TRENDS IN THE PRODUCTION AND PRODUCTIVITY OF SELECTED CASH CROPS IN PUNE DISTRICT (1991-92 TO 2017-18)

A Thesis

SUBMITTED TO

TILAK MAHARASHTRA VIDYAPEETH PUNE

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

In ECONOMICS

NEHRU INSTITUTE OF SOCIAL SCIENCES

Under the Board of Moral and Social Sciences

BY

BHUMA SUNDAR RAMAN

(Registration No. 02116009634)

UNDER THE GUIDANCE OF

Dr. JYOTI PATIL
Assistant Professor (Retd.)

DEPARTMENT OF ECONOMICS
TILAK MAHARASHTRA VIDYAPEETH

MARCH 2021

Tilak Maharashtra Vidyapeeth, Pune

<u>Undertaking</u>

I, **MRS. BHUMA SUNDAR RAMAN**, a Ph. D Scholar of the Tilak Maharashtra Vidyapeeth in **ECONOMICS subject**, having authored a thesis titled **"TRENDS IN PRODUCTION AND PRODUCTIVITY OF SELECTED CASH CROPS IN PUNE DISTRICT (1991-92 TO 2017-18)"** under the supervision of **Dr. JYOTI PATIL**,

solemnly affirm that the thesis submitted by me is my own work. I have not copied it from any source. I have gone through extensive review of literature of the related published / unpublished research works and the use of such references made has been acknowledged in my thesis. The title and the content of research is original. I understand that, in case of any complaint especially plagiarism, regarding my Ph.D. research from any party, I have to go through the enquiry procedure as decided by the Vidyapeeth at any point of time. I understand that, if my Ph.D. thesis (or part of it) is found duplicate at any point of time, my research degree will be withdrawn and, in such circumstances, I will be solely responsible and liable for any consequences that arise thereby. I will not hold the TMV, Pune responsible and liable in any case.

I have signed the above undertaking after reading carefully and knowing all the aspects therein.

Signature

Address: C 101, NECO SKY PARK, VISHALNAGAR,
PIMPLE NILAKH, PUNE-411027
Mob. No.: 8378995269
e-mail: coolbhuma.raman@gmail.com

Date: **Place:** Pune

CERTIFICATE OF THE SUPERVISOR

It is certified that the work titled **"TRENDS IN THE PRODUCTION AND PRODUCTIVITY OF SELECTED CASH CROPS IN PUNE DISTRICT (1991-92 TO 2017-18)"**

is an original research work done by **MRS. BHUMA SUNDAR RAMAN**

under my supervision for the degree of Doctor of Philosophy in **ECONOMICS**

to be awarded by Tilak Maharashtra Vidyapeeth, Pune. To the best of my knowledge this thesis

- embodies the work of the candidate herself
- has duly been completed
- fulfils the requirement of the ordinance related to Ph. D. degree of the TMV
- is up to the standard in respect of both content and language for being referred to the examiner.

Signature of the Supervisor

ACKNOWLEDGEMENT

I would like to express my sincere gratitude towards my guide Dr. Jyoti Patil who has been a pillar of support and guiding light in the successful completion of this research work. I will forever remain indebted to her for her unstinted kindness and understanding, as also her vast knowledge and experience through which this work was so generously enriched. I would also like to express my thanks towards Dr. Praveen Jadhav, HOD, Economics Department, Tilak Maharashtra Vidyapeeth and Dr. Avinash Kulkarni for guiding me from time to time on various issues. In the process of data collection, the cooperation of Mr. Mahendra Lokhande, Asst. General Manager (IT), at Maharashtra State Agricultural Marketing Board (MSAMB) played a crucial role in accessing all the required data on priority basis through mail. Another important luminary whose assistance in this work has been invaluable is Mr. Shekhar Gaikwad, Sugar Commissioner of Maharashtra, who took personal interest in ensuring that the Statistics Department extended their full cooperation in providing the required data. A special thanks to Ms. Rehana of Statistics Department in the Department of Agriculture, Shivajinagar, who provided the PMKSY report which was of immense value in analyzing the irrigation profile of Pune district. The Economic and Political Weekly Research Foundation (EPWRF) proved to be the last resort (since any data not available through any other source was provided by them almost immediately at a very nominal cost). As such, any note of Acknowledgement would be incomplete without mention of the preeminent EPWRF. A special mention for my husband, Col. Sundar Raman (Retd.), who enabled me to undertake this seemingly impossible task, pushed me whenever I lost heart, and goaded me to complete it successfully. Last but not least, I would like to thank the Almighty for making it possible for me to achieve the dream of my lifetime.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AES – Agro Ecological Zones

AFARM – Action for Agricultural Renewal in Maharashtra

ANOVA – Analysis of Variance

APY – Area, Production and Yield

BCM – Billion Cubic Meters

C-DAP – Comprehensive District Action Plan

CACP – Commission for Agricultural Costs and Prices

CAGR – Compounded Annual Growth Rate

CoP – Cost of Production

DES – Directorate of Economics and Statistics

df – Degrees of Freedom

EPWRF – Economic and Political Weekly Research Foundation

EVA – Extreme Risks, Vulnerabilities and Community-Based Adaptation

FA – Area under Food grains

FAO – Food and Agriculture Organization

FCI – Food Corporation of India

FHP – Farm Harvest Prices

FRP – Fair and Remunerative Price

FY – Financial Year

FYM – Farm Yard Manure

FYP – Five Year Plan

GCA – Gross Cropped Area

GDP – Gross Domestic Product

H&T – Harvest and Transportation

Ha – Alternate Hypothesis

Ho – Null Hypothesis

HYV – High Yielding Variety

ICRISAT – International Crops Research Institute for the Semi-Arid Tropics

IEM – Industrial Entrepreneur Memorandum

IGP – Indo-Gangetic Plains

IT – Information Technology

IWP – Irrigation Water Productivity

Mha – Million hectares

MSAMB – Maharashtra State Agricultural Marketing Board

MSP – Minimum Selling Price

Mt – Million Tons

NABARD – National Bank for Agriculture and Rural Development

NAFED – National Agricultural Cooperative Marketing Federation of India Ltd.

NFA – Area under Non-Food grains

OECD – Organization for Economic Cooperation and Development

PEC – Project & Equipment Corporation of India Limited

PMKSY – Pradhan Mantri Krishi Sinchayee Yojana

PWP – Physical Water Productivity

RSF – Revenue Sharing Formula

SARFAESI – Securitisation and Reconstruction of Financial Assets and Enforcement of Security Interest

SCH – Single Cross Hybrid

SMP – Statutory Minimum Prices

SS – Sum of Squares

TCD – Tons of cane per day

TCWU – Total Consumptive Water Used

TE – Triennium Ending

TFPG – Total Factor Productivity Growth

TRQ – Tariff Rate Quota

VOP – Value of Product

WTO – World Trade Organization

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

India is largely an agrarian society. The share of agriculture in gross domestic product (GDP) has come down considerably since independence but it continues to provide employment to nearly half the population. 54.6% of the population is engaged in agriculture and allied activities and it contributes 17.4% to the country's Gross Value Added for the year 2016-17 at current prices (Annual Report 2017-18, Department of Agriculture, pp 1). Agriculture continues to play an important role in the process of economic development of our country because the forward and backward linkage effects of agricultural growth provides employment opportunities in allied sectors like agro-based industries, textile industries, biofuel industries etc. Thus, the inclusive nature of the agricultural sector continues to provide sustenance to millions. The liberalization process initiated in 1991 had industrial and trade reform as its main focus and was backed up by reforms in taxation, banking and capital markets as well. However, the agricultural sector was largely ignored and while the rest of India benefitted from the economic reforms, the performance of agricultural sector actually saw a decline in the decade following reforms. The growth rate of GDP from agriculture and allied activities was highest at 3.9 per cent per annum between 1992-93 and 1996-97. The decadal average of 1980s showed the highest growth rate of more than 3 per cent per annum. However, between 1997-98 and 2004-05, agricultural growth fell to 1.6 per cent per annum. This reduction in growth rate was largely due to a fall in agricultural productivity across crops and regions. Following several initiatives by the central and state governments, the agricultural sector recovered and grew at an average rate of 3.5 per cent per annum between 2004-05 and 2010-11 (Dev, 2012, p. 3). Agricultural output has been volatile over the past 10 years, with annual growth ranging from 8.6% in 2010-11, to -0.2% in 2014-15 and 0.8% in 2015-16 (Deshpande, 2017, p. 3). Notwithstanding the hiccups at various points of time, agricultural output in India has seen a steady rise over the years due to significant increase in the use of modern inputs like high yielding variety seeds, application of fertilizers to irrigated crops, institutional credit and insurance etc. At the same time, the cropping pattern at the macro and district levels have also undergone a sea change over the decades. Beginning with the green revolution (1968-1980) and then followed by the post green revolution period (1980-1990), the post reforms era (1991-2005), and then finally the renaissance of the agricultural sector in recent times (2005-2012), the cropping pattern in India has seen several changes.

This chapter begins with the explanation of various concepts related to cropping pattern and then traces the cropping pattern of India, Maharashtra and Pune in broad terms. The chapter then proceeds to describe the Subject of Research after which the detailed crop profiles of three selected cash crops viz., maize, soybean and sugarcane have been presented.

1.2 CROPPING PATTERN AND CROPPING SYSTEM

A system is defined as "a set of components that are interrelated and interact among themselves". A cropping system refers to "a set of crop systems, making up the cropping activities of a farm system. Thus, cropping system comprises cropping pattern plus all components required for the production of a particular crop and the interrelationships between them and environment" (eagri.org, n.d.). Depending on the availability of water, type of climate and soil, the cropping system for a region gets established. The cropping system thus evolved provides subsistence for the farmer and his family including livestock as well as additional income for other domestic and capital expenses.

Cropping pattern is defined as "the yearly sequence and spatial arrangement of crops or of crops and fallow on a given area" (eagri.org, n.d.). Thus, a cropping pattern could refer to a combination of crops in time and space. When crops occupy different growing periods, the combination is with reference to time, and if the crops are interplanted, the combination is with reference to space. When a single crop is grown on the same farm year after year, it is termed "mono cropping", for example, tea, coffee, sugarcane etc. "Multiple cropping" is an umbrella term used to describe all kinds of "intensive cropping patterns".

Intensive Cropping

The practice of taking two, three or four crops in a year is referred to as intensive cropping. It is possible when irrigation is particularly available in plenty. Intensive cropping pattern is characterized by a low fallow ratio, higher use of inputs (capital and labour) and hence greater crop yields. Thus, cropping intensity is higher in intensive cropping system. Whereas the cropping intensity is around 140%-150% in Punjab and Tamil Nadu, it is relatively less in Rajasthan (eagri.org, n.d.). The different types of multiple cropping patterns adopted include crop intensification techniques like intercropping, relay cropping, sequential cropping, ratoon cropping etc.

The different types of multiple cropping patterns are described below:

Intercropping: This refers to a cropping pattern when two or more crops are grown simultaneously on the same field, i.e., when crop intensification takes place in both time and space dimensions. Intercrop competition happens throughout or during part of crop growth.

(a) *Mixed intercropping:* Mixed intercropping happens when two or more crops are grown simultaneously with no distinct row arrangement. It is also referred to as mixed cropping. For example, sorghum, pearl millet and cowpea are mixed and broadcasted in rain fed conditions (eagri.org, n.d.).

(b) *Row intercropping:* When two or more crops are planted simultaneously where one or more crops are planted in rows, it is referred to as row intercropping. It is also simply referred to as intercropping. For example, maize + green gram (1:1), maize + black gram (1:1), groundnut + red gram (6:1) (eagri.org, n.d.).

(c) *Strip intercropping:* Two or more crops are cultivated simultaneously in strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically in strip intercropping. For example, groundnut + red gram (6:4) strip (eagri.org, n.d.) .

(d) *Relay intercropping:* Relay intercropping happens when two or more crops are planted simultaneously during the part of the life cycle of each, that is, the second crop is planted after the first crop has matured but before it is ready for harvest. It is often simply referred to as relay cropping. For example, rice-rice-fallow-pulse (eagri.org, n.d.).

Advantages of intercropping

Intercropping enables better use of resources like light, soil nutrients and irrigation. It helps in the suppression of weeds and reduces the incidence of pests and other diseases. The farmers enjoy higher equivalent yields, that is, yield of base crop plus yield of intercrop. At the same time, intercropping protects farmers from uncertainty by increasing yield stability; the loss of income due to failure of one crop can be offset by the income from the other crop. As against mono cropping which strips the soil of its nutrients, intercropping leads to improvement of soil health and agro-eco system.

Sequential cropping: Under sequential cropping, two or more crops are grown in sequence on the same field in a farming year. Once the first crop has been harvested, the second crop is planted. Thus, crop intensification takes place only with respect to time and there is no intercrop competition. The different types of sequential cropping are as follows:

(a) Double, triple and quadruple cropping*:* Under this method, two, three and four crops, respectively are grown on the same land in a year in sequence. Examples of double cropping, triple cropping and quadruple cropping can be rice-cotton, rice-rice-pulses, and tomato-ridge gourd-Amaranthus greens-baby corn respectively (eagri.org, n.d.) .

(b) Ratoon cropping*:* Also referred to as stubble cropping, the cultivation of crop re-growth after harvest, although not necessarily for grain is called ratoon cropping. Example: banana/plantain: ratoon; sorghum: ratoon (for fodder) (eagri.org, n.d.).

Thus, intercropping and sequential farming are both techniques used for intensive farming. A region or a farm may use either or both of these techniques to maximize output while maintaining soil nutrients at optimum level (eagri.org, n.d.).

The cropping system adopted in a region largely depends on the soil and climatic conditions which determine the suitability of a crop/crops for that particular environment. However, at the micro level, a farmer's decision regarding the adoption of a cropping pattern is mostly influenced by the yield levels of the crop/crops and the returns which the farmer can hope to earn by planting those particular crops. Not only that, a host of other factors such as infrastructural facilities available to the farmer, socio economic factors as well as technological factors also play a role in determining the cropping pattern. Thus, factors like irrigation, size and type of land holding, levels of mechanization, transport and storage, household needs of food, fibre, fuel and fodder etc. shape the cropping pattern in a region (Das, 2006). In his article, Changes in Cropping Pattern: Economic Criteria, H.S. Singh has argued that the yield levels of crops cannot act as a yardstick in determining cropping pattern as proposed by S. C. Jain. Nor according to him is cropping dependent largely on physio-cultural environment and geographical factors as suggested by S.S. Bhatia. According to H.S. Singh, the importance of economic criterion in determining cropping pattern is only increasing. This has been proved by the shift in cropping pattern from food grains to cash crops in recent decades. However, he also emphasises the need to consider the physical suitability of land, climatic factors etc., rather than economic considerations alone in deciding the adoption of a cropping pattern. "In some of the lands under small millets and pulses it would be virtually impossible to grow rice, e g, in some sandy soils of the south-eastern portions of the Punjab. And, in some of the lands under small millets and pulses where rice *can* be grown today if water is made available, it should not be grown on long-run agronomic and physiographic considerations. In brief, economic motivations should not supersede non-economic considerations relevant to the planning of efficient and flexible land use pattern" (Singh, 1962, p. 954).

Sustainable Agriculture

While the cropping pattern adopted by farmers/regions are dictated by the endowment of natural factors as well as irrigation facilities, it should be borne in mind that a cropping pattern which strips the soil of its fertility and/or leads to the depletion of natural resources will prove to be a disastrous one in the long run for the region. Accordingly, experts in the field have suggested Sustainable Agricultural Systems wherein the cropping pattern adopted is not only economically viable for the farmer but is also environmentally sustainable. Sustainable agricultural systems are those farming systems that are "capable of maintaining their productivity and usefulness to society indefinitely and must be resource-conserving, socially supportive, commercially competitive, and environmentally sound" (eagri.org, n.d.).

The United States Department of Agriculture has defined Sustainable Agricultural Systems as follows:

Sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:

- satisfy human food and fibre needs;
- enhance environmental quality and the natural resource based upon which the agricultural economy depends;
- make the most efficient use of non-renewable resources and on-farm resources and
- integrate, where appropriate, natural biological cycles and controls;
- sustain the economic viability of farm operations;
- enhance the quality of life for farmers and society as a whole.

The practice of sustainable agricultural system is generally assumed to be one in which the use of inputs are reduced leading to a reduction in returns, thus requiring these systems to become extensive rather than intensive. However, replacing chemical fertilizers and pesticides with natural alternatives as well as adopting other organic practices (shifting from ploughing to zero-tillage) have been found to be successful. Thus, these systems are actually about "intensification of resources", that is, making better use of limited resources like land, water etc., rather than being extensive.

"The critical question centres on the 'type of intensification'. Intensification using natural, social and human capital assets, combined with the use of best available technologies and inputs (best genotypes and best ecological management) that minimize or eliminate harm to the environment, can be termed 'sustainable intensification' " (Pretty, 2008).

1.3 PREVALENT CROPPING SYSTEMS IN INDIA

Indian agriculture was characterized by extensive cultivation in the era following independence. However, the practice of intercropping, especially in dry land conditions, to minimise risk of total crop failure has always been adopted. Indian agriculture is characterised by multiple cropping pattern being adopted primarily due to the following two factors:

- Agriculture continues to remain rainfed over nearly 65 per cent of cropped area (around 93 million hectares) (Das, 2006, p. 33). The high-risk factor involved in cultivating a particular crop over vast areas is sought to be overcome largely by adopting intercropping in the rainfed and dryland areas.
- Indian agriculture is more of subsistence farming in nature rather than commercial farming. This is a result of small land-holding size wherein 90 per cent of the 97.15 million operational holdings are made up of marginal, small and semi-medium farmers whose land holdings vary from less than 1 hectare to 2-4 hectares. As a result, farmers resort to combinations of crop rotations over cycles of 3-4 years which enable them to provide for their household consumption (Das, 2006, p. 33-34).

Due to the above two factors, cropping systems in India are so dynamic that it is extremely difficult to enumerate in a precise manner their spread over vast areas. More than 250 cropping systems are believed to be prevalent throughout the country out of which 30 principal cropping patterns have been identified as follows: rice-wheat, rice-rice, rice-gram, rice-mustard, rice-groundnut, rice-sorghum, pearl millet-gram, pearl millet-mustard, pearl millet-sorghum, cotton-wheat, cotton-gram, cotton-sorghum, cotton-safflower, cotton-groundnut, maize-wheat, maize-gram, sugarcane-wheat, soybean-wheat, sorghum-sorghum, groundnut-wheat, sorghum-groundnut, groundnut-rice, sorghum-wheat, sorghum-gram, pigeon pea-sorghum, groundnut- groundnut, sorghum-rice, groundnut-sorghum and soybean-gram (Das, 2006, p.34)

Among the irrigated areas of the country, two distinct irrigated ecosystems have been identified. These are the Indo-Gangetic Plain region (consisting of states like Punjab, Haryana, plains of Uttar Pradesh, Bihar and plains of Jammu & Kashmir) and the coastal areas of Andhra Pradesh and Tamil Nadu (Das, 2006).

Table 1.01: Cropping Ecosystems

	Irrigated Ecosystems	**Rainfed Ecosystems**
Net Cropped Area	51 MILLION HECTARES	92.8 MILLION HECTARES
Share In Total Net Cropped Area	35 PER CENT	65 PER CENT
Share In Food Grains Production	56 PER CENT	44 PER CENT

Source: Cropping Pattern in Different Zones, p. 34, Indian Council of Agricultural Research, New Delhi, 2006

As can be seen from the above table, rain fed agricultural ecosystems cover almost twice the area of irrigated ecosystems. In other words, the share of the rain fed ecosystems is nearly two-thirds in the total net cultivated area, however, their share in food grains production is less than half of the total food grains production in the country. Given the above statistics, the burden of increasing crop productivity in order to provide for the incremental food needs over the next few years falls on the irrigated ecosystems through the adoption of new genotypes and intensive use of fertilizers.

The principal crops having sizeable percentage of area under irrigation in the country are: sugar cane (87.9%), wheat (84.3%), barley (60.8%), rapeseed and mustard (57.5%), rice (46.8%), tobacco (41.2%), cotton (33.2%), chickpea (21.9%), maize (21.8%) and groundnut (19.2%). Among the states, Punjab ranks first with 94.6 per cent cropped area under irrigation followed by Haryana (76.4%) and Uttar Pradesh (62.3%) (Das, 2006, p.34).

Changing Cropping Patterns In India

The cropping pattern in India has been predominantly structured around food grains which account for two-thirds to three-fourths of the gross cropped area since Independence. This is primarily because of the subsistence nature of Indian farming. The government has been promoting crop diversification which it considers quintessential for agricultural development. Such diversification not only will contribute towards increasing farm incomes, but is also essential to meet the increasing demand for oilseeds, fibres, sugarcane, livestock and horticultural products which is bound to follow with a rise in per capita income. The demand for food grains also grows with a rise in per capita income, but at a slower rate.

Before the green revolution, most of the food grain crops, including coarse cereals and some pulses had low yield and low value. The introduction of hybrid varieties of seeds as well as better inputs like fertilisers and irrigation during the mid-1960s dramatically improved the yield levels of food grain crops, especially wheat and rice. Since they also procured better prices, area allocation to these crops increased substantially. The green revolution also impacted the yield levels of non-food grain crops like oilseeds, fibre crops, sugarcane and horticultural crops, but after some time lag. This caused a sea change in cropping patterns over time. Between 1962-65 to 1980-83, there was not much change in the gross cropped area and share of food grains in the total value of crop output. However, within the food grains segment, there was a huge shift from coarse cereals and pulses to high yielding wheat. There was significant change in the cropping pattern during 1980-83 to 1990-93 pan-India. There was decline in absolute terms (of over 4 million hectares) in the gross cropped area under food grains. This decline was mainly due to a shift away from production of coarse cereals. The crop which gained due to this shift was primarily oil seeds whose share in gross cropped area increased by almost eight million hectares during this period. However, the decline in area from coarse cereals went to an increase in the share of oilseeds only in the central and southern parts of the country. In the north-western region, the crops which gained mainly were rice, wheat and remaining crops. (Bhalla and Singh, 1997).

The green revolution led to increased crop production mainly through substitution effect, that is, the area under a given crop increased mainly by substituting it for other crops. This was because expansion of gross cropped area for a given crop by bringing more land under cultivation had its limitations, primarily institutional limitations like irrigation. The primary motives for such substitution were relative profitability and subsistence requirements. To sum up, we can say that the success of the green revolution in increasing food grain production, primarily of paddy and wheat had been at the cost of other crops like coarse cereals, millets, pulses and in some areas cotton. Cultivation of paddy and wheat became highly profitable vis a vis other crops due to several factors including high yielding varieties of seeds, price support from the government, availability of irrigation, lower yield risks etc. This success, however, led to lop-sided cropping pattern and increasing regional disparities. The category of crops most affected has been that of coarse cereals and millets. Due to their low yield and low value as compared to superior cereals like paddy and wheat, their share in area has consistently declined. The situation has been exacerbated by the low use of fertilisers, lack of marketing infrastructure, lack of irrigation and non-development of high yielding variety seeds. However, among the coarse cereals, the production of maize has seen an upswing mainly due to its diversified uses in industry and as poultry feed/animal feed. Gram and groundnut are other dry land crops like coarse cereals which though highly valued in these areas did not receive sufficient inputs in the form of fertilizers, irrigation and price support from the government. Hence, their productivity continued to remain low. Even cash crops like sugar cane and cotton faced setbacks in some regions either due to faulty government policy or inappropriate use of irrigation (Mruthyunjaya and Pradhyuman Kumar, 1989).

This shift in cropping pattern from food grains to high value non-food grains continued in the period between 1990-93 to 2003-06, but at a much slower rate than expected. This was due to the fact that even though economic reforms were initiated in the early 1990s, the post-reform period showed a considerable decline in yield growth rates of most of the important crops across India. During this period, there was a shift from the area under coarse cereals and some other pulses. However, oilseeds, sugarcane and cotton were only benefitted marginally by this shift. The main gainers during this period were other remaining crops like fibre crops, plantation crops, cardamom, spices and remaining crops that included horticultural produce. The exceptions to this trend were the central region and the north-western region. The share of area and value of output of oilseeds and cotton registered an increase in the central region. Though this is a welcome development, this shift exposed farmers to greater risks, especially in dryland areas. These risks increased manifold when commodity price volatility following trade liberalisation is factored in. In the north-western region, the share of rice and total food grains in total area actually increased and the share of food grains in total value of output remained constant during this period. Thus, economic reforms were not successful in hastening crop diversification in this region (Bhalla and Singh, 2009).

After the setback between mid 1990s to mid 2000s, the central and state governments undertook several key initiatives to restore the agricultural sector. This led to a reversal of the decline the sector was facing and a healthy growth rate of 3.75% was witnessed for the period

2004-05 to 2012-13. Along with growth in the agricultural sector, several other measures for achieving inclusiveness, reducing regional disparities and improving food security have been taken. Even though 2009-10 was reported to be a drought year, the sector did not show negative growth even during that year. A resilience and stability not witnessed before was seen in this sector due to several factors like increasing irrigation, adoption of drought proofing technology, developing alternative crops depending on the variations in the seasons and increasing the overall production in the country. Thus, while overall food grain production increased by more than 50 million tonnes (mt) during the period 2003-05 to 2011-13; the same level of increment was witnessed with respect to cereals like rice, wheat and maize. In fact, maize production doubled during the 15 years between 1995 and 2011. Similar success was achieved in pulses production with output jumping by 25 per cent in just one year, 2010-11. Oilseed production too increased by 5.6 mt to reach 30.4 mt during 2011-13 as compared to a marginal increase of 1.6 mt for the period 1995-97. It must be noted that almost the entire increase in oilseed production was due to an increase in output of soybean which has shown miraculous growth with doubling of output in those 8 years. Other cash crops like cotton and sugarcane also showed good recovery rates with the production of cotton too doubling during this period. Sugarcane production which had declined in 1999-2000 staged a big comeback in 2006-07 with output increasing from 300 mt in the year 1999-2000 to 350 mt in 2012-13, thus creating a large surplus of sugar (Chand, 2014).

To sum up, while the post reforms period showed a negative growth rate for many crops, the trend has been reversed emphatically during the decade between 2003-04 to 2011-13 with many crops registering a sharp acceleration in their growth rates. Thus, while cotton production followed double digit growth in that period, crops like soybean, maize and gram witnessed more than 5 per cent annual growth and the output of pulses which had been stagnating for a long time also increased at a growth rate of more than 3 per cent (Chand, 2014).

This increase in agricultural production was however not caused either due to area expansion (there was no expansion in the net sown area) nor due to a significant change in the cropping patterns (the area share of horticultural crops, which are considered high-value crops, did not register any increase after 2005-06). The increase in agricultural output was almost entirely due to increased productivity of per unit land. Almost all crops like rice, wheat, maize, pigeon pea, cotton etc. registered 2-3 per cent growth rate in yields, with cotton recording highest productivity growth rate of 5.7 per cent per year. The only poor performers were groundnut, which saw a decline in its yield rate, and mustard which registered a marginal increase in its yield rate (Chand, 2014).

One of the main factors for the resurgence of the agricultural sector after 2004-05 was the increase in prices received by farmers. Such an increase was due to the hiking of Minimum Support Prices, higher procurement of food grains, rise in global prices for agricultural produce as well as increasing domestic demand for food. All this lead to the farmers using better inputs like seeds, fertilisers, technology. The growth was further bolstered by easier availability of credit and irrigation expansion. "Slowdown of agriculture growth and its recovery in response to changes in price and non-price factors clearly establish that Indian farmers respond rather strongly to various types of incentives. It also refutes to some extent the argument that the interest in farming is diminishing. We find the interest depends on profitability from farming." (Chand, 2014).

1.4 CROPPING PATTERNS IN MAHARASHTRA

Since agriculture plays an important role in the development process of developing countries but increasing agricultural production through area expansion has its limitations, diversification of agriculture has become an important method through which the objectives of growth in output, generation of employment and preservation of natural resources can be achieved. The geographical region of Maharashtra displays a remarkable variety of soils, topography, climatic conditions, irrigation and other infrastructural conditions. Agriculture continues to remain the backbone of the region's economy even though it is the richest state in the country and the second largest state both in terms of population and geographical area (3.08 lakh sq. km.) (Shinde, 2016).

Irrigation is an important input in agricultural development since it enables the farmers to adopt intensive farming techniques and also raises crop productivity. It is estimated that the productivity of land is enhanced six times when irrigation is applied to it. This becomes even more pertinent in the case of Maharashtra where vast areas of the region are dry and arid. However, agriculture in Maharashtra is primarily rain fed with around 83 per cent of the cropped area not having access to irrigation. The proportion of gross area irrigated to gross cropped area in the state is only around 18 per cent which is way below the national average of 43 per cent in 2006-07. In 18 districts, it was less than 15 per cent in 2002-03. (Kalamkar, 2011, p. 31). The normal rainfall of a majority of the districts in the state is below the state's average rainfall. Out of the 33 reported districts for the period 2001-05, 6 districts were in high rainfall group, 10 districts fell in medium rainfall group and the remaining 17 districts belonged to the low rainfall category. Most of the districts from Pune, Latur and Amravati divisions fell under low rainfall group (Kalamkar, 2011, p. 24-25). Due to these wide variations in rainfall across regions and years, the process of agricultural development in Maharashtra is highly constrained. All this has discouraged the farmers in many regions in the state from adopting multiple cropping pattern. Added to this drawback is the issue of the type of land holdings in the state. As per the Ninth Agricultural Census (2010-11), number of operational holdings and area of operational holdings was 1.37 crore and 1.98 crore hectares (ha) as against 0.50 crore and 2.12 crore ha respectively as per the First Agricultural Census (1970-71). Over this period, the average size of holding decreased from 4.28 ha to 1.44 ha (Economic Survey of Maharashtra 2017-18, p.88). The average size of holding in 2000-01 census was 1.66 ha (Kalamkar, 2011, p.38). Out of this 1.37 crore number of holdings, nearly half of the holdings, around 67 lakhs are that of the marginal farmers who own less than one hectare of land. Small farmers who own between 1 and 2 hectares of land form another major chunk of 40 lakhs of farmers. Around 25 lakh farmers belong to the semi medium category with land holdings between 2 and 5 hectares. Only around 4 lakh farmers belong to the medium category with holdings between 5 and 10 hectares, while a measly 68,000 large farmers hold more than 10 hectares of land (Economic Survey of Maharashtra 2017-18, p.89). Thus, around 96 percent of the farmers in Maharashtra are small, marginal and semi-medium farmers, as compared to the national average of 90 percent.

Following the all-India trend, the cropping pattern in Maharashtra has also changed considerably over the last few decades. The pre-green revolution was characterized by area expansion in the cultivation of cereals and pulses; yet the production of almost all the crops fell due to decrease in productivity which could not be substituted by an increase in area under cultivation. This trend was reversed during the green revolution (1968-69 to 1979-80) when productivity of food grains increased significantly which resulted in the increase in food grains production at almost 5 per cent per annum even though area under cultivation increased only marginally by around 0.88 per cent. The area under groundnut also reduced drastically. In the post green revolution period (1980-81 to 1989-90), the production of almost all crops increased significantly due to increase in the productivity. The only exceptions were wheat, rice and sugarcane. While the production of wheat and sugarcane fell due to a decrease in area, the production of rice declined due to a decline in productivity. However, production of pulses and oilseeds saw a significant increase (Kalamkar, 2011, p.175).

During the post reform period (1990-2005), the productivity of almost all crops declined. This combined with a decrease in area led to fall in production of all major crops, including cereals, during this period. This is particularly true for jowar and bajra which have been traditionally cultivated in the state. However, maize was a big gainer in the state with area, production and productivity picking up steadily. The regions where maize is cultivated mainly are Nashik, Pune, Aurangabad and Kolhapur divisions and Buldhana district of Amravati division. The only regions to show negative productivity growth in maize were Ahmednagar and Solapur districts. Ragi and wheat showed mixed trends in the state. While the productivity of ragi had declined in Pune and Thane, it was stagnant in most of the districts or had increased in some districts while its production declined in almost all of the districts. In the case of wheat, the major wheat growing districts of Ahmednagar, Pune and Nagpur witnessed a decline in area under wheat. The performance of pulses was mixed during the post reform period. While tur which is a major crop among pulses performed well in terms of area, production and productivity, moong showed a decline in all the three respects in almost all the districts in the state. The production of udid was enhanced in terms of area, production and productivity only in Buldhana district while its production and productivity had gone down in other major districts like Latur and Jalgaon. Again, the productivity of gram had decelerated in almost all the major districts in the state, though it recorded an increase in area and production. Among oilseeds, soybean was fast gaining tract with increase in area particularly in rain fed regions where it was replacing cotton and cereals. This was due to its high yield and profitability. It was also the star performer amongst all oilseeds with the area, production and productivity of groundnut, sunflower and safflower declining during this period. With respect to the two important cash crops of Maharashtra, sugarcane and cotton, while the area and production of cotton showed a decline in almost all the major cotton growing districts, sugarcane which was cultivated continuously for nearly four decades, especially in Western Maharashtra (accounting for 62 per cent of the area under sugarcane in the state in 2004-05) also witnessed a decline in area and production (Kannan, 2011, p.194).

To sum up, the area under cereals declined from around 55 per cent before the green revolution to around 40 per cent in 2004-05, mainly because of reduction in jowar cultivation. Even though the yield rate of pulses was low, the area under pulses increased from 12.6 per cent to

15.26 per cent for the same period as above, while in the case of oilseeds, there was substantial gains in the area cultivated since 1990s primarily due to soybean. Cash crops like cotton and sugarcane actually showed declining share in areas. While area under cotton cultivation declined from 3.2 m ha to 2.8 m ha, the share of sugarcane area in GCA also declined from 3 per cent to 1.98 per cent between 2000-01 and 2004-05. (Kalamkar, 2011, p.173-174).

1.5 PUNE'S CROPPING PATTERN

Pune's cropping pattern closely follows the trends in the cropping pattern of Maharashtra. Before the green revolution, jowar and bajra were traditionally cultivated due to the arid climatic conditions in the district. With irrigation becoming available in ample measure after the green revolution, sugarcane cultivation was taken up as one of the most important cash crops in the district as opposed to cotton which found favour with farmers in Vidarbha. The period from 1970s to 1990s saw a huge shift in the cropping pattern from traditionally grown coarse cereals to high value cereals like rice and wheat along with pulses and oilseeds. Post 2000, high value cash crops like maize, soybean, sugarcane and horticultural crops have dominated the scene in Pune's agricultural sector. Being the largest cultivator of sugarcane (a very important cash crop) in the state, Pune wields a lot of political as well as economic clout. Agriculture plays a very important role in the district economy with an income generation of nearly Rs.9000 crores. Yet, Pune ranks second to Nashik (which though far behind Pune in other parameters like GVA, irrigated area etc.,) generates twice the agricultural income as Pune. As such, the researcher felt the need to undertake a detailed study of Pune's cropping pattern with reference to its economic efficiency.

1.6 SUBJECT OF RESEARCH

This study intends to analyse the trends in the production and productivity of three selected cash crops viz., maize, soybean, and sugarcane in Pune district for the period 1991-92 to 2017-18. The three crops have been selected for the study since they are the prominent cash crops grown in the region. A comparison between cash crops and food crops in terms of profitability would be inconsistent conceptually. Moreover, while horticultural crops are also emerging as important crops in terms of economic value in Pune district, a comparison with cash crops like maize, soybean or sugarcane becomes difficult since horticultural crops cover a wide range of vegetables, fruits and flowers. As such, a one to one comparison would become impossible. Moreover, horticultural crops do not have the kind of industrial applications, usage in animal feed or potential in food processing industry like maize and soybean. The three cash crops maize, soybean and sugarcane hence provide an appropriate basis for a comparative study. Further, while conducting an extensive literature survey, the researcher found that there has been no study with exclusive reference to the influence of prices obtained by farmers on Pune's cropping pattern. Since the farmer undertakes farming activities as a source of livelihood, the researcher felt the need for analysing cropping pattern only with regard to prices procured by farmers. This fact becomes even more relevant nowadays as agriculture is getting more and more commercialized.

The sustainability quotient of the cropping pattern is to be studied as a secondary issue in this research work. Water being a scarce resource, though the demand for water will decrease as more and more agricultural land is converted to non-agricultural land in Pune, the decrease will certainly be offset by an increase in demand for water for urban habitations and industrial purposes. It will also lead to increased pressure on land since more food will have to be produced in lesser area. Increasing agricultural productivity is the only way to go in order to tackle both ends of the problem and adopting suitable cropping pattern is one of the ways for increasing agricultural productivity. With this end in view, the cropping pattern of Pune district was studied with reference to trends in the production and productivity of the three important cash crops viz., maize, soybean and sugarcane. Thus, an attempt has been made to ascertain the economic feasibility and environmental sustainability of the current cropping pattern and suggest an alternative cropping pattern.

1.7 CROP PROFILES

1.7.1 MAIZE

Maize is one of the most important cereal crops in the world. Being used for diverse purposes (as food for humans and feed for animals), maize has gained popularity both as a food crop and cash crop among cultivators. While whole green cobs are roasted and savoured, boiled corn and popcorn are also widely popular. Maize is fractionated into food and industrial ingredients using dry or wet milling process. The major component of the kernel of maize is its starch. The starch from maize is used either in its original form or after processing, in foods and industrial products. The starch is also used as food sweetness (by converting into glucose) and further, the glucose on fermentation can be converted in to ethanol (for fuel or beverages or into many other chemicals).

Origin

Central America is generally considered the primary centre of origin of maize. The discovery of fossil maize pollen with other archaeological evidence in Mexico indicates Mexico to be the native home of maize. The studies indicate that maize was a significant crop in Mexico 5,000 years ago and perhaps earlier. American Indians grew and selectively improved maize from 3400 B.C. to 1500 A.D. The maize plant was unknown in the old world before 1492, by the time Columbus arrived in America. In Europe maize was first introduced in Spain sometime after Columbus returned from his second voyage. Later on, it spread from Spain to southern France and Italy. Its introduction into India probably occurred about the beginning of the seventeenth century, during the early days of the East India Company. Maize is one of the most important cereal crops in the world agricultural economy both as food for man and feed for animals. It is a miracle crop with a very high yield potential, and hence it is called 'queen of cereals'. Maize is primarily used for feed (64%) followed by human food (16%), industrial starch and beverage (19%) and seed (1%). Thus, Maize has attained an important position as industrial crop because 83% of its produce is used in starch and feed industries. Maize consists of three main parts – the full or bran coat with high fibre content, germ rich in oil and starchy endosperm. The normal maize grain under Indian conditions on an average, contains 14.9% moisture, 9 to 11% protein, 3.6% fat, 2.7% fibre, 66.2% other carbohydrates and 1.5% minerals. Maize kernel protein is made up of five different fractions. The percentage of different fractions to total nitrogen in maize kernel is albumin 7%, globulin 5%, non-protein nitrogen 6%, prolamine 52% and glutelin 25% and the left over 5% is residual nitrogen (Status Paper on Coarse Cereals, pp. 115-116).

Global maize production

The total world maize production in 2016-17 stood at around 1040 million metric tonnes. The United States of America (USA) USA is the largest producer of maize accounting for 38% followed by China which contributes 23% of the total maize production in the world. The production of maize in the USA has increased due to increase in plantings while in China, drought and other adverse climatic conditions have caused a decline in maize production. Other major contributors include Brazil at 9% and the European Union (EU) at 7%. The contribution of India to total world maize production is very low at 2%. It can be seen from the Table 1.02 that yield has shown significant spurt in US and Brazil in last 4 years with CAGR of 5% and 4% respectively. During this time period yield has remained stagnant in India (Maize Vision 2022, 2018, pp32).

Table 1.02: Comparative analysis of Yield (MT/ha) and Production (Mn MT) of Maize in leading nations of the world

Country	% in world production	Yield/Prod	2013-14	2014-15	2015-16	2016-17	CAGR%
US	38	Yield Production	9.93 351	10.73 361	10.57 345	10.96 384	5.06 4.6
China	23	Yield Production	6.02 218	5.81 215	5.89 224	5.97 219	-0.42 0.23
Brazil	9	Yield Production	5.06 80	5.4 85	4.19 67	5.49 96	4.16 9.54
India	2	Yield Production	2.68 24	2.63 24	2.56 20.5	2.54 26	-3 4
World		Yield Production	**5.5** **993**	**5.67** **1018**	**5.44** **968**	**5.82** **1040**	**2.87** **2.34**

Source: Maize Vision 2022, FICCI and PwC, India Maize Summit, 5th Edition. Pp-33.

Global Consumption

The USA and China are also the leading consumers of maize accounting for 32% and 23% of total world maize consumption while the EU and Brazil account for 6% and 7% of the world maize consumption respectively. India's consumption of maize is also a very low figure of 2% of the total world maize consumption. With the feed industry growing at a CAGR of 6 - 7% globally and at 9% in India, maize cultivation presents a huge opportunity for farmers (Maize Vision 2022, 2018, pp37).

World Maize Trade

World maize trade is characterized by a high level of concentration in exports (since there are a very few countries with exportable surplus) while there is a very low concentration in terms of imports (that is, there are a very large number of countries which rely on imports for their animal feed purpose). The lion's share of total maize exports in the world (around 40%) comes from the United States. The other major exporters of maize include Argentina, Brazil, the Republic of South Africa and Ukraine. The international trade in maize accounts only for 10 percent of the world maize production, but it constitutes around one-third of the total cereal trade in the world. On the other hand, most countries in Asia and Africa are net maize importers with Japan being the world's leading importer for 2016-17. The fast expansion of the livestock industry, along with decline in trade barriers and rising incomes have contributed to the fast growth in Asian imports (Maize Vision 2022, 2018, pp 40).

Production outlook in India

Maize has become the third most important food crop in India after rice and wheat over the last two decades. This has been mainly due to the expansion of area in non-traditional regions like Andhra Pradesh, Karnataka and Maharashtra. Traditionally maize was cultivated as a kharif crop, however, in recent times the rabi maize has attained significance especially in the southern and eastern parts of India. In 2011-12, maize was grown in 8.7 million hectares (M ha) occupying about 4 per cent of the gross cropped area (GCA) with a record production of 21.76 million tonnes (Mt) in India. This included 16.49 Mt in kharif season and 5.27 Mt in rabi season. A comparative picture of average annual growth rates of area, production and yield of different crops for two previous Five Year Plan (FYP) periods, viz. 10th FYP (2002-03 to 2006-07) and 11th FYP (2007-08 to 2011-12) shows that there is clear evidence that maize is the only food crop for which area and production have consistently increased with impressive growth during both the plan periods. A continuous growth in maize production has also been observed due to the adoption of single cross hybrids and expansion of area. Yield levels of maize have also shown an increasing trend in the last two decades due to the adoption of *Rabi* (winter) and spring maize and introduction of hybrid (including single cross hybrid) maize. These hybrids are being widely adopted by the farmers which has resulted in a significant increase in maize yield with unprecedented rate of enhancement, touching 10 t/ha. This yield is 3-4 times higher than that witnessed during the first plan period. (Kumar et al, 2013, pp 6-7). Maize production in the country took a hit in 2015-16 due to two continuous years of below normal monsoon rains, followed by drought. (Maize Vision 2022, 2018, pp. 34)

State-wise Maize production

Maize is cultivated in almost all types of agroecological regions in India. Since maize cultivation has shifted to non-traditional states in the south and east, Andhra Pradesh and Karnataka have become major maize-producing states in recent times as against Bihar, Uttar

Pradesh and Madhya Pradesh which were the prominent maize producing states during the 1990s. Nearly 75% of the area under maize cultivation as well as production of the crop can be attributed to hardly 7-8 states. Thus, nearly half of the total maize area under cultivation in the country is in the four states of Karnataka, Rajasthan, Andhra Pradesh and Madhya Pradesh while nearly two-thirds of the total maize production in the country comes from the five states, namely, Karnataka, Andhra Pradesh, Maharashtra, Rajasthan and Bihar. Even though Rajasthan and Madhya Pradesh have large shares in the total area under maize cultivation, but their share in total maize production is low (Maize Vision 2022, 2018, pp 34). According to the maize production data for the year 2011-12, the states with more than 1 per cent of maize area in the country can be categorized as:-

High maize yield states (Maize grain yield:>4 t/ha): Andhra Pradesh (highest yield of 4.55 t/ha) and Tamil Nadu constituting about 13.0 per cent of total maize area in the country

Medium maize yield states (Maize grain yield: 2-4 t/ha): Bihar, Himachal Pradesh, Karnataka, Maharashtra, Odisha, Punjab and West Bengal constituting about 40.2 per cent oftotal maize area in the country

Low maize yield states (Maize grain yield : <2 t/ha): Chhattisgarh, Gujarat, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Rajasthan and Uttar Pradesh representing 43.8 per cent of total maize area in the country.

(Kumar et al, 2013, pp.8)

Only five states in India viz. Andhra Pradesh, Karnataka, Punjab, Tamil Nadu and West Bengal, had maize yield equal to/ more than 4 t/ha. The states that had yield levels between 1-2 t/ha were Gujarat, Madhya Pradesh, Odisha, Rajasthan, Uttar Pradesh, Jharkhand and the North-Eastern states. The reason behind such a low yield is that in these states maize is generally cultivated under rainfed conditions as a food crop and traditional or composite varieties are used for cultivation (which have very low yields) for this purpose. The report by Kumar et al also found that yield levels in around 143 districts in the country was above the national average of 2.07 t/ha. Although, Bihar comes under moderate / medium yield range in average terms, but the state has witnessed significant growth in terms of production and acreage expansion in last decade (Kumar et al, 2013, pp. 10).

Consumption outlook in India

Only one third of the maize produced in India is used for food; nearly two third of the maize production is used for feed and other industrial purposes. With the feed industry growing at a CAGR of 6-7% (at the global level) and at around 9% (at the national level), there is going to

be no dearth of demand for maize, at least in the foreseeable future. With the largest global livestock population, India has always remained a feed starved country. Besides, the Indian poultry industry i.e. eggs and poultry meat sector, is growing at a CAGR of around 6% and 9% respectively. Keeping these factors in view, maize will continue to remain an important crop for food, feed and fodder purposes. While the total consumption of maize has increased at a CAGR of 11% over the period of 5 years (from 2007-08 to 2011-12), feed consumption has increased at a CAGR of 20% with significant demand from poultry industry, whereas food, seed and industrial (FSI) segment has increased at only 2% CAGR. As already mentioned, feed accounts for about 60% of the maize consumption in India. The most important use and demand driver of maize is poultry feed which accounts 47% of total maize consumption. Livestock feed accounts for 13%. The food consumption accounts for 20% of Maize consumption, with direct consumption being 13% and that in form of processed food being 7%. In the industrial use category accounting for 20% of the consumption, 14% of the consumption takes the form of starch while the remaining 6% is taken up by exports and other industrial uses.
(Maize Vision 2022, 2018, pp. 38)

Trade outlook for India

With bumper harvests of maize crop at the global level keeping international prices depressed, Indian maize is uncompetitive in the global market. But, the domestic prices have remained firm on strong demand, rising MSPs, and tariff and non-tariff barriers to import. Traditionally, India has been a net importer of maize. It is only recently with the adoption of hybrids by states like Karnataka, Andhra Pradesh, Bihar and Maharashtra as well as the introduction of rabi maize that the recent decades have seen a phenomenal growth in the area and production of maize. Currently, there are no restrictions on exports of corn, while imports are allowed subject to phyto-sanitary conditions specified in the Plant Quarantine (Regulation of Imports into India) Order 2003. There is zero duty on maize imports under a tariff rate quota (TRQ) of 500,000 tonnes, while imports of outside the TRQ are subject to a 50 per cent import duty. As a result, exports of maize (especially to South Asian and Gulf countries) rose to 4.27 Mt in 2012 (Kumar et al, 2013, pp 83). South-East Asian countries like Indonesia, Vietnam, Malaysia, Taiwan, etc. form the bulk from where import demand comes (around 85-9-%) while the Middle-East countries and Bangladesh, Nepal, Bhutan, etc. constitute the remaining 10-15% of import demand for India. India enjoys both price and freight advantage in such a huge global maize market and particularly with these countries due to its geographical proximity. (Kumar et al, 2013, pp. 84-85). However, after four consecutive years of bumper exports, Indian Maize exports have slowed down significantly since FY 2015- 16 on uncompetitive prices and two consecutive drought years. (Maize Vision 2022, 2018, pp.40).

Assessment of supply demand situation of Maize clearly reveals that India is one of the serious players among maize producing nations in terms of production, consumption and trade

Maize Prices

Domestic wholesale prices of maize were lower than the international prices from the first quarter in 2012 to the third quarter in 2013 but higher than international prices from the fourth quarter 2013 onwards. Wholesale price of maize increased continuously from 2015 to third quarter of 2016 with peak price of Rs. 1546 per quintal in third quarter 2016. However, price declined to Rs.1468 per quintal in the fourth quarter of 2016 due to increased kharif production (20 percent) in 2016-17 mainly attributed to higher area (12 percent) under cultivation. Currently, Indian maize is not export competitive. The Minimum Selling Price (MSP) of maize is lower than the domestic prices but it is much higher than international prices. (CACP, 2017-18, pp 23 and 65).

Future Trends

Global maize production is expected to grow by 161 Mt to 1.2 bln t over the next decade, with the largest increases in China (31 Mt), followed by Brazil (24 Mt), the United States (22 Mt), the European Union (11 Mt) and Argentina (10 Mt). While maize is the second important crop in Brazil (following soybeans), the growth in the production of maize in the United States is projected to be at 1% p.a., much lower than the figure of 2.4% for the previous decade. This expected decline in production is attributed to declining domestic demand, especially for ethanol, as well as increase in competition (exports) in the global markets. Slow production growth in the United States will be supported by higher yields as planted area is expected to decline with pressure from higher soybean area and slightly higher wheat area. On the other hand, the removal of export taxes in 2016 in Argentina is expected to propel exports in Argentina. With feed demand driving maize production, the bulk of the increase is expected to come from yellow maize. On the other hand, in Sub-Saharan Africa the total maize output is expected to rise by 24 Mt and white maize which is a major staple crop in this region is expected to contributed the largest share to this increase. Even though area under white maize is expected to decline and give way to yellow maize and soybeans, the increase in yield levels of white maize (projected to rise by more than 1%) are expected to compensate and thus contribute to its increase in its production. At the same time, maize production is projected to rise by around 3 Mt in the Russian Federation in an attempt to provide domestic feed for their growing meat and dairy industries. Although China will contribute the most to increases in global maize output, production in China is projected to grow much slower (1.3% p.a.) than over the previous decade (3.7% p.a.), due to policy change in China in 2016. Under the new policy price supports were reduced and replaced with market-oriented purchasing combined with direct subsidies for farmers so that stock piling was reduced. In spite of this change in policy, area under maize is expected to increase (0.3% p.a.) as demand for feed rises at 1.9% p.a. over the next decade. Thus, as consumption growth outstrips production growth it is expected lead to the release of maize stock piles. As a result, China's stocks are expected to decline by around 30 Mt over the next decade. Since China held about 70% of global stocks during 2015-2017, as production slows and China's maize stocks are released, the global stocks-to-use ratio will decline from 24% in the base period to 21% in 2027 (OECD/FAO, 2018, pp.114-115).

Global maize consumption is projected to increase by a lower rate of 1.3% p.a. over the next decade, as compared to 3.3% p.a. in the previous decade. This rise is attributable to the rise in demand for feed (which has the largest share in total maize consumption) and which is expected to increase from 56% to 58% in 2027. Nearly 75% of this demand for feed consumption comes from developing countries due to the rapid expansion of livestock and poultry sectors in these countries. Thus, feed demand is expected to rise 120 Mt to 699 Mt, and major countries that account for the increase are China (+32 Mt), the United States (+20 Mt), Argentina (+5 Mt), Indonesia (+5 Mt) and Viet Nam (+5 Mt). Again, the demand for food consumption of maize is also expected to increase mainly in developing countries where expanding populations make maize an important part of their diets. As already mentioned in Sub-Saharan Africa white maize forms nearly 25% of the total caloric intake and as such forms an important part of the staple diet in the region. The demand for food consumption in the African countries is expected to grow at a strong 3% p.a. The use of maize in the production of biofuel almost doubled in the previous decade (2007-2017). However, due to changes in the biofuel policies and slow growth in the international ethanol market, this growth is expected to be more restrained in the coming decade (OECD/FAO, 2018, pp.116-117).

World maize exports are projected to rise by 19 Mt to 157 Mt over the next decade. The export share of the top five exporters – the United States, Brazil, Ukraine, Argentina, and the Russian Federation – accounts for nearly 90% of total trade through the projection period. While the export share of the US is expected to decline from 38% to 34%, Brazil is expected to pump up its exports from 19% to 23% in the next ten years. Similarly, Argentinian exports are expected to get buoyed by removal of taxes. It is also expected that production will outstrip consumption in Ukraine and Russian Federation thus making large surpluses available for exports. As far as the Sub-Saharan African region and South Africa is considered, it will be a major supplier of white maize for food consumption in the region. Finally, with regard to maize imports, Japan, the European Union, Mexico, Korea, and Egypt are the major importers accounting for nearly 45% of the total world imports and this share is projected to decline to 41% by 2027. This decline in European Union is expected to be cause by increased domestic production to support the rise in feed demand while in Japan a declining population is expected to cause a decline in the food consumption of maize. Vietnam and Malaysia are expected to be the leading importers of maize in the coming decade fuelled by a vibrant growth in the livestock sector in these countries and thus facing a higher demand for feed consumption of maize (OECD/FAO, 2018, pp.120).

Significance of Maize cultivation in Maharashtra

Maize is a sturdy crop which can be grown in different agro climatic conditions. This along with the fact that indiscriminate cultivation of paddy has depleted the water table in the rice growing regions of India has led to the increase in area and production of maize in the country. Maharashtra is the third largest producer of maize in India with a 12% share in the total maize production in the country. While large areas of Maharashtra are highly suitable for maize cultivation, this spike in maize cultivation has taken place only over the last few years since the highest growth in MSP was seen in maize since 2011 at 34%. While demand for maize continues to increase given its vast applications for food, feed and industrial purposes, by 2025, the total global demand for maize is expected to surpass that for wheat and rice. However, this increase in production cannot be met by increase in area alone and will have to be supplemented by improvements in productivity so that the productivity level of maize in Maharashtra can match those of other states. The low yield levels of maize can be attributed to following factors:

(a) Maize cultivation is undertaken mainly by marginal farmers under rainfed conditions with inadequate access to irrigation

(b) Single cross hybrid (SCH) technology which has led to high productivity of maize in US and China is yet to be adopted in a big way (in India only 25% of area is under SCH in maize).

(c) Drawbacks in the production and distribution of good quality seeds

(d) Small size of farm holding and lack of resources amongst farmers.

The most important aspect for increasing productivity is the provision of irrigation. Lack of water supply during crucial stages of growth, especially from flowering to grain filling stage, can seriously dent the yield levels. Hence, agronomic management of maize under rainfed conditions/restricted irrigation becomes essential. It has been found in the USA that the yield levels of maize grown under irrigated conditions is 30% higher than maize cultivated under non-irrigated conditions. Maharashtra being drought prone and facing low rainfall conditions, effective irrigation and agronomic management strategies are of utmost significance. It must also be mentioned that there is no dearth of supply of seeds in both the kharif and rabi seasons in Maharashtra. However, the right kind of hybrids suitable for the region and soil conditions (irrigated vis a vis rainfed conditions) need to be developed. This will lead to enhancement of yield levels of maize in the state (Evaluation of PPIAD project on maize, 2013).

1.7.2 SOYBEAN

Soybean is fast becoming a prominent export product yielding huge economic gains to the cultivators. Countries with surplus soybean production find it an invaluable source of foreign currency. In soybean growing regions of Asia, sales from soybean constitute 30% to 60% of the average farm incomes which is then channeled into the purchase of inputs for the next crop like rice or other cereals. Thus, soybean is found to be essential to the sustainability of cereal based cropping systems in the world. With the introduction of soybean, there has been a shift in the cropping systems in several countries. The result of such a change is the rise in the cropping intensity and thereby increase in the per unit profitability from the land.

Origin

Soybean is historically thought to have originated as a food crop between 1700 – 1100 B.C. in North-eastern China. Over the next fifteen hundred years soybeans spread over the entire Asian and east Asian region including Burma, India, Indonesia, Japan, Korea, Malaysia etc. In the West, soybean was first found to have been used in the late 18th century. However, the primary use of soybean was restricted to vegetable oil and manufacturing of processed food products. In the beginning of the 20th century new uses for soybean were discovered for livestock feed thus spawning the growth of the soybean processing industry, and its uses as protein and oil in today's times. Asia continued to be the major producer of soybean in the first half of the 20th century. Post 1970, the US and Latin America emerged as the major soybean producing regions of the world with the former supplying nearly two-thirds of the world's soybean requirements.

Global Scenario

As per USDA, the global production of soybean was 305.3 million tonnes during TE2015-16, out of which about 41 percent was traded. Global production of soybean has declined from 319.8 million tonnes in 2014-15 to 313.5 million tonnes in 2015-16. The following table shows the figures for production and trade in soybean, soybean oil and soybean meal.

Table 1.03: World statistics on soybean for TE 2015-16

Country	Soybean			Soybean Oil			Soybean Meal		
(% share)	Production	Imports	Exports	Production	Imports	Exports	Production	Imports	Exports
USA	33.3%		39.7%	19.7%			19.2%		17.4%
EU		11.4%						31.6%	
Argentina	18.7%			15.6%		46.1%	14.9%		43.9%
Brazil	30.6%		40.9%	15.4%		13.7%	14.7%		22.9%
China		62.6%		27.5%	8.8%		28.9%		
India	**2.8%**			**2.7%**	28.7%		**2.9%**		
Vietnam and Indonesia								7.0% and 6.7%	

Source: CACP 2017

USA is the largest producer of soybean with a share of 33.3 percent, followed by Brazil (30.6 percent) and Argentina (18.7 percent). India's share in global production of soybean is 2.8 percent. Brazil and USA contribute 80 percent of world exports, with a share of 40.9 percent and 39.7 percent, respectively. China and EU account for about three-fourth of total world imports of soybean, with a share of 62.6 percent and 11.4 percent, respectively. The global production of soybean oil in TE 2015-16 was 48.8 million tonnes, out of which 22 percent was traded. China is the largest producer with a share of 27.5 percent, followed by USA (19.7 percent), Argentina (15.6 percent) and Brazil (15.4 percent). These top four producers account for about 80 percent of total world production of soybean oil. India's share in global production of soybean oil is 2.7 percent. Argentina and Brazil account for nearly 60 percent of total world exports, with a share of 46.1 percent and 13.7 percent, respectively. India is the largest importer, with a share of 28.7 percent followed by China (8.8 percent). India's imports of soybean oil have increased from about 1.1 million tonnes in 2010-11 to 3.96 million tonnes in 2015-16. The global production of soybean meal was 205.2 million tonnes in TE2015-16, out of which 31 percent was traded. As in case of soybean oil, China is the largest producer of soybean meal with a share of 28.9 percent, followed by USA (19.2 percent), Argentina (14.9 percent) and Brazil (14.7 percent). India's share in global production of soybean meal is 2.9 percent. Argentina, Brazil and USA export nearly 85 percent of total world exports, with a share of 43.9 percent, 22.9 percent and 17.4 percent, respectively. EU is the largest importer of soybean meal with a share of 31.6 percent, followed by Vietnam (7.0 percent) and Indonesia (6.7 percent). India exports small quantities of soybean. However, the country imports soybean oil to meet domestic demand. Imports of soybean oil have fluctuated between 7 lakh tonnes in 2008-09 and 39.6 lakh tonnes in 2015-16. Imports of soybean oil have significantly increased in 2014-15 and 2015-16 due to decline in domestic production and also decline in international prices of soybean oil during this period. Domestic wholesale prices of soybean have been higher than international prices during the period 2012 to 2016, while MSP has been lower than domestic and international prices from 2012 to 2015 (Q1) after which it was above international prices till 2016 (Q3) before rising again. The MSP of soybean, which was lower than world prices, is currently higher than international prices. Domestic wholesale prices of soybean oil have been continuously higher than international prices but the gap has widened after 2013, thereby increasing imports. However, there is a broad consistency in the trend of domestic and international prices (CACP, 2017).

Overview of soybean in India

With almost stagnant production and low productivity of oilseeds, India's dependence on import to meet edible oil requirement has reached alarming proportions. Thus, imports of edible oils rose by 4 million tonnes (from 11.0 million tonnes in 2012-13 to 15.6 million tonnes) out of which the share of soft oils increased by 22 percent (from 20 percent in 2012-13 to 42 percent in 2015-16). During the last five years, the imports of soybean, rapeseed and sunflower oils increased remarkably. Soybean oil imports rose by nearly 3 million tonnes (from about one million tonnes in 2012-13 to about 4.2 million tonnes in 2015-16) and rapeseed oil imports increased by nearly 3.5 lakh tonnes (from about 13000 tonnes to nearly 3.8 lakh tonnes). This rise in imports of soft oils have an adverse effect on domestic producers. While the scope for expanding area under oilseeds production is restricted, increasing production through increased productivity is the only viable solution. Such an increase in production levels of groundnut due to improved productivity was witnessed during the past two and a half decades even though there was a negative growth rate in area under groundnut cultivation in Andhra Pradesh and Gujarat where groundnut was replaced by cotton. But average yield levels of kharif oilseeds in India at 12.63 quintal per hectare is very much below the world average. This is not only due to climate change (scanty/excessive rainfall), but also due to lack of irrigation facilities and non-availability of quality seeds. Soybean has seen a negative growth rate of -2.87 percent in production in the current decade which is disheartening after a phenomenal growth rate of 9.85 percent and 9.39 percent in the 1990s and 2000s. Soybean yield levels also have followed the trend by showing negative growth rate of -4.82 percent in the 2010s. Other oilseeds like sunflower and nigerseed have declined both in terms of area under cultivation as well as production during the period between 1991-92 to 2016-17, while sesamum registered an increase in production due to improved productivity even though area under sesamum declined in 2010s vis a vis the 2000s. All-India productivity CAGR during the period from 2001-02 to 2016-17 for soybean was 0.7%. Between 2001-02 to 2010-11 the states showing greater than national average productivity figures for soybean were Madhya Pradesh (5.3%), Chattisgarh (5.0%), and Rajasthan (4.1%) while the states showing lower than national average productivity figures for soybean were Gujarat (-0.3%), and Maharashtra (-1.9%). The corresponding figures for the period 2011-12 to 2016-17 are available only for the states showing negative productivity figures for soybean. This includes almost all the soybean producing states. Hence, it can be said that the productivity for soybean was negative at an all-India level. These statistics read as follows: Madhya Pradesh (-0.5%), Gujarat (-4.5%), Chattisgarh (-7.6%), Rajasthan (-7.6%), and Maharashtra (-10.5%). It can be seen that in spite of being the second largest producer of soybean after Madhya Pradesh, Maharashtra has seen the highest fall in productivity growth rates in the entire country for soybean (CACP 2017-18, Page 47).

Yield gap in oilseeds is also large and ranges from about 5 percent to over 200 percent. In case of groundnut, yield gaps are wide in Andhra Pradesh, Karnataka and Maharashtra, while in case of soybean and sunflower yield gaps are high for almost all major producing states. Therefore, production of kharif oilseeds can be increased by about 4 million tonnes even with the existing technologies if gap between state average and realized farm yields can be bridged. If state average yields can be further improved and reach a level of potential yield, about 8 million tonnes of additional oilseeds, particularly soybean can be produced. Therefore, efforts are needed to improve availability of quality seeds along with other inputs and services like extension and credit. Low seed replacement rates and lack of even protective irrigation in pulses and oilseeds are other reasons for low productivity (CACP, 2017)

Contextualizing Maharashtra

Groundnut was the major oilseed crop grown in Maharashtra till the mid 1980s which has since then given way to the more non-conventional soybean. The farmers in the north east region of Maharashtra took to soybean cultivation in larger numbers especially since that region's climatic conditions were particularly favorable for the crop. Since soybean crop can be harvested within a very short duration of 3 to 3.5 months, it enables farmers to take 2-3 crops and thus augment their earnings from their land. This is not possible in the case of another **kharif cash crop** like cotton. Moreover, harvesting operation is easier in case of soybean since it is a one-time harvest crop. Thus, ease in cultivation, increased profitability as well as the enhancement in soil fertility caused by soybean cultivation has resulted in the farmers taking to this crop favourably. As a result, soybean has not only replaced other kharif oilseeds but also other kharif food crops like jowar and rice. Currently, soybean cultivation is mainly found in Vidarbha and Marathwada which lie in the eastern part of the state and these contribute to 80 percent of the soybean production in the state. While the highest area under soybean is to be found in Vidarbha region in Nagpur district, the yield levels of soybean are highest for Kolhapur region which is situated in the western part of Maharashtra and is blessed with large scale irrigation facilities (Kajale and Shroff, 2013).

Even though Vidarbha has a very rich resource base and contributes around 15.6 percent of Maharashtra's GDP, the region has not achieved a high level of development primarily due to the plight of farmers. Accordingly, the government of Maharashtra through its two flagship programmes (a) public-private partnership for integrated agriculture development (PPPIAD programme) and (b) CAIM (Convergence of Agriculture Intervention Management) aimed at assisting the farmers in the Vidarbha region through capacity building modules. Through the PPIAD programme, the government along with Archer Daniels Midland Company (ADM), a major processor of Soybean in Vidarbha, aimed at improving the productivity of crops as also assisting the farmers with agri input, resource conservation, better extension services and market linkages. This was hoped to improve the income of small and marginal farmers growing soybean. Another region which has reaped the benefits of soybean cultivation in the last fifteen years is Latur district in Marathwada region of Maharashtra after ADM entered the region and introduced agro technologies across the soybean chain. Since farmers in India are small and scattered, the challenge of running extension programs and disseminating new technologies to them is immense. ADM has successfully handled this situation and over the last 8-9 years has helped small and marginal farmers adopt new technologies in soybean cultivation. As a result, soybean cultivation has increased from a mere 7,000 hectares in 2001 to 380,043 hectares presently in Latur with the yield rising to 1.8 MT/ha as against the national average of 1.2 MT/ha (Evaluation of the PPIAD Project on Soybean, 2014).

1.7.3 SUGARCANE

Sugarcane is an important cash crop in India contributing 5 percent to the total value of agricultural output and accounting for around 2.6 percent of the gross cropped area in the country. Nearly 50 million farmers and labourers are engaged in cultivation of sugarcane and allied activities and hence it plays a vital role in driving the rural economy. India is the largest consumer and the second largest producer of sugar in the world. India's sugar production at around 30 million tonnes in the recent past contributes to around 15 percent of the world sugar production. In 2015-16, around 5 million hectares of land in India was under sugarcane cultivation with an annual sugarcane production of about 356 million tonnes and average yield of around 71 tonnes per hectare (CACP, 2016). Historically, sugarcane is being cultivated in India since the Vedic times with mention of it found in manuscripts as old as 3000-3400 years. Out of the various Saccharum species, India is believed to be home to the Sachharum Barberi species while New Guinea is considered the home to the Sachharum officinarum species (Status paper on Sugarcane, 2013).

Global Scenario: Production and Trade in Sugar

The two main sources of sugar are sugarcane and sugar beet. While 80 percent of the sugar in the world is produced from sugarcane, sugar beet contributes around 20 percent. The global production of sugarcane was 1.88 billion tonnes in TE 2014 according to Food and Agriculture Organization (FAO). While Brazil with a share of 39.5 percent (0.74 billion tonnes) is the largest producer of sugarcane, India, China, and Thailand are the other major producers with shares of 18.7 percent, 6.7 percent and 5.4 percent in the global sugarcane production respectively. On the other hand, out of a total sugar beet production of 0.26 billion tonnes in the world, the European Union (EU) was the major contributor with a 45.1 percent (0.12 billion tonnes) share. Russia (15.0 percent), USA (11.5 percent) and Turkey (6.1 percent) are the other major producers of sugar beet. Further, sugar production in the world stood at 172.2 million tonnes in TE 2015-16 as per the United States Department of Agriculture (USDA) and 32 percent of this produce was traded globally. Again, Brazil is the leading producer of sugar producing 36.1 million tonnes and thus contributing 20.9 percent of the world production and India (16.4 percent), EU (9.4 percent), China (6.5 percent), Thailand (6.1 percent) and USA (4.6 percent) are the other major contributors to world sugar production. With regard to exports, according to USDA, Brazil was the leading exporter supplying 24.8 million tonnes (44.4 percent) of sugar for world trade. This was followed by Thailand (14.5 percent), Australia (6.2 percent), India (4.9 percent) and Guatemala (4.0 percent). The top five exporters together contribute 75 percent of the total exports. On the other hand, China is the largest importer of sugar at 5.3 million tonnes (10.2 per cent), followed by Indonesia (6.3 percent), EU (6.2 percent), USA (6.1 percent), UAE (4.4 percent) and Bangladesh (4.1 percent). Sugar exports are thus highly concentrated due to the increased dominance of Brazil while sugar imports are more diversified.

Table 1.04: World statistics for sugarcane

Country (%share)	Sugarcane (1.88 billion tonnes) (TE 2014-15)	Sugar beet (0.26 billion tonnes)	Sugar (172.2 million tonnes) (TE 2015-16)		
			Production	Imports	Exports
Brazil	39.5%		20.9%		44.4%
India	18.7%		16.4%		4.9%
China	6.7%		6.5%	10.2%	
Thailand	5.4%		6.1%		14.5%
USA		11.5%	4.6%	6.1%	
EU		45.1%	9.4%	6.2%	
Russia		15.0%			
Turkey		6.1%			
Australia					6.2%
Guatemala					4.0%
Indonesia				6.3%	
UAE				4.4%	
Bangladesh				4.1%	

Source: Price Policy for Sugarcane: 2017-18 season

Sugar Status in India

Being the fourth largest exporter of sugar in the world, India has usually been a net exporter of sugar. The volatile nature of the sugar industry with varying demand and supply has caused India to become a net importer of sugar during a few years in the last decade (2004-05, 2005-

06 and 2009-10). The highest and lowest figures for exports of sugar were in 2007-08 at 46.8 lakh tonnes and in 2009-10 at 0.4 lakh tonnes respectively. The corresponding figures for imports were in 2009-10 (25.5 lakh tonnes) and lowest in 2007-08 (negligible).

Area under sugarcane cultivation increased from 49.93 lakh hectares in 2013-14 to 50.67 lakh hectares in 2014-15 and then fell to 49.53 lakh hectares in 2015-16, a decline of 2.2 percent. Correspondingly, production of sugarcane declined by 2.8 percent and yield declined by 0.6 percent in 2015-16. India's sugarcane production peaked at 362 million tonnes in 2014-15 after which it fell to 352 million tonnes in 2015-16. Cane production in India rose from 328.3 million tonnes in TE 2007-08 to 355.5 million tonnes in TE 2015-16. Around 64 percent of the sugarcane crushed was used for sugar production and the remaining 36 percent was used in the production of jaggery, khandsari etc. More than two thirds of this increase in production was caused by an increase in area under cane cultivation while one third of the rise in production was brought about by an increase in yield. The production of sugar increased at a CAGR of 3.5 per cent between 2005-06 and 2014-15 which was greater than the CAGR in cane production of 1.82 percent during the same period thus indicating an improvement in sugar recovery rates. The largest producer of sugarcane in India is Uttar Pradesh with a share of 38.7 percent in TE 2015-16 and the second largest producer is Maharashtra with a share of 21.9 percent. However, Maharashtra is the largest producer of sugar with a 34.5 percent share in total sugar production in the country and Uttar Pradesh is the second largest producer of sugar with a share of 26.4 percent. This is due to higher recovery rates of sugar in Maharashtra and greater diversion of sugarcane to khandsari and gur production in Uttar Pradesh. However, there is an important difference between the sugarcane crops in UP and Maharashtra. The sugarcane crop in UP requires only 7.6 irrigations on an average, while in Maharashtra it requires 25 irrigations. This makes the sugarcane crop in Maharashtra highly inefficient as compared to UP when productivity per unit of water consumption is considered. This analysis becomes more pertinent due to the fact that Maharashtra receives much lower rainfall and its per capita water availability is also lower than UP. According to the sugarcane price policy report, issued by the Commission on Agricultural Costs and Prices (CACP), 2014-15, "In Maharashtra, sugarcane cultivation, which is on less than 4% of the total cropped area of the state, takes away almost 70% of irrigation water in the state, leading to massive inequity in the use of water within the state," The report further adds that sugarcane is the only crop in Maharashtra which is wholly irrigated with only 9 per cent of pulses and 4 per cent of oilseeds being irrigated. Thus, farmers who grow *jowar,* pulses and oilseeds use about 2.2 million liters of water per hectare, about 2,000 million cubic meters (MCM) of water through the year while sugarcane farmers use 18.7 million liters per hectare and consume 18,000 MCM – nine times that of *jowar,* oilseeds and pulses – annually across the state.

Other major producers of sugarcane include Karnataka at 11.3 percent, Tamil Nadu at 8.2 percent, Bihar at 3.9 percent, Gujarat at 3.7 percent and Andhra Pradesh at 3.3 percent. It is only in the recent 10-15 years that Maharashtra's share in sugarcane production has increased from 15.6 percent to 21.9 percent while there has been a marginal decline in the share of Uttar Pradesh during the same period. Another gainer has been Karnataka which has doubled its share in sugarcane production from 8.7 percent to 16.9 percent (CACP, 2016, pp. 1-2)

As far as sugarcane production and productivity of sugarcane in various states is concerned, the highest productivity level of sugarcane is seen in Tamil Nadu at 104.4 t/ha. The productivity level of sugarcane for other major sugarcane producing states are at 89 t/ha in Karnataka, 79.2 t/ha in Maharashtra, 63.2 t/ha in Uttar Pradesh and 54.7 t/ha in Bihar. While the productivity of sugarcane in Karnataka, Maharashtra and Tamil Nadu is cyclical, the productivity of sugarcane in Uttar Pradesh has shown steady marginal improvement since 2010-11(CACP, 2016, pp.21). When compared to world productivity levels of sugarcane (70.3 t/ha), average sugarcane productivity in India is slightly less at 69.5 t/ha. Sugarcane productivity levels in other benchmark countries like Guatemala, Colombia, Australia, U.S.A., Thailand, Mexico and Brazil are higher than that in India (CACP, 2016, pp.23).

Profitability in Sugarcane Crop

According to Narayanamoorthy (2013), the widespread perception is that sugarcane cultivation is highly profitable due to three reasons; firstly, since it is cultivated under 100 percent irrigated condition and hence not subject to vagaries of monsoon; secondly farmers do not face risk of price volatility since the government fixes the statutory minimum support (SMP) price that is linked with the sugar recovery; thirdly, being cultivated under the model of contract farming whereby farmers are assured of cane purchase from sugar industries, sugarcane cultivators are able to access invaluable credit and marketing facilities, a luxury for most of the farmers in India. However, the profit margin which was around 50% in 1970s has reduced substantially over the decades. In fact, profitability in sugarcane cultivation has been steadily declining post 1990s vis a vis pre1990s situation. The sugarcane cultivators have either incurred heavy losses or the cost of cultivation was nearly equal to the Value of Product (VOP) during the post 1990s. Thus, farmers are not able to realize any profit in sugarcane even though it is a highly valued commercial crop.

Detrimental effects of State Intervention in Sugarcane Industry

Due to high patronage of the state government in the form of support prices, subsidies on fertilizers and electricity and assured demand, there has been a shift in the cropping pattern not only in Maharashtra (from other crops to cane), but also in the country from sub-tropical regions like Uttar Pradesh, Bihar and Punjab to a tropical state like Maharashtra which is highly drought prone and dry. However, even though the area and production of sugarcane in Maharashtra have increased, the yield levels of sugarcane have not improved. Due to support price provided by government, sugarcane cultivation is being undertaken by farmers even though the soil and climatic conditions are not favourable for it. Forty per cent of the sugarcane mills in Maharashtra are located in drought-prone districts which are more suitable for cultivation of pulses and oilseeds. According to a study conducted in 2010-11, the average fertilizer consumption for all crops is 136 kg per hectare while sugarcane cultivation requires 208.4 kg per hectare. The distorted pricing policy as well as subsidies have led to indiscriminate sugarcane cultivation thus leading to increased soil salinity and lower productivity level. An additional factor contributing to the setting up of sugar mills in Maharashtra is the licensing policy in the state which is in favour of setting up new mills only in the cooperative sector. These mills in the cooperative sector enjoy huge state patronage in Maharashtra and has led to distorted cropping pattern, misallocation of resources and water exploitation in the state. Even though drip and sprinkler irrigation is being undertaken in a big way in the state, it has not resulted in alleviating the water situation in the state. Moreover, flood irrigation is used for sugarcane cultivation in Maharashtra to a large extent. The justification given for state intervention in sugar pricing is to provide sugar supply in the domestic market at affordable prices for household consumption. However, only 30 percent of the domestic sugar consumption can be attributed to households and the remaining 70 percent is consumed by industries like beverages, chemicals etc., but at the same rate. Thus, subsidizing sugar is benefitting industries more than households. Another point of contention in fixing the price of sugarcane is the consideration of prices of byproducts like molasses, ethanol, electricity etc. Farmers earn only 55-60 percent of total revenue earned from sugar and its by-products even though the Rangarajan Committee in 2012 has recommended a 70:30 revenue sharing formula (RSF). Karnataka is the only state which has adopted this RSF and yet its sugarcane industry has been facing a crisis. A major fallout of state intervention in sugar pricing is the huge pileup of cane arrears to be paid by the mills to the sugarcane cultivators. This has happened particularly after the government replaced the Statutory Minimum Price (SMP) with Fair and Remunerative Price (FRP) in 2009-10. Even though the change was made with the intention of improving profit sharing from sugar for the farmers, it has actually led to increasing the gap between the price payable by the mills and price actually paid to the farmers in the last decade. Under SMP, farmers were supposed to get a 50:50 share in the profits, but this was mostly not implemented. The FRP was thus to be fixed taking the following factors into consideration:

(1) the sugarcane production cost
(2) the margin to the sugarcane farmers
(3) the availability of sugar to the consumers
(4) the price of sugar
(5) recovery
(6) the prices of by-products and
(7) providing sufficient profit margin to the cultivators which will also take in to consideration the associated risk

In spite of the best of intentions, cane arrears grew from 3 percent in 2008-09 to around 50 percent in 2014-15. According to the sugar mills, depressed sugar prices in the national and international markets was the major cause for the pile up of the arrears. However, the sugar industry in India depends more on domestic sugar prices which is influenced by factors like supply and demand, increasing population and income level, changes in government policies, availability of alternative sweeteners, increase in crude oil prices, diversions of sugarcane for the ethanol production and adverse climatic conditions. A comparison of sugar prices before and after 2012-13 shows that even though the domestic and international sugar prices were higher before 2012-13 than in the post 2012-13 period and sugarcane prices were lower than that of sugar, yet the mills could not pay the cane arrears to the farmers. Even though the Sugar Control Act (2013) contains provisions for acting against defaulter mills, successive state governments in Maharashtra have been generally reluctant to act against the defaulting mills since the mills are mostly owned by the politicians. Politicians controlling sugar mills have a large section of voters under their influence and thus have a vested interest in keeping sugar prices low (keeping their vote bank intact). Further, politicians also are a part of the water committees which distribute and recommend water requirement. Needless to say, most of the water for irrigation gets diverted to sugarcane cultivation thus depriving other crops of much needed irrigation. In recent times, the government has been mulling the option of banning sugarcane cultivation in areas prone to drought. Such a measure would be effective in reigning in the powerful sugar lobby which was something not even considered for obvious reasons earlier. Around a third of the members of the state cabinets at one time had direct or indirect interest in sugar factories (Abnave and Babu, 2017).

Maharashtra's Cooperative sugar industry

The story of Maharashtra's cooperative sugar industry started with the establishment of the first sugar cooperative by Vithalrao Vikhe Patil in 1950 which was an attempt to resist the exploitation of farmers by money lenders and private mill owners. This was Asia's first cooperative sugar factory in which farmers from nearly 44 villages in Ahmednagar were brought together so that they could afford production of sugar rather than jaggery. The cooperative sugar mills provided consistent incomes to its large numbers of shareholders and thus contributed in a big way to the development of rural Maharashtra. Members of the cooperative society can easily access management and meeting of the board of meeting and hence there is better stakeholder participation in the overall management of the mills. Thus, they can resort to better vigilance on the factory premises during and after crushing, ensure better sugar recovery and reduction in cost of harvest and transportation (H&T). All this is naturally highly beneficial to the cane farmers. Though started with good intentions (giving shareholding status to the smallest farmer), it was a flawed model from the word go since the cooperative sugar industry was given special status and given preference over the private sector irrespective of performance. The cooperative sugar sector became highly unprofessional in its management in every respect over the decades. Moreover, the interconnectedness of positions in sugar cooperatives and members of state governments, local governments and other social institutions had rendered the system more and more dysfunctional. Thus, policy decisions with respect to irrigation facilities and financial support of the government have largely been in favour of Western Maharashtra which is politically stronger than eastern Maharashtra. The factory owners used cane prices as a tool to create vote banks. This can be seen from the fact that cane prices in Western Maharashtra have been much higher than could be economically justified. Thus, the cooperative sugar industry was a classic example of the 'capture' of the regulators by the regulated (Mala, 2008).

The amendment to Section 6A of the Sugarcane Control (Order), 1966, however, has resulted in a change in the ownership profile of sugar factories (cooperative to private) in the state. This trend has been noticeable especially since lending banks, especially the Maharashtra State Cooperative Bank, began taking over assets of sick cooperative mills under the provisions of the SARFAESI (Securitisation and Reconstruction of Financial Assets and Enforcement of Security Interest) Act, 2002. While 68 cooperative mills were liquidated and sold to the private sector, it later came to light that the buyers from the private sector were entities mostly owned by the same cooperative tycoons. From 2006-07 onwards there has been a consistent rise in the number of private sugar factories in Maharashtra; 154 private sugar units have obtained Industrial Entrepreneur Memorandum (IEM) and presently there are 78 operational private sugar mills with a crushing capacity of 2.48 lakh tons of cane per day (TCD) as compared to a meagre 12 private sugar units around ten years ago. On the other hand, the total number of operational cooperative sugar units stand at 102 with a capacity of 3.52 lakh TCD. The capacity of private sector in total sugar production has gradually increased from 10 percent to 45 percent in the state. The effect of such privatization on sugarcane mills, instead of bringing in more efficiency, competition and professionalism has been in fact been detrimental. The FRP paid to farmers in Maharashtra is net of the Harvest and Transport cost incurred by the mills for these operations. The private units have incurred Rs.57.07, Rs.48.58 and Rs.83.14 per ton on H&T more than cooperative units in 2013-14, 2014-15 and 2015-16 respectively, implying thereby that the cane farmers are burdened by an additional Rs.477.20 crore. Moreover, the recovery rate of the mills in cooperative sector was higher than those for the private mills during the same period. The monetized value of the difference between cooperative and private sector in recovery works out to a whopping Rs.1076.10 crores. In fact, before being taken over by the private management, the cooperative sector reported lower H & T costs and better recovery. The double loss of higher H & T and lower FRP due to lower recovery rates are being borne by the farmers in the form of dwindling payments under private sector mills. Thus, simply privatization has not been able to solve the problems faced by the sugarcane industry in Maharashtra. The provisions of the Maharashtra Regulation of Sugarcane Price (Supplied to Factories) Act, 2013, enacted on the recommendation of the C. Rangarajan committee, may provide an effective instrument for the administration to limit H&T cost per ton of sugar cane and dwindling sugar recovery rate of the private sector in the State (The Hindu, 2016).

Recent Measures

One of the solutions proposed to solve the issue of cane arrears has been to link the prices of sugarcane and sugar. Even though Maharashtra has taken this policy decision, the state government added a rider that the farmer will not be paid a price below the FRP. However, due to a bumper harvest if domestic sugar prices fell sharply, the mills found it difficult to pay the FRP. Thus, the Bharatiya Janata Party-led Maharashtra government announced waiver of sugarcane purchase tax and Rs 2,000-crore interest-free loan so that mills can clear the dues of the farmers (business-standard.com, May 7, 2015). Successive governments have been subsidizing a corrupt and inefficient sugar sector at the cost of the exchequer. Some positive news on this front is that given the volatility of sugar prices and the need to protect the interests of farmers, the government of India has introduced the concept of Minimum Selling Price of sugar with effect from 07th June 2018. This will ensure that the industry recovers the minimum cost of production of sugar which will make it possible for them to clear the cane arrears due to farmers. Under the provisions of the Sugar Price (Control) Order, 2018, the Minimum Selling Price of sugar was fixed by the Government at Rs.29/kg. That is, with effect from 07th June 2018, the sugar mills could sell sugar at the factory gate at the MSP for domestic consumption. Apart from the FRP of sugarcane, the minimum conversion cost incurred by the most efficient mills is taken into consideration in the calculation of MSP. A further revision took place when the Government decided to fix the MSP retrospectively from 14th Feb 2018 at Rs.31/kg (GoI, 2018). However, fixing the MSP does not solve the problems of the sugarcane industry. This is because while domestic consumption is only 25 million tonnes, this leaves the industry with a surplus production of 10 million tonnes. The excess sugarcane can be converted into ethanol; however, India's sugarcane industry does not have the required distillery capacity. Moreover, the current minimum prices of ethanol in India makes its production unviable. In order to address this issue a Rs. 44.4 billion package has been approved by the central government to increase the domestic ethanol production capacity. Parallelly, the Maharashtra government plans an export subsidy scheme for sugar producers. This course of action has its limitations since India's low quality white sugar does not have sufficient demand in the international market. Moreover, injecting additional sugar stocks into the global market would only serve to depress sugar prices even more (business insider.in, Sep 3, 2018).

1.8 CONCLUSION

The development of agricultural sector is possible only if the productivity of land increases. This is because extensive cultivation is possible only to a limited extent. Under extensive cultivation, agricultural production is increased by bringing more and more land under cultivation. This was the method adopted for increasing agricultural production in India prior to the Green Revolution. During the green revolution (1970s and 1980s) with the introduction of hybrid variety seeds and improved application of inputs like fertilizers and irrigation, the productivity of land increased tremendously and India became self-sufficient in the production of wheat initially, and later rice. The effects of green revolution were also felt on other crops, notably cash crops like sugarcane and cotton in Maharashtra. Post green revolution (1995 to 2005), the productivity of almost all crops stagnated across India. For more than a decade, the agricultural sector witnessed this stagnation in the productivity of most crops, while the productivity of some crops actually declined. Following a robust agricultural policy adopted by the government post 2005, the agricultural sector has once again witnessed an increase in the productivity of crops, notably pulses, oilseeds and horticultural crops. The effect of the green revolution was visibly felt in Maharashtra with the rise in sugarcane cultivation. Though not blessed with abundant rainfall and the fact that Maharashtra's ability to provide irrigation is limited to 18 per cent of the gross cropped area, the rampant usage of underground water through tube wells and construction of canals has resulted in the state becoming the second highest producer of this water intensive crop. Traditionally, jowar and bajra were the crops grown extensively in this state. Most of the farming was in the form of subsistence farming like the rest of the country. However, with the advent of irrigation facilities and increasing use of fertilizers, sugarcane and Bt cotton became very important cash crops in the state. It may be noted that Bt cotton, a genetically modified variety of cotton, is also a very water intensive crop and has failed where adequate irrigation has not been made available. Thus, sugarcane in Western Maharashtra and Bt cotton in Vidarbha were prominent crops in the 80s. Though occupying only 2 percent of the land under cultivation, sugarcane uses up almost 80 percent of the irrigation available in the state. This seriously affects the productivity of other crops. Moreover, the monocropping of sugarcane has resulted in increasing the salinity of the soil which in turn requires more and more application of fertilizers. Thus, the increasing productivity of sugarcane is questionable – it is neither water efficient nor ecologically efficient. The farmers in Vidarbha have already realized the inefficiency of the cotton crop and have started to replace cotton with soybean. This latter crop is sturdy and can face the vagaries of weather, is suitable for the dry climatic conditions of Vidarbha and is a wise choice because of the increasing profile of soybean as an important cash crop. Western Maharashtra falls under the scarcity zone in geographical classification of various climatic zones of Maharashtra. Thus, it is also not suitable for sugarcane cultivation. Adopting a cropping pattern which is more suitable to the climatic conditions of the geographical area is not only ecologically sensible, but also the efficiency of irrigation can be increased by employing it over a larger area of agricultural production covering wider variety of crops. Just like soybean, maize is also a very sturdy crop, capable of facing the vagaries of weather and its importance as a cash crop has been increasing over the last decade. This chapter gives in depth knowledge of the crop profiles viz., maize, soybean and sugarcane (global scenario, domestic outlook, and future prospects/recent developments) which have been selected for this study in Pune district. This study intends to analyze the production and productivity of selected cash crops, namely, sugarcane, maize and soybean in Pune district for the period 1991-92 to 2017-18. This will make it possible to evaluate the performance of the crops and arrive at a conclusion about the most suitable cropping pattern to be adopted by the district. Though the study will be focusing on the financial viability of the cultivation of the said crops, the ecological impact of their cultivation cannot be ignored and will also be taken into consideration for evaluating the desirability of their cultivation.

REFERENCES

BOOKS

Kalamkar, S. S. (2011). Agricultural Growth and Productivity in Maharashtra, Trends and Determinants. Allied Publishers, New Delhi.

JOURNAL ARTICLES/PAPERS

Abnave, V. B. and Babu, M.D. (2017). *State Intervention: A Gift or Threat to India's Sugarcane Sector?* Working Paper 385. ISBN 978-81-7791-241-8. The Institute for Social and Economic Change, Bangalore.

Bhalla, G. S., & Singh, G. (1997). *Recent Developments in Indian Agriculture: A State Level Analysis.* Economic and Political Weekly, 32(13), A2–A18. Accessed on 25/09/2018.

Bhalla, G. S., & Singh, G. (2009). *Economic liberalisation and Indian agriculture: a State wise analysis.* Economic and Political Weekly, xliv(52), 34–44. Accessed on 25/09/2018.

Chand, R. (2014). *From Slowdown to Fast Track: Indian Agriculture since 1995.* Working Paper 01/2014. National Centre for Agricultural Economic and Policy Research. Retrieved from http://www.ncap.res.in/upload_files/Slowdown_final for printing.pdf. Accessed on 25/09/2018.

Das, P. (2006). *Cropping pattern (agricultural and horticultural) in different zones, their average yields in comparison to national Average/Critical Gaps/Reasons identified*. Indian Council of Agricultural Research, New Delhi, pp 33–47. Retrieved from https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwil66Pfjd3dAhUHKY8KHXaSCDcQFjAAegQICRAC&url=http%3A%2F%2Fwww.insightsonindia.com%2Fwp-content%2Fuploads%2F2013%2F08%2Fcrop-pattern-in-india.pdf&usg=AOvVaw2AlZPA8D4QdUPw0VGMRZoI. Accessed on 25/09/2018

Dev, Mahendra. (2012). Small Farmers in India: Challenges and Opportunities. Indira Gandhi Institute of Development Research, Mumbai. WP-2012-14. Retrieved from: https://www.researchgate.net/publication/241757590. Accessed on 23/09/2018.

Lalvani, M. (2008). Sugar Co-operatives in Maharashtra: A Political Economy Perspective. *The Journal of Development Studies.* 44. 1474-1505. 10.1080/00220380802265108.

Mruthyunjaya and Praduman Kumar. (1989). Crop Economics and Cropping Pattern Changes. *Economic and Political Weekly, Dec 23-30, pp A159-A166.* https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwinhM3_z9XdAhVEU30KHSwcD5kQFjABegQICRAB&url=

https%3A%2F%2Fwww.epw.in%2Fjournal%2F1989%2F51-52%2Freview-agriculture-uncategorised%2Fcrop-economics-and-cropping-pattern-changes.html&usg=AOvVaw1tg8NOmpBgNIEY5tsXlf8l

Narayanamoorthy, A. (2013). Profitability in Crops Cultivation in India: Some Evidence from Cost of Cultivation Survey Data. *Ind. Jn. of Agri. Econ*. Vol.68, No.1, Jan.-March 2013

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 447–465. http://doi.org/10.1098/rstb.2007.2163.

Shinde, M. V. (2016). *Recent Trends in Agricultural Diversification*. VOLUME-III, ISSUE-VII ISSN (Online): 2350-0476 ISSN (Print): 2394-207X IMPACT FACTOR: 4.205 INTERNATIONAL JOURNAL OF MULTIFACETED AND MULTILINGUAL STUDIES. Retrieved from eprints.icrisat.ac.in/14407/1/IJMMS_3_7_1-8_2016.pdf Accessed on 21/09/2018.

Singh, H. S. (1962). *Changes in Cropping Pattern: Economic Criteria.* The Economic Weekly. Vol. 14, Issue No. 24, pp. 951-954. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwjLnLqal6neAhXCbSsKHQttB0oQFjABegQIBxAC&url=https%3A%2F%2Fwww.epw.in%2Fsystem%2Ffiles%2Fpdf%2F1962_14%2F24%2Fchanges_in_cropping_patterneconomic_criteria.pdf&usg=AOvVaw2R0AGXaXXmpmcgyDvNZ6ah
Accessed on 25/09/2018

REPORTS

Annual Report 2017-18. Department of Agriculture, Cooperation and Farmers' Welfare. Extracted from agricoop.nic.in (Documents/Reports and Publications). Accessed on 23/09/2018.

Deshpande, T. (2014). *State of Agriculture in India*. PRS Legislative Research, (113), 1–29. Extracted from https://www.google.com/search?client=safari&rls=en&q=www.prsindia.org/uploads/media/Analytical%2520Report/State%2520of%2520Agriculture%2520in%2520+India.pdf&ie=UTF-8&oe=UTF-8. Accessed on 23/09/2018

Economic Survey of Maharashtra 2017-18. Department of Economics and Statistics, Planning Department. Government of Maharashtra. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiVoez6ltHeAhXPXCsKHSk5BaYQFjAAegQICBAC&url=https%3A%2F%2Fmahades.maharashtra.gov.in%2Ffiles%2Fpublication%2FESM_17_18_eng.pdf&usg=AOvVaw3kMJ16TsOYNHQze3rLdfg1

Evaluation of the PPPIAD Project on SOYBEAN.(2014). FICCI. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&ved=2ahUKEwjf_MjW6OfeAhUlSo8KHa1WCvQQFjAHegQICBAB&url=http%3A%2

F%2Fficci.in%2Fstudy-page.asp%3Fspid%3D20539%26sectorid%3D1&usg=AOvVaw1Z8YJJPgcJ5vSaLfG505ot

Kannan, E. (2011). Determinants of Stagnation of Productivity of Important Crops (Consolidated Report). Institute for Social and Economic Change. Research Report: XI/ADRTC/127. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=2ahUKEwjG2ujhxNXdAhXHbisKHfEgBukQFjABegQIBxAC&url=http%3A%2F%2Fwww.isec.ac.in%2FProductivity%2520Stagnation_All%2520India-Final.pdf&usg=AOvVaw0_HtbDNRp_0phnAYbz-4LE. Accessed on 25/09/2018.

Kumar, R., K. Srinivas and N. Sivaramane (2013), Assessment of the maize situation, outlook and investment opportunities in India. Country Report – Regional Assessment Asia (MAIZE-CRP), National Academy of Agricultural Research Management, Hyderabad, India.

Maize Vision 2022. Agricultural Division, The Federation of Indian Chambers of Commerce and Industry (FICCI). March 2018.

OECD-FAO Agricultural Outlook 2018-2027, OECD Publishing, Paris/Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.1787/agr_outlook-2018-en

Price Policy for Kharif Crops: The Marketing Season 2017-18. Commission for Agricultural Costs and Prices. Department of Agriculture, Cooperation and Farmers Welfare. New Delhi, March 2017.

Price Policy for Sugarcane. 2017-18 Sugar Season. Commission for Agricultural Costs and Prices. Department of Agriculture, Cooperation and Farmers Welfare. New Delhi, March 2017.

Status Paper On Coarse Cereals, Directorate Of Millets Development, Jaipur, Department Of Agriculture And Cooperation, Ministry Of Agriculture, Government Of India, March 2014.

Status Paper on Sugarcane. DIRECTORATE OF SUGARCANE DEVELOPMENT, GOVT. OF INDIA, Ministry of Agriculture, January 2013.

WEBSITES

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiAt9fG9NDdAhUPfSsKHb9WCE4QFjAAegQIABAC&url=http%3A%2F%2Feagri.org%2Feagri50%2FAGRO101%2Flec15.pdf&usg=AOvVaw0AmimCVag8ppaNT-M3OTKb. (Cropping pattern and cropping system - Intensive cropping- Sustainable agriculture – IFS) Accessed on 23/09/2018.

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=13&cad=rja&uact=8&ved=2ahUKEwjM3qr8wN_dAhXKvI8KHbmuBN4QFjAMegQICxAB&url=https%3A%2F%2Fwww.nal.usda.gov%2Fafsic%2Fsustainable-agriculture-definitions-and-terms&usg=AOvVaw2rqHvypbd2Drkdl4z8Gbqi
(United States Department of Agriculture)
Accessed on 29/09/2018.

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiCsozK1vnpAhUTfisKHQ9mCMEQFjADegQIAxAB&url=https%3A%2F%2Fdmi.gov.in%2FComProfiles.aspx&usg=AOvVaw3c7e3XI3nOw9Rh155LStYx
(Department of marketing and inspection)

https://dfpd.gov.in/gen_policy.htm
(General Policy, Department Of Food And Public Distribution, Government of India, 2018.)

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjyt-6v3ZfqAhX8xDgGHdx8BjAQFjAAegQIBBAB&url=https%3A%2F%2Fwww.businessinsider.in%2Findia-could-soon-become-the-worlds-largest-sugar-producer-but-heres-why-thats-a-problem%2Farticleshow%2F65657844.cms&usg=AOvVaw1TCkYIOeqo5cVBZGv3H00P
(Business insider)

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjWxLKL3pfqAhWbyTgGHRDyB54QFjAAegQIBhAB&url=https%3A%2F%2Fwww.business-standard.com%2Farticle%2Feconomy-policy%2Fcan-maharashtra-s-sugar-mills-bounce-back-115050701096_1.html&usg=AOvVaw0YkakpgOom-OqMNsCzyDL1
(Business-standard)

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwju-ZqLh5bqAhV3zTgGHdaRDeoQFjABegQIAxAB&url=https%3A%2F%2Fwww.sugarnews.in%2Fcrushed-by-the-cane-lobby%2F&usg=AOvVaw04A7MBi6-gspQyP4xen-fL
(The Hindu)

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

2.2 Books

2.3 Journal Articles/Research Papers

2.4 Reports

2.5 Theses

2.6 Research Gap

2.7 Conclusion

2.1 INTRODUCTION

An extensive literature survey was undertaken by the author to study the various works published related to cropping pattern and factors influencing the same. While some of the work pertains to the cropping pattern of India, others refer to the cropping pattern of particular regions, like states or districts. The factors influencing cropping patterns include a whole host of issues viz., the size of land holdings; climatic conditions; social and cultural influences; topography; availability of inputs like irrigation, credit, technology; marketing infrastructure; returns obtained on the crops etc. It was found that the relationship between trends in cropping pattern and prices procured by the farmers for their crops has not been studied particularly for Pune district. The fact that in the absence of remunerative prices for their produce, farmers are either dumping their produce on the road or committing suicide shows that financial reward for undertaking a risky occupation like agriculture is of paramount importance. Hence, a need was felt for studying the trends in cropping pattern with respect to prices obtained by farmers for their produce in Pune district with respect to selected cash crops viz. sugarcane, maize and soybean.

2.2 BOOKS

Mitra (1996) has studied, inter alia, the trends in cost of production relative to crop yield and to examine the behaviour of prices relative to cost of major crops in India for the period from early seventies to mid-late eighties. He found that with reference to sugarcane while the growth in cost of production has far exceeded the growth of productivity all over India, the increase in costs was highest for Maharashtra. Since the yield levels have stagnated in Maharashtra, the fact that sugarcane was being cultivated under conditions of assured irrigation, better seed varieties, and high fertiliser use in the state led to ever increasing costs per hectare of sugarcane cultivated. The improvement in yield levels in sugarcane witnessed in the early seventies due to technological breakthroughs tapered off and could not be found in the later years of the study period. On the other hand, the costs of production, both variable and the rental cost of land owned have been rising. In order to keep up with the rising costs, the procurement prices and thus, in turn, the farm gate prices for sugarcane have been hiked regularly. While the ratios of procurement and farm gate prices to costs had been declining, it continued to remain favourable and hence acted as an incentive for farmers to continue with sugarcane cultivation.

Expert Consultation on "Crop Diversification in the Asia Pacific region" was held at Thailand by the Food and Agricultural Organization of the United Nations in **2000**. The outcome of the Consultation was edited and published as a compilation of papers presented by experts from various countries like India, China, Japan, Philippines, Sri Lanka, Bangladesh, Thailand, Malaysia and Vietnam. The consensus that emerged among the experts was that crop diversification was instrumental in alleviating poverty, providing food security, nutrition to the marginalised farmers as well as in providing sustainable solutions to the agricultural sector which is coming under increasing pressure due to population growth and climate change. The editor has talked about two kinds of diversification; horizontal diversification wherein crops are added or substituted into the existing cropping systems which is commonly found across the world, and vertical diversification where downstream activities are undertaken to provide value addition and thus increased returns to the farmers. He has pointed out that several countries have adopted crop diversification, mostly with respect to fruits, vegetables and ornamentals with the objective of providing new opportunities to farmers. Further, diversification also led to establishment of agro processing industries in various new sectors, thus leading to increase in productivity and employment. It has also been highlighted by various experts that while rice is a major crop in Asia, it yields very low returns to the marginal farmers. Hence, for such farmers also crop diversification into horticultural products could prove to be beneficial. However, the editor has also highlighted that replacing perennial crops and rice which is being considered by many countries should be thought through carefully since such a policy decision can have serious repercussions on food and industrial product supply. Finally, the loss in soil fertility caused by intense cultivation is sought to be addressed by application of organic manure, crop rotation, insertion of green manure crops and legumes. Thus, it is seen that crop diversification through the adoption of proper cropping pattern can solve various issues in the agricultural sector.

Kalamkar (2011) has studied the Agricultural Growth and Productivity in Maharashtra (Trends and Determinants). He has used secondary data from various government publications for the period 1960-61 to 2004-05 to analyze the growth pattern, determinants for changes in productivity and stagnation of important crops as also the regional variations in the productivity of important crops. According to Kalamkar, irrigation is an important input in agricultural development since it enables the farmers to adopt intensive farming techniques and also raises crop productivity. It is estimated that the productivity of land is enhanced six times when irrigation is applied to it. This becomes even more pertinent in the case of Maharashtra where vast areas of the region are dry and arid. However, agriculture in Maharashtra is primarily rain fed with around 83 per cent of the cropped area not having access to irrigation. The proportion of gross area irrigated to gross cropped area in the state is only around 18 per cent which is way below the national average of 43 per cent in 2006-07. In 18 districts, it was less than 15 per cent in 2002-03. (p. 31). The normal rainfall of a majority of the districts in the state is below the state's average rainfall. Out of the 33 reported districts for the period 2001-05, 6 districts were in high rainfall group, 10 districts fell in medium rainfall group and the remaining 17 districts belonged to the low rainfall category. Most of the districts from Pune, Latur and Amravati divisions fell under low rainfall group (p. 24-25). Due to these wide variations in rainfall across regions and years, the process of agricultural development in Maharashtra is highly constrained. All this has discouraged the farmers in many regions in the state from adopting multiple cropping patterns. Added to this drawback is the issue of the type of land holdings in the state. The average size of holding in Maharashtra according to 2000-01 census was 1.66 ha (p.38). Out of the 1.37 crore number of holdings, nearly half of the holdings, around 67 lakhs are that of the marginal farmers who own less than one hectare of land. Small farmers who own between 1 and 2 hectares of land form another major chunk of 40 lakhs of farmers. Thus, around 96 percent of the farmers in Maharashtra are small, marginal and semi-medium farmers, as compared to the national average of 90 percent. Following the all-India trend, the cropping pattern in Maharashtra has also changed considerably over the last few decades. The pre-green revolution was characterized by area expansion in the cultivation of cereals and pulses; yet the production of almost all the crops fell due to decrease in productivity which could not be substituted by an increase in area under cultivation. This trend was reversed during the green revolution (1968-69 to 1979-80) when productivity of food grains increased significantly which resulted in the increase in food grains production at almost 5 per cent per annum even though area under cultivation increased only marginally by around 0.88 per cent. The area under groundnut also reduced drastically. In the post green revolution period (1980-81 to 1989-90), the production of almost all crops increased significantly due to increase in the productivity. The only exceptions were wheat, rice and sugarcane. While the production of wheat and sugarcane fell due to a decrease in area, the production of rice declined due to a decline in productivity. However, production of pulses and oilseeds saw a significant increase (p.175).The area under cereals declined from around 55 per cent before the green revolution to around 40 per cent in 2004-05, mainly because of reduction in jowar cultivation. Even though the yield rate of pulses was low, the area under pulses increased from 12.6 per cent to 15.26 per cent for the same period as above, while in the case of oilseeds, there were substantial gains in the area cultivated since 1990s primarily due to soybean. Cash crops like cotton and sugarcane actually showed declining share in areas. While area under cotton cultivation declined from 3.2 m ha to 2.8 m ha, the share of sugarcane area in GCA also declined from 3 per cent to 1.98 per cent between 2000-01 and 2004-05. (p.173-174).

Rana (2011) has written about Cropping Systems. In the chapter on Crop Diversification he has talked about the need for crop diversification as necessary to protect the farmers from price risks arising from reliance on mono cropping, as also for sustainability (retaining soil fertility, moisture retention, controlling weeds and pathogens. In explaining the concept of crop diversification he has said, “With globalization of the market, crop diversification in agriculture means to increase the total crop productivity in terms of quality, quantity and monetary value under specific, diverse agro-climatic situations world-wide” (pp54). As against the general understanding of crop diversification being the cultivation of multiple crops consecutively during a particular season, in modern times, crop diversification has come to mean the substitution of low value crops with high value crops which have complementary marketing opportunities. According to him, optimum diversity is obtained when crop cultivation is combined with livestock breeding. This not only helps in preventing soil erosion (cultivating food crops in plains and pastures/forages on steep slopes) and increases soil fertility (livestock manure), but also acts as an economic buffer to farmers in case of crop failure. He has also talked about horizontal diversification (through the addition of high value crops in the existing cropping system) and vertical diversification (through value addition in agro processing industries). He also believes that diversification can be brought about by the adoption of appropriate government policies which thrust change on farmers, for ex., The Technology Mission on Oilseeds, Spices Development Board etc. He has identified different kinds of crop diversification areas:

1. From Low value to High value crops
2. From Single crop to Multiple / Mixed crop
3. From Crop alone to Crop-livestock-fish-apiculture
4. From Agriculture Production to Production with Processing and Value Addition

The author is of the opinion that since a major portion of farmers in India are small and marginal farmers, crop diversification will protect them from fluctuating price risks arising from mono cropping (rice/wheat). It will also help in mitigating the risks arising from climate change, especially in the drought prone and dry land regions of the country.

Lele et al (2018) have discussed the Patterns of Structural Transformation and Agricultural Productivity Growth with Special Focus on Brazil, China, Indonesia and India. In discussing the overall agricultural strategy for India, the authors opine that small scale efficient farming adopted by China and Indonesia is more suitable than large scale mechanized farming adopted by Brazil. According to them, all the other three countries have performed better than India with respect to Millennium Development Goals indices pertaining to farm households' primary education, health, water and sanitation. This in turn has led to greater agricultural productivity in these countries. Moreover, a greater enabling environment for agricultural growth in China and Brazil was seen in the form of favourable policy formulation as well as implementation. They believe that more openness in all the three countries has led to greater access of technologies with respect to various crops. On the other hand the institutions in India established at the time of Green Revolution have been stagnating. As a result, there has been very marginal progress in agricultural research, education, and extension. Without adoption of suitable policies, the development of markets, both for inputs and outputs in the agricultural sector has taken a beating. The authors have argued that crop diversification is a strategy which will not only help in increasing agricultural productivity in India, but also provide food security to the millions of marginal farmers. Though crop diversification is finding a mark in Indian agriculture in recent times, the adoption of rice-wheat based agricultural development strategy has led to India lagging behind other countries in this respect. The authors have pointed out that increasing pressure on resources and the need for developing sustainable agricultural practices are huge challenges facing Indian agriculture. This would require the adoption of modern inputs for increasing productivity along with sustainable technologies which will help overcome the problems of depletion of ground water levels, salination and soil degradation. The authors have suggested that along with the development of physical infrastructure, Indian agriculture is in need of knowledge intensive innovations with respect to sustainable farming practices. This according to them will not only provide more employment opportunities, but also help overcome the problems of mono cropping which an adherence to rice-wheat based agricultural strategy has promoted.

2.3 JOURNAL ARTICLES / RESEARCH PAPERS

Dantwala (1986) has challenged the official view that the change in the relative prices of different crops can be instrumental in establishing a more balanced cropping pattern in the country. According to him, while the change in relative prices of competing crops can succeed in bringing about a shift towards the production of some crops in certain regions, such a policy would in all likelihood lead to inflationary conditions in the agricultural sector. The reason for this according to him was that the cropping pattern was determined more by the net revenue obtained by the farmer in cultivating a crop rather than its price. Thus, if the farmer's revenue has to be maintained at his expectation level, the rise in prices of the preferred commodity may have to be so large that it might become out of reach for the common man. Moreover, the reduction in the production of the crop which is sought to be discouraged (without a reduction in its unit cost) would also lead to a rise in its prices. Thus, the prices of the crops which are preferred would have to be increased even more to provide the farmers with the same level of remuneration. The author has given the examples of how cereals are twice as remunerative as pulses in Haryana and Rajasthan and hence a shift in the cropping pattern from cereals to pulses would require more than just relative price rises; it would require non-price measures such as reducing the per unit cost of production through improved technology as well as providing crop insurance / assured irrigation to preferred crops. He has quoted The Economic Survey, 1985-86 in saying that the cropping patterns followed in different states showed that they are not suitable with regard to their comparative advantage in yields. This was because the farmers' decisions were based on the revenue obtained from growing different crops instead of on their yield potential.

Chand (2003) in the Commentary on Minimum Support Price (MSP) in Agriculture has written about the distorting effects of MSP on the cropping pattern in the country. The policy of fixing MSPs for rice and wheat coupled with procurement by government agencies was adopted in order to encourage adoption of HYV seeds of the said crops by the farmers and thus increase production. The policy's objectives were achieved and India went from a deficient to surplus country with respect to food grains production. The excessive supply of food grains being procured and stored in government godowns or exported at a huge cost to the state exchequer is defeating the very purpose of formulating the MSP which is to provide food security to the millions living below the poverty line. The author has argued that while the government has only focused on announcing the MSP, it has not paid attention to implementing the same. Except for rice and wheat in five states and sugarcane and cotton in a few states, there is no mechanism to ensure that the farmers do not receive a price below the MSP. Accordingly, food grains production in these five states have increased exponentially without paying heed to the demand situation. Thus, while bumper harvests of food grains rot in government warehouses, a shortage of pulses and oilseeds lead to government resorting to imports to meet their demand. This creates unfavorable market conditions for these crops in dry land areas. Moreover, the guarantee of MSPs in states like Punