{\text{Imputed value of crops grown for subsistence purposes}}{Value\ of\ output}\right) * 100$$

The paddy-bajra ratio, paddy-cotton ratio, and paddy-soybean ratio are computed using the visit one database, and paddy-gram and paddy-rapeseed and mustard ratios are computed using visit two database.

The impact of commercialization on crop diversification is debatable, as some literature has found positive relation (Jayne et al. 2011), while some other literature suggests that it leads to more diversification at national level, but specialisation at farm level (Pingali et al. 1995, Timmer 1997, Kurosaki 2003).

It is expected from the literature that greater the above price ratios, lesser will be the diversification because more paddy will be grown (Vyas 1996, Birthal et al. 2007, Buhera et al. 2007). It is important to note that the impact of price ratios on crop diversification could be analysed using descriptive analysis only. It could not be taken during regression analysis because the number of observations become too less when these ratios are computed, as such computation demand that farmers grow paddy as well as the other crop for which price ratio is to be computed.

The household characteristics are captured in terms of total monthly consumption expenditure, household size, education, and formal agricultural training status of members. The household monthly consumption expenditure is taken as a proxy for the income of households. The present study analyses whether there is still an incentive to diversify their farms and increase their farm income when they already have a better income. Studies have not generally considered this variable. It is hypothesized that increased consumption expenditure and hence, well-being of a farmer increases its risk taking ability to diversify its farm holdings, and thus, have a positive impact on crop diversification. It may be noted that income of households is a supply-side variable here rather than the demand side[11].

The household size is taken as a proxy to determine the labor intensiveness, assuming that the larger the household size is, the larger the number of members employed in crop production activities. It is expected that as labor intensiveness increases, diversification will increase as most of the high-value commodities are labor-intensive (Birthal et al 2007, Malaiarasan et al. 2019, Joshi et al 2002, Weinberger et al 2005, Bargouti et al 2005).

Education is taken as a dummy variable, which is equal to one if any member of the household has studied up to lower secondary class and is zero otherwise. Besides, a dummy variable is taken for training status, which is equal to one if any household member has taken any formal training in agriculture and is zero otherwise. The literature has found that there is a positive relationship between education and crop diversification (Malaiarasan et al. 2019, Dey 2020, Aheibam et al. 2017, Birthal et al. 2015, Rahman2008, Mango et al. 2018). Literature also finds that training impact crop diversification positively and significantly (Dey 2020, Basantaray et al 2017). Education, as well as formal training, helps in increasing awareness of techniques, and methods for better cultivation of a different variety of crops. So, it is hypothesized that both will have a significant positive impact on the diversification pattern.

The infrastructure and inputs variables include farm size, net irrigated area, input-output ratio and loan taken for farm purposes. The farm size is measured by taking log of operational area of household, net area irrigated is measured by taking its percentage in net sown area, input-output

[11]Demand-side impact of income refers to the impact of increased income on the purchase of a variety of crops for consumption, thereby impacting the decision-making of farmers to diversify their cropping as per the demand conditions.

ratio is measured using total crop production expenses (actual and imputed) as a percentage of the value of total crop output, and loan taken for farm purposes is measured by taking percentage of total loan outstanding for farm purposes over net sown area.

The impact of farm size on crop diversification is debatable. Small and marginal farmers may be able to diversify themselves better because diversification reduces risk and because they have abundant labour, so can cultivate high-value commodities better as these commodities are labor-intensive in nature, with low gestation period, high returns (Birthal et al. 2007, Joshi et al 2002, Weinberger et al 2005, Bargouti et al 2005). However, crop diversification may get constrained if small and marginal farmers have limited choices to diversify themselves because of diseconomies of scale and input, credit, and knowledge constraints which they often face (Singh 1984, Buhera et al. 2007, Gunasekera et al. 2017, Malaiarasan et al. 2019).

Irrigation technology is expected to impact crop diversification negatively. This is because according to literature, although irrigation technology has potential to make a shift towards multiple cropping systems, gaining higher productivity and making cropping patterns more diversified, it has actually resulted in specialisation in India (Vyas 1996, Hazra 2001).

Literature argues that credit may influence crop diversification positively or negatively. This is because since credit helps in increasing the risk-bearing capacity of farmers, farmers may undergo a structural change from low-value to high-value cropping pattern (Panda 2015, Jha et al. 2009, Birthal et al. 2006). However, credit may be put in non-farm uses in case existing crops are renumerative or in case market infrastructure is relatively underdeveloped, thus constraining diversification (Nayak et al. 2019).

Finally, the institutional factors include the area of land entirely leased-in by a household as a percentage of net sown area, the status of whether households are part of a registered farm organization (RFO), whether they possess a bank account or a Kisan Credit card (KCC) or are insured under PM Fasal Bima Yojana, or whether have undertaken MNREGA activity during last 365 days and finally, the status of whether the household has applied fertilizer, soil amendments as per recommendations of soil health card (SHC) or not. The impact of some of these variables such as RFO, bank account, KCC, PM Fasal Bima and SHC are not analysed in

the literature under analysis of determinants of crop diversification, but are analysed under specific studies of that particular institutional factor.

It is expected that tenancy farming discourages crop diversification because tenants are reluctant to diversify compared to their counterpart farmers with own land (Malaiarasan et al. 2019). The dummy variable named Registered Farmers' Organization takes the value of one in case any of the household members is a part of such organization, and takes value of zero otherwise. It is hypothesized that it has a positive impact on crop diversification (Rondot and Collion 2001, Shylendra 2009, Pathania 2021, Birthal et al. 2014, Roy et al. 2008). The dummy variable named Soil Health Card recommendations takes value of one in case the household has both possessed as well as applied the recommendations of soil health card. It is also hypothesized to positively impact diversification of crops (Chakrawarty et al. 2018, Bordoloi et al. 2017, Grover et al. 2019). This is also justified as crop diversification is a good strategy to improve soil quality (Ghimire et al. 2016, Kumar et al. 2021), so the recommendations will automatically show fewer fertilizers need in case multiple cropping patterns are followed, thereby creating incentives for farmers to reduce their fertilizer and manure costs through the adoption of diversified or multiple cropping.

The impact of financial inclusion as an admirable instrument for improving agricultural productivity and empowerment of farmers is well-established (Kumar et al. 2019). Having bank account and Kisan credit card are some of the forward steps towards achieving financial inclusion, but their impact on crop diversification is analyzed in the present chapter. The dummies variables named Bank account and Kisan Credit Card take values of one if any of the household possess them respectively, and takes value of zero otherwise.

The dummy variable named Insurance under Fasal Bima Yojana takes value of one in case the household has registered any crop under this scheme. Although it is one of the key objectives of that the scheme should contribute to crop diversification (Government of India 2020), but it is hypothesized to negatively impact crop diversification because of limited number of crops in the scheme (Bhushan et al. 2017).

The dummy variable named Participation in MNREGA takes value of one if any of the household members has participated under MNREGA during the last 365 days, and takes value of zero otherwise. It is hypothesized to positively impact diversification (Basantaray et al 2017).

The relationship between crop diversification and above independent variables is also analyzed using descriptive analysis. One more market variable is considered in descriptive analysis namely relative price ratio. The price ratios considered are paddy-bajra ratio, paddy-cotton ratio, paddy-soybean ratio, paddy-gram ratio and paddy-rapeseed and mustard ratio. The reason regression analysis could not be conducted after considering this variable is that the number of observations becomes very less, as such price ratios between two crops require that both paddy and other crop must be cultivated by the same farmer.

## 5.3 THE STATE-WISE STATUS OF THE CROP DIVERSIFICATION INDEX

Table 5.2 shows the state-wise status of crop diversification, arranged in the descending order of CDI. The numbers represent the percentage of gross sown area where crop diversification is low, medium and high. For instance, in Mizoram, there is high level of crop diversification on 17.94 percent of its gross sown area.

The table reveals that the hilly states of Mizoram and Uttarakhand are the most diversified. For instance, around 18 and 14.5 percent of their gross sown area come under the high category of diversification. Except for Chandigarh, the top states which have diversified are the ones whose topography is a bit undulating or mountainous. Besides Mizoram and Uttarakhand, these include Meghalaya, Sikkim, and Himachal Pradesh too. So, exogenous geographical factors also play a potentially major in determining the diversification status of cropping pattern of a state. This is because, in these states, specialization becomes difficult due to factors like low irrigation, fewer market facility, and other similar things there (Vyas 1996, Hazra 2001, Negi et al. 2020). The next state which shows high diversification proportion is Rajasthan, where again the geographical climate does not allow for crop diversification. The states such as Punjab, Haryana, and Bihar are a few of the most specialized states. These are located on northern plains and receive irrigation levels the most, providing a good chance to specialize themselves.

**Table 5.2: Status of crop diversification in various states (July 2018 to June 2019)-Combined visit**

| | | Level of crop diversification (% of gross sown area) | | | |
|---|---|---|---|---|---|
| **Region** | **State** | **Low** | **Medium** | **High** | **Total** |
| Southern | Kerala | 29.1 | 59.76 | 11.14 | 100 |
| | Karnataka | 60.11 | 38.49 | 1.4 | 100 |
| | Andhra Pradesh | 79.46 | 20.15 | 0.38 | 100 |
| | Tamil Nadu | 84.88 | 14.92 | 0.2 | 100 |
| | Telangana | 64.31 | 35.55 | 0.14 | 100 |
| Central | Uttarakhand | 28.43 | 57.01 | 14.56 | 100 |
| | Madhya Pradesh | 66.59 | 32.72 | 0.69 | 100 |
| | Uttar Pradesh | 76.39 | 23.38 | 0.23 | 100 |
| | Chhattisgarh | 87.83 | 12.04 | 0.13 | 100 |
| Western | Maharashtra | 53.53 | 44.15 | 2.32 | 100 |
| | Gujarat | 60.95 | 38.09 | 0.95 | 100 |
| | Goa | 28.21 | 71.79 | 0 | 100 |
| Northern | Himachal Pradesh | 52.51 | 44.65 | 2.84 | 100 |
| | Rajasthan | 51.56 | 45.65 | 2.79 | 100 |
| | Jammu and Kashmir | 46.11 | 51.79 | 2.1 | 100 |
| | Haryana | 66.2 | 33.64 | 0.16 | 100 |
| | Punjab | 64.19 | 35.79 | 0.02 | 100 |
| Eastern | Jharkhand | 56.08 | 41.46 | 2.46 | 100 |
| | Odisha | 87.69 | 11.46 | 0.85 | 100 |
| | West Bengal | 85.82 | 13.7 | 0.48 | 100 |
| | Bihar | 94.52 | 5.42 | 0.06 | 100 |
| North east | Mizoram | 15.23 | 66.84 | 17.94 | 100 |
| | Meghalaya | 29.3 | 60.7 | 10 | 100 |
| | Sikkim | 24.74 | 65.74 | 9.52 | 100 |
| | Tripura | 84.08 | 14.77 | 1.14 | 100 |
| | Assam | 76.61 | 22.35 | 1.04 | 100 |
| | Manipur | 72.23 | 26.92 | 0.85 | 100 |
| | Arunachal Pradesh | 62.12 | 37.24 | 0.63 | 100 |
| | Nagaland | 35.08 | 64.85 | 0.07 | 100 |
| Union Territories | Chandigarh | 67.5 | 22.5 | 10 | 100 |
| | Delhi | 90.99 | 9.01 | 0 | 100 |
| | Daman and Diu | 96.46 | 3.54 | 0 | 100 |
| | Dadar and Nagar Haveli | 64.75 | 35.25 | 0 | 100 |
| | Lakshadweep | 100 | 0 | 0 | 100 |
| | Puducherry | 98.39 | 1.61 | 0 | 100 |
| | Andaman and Nicobar Islands | 79.63 | 20.37 | 0 | 100 |
| | **Total** | **70.08** | **28.61** | **1.31** | **100** |

**Source: Computed based on NSS 77th round (2019)**

### 5.3.1 Crop Diversification Index by market characteristics

**Table 5.3: Status of crop diversification index by market characteristics**

| CDI status | % marketed surplus | Relative price ratios | | | | |
|---|---|---|---|---|---|---|
| | | Paddy/ Bajra | Paddy/ Cotton | Paddy/ Soybean | Paddy/ Gram | Paddy/ Raperseed and mustard |
| **Visit 1** | | | | | | |
| Low | 96.80 | 14.8 | 2.14 | 14.8 | | |
| Medium | 97.27 | 7.47 | 2.79 | 4.75 | - | |
| High | 97.80 | 2.94 | 0.94 | 1.53 | | |
| Total | 96.99 | 7.3 | 2.29 | 4.58 | | |
| **Visit 2** | | | | | | |
| Low | 96.68 | | | | 3.59 | 3.02 |
| Medium | 97.59 | - | | | 0.71 | 0.64 |
| High | 97.74 | | | | 0.14 | 0.16 |
| Total | 97.15 | | | | 0.55 | 0.53 |
| **Combined visits** | | | | | | |
| Low | 94.58 | | | | | |
| Medium | 96.34 | - | | | | |
| High | 97.45 | | | | | |
| Total | 96.12 | | | | | |

Source: Computed based on NSS 77th round (2019)

Note: - denotes not applicable as the two crops are not grown in that season. The relative price of paddy with respect to bajra, cotton and soybean were computed based on visit 1 data. Similarly, relative price of paddy with respect to gram and rapeseed and mustard were computed based on visit 2 data.

Table 5.3 shows that as the farmers have brought in more percentage of their produce to the marketplace, the diversification has increased. This is in agreement with some literature (Jayne et al. 2011), but in contrast to some other studies (Pingali et al. 1995, Timmer 1997, Kurosaki 2003). The price parity between the select crops has shifted away from paddy. The crop diversification has increased with shift in terms of trade away from the paddy crop and in favor of crops like bajra, cotton, soybean, gram and rapeseed & mustard, which is in agreement with the literature.

### 5.3.2 Crop Diversification by household characteristics

Tables 5.4 and 5.5 reveal that there is a drastic positive difference in crop diversification between the farming households which are educated and/ or in which any of the members have undertaken any formal training in agriculture. For instance, in table 5.4, out of the households in which all are illiterate, only around 8 percent of them have highly diversified their farms, while out of the households in which at least one has done post graduation, around 17.5 percent of them have highly diversified their farms. Similarly, out of the households in which all are illiterate, only around 23 percent of them have low level of crop diversification, while out of the households in which at least one has done post graduation, only around 13 percent of them have low level of crop diversification. This is in agreement with the hypothesis. Similarly, in the case of training, the households in at least one member have undertaken formal agricultural training are the ones that fall under the highly diversified category in both the visits, which is also in agreement with the states hypothesis. To analyze the effect of the standard of living or well-being of the family on the cropping diversification pattern, table 5.5 finds that there is a positive relationship between the well-being of the family increases (as is revealed by the increase in mean monthly consumption expenditure) and its crop diversification pattern.

**Table5.4: Status of crop diversification index by level of education- Combined visit**

| Maximum level of education by most literate member of the household | Level of Crop diversification (% of households belonging to a particular category of education) | | | |
|---|---|---|---|---|
| | **Low** | **Medium** | **High** | **Total** |
| Not literate | 22.74 | 69.27 | 7.99 | 100 |
| Literate, below primary | 21.18 | 69.36 | 9.46 | 100 |
| Primary | 23.1 | 68.13 | 8.77 | 100 |
| Upper primary/middle | 20.3 | 69.4 | 10.3 | 100 |
| Secondary | 18.36 | 70.85 | 10.79 | 100 |
| Higher secondary | 15.45 | 71.52 | 13.04 | 100 |
| Diploma/ certificate course (up to secondary) | 27.31 | 61.4 | 11.29 | 100 |
| Diploma/ certificate course (up to higher secondary) | 15.81 | 64.06 | 20.12 | 100 |
| Diploma/ certificate course (graduation & above) | 21.15 | 69.33 | 9.53 | 100 |
| Graduate | 16.62 | 70.49 | 12.89 | 100 |
| Post graduate and above | 13.32 | 69.19 | 17.49 | 100 |
| **Total** | **18.65** | **70** | **11.35** | **100** |

Source: Computed based on NSS 77th round (2019)

**Table 5.5: Status of crop diversification index by some household characteristics**

| CDI status | Mean monthly consumption expenditure of household (in Rs.) | % households in which at least one member has done formal training in agriculture |
|---|---|---|
| **Visit 1** | | |
| Low | 8265 | 1.82 |
| Medium | 9788 | 2.82 |
| High | 10559 | 5.95 |
| Total | 8731 | 2.16 |
| **Visit 2** | | |
| Low | 8583 | 1.62 |
| Medium | 9437 | 2.85 |
| High | 9826 | 6.14 |
| Total | 8911 | 2.14 |
| **Combined visits** | | |
| Low | 7658 | 2.12 |
| Medium | 8755 | 1.86 |
| High | 10286 | 4.23 |
| Total | 8706 | 2.18 |

Source: Computed based on NSS 77th round (2019)

The household size represents family labor availability for agricultural activities. It is hypothesized that that the larger the household size or labour intensiveness, more the crop diversification. The results from table 5.6 reveal that crop diversification increases as the household size increases. For instance, when the household size is just one, only around 4 percent of the households were diversifying under the high category, and as much as around 35 percent of them were in the low diversification category. On the other hand, when the household size increases to more than 11, then more than 18 percent of households were able to fall under the high diversification category.

**Table 5.6: Status of crop diversification index by household size-Combined visit (% of household size of a given category)**

| Household size | CDI | | | |
|---|---|---|---|---|
| | **Low** | **Medium** | **High** | **Total** |
| 1 | 35.07 | 60.91 | 4.03 | 100 |
| 2 | 25.73 | 63.57 | 10.7 | 100 |
| 3 | 22.91 | 66.7 | 10.39 | 100 |
| 4 | 21.76 | 68.23 | 10.01 | 100 |
| 5 | 20.55 | 68.76 | 10.69 | 100 |
| 6 | 15.65 | 72.07 | 12.29 | 100 |
| 7 | 16.57 | 72.59 | 10.84 | 100 |
| 8 | 14.5 | 71.28 | 14.22 | 100 |
| 9 | 9.64 | 75.21 | 15.14 | 100 |
| 10 | 14.75 | 69.39 | 15.87 | 100 |
| 11 | 9.27 | 72.19 | 18.53 | 100 |
| 12 | 7.96 | 73.63 | 18.41 | 100 |
| 13 | 4.57 | 79.79 | 15.64 | 100 |
| 14 | 19.42 | 61.22 | 19.36 | 100 |
| >15 | 26.95 | 63.53 | 9.52 | 100 |
| **Total** | **20.08** | **68.82** | **11.1** | **100** |

Source: Computed based on NSS 77th round (2019)

### 5.3.2 Crop Diversification by infrastructural[12] facilities and input use

In table 5.7, the effect of the input-output ratio is captured through average expenses on crop production as a percentage of value of output. It shows that the low diversified households are the ones that are incurring significantly more expenses as a percent of the value of output than the ones which have diversified their farms adequately. For instance, under combined visits, the low-diversified households are incurring 65 percent of expenses compared to just 47.5 percent in the case of highly-diversified households. In other words, higher input and other expenses create hindrances in the process of diversification. Moreover, results reveal the higher the irrigation cover is, lower is the crop diversification, which is in agreement with the hypothesis.

[12]Agricultural infrastructure generally includes a wide range of facilities or public services that aids the production, processing, marketing, and storage of agricultural produce. These can be divided into (a) input based infrastructure such as seeds, fertilizers, farm machinery, and equipment; (b) physical infrastructure such as roads, transportation, and storage; (c) resource-based infrastructure such as irrigation and power; (d) institutional infrastructures such as education and training, research and extension services, financial services, and information and communication services (Patel 2014).

The results on the impact of credit on the level of crop diversification depict that the households which has low amount of outstanding loan are the ones which are ones which are least diversified while which have highest amount of loan outstanding are the ones which are medium, rather than highly diversified. Thus, it can be interpreted that low access to credit is constraining households from taking risk which is in agreement with the literature.

The classification of operational holdings is made in Table 5.8 according to standard criteria used in the Agricultural Census; less than one hectare (marginal), one to two hectares (small), two to four hectares (semi-medium), four to ten hectares (medium), and greater than ten hectares (large). The issue explored here is that 'do small farm holders diversify more than large farm holders?' The table reveals that the marginal farmers are significantly showing low diversification patterns, while the semi-medium medium, and large farm holders are significantly engaging more in higher diversification of their farms. The small farm holder category can diversify more when the combined visit is seen as a whole but show mixed results when visits are taken separately. As a whole, we can say that it is only the marginal farm-holding category that is facing constraints in diversification, which might be due to the so meager area of land it possesses that growing a single crop only makes sense.

**Table 5.7: Status of crop diversification index by input and infrastructural factors**

| CDI status | Average % area irrigated by households | Average expenses on crop production as percentage of value of output | Average loan outstanding per unit of net sown area (Rs. per acre) |
|---|---|---|---|
| **Visit 1** | | | |
| Low | 53.82 | 54.40 | 15215.25 |
| Medium | 42.94 | 52.01 | 19216.74 |
| High | 28.61 | 52.74 | 17844.87 |
| Total | 48.80 | 48.80 | 16779.96 |
| **Visit 2** | | | |
| Low | 67.51 | 54.40 | 18187.93 |
| Medium | 67.09 | 48.60 | 19601.04 |
| High | 48.72 | 52.50 | 18431.58 |
| Total | 67.02 | 51.60 | 18670.30 |
| **Combined visits** | | | |
| Low | 62.28 | 65.20 | 16354.45 |
| Medium | 61.25 | 52.40 | 19391.40 |
| High | 58.45 | 47.50 | 18126.52 |
| Total | 59.99 | 51.40 | 17572.83 |

Source: Computed based on NSS 77th round (2019)

**Table 5.8: Status of crop diversification by size of operational holdings (% of CDI category)**

| CDI status | Marginal | Small | Semi medium | Medium | Large | Total |
|---|---|---|---|---|---|---|
| **Visit 1** | | | | | | |
| Low | 76.28 | 15.82 | 6.01 | 1.63 | 0.27 | 100 |
| Medium | 54.62 | 24.15 | 14.85 | 5.84 | 0.53 | 100 |
| High | 52.11 | 20.49 | 14.99 | 8.98 | 3.43 | 100 |
| Total | 69.76 | 18.26 | 8.66 | 2.93 | 0.38 | 100 |
| **Visit 2** | | | | | | |
| Low | 77.02 | 14.63 | 6.31 | 1.79 | 0.24 | 100 |
| Medium | 61.4 | 22.34 | 11.71 | 3.86 | 0.7 | 100 |
| High | 65.74 | 16.87 | 12.17 | 3.89 | 1.33 | 100 |
| Total | 71.21 | 17.44 | 8.35 | 2.57 | 0.42 | 100 |
| **Combined visits** | | | | | | |
| Low | 75.47 | 17.45 | 5.45 | 1.42 | 0.21 | 100 |
| Medium | 71.84 | 17.28 | 7.91 | 2.7 | 0.26 | 100 |
| High | 51.3 | 24.77 | 16.92 | 5.72 | 1.3 | 100 |
| Total | 70.29 | 18.15 | 8.42 | 2.78 | 0.36 | 100 |

Source: Author's calculation from NSSO 77th round database

### 5.3.3 Crop Diversification by institutional characteristics

Table 5.9 shows the relationship between the status of crop diversification and the institutional characteristics. The institutional variables provided in this table are given as the 'percentage of households which possess or are a part of the above characteristics'. It is to be noted that the total of the two visits differ slightly for each variable because firstly, the same household might have diversified its cropping pattern differently in the two visits; and secondly, the comparatively fewer sample households could be surveyed in the second visit as compared to the first visit due to some data collection issue. Also, the total of each or combined visit is the weighted average of the low, medium, and high categories, weighted by the proportion of households.

It can be seen that around four percent of the agricultural households is a part of registered farmers' organizations. Of these, the households which have grown better-diversified cropping patterns were also found to be more likely to be a part of registered farmers' organizations in each category, which is in agreement with the hypothesis. For instance, the under highly diversified CDI category, more than 5.5 percent of the farmer households are found to be a part of registered farmers' organizations in the combined visits, while the households which had specialized cropping patterns were found to be less registered under such organizations (less than four percent).

Similar is the case with Kisan credit cards and the workers who have worked under MNREGA during the past 365 days. The results show that the households which have grown more diversified cropping patterns are found to be more likely to risk secured through PM Fasal Bima Yojana and MNREGA coverage. The higher the diversified cropping pattern of a farmer is, the more are his chances of being covered under PM Fasal Bima Yojana and possessing a Kisan Credit Card. Besides, around 98 percent of the households possess bank accounts as of the date of visit, and there is a clear difference shown here also that households which possess banks accounts are more likely to have diversified their cropping pattern.

The soil health card recommendations play a crucial role in achieving diversified cropping patterns while keeping soil quality in check. Even when just around 0.6 percent of the farming household population actively possesses and applies its recommendation, the difference is still clearly revealed. This is also in agreement with the hypothesis. Table 5.9 also shows that the type of holding that is, whether the farmer has self-owned or leased-in landholding does not possess much effect on crop diversification, which is not in agreement with the literature which states that tenancy negatively impact crop diversification because of reluctance by tenants Malaiarasan et al. 2019).

**Table 5.9: Status of crop diversification index by institutional characteristics**

| CDI status | % households as part of Registered Farmers' Organization | % households possessing bank account | % households possessing Kisan credit card | % households which are part of PM Fasal Bima Yojana | % households undertook MNREGA work in last 365 days | % households possessing & applying recommendations of soil health card | % households that have entirely leased-in holding |
|---|---|---|---|---|---|---|---|
| **Visit 1** | | | | | | | |
| Low | 3.68 | 97.96 | 18.79 | 6.36 | 51.49 | 0.4 | 1.93 |
| Medium | 4.79 | 98.09 | 18.75 | 9.43 | 55.47 | 0.99 | 1.05 |
| High | 7.42 | 99.37 | 23.53 | 9.28 | 57.56 | 1.38 | 1.55 |
| Total | 4.05 | 98.02 | 20.13 | 7.28 | 52.79 | 0.58 | 1.68 |
| **Visit 2** | | | | | | | |
| Low | 3.87 | 98.14 | 18.65 | 6.08 | 53.24 | 0.38 | 1.42 |
| Medium | 4.02 | 98.27 | 20.59 | 8.23 | 48.92 | 0.98 | 1.01 |
| High | 10.81 | 99.71 | 28.17 | 7.43 | 57.94 | 0.96 | 3.33 |
| Total | 4.05 | 98.22 | 22.09 | 6.87 | 51.8 | 0.6 | 1.31 |
| **Combined visits** | | | | | | | |
| Low | 3.92 | 97.7 | 13.14 | 9.18 | 56.64 | 0.31 | 2.42 |
| Medium | 3.87 | 98.05 | 20.84 | 6.63 | 52.1 | 0.51 | 1.59 |
| High | 5.88 | 98.59 | 27.54 | 9.73 | 52.84 | 1.52 | 1.04 |
| Total | 4.11 | 98.04 | 20.04 | 7.49 | 53.26 | 0.58 | 1.69 |

Source: Computed based on NSS 77th round (2019)

## 5.4 REGRESSION ANALYSIS OF FACTORS AFFECTING CROP DIVERSIFICATION AT FARMERS HOUSEHOLD LEVEL

This section analyses the factors influencing farmers' decision to allocate cultivable area under different crops. The results depict that percentage of marketable surplus doesn't have a very significant impact on crop diversification. The operational holding variable is taken as to capture the impact of the effect of farm size on diversification. The regression results reveal that the larger the farm size, the more crop diversification will be there. The other related factor is the household size, which is taken as a proxy to capture the effect of labor intensiveness on CDI. The regression results depict that the diversification increase as a result of an increase in household size. This is in confirmation with the literature (Thorat 2007).

Under household characteristics, the regression finds that the higher the consumption status. more is the crop diversification. It is probably since the increased income releases them from facing various constraints such as access to credit, input, etc, and makes them more capable to diversify better. However, participation in MNREGA has not affected the diversification pattern significantly, although the coefficient is positive.

**Table 5.10: Regression results for determinants of CDI**

| Independent variables | Coefficient | Standard error | P>z |
|---|---|---|---|
| **Institutional Characteristics** | | | |
| Bank account | 0.023 | 0.060 | 0.094 |
| KCC | 0.074 | 0.020 | 0 |
| Registered farm organisation | 0.077 | 0.020 | 0.002 |
| PM Fasal Bima Yojana | -0.028 | 0.020 | 0.224 |
| MNREGA | 0.014 | 0.010 | 0.249 |
| Soil health card recommendations | 0.075 | 0.070 | 0.024 |
| Type of holding | -0.105 | 0.040 | 0.008 |
| **Household characteristics** | | | |
| Max education by any household | 0.010 | 0.010 | 0.093 |
| Training by any household | 0.025 | 0.030 | 0.006 |
| log household size | 0.106 | 0.020 | 0.000 |
| log cons exp | 0.231 | 0.020 | 0.000 |
| **Market, infrastructure, and input characteristics** | | | |
| Marketable surplus ratio | 0.001 | 0.000 | 0.327 |
| log operational holdings | 0.038 | 0.010 | 0.000 |
| Percent area irrigated | -0.001 | 0.000 | 0.000 |
| Expenses percent of output | -0.001 | 0.000 | 0.000 |
| Percent loan of NSA | 0.000 | 0.000 | 0.016 |
| **Constant** | -1.750 | 0.170 | 0.000 |

Education, as well as formal training, helps in increasing awareness, techniques, and methods for better cultivation of a different variety of crops. The result also confirms that education and formal training in agriculture have a significant positive impact on the diversification pattern at 10 percent and 1 percent respectively. The households which possess soil health cards and follow its recommendations related to the application of fertilizer, manure, and soil amendments in their field are the ones that are found to be significantly able to diversify their cropping pattern. However, out of total farming households, only a mere 1.51 percent possess soil health card, and only 0.57 percent of the population is reaping its benefits by application of its recommendations.

The present study reveals that as the increased irrigation has led to a significant decrease in diversification. This is in conformity with the previous literature (Vyas 1996). The input-output ratio is captured by the amount of input and other expenses for crop production as a percentage of the value of output. The results depict that as the percentage of input-output ratio increased the crop diversification decreased significantly. The access to the credit facility is captured by a loan taken for farm purposes and is outstanding as a percentage of net sown area. The results show that the loan amount has a very significant, but low amount of impact on the diversification pattern.

Institutional factors play a major role in the determination of crop diversification patterns. Here, two variables are used viz. access to credit and the actual amount of loan taken. These are captured by whether a farmer holds a Kisan Credit Card and the amount of loan taken for farm purposes which is outstanding as a percentage of net sown area. The results show that what matters more is whether the household has access to credit or not, rather than the actual amount of loan taken. Thus, although the loan amount per se had a very low significant impact on the diversification pattern, the farming households which possessed Kisan credit cards were able to significantly diversify their cropping pattern more. Similarly, the farming households which possessed their bank account and thus are financially included are significantly better able to diversify. One of the important institutional questions that arise is should the lease markets and registered farmers' organizations be encouraged or not in light of their impact on the diversification of cropping patterns. In this sense, the present study finds that the household

which had entirely leased were less able to diversify, but the household who is a part of registered farm organizations are very much able to diversify their holdings.

### 5.5 Summary of major findings

This chapter analyzed the trends and determinants of crop diversification in India using household level database. The descriptive analysis is made by categorizing the level of crop diversification into low, medium and high, where dividing values were mean plus-minus standard deviation that is, 0.2 and 0.7. Fractional outcome model (fractional logit response model) was used to capture non-linear relationship between crop diversification and independent variables. State-wise merger of households revealed that the hilly states of Mizoram, Uttarakhand, Meghalaya, Sikkim, and Himachal Pradesh are the most diversified, while the states such as Punjab, Haryana, and Bihar are few of the most specialized states.

The results reveal that from market side, crop diversification has increased with shift in terms of trade away from the paddy crop and in favor of crops like bajra, cotton, soybean, gram and rapeseed & mustard. This creates policy implication that the government must make efforts to ensure that farmers receive a good return on alternative crops away from paddy. The extent of commercialization was found to be positive but insignificant.

The household characteristics such as consumption expenditure and household size were found to be significantly and positively affect crop diversification. Here, household size and consumption expenditure were used as a proxy of the extent of labor intensiveness and income or well being respectively. There is a need to invest in education and agricultural training as a key to achieving diversification. The infrastructure and input side factors such as irrigation cover and input-output ratio had significantly negative impact on crop diversification, although of low magnitude. Larger the farm size, more diversified the cropping pattern is found. This means small farm holders face constraints in diversifying their holding. Lower access to credit is found to significantly hinder the diversification process.

The impact of institutional factors such as possession of a bank account and a Kisan credit card was found to be significantly positive, and hence must be promoted. The active involvement of households in soil health card scheme led to significantly positive impact on crop diversification, while the impact of PM Fasal Bima Yojana and MNREGS was found to be insignificant.

However, the benefits of being a part of a registered farm organization, being insured under PM Fasal Bima Yojana, and being an active user of a soil health card is currently reaped by just around 4.0 percent, 7.5 percent, and 0.6 percent[13] of the agricultural households respectively. Such policy needs to be given a thrust. The households which have grown better-diversified cropping patterns were also found to be more likely to be a part of registered farmers' organizations in each category. The tenancy institution was found to significantly constraint diversification because of reluctant by tenants.

[13] Currently only a mere 1.51 percent of total farming households possess soil health card and only 0.57 percent of the population is reaping its benefits by application of its recommendations.

# CHAPTER-VI

# *SUMMARY AND CONCLUSION*

# CHAPTER 6

## *SUMMARY AND CONCLUSION*

### 6.1 BACKGROUND

Despite a fall in share of agricultural sector in national income and employment, the need for achieving a rapid growth in agriculture is not a paradox (Timmer, 1988; de Janvry, 2010). The widespread adoption of Green Revolution technology introduced in the late 1960sled to a reasonable growth of over 3.0 per cent in India's agricultural output during the 1980s (Bhalla and Singh 2009; Chand et al., 2007; Kannan, 2011). The Green Revolution technology could transform the status of the country from food deficit to self-sufficiency in food production (Gulati 2003). But agricultural output growth had tapered during the 1990s and consequently the agrarian sector had witnessed a worst phase of crisis from the late 1990s to the early 2000s (Reddy and Mishra, 2010; Deshpande and Arora, 2010). There was a recovery in agricultural growth during the mid-2000s (Chand and Parappurathu, 2012; Deokar and Shetty, 2014). Since then, the growth momentum has continued with great resilience despite inter-year fluctuations. However, it is argued that the growth strategy led by the Green Revolution technology is losing its steam and it is not sustainable due to its adverse effects on the environment such as soil salinity and alkalinity, water logging, declining water table from increased use of fertilizers and mono-cropping pattern (Pingali 2012).Crop diversification from cereals particularly rice-wheat cropping system to high-value commodities is considered to be a key strategy to overcome some of these sustainability issues confronting the India's agricultural sector. Further, crop diversification has huge potential as an important source of crop output growth, employment generation, and nutrition security (Joshi et al., 2003 and 2007; Mishra et al., 2020).

The subject of agricultural growth pattern in India is a well-researched area; but most of the studies have divided the time period into known structural break dates assuming some prior known criteria such as the phases of spread of Green Revolution technology, domestic economic reforms/external trade liberalization policy being implemented since early 1990s (Bhalla, 2007; Vaidyanathan, 2010); or simply decadal analysis of agricultural growth pattern (Kannan, 2011;

Bhalla and Singh, 2001). A few studies have computed structural break points endogenously, buttheir analysis have focused on overall economic growth rather than specifically examiningthe agricultural growth pattern (Dholakia, 1994; Balakrishnan and Parameswaran, 2007). Even those studies that have analysedthe agricultural growthpattern by identifying structural breaks in agricultural GDP,confined to the periods of GreenRevolution and economic reforms of 1990s (Ghosh, 2002 and 2010; Chand and Parappurathu, 2012).

No recent study looked into India's agricultural growth performance by identifying the structural break points and related the growth pattern with crop diversification at state level. The present study fills this research gap by analyzing agricultural growth performance and crop diversification in India for nearly four decades, i.e., from 1981-82 to 2019-20.This research analyses the nature and timings of structural changes in India's agricultural economy endogenously and examines the trends and patterns in crop agricultural growth and crop diversification at state level.

*The specific objectives of the study were as follows:*

4. To analyze the trend and changing pattern of agriculture growth at state-level in India from 1981-82 to 2019-20
5. To examine the pattern and determinants of crop diversification in India
6. To analyze the factors determining the decision of agricultural households to diversify the cropping pattern at farm level

*To fulfill these objectives, the data sources and methodology used are described as follows:*

The study used secondary data for analysis. Data on crop agricultural GDP were compiled from National Accounts Statistics published by Central Statistics Office (CSO), Government of India. Data on area, production, irrigation, fertilizer consumption and agricultural workers were compiled from various issues of Agricultural Statistics at a Glance published by the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, and also from Land Use Statistics and the ICRISAT database. Data from schedule 33.1 of NSS 77$^{th}$ round on 'Land and Livestock holdings of households and Situation Assessment of Agriculture Households' was compiled to analyze factors affecting crop diversification at the household level. For state-level

analysis, the study considered 17 major states/Union Territories. The states which were bifurcated after the year 1981-82 were merged into the parent states for maintaining uniformity and consistency in the analysis; these included Andhra Pradesh and Telangana, Bihar and Jharkhand, Madhya Pradesh and Chhattisgarh, and Uttar Pradesh and Uttarakhand.

The structural breaks were endogenously computed using year-on-year crop agricultural GDP growth from 1981-82 to 2019-20. The breakpoints were computed using Bai-Perron multiple breakpoint test, which helps in the identification of multiple breakpoints by using global minimizers of the sum of squared residuals from OLS regression.Crop diversification was computed based on the Herfindahl-Hirschman Index (HHI).

The regression analysis to determine factors affecting crop diversification was carried out at two levels, one using state-level database and other using household level database.Paneldata regression analysis had been carried out using fractional outcome model (beta regression) to examine the determinants of crop diversification at state-level by using 17 cross-section units (states) for the period, 1980-81 to 2019-20.Under independent variables, demand side variables included net state per-capita income and urbanization and supply side variables are irrigation, fertilizer consumption, cropping intensity and proportion ofsmall and marginal holdings. Market related variables included price (terms of trade) and road density. The socio-economic characteristics of agricultural workerswere captured through rural literacy rate andproportion of agricultural workers in the total population.The share of industry GSDP in total GSDP was also taken to analyze the possible impact of backward and forward linkages on crop diversification.

For household level analysis, descriptive analysis is made by categorizing the level of crop diversification into low, medium and high, where dividing values were mean plus-minus standard deviation that is,0.2 and 0.7. Fractional outcome model (fractional logit response model) was used to capture non-linear relationship between crop diversification and independent variables. Under independent variables, market variables include extent of commercialization (captured by marketed surplus ratio) and relative price ratios (paddy-bajra ratio, paddy-cotton ratio, paddy-soybean ratio, paddy-gram ratio and paddy-rapeseed and mustard ratio).The household characteristics are captured in terms of total monthly consumption expenditure, household size, education, and formal agricultural training status of members. The infrastructure and inputs variables include farm size (computed using log of operational area of household,

irrigated area, input-output ratio (computed as total expenses on crops as a percentage of value of output) and access to credit (computed using loan taken for farm purposes). Finally, the institutional factors include the area of land entirely leased-in by a household as a percentage of net sown area, the status of whether households are part of a registered farm organization (RFO), whether they possess a bank account or a Kisan Credit card (KCC) or are insured under PM Fasal Bima Yojana, or whether have undertaken MNREGA activity during last 365 days and finally, the status of whether the household has applied fertilizer, soil amendments as per recommendations of soil health card (SHC) or not.

## 6.2 SUMMARY OF FINDINGS

India's agricultural growth pattern was analysed by endogenously identifying structural break dates over four decades. Five national level structural breaks in crop agricultural GDP were identified: they included 1987-88, 1992-93, 1997-98, 2003-04, and 2011-12. Although variations were found at the state-level, the major structural breakpoints identified include 1987-88, 1988-89, 1993-94, 1998-99, 2004-05, 2014-15, and 2015-16. The agricultural GDP has grown at an average rate of 2.82 percent per annum during 1981-82 to 2019-20. So far, the highest growth in agricultural GDP was registered at 3.74 per cent during 2004-05 to 2011-12 followed by 2.98 per cent during 2012-13 to 2019-20. These growth rates even much higher than those registered during the 1980s during which the Green Revolution technology spread to a wider geographical area in the country. Agriculture in the states such as Madhya Pradesh, Bihar and Punjab still contributes to more than 25 percent of their respective state income. The states such as Punjab, Haryana and West Bengal registered a higher agricultural growth during the 1980s, but have witnessed deceleration in growth rates during the recent periods. The states that have registered a higher agricultural growth in the recent periods included Bihar, Rajasthan, Andhra Pradesh and Gujarat.

Analysis of crop diversification had shown that India has a highly diversified cropping pattern with a score of 0.90.The southern, western, and central regions have highly diversified cropping pattern, whereas eastern and northern regions follow a specialized cropping pattern. There is a positive association between agricultural growth and crop diversification. Among the sub-periods, the correlation coefficient was much higher and statistically significant during 1998 to 2011-12. But strength of the correlation has weakened in the subsequent periods. Regression

results on factors affecting diversification revealed that per capita income and urbanization had positive and significant effect on crop diversification. While availability of irrigation encourages crop diversification, fertilizer use and cropping intensity are associated with specialisation. Better road network facilityhas encouraged people to import better quality products, affecting the production of local horticultural produce. Effect of rural literacy and proportion of agricultural workers on crop diversification was positive and statistically significant.However, coefficient of industry value added was negative and statistically significant implying that there exists industry-crop relationship leading to cultivation of specialized crops required as raw materials for the industry.

India has a highly diversified cropping pattern with significant variations across the states. Analysis of crop diversification at the state-level had shown that the states in the southern, western, and central regions have highly diversified cropping pattern, whereas the states in the eastern and northern regions follow a specialized cropping pattern. Karnataka topped the list in diversification and had shown a remarkable and consistent increase in diversification in each sub-period from 1981-82 to 2019-20. Tamil Nadu and Rajasthan are yet other states where diversification is not only high, but are also moving towards diversification. The most specialized states of eastern and north-eastern regions such as Assam, West Bengal, undivided Bihar are gaining a greater crop diversification during each successive sub-period. Odisha is yet another specialized state which has moved towards diversification during recent sub-periods. Although high, diversification is almost stagnant in undivided Andhra Pradesh and is consistently declining in the state of Kerala. The major concern is that central regions such as undivided Madhya Pradesh and undivided Uttar Pradesh have high level of crop diversification, but have shown consistent movement towards specialization; while diversification in the western region has remained almost stagnant during the whole period of study. In the northern region, states such as Punjab and Haryana have moved towards specialization, while Himachal Pradesh and Jammu & Kashmir have shown stagnancy in diversification pattern.

The analysis based on the NSS household level survey revealed that the hilly states of Mizoram, Uttarakhand, Meghalaya, and Sikkim are the most diversified, where more than 9.5 percent of their gross sown area have crop diversification index of more than 0.7. Kerala has shown the most diversification at farm level, where just 29 percent of the gross sown area has low level (0.2

or less) of crop diversification score. In contrast, states such as Punjab, Haryana, and Bihar are few of the most specialized states, where crop diversification index of more than 0.7 is found only at mere less than 0.2 percent of the land. Except the union territories of Chandigarh and undivided Jammu & Kashmir, all other union territories have a specialized cropping pattern.

Regression results on determinants of crop diversification revealed that from market side, crop diversification has increased with shift in terms of trade away from paddy to bajra, cotton, soybean, gram and, rapeseed and mustard. The extent of commercialization was found to be positive but insignificant. The impact of household characteristics such as education, training, consumption expenditure and household size were found to be significantly positive. Here, household size and consumption expenditure were used as a proxy of the extent of labor intensiveness and income or well being, respectively. The infrastructure and input side factors such as irrigation coverage and input-output ratio had significantly negative impact on crop diversification, although of low magnitude. Larger the farm size, more diversified the cropping pattern is found. This means small farm holders face constraints in diversifying their holding. Lower access to credit is found to significantly hinder the diversification process.

The impact of institutional factors such as financial inclusion in terms of having bank account and Kisan credit card was found to be significantly positive. The active involvement of households in soil health card scheme led to significantly positive impact on crop diversification, while the impact of PM Fasal Bima Yojana and MNREGS was found to be insignificant. The households which have grown better-diversified cropping patterns were also found to be more likely to be a part of registered farmers' organizations in each category. The tenancy relation was found to significantly constraint crop diversification.

## 6.3 CONCLUSION AND POLICY SUGGESTIONS

- At national level, five structural breaks in agricultural GDP were identified: 1987-88, 1992-93, 1997-98, 2003-04, and 2011-12. There exists variation in structural break points at state level indicating state-specific changes in policy or occurrence of extreme climatic events.
- Agricultural growth and crop diversification index are positively correlated with a high degree of association found during 1998-99 to 2003-04.Crop diversification will hold the key to sustain the current momentum in India’s agricultural growth.

- Both agriculture growth and diversification have increased temporally in most of the sub-periods. Spatially, southern, western, and central regions have highly diversified cropping pattern, whereas eastern and northern regions follow a specialised cropping pattern.
- Regression results reveal that demand-driven factors namely per capita income and urbanization had significantly positive impact on crop diversification, and would further fuel diversification in coming years.
- Education (especially in rural areas) and formal training in agriculture must be promoted to aid the diversification of crops. Household consumption expenditure, household size and engagement of a greater proportion of agricultural workers were found to significantly and positively affect crop diversification.
- Institutions such as registered farm organizations and schemes such as soil health card scheme,Kisan Credit Card should be promoted as these have significantly improved diversification process. Ensuring possession of a bank account is also a forward step towards diversification of crops.
- The main concern are supply-side factors such as input use, fertilizer use and cropping intensity, as there were found to be associated with specialisation. While availability of irrigation encouraged crop diversification at state-level, it still constrained diversification at a farm level.Policy must be directed towards releasing small farmers from credit and input constraints which hinder their ability to diversify their holdings.
- From market side, the terms of trade in favor of agriculture sector had constrained diversification, while shift of relative price against the staple crop paddy was found to aid diversification. Thus, there is need to move relative price against paddy so that improvement in terms of trade in favor of agriculture may lead towards the path of crop diversification. The industry-crop relationship is required to be modified so that industries may demand non-staple crops as raw materials.

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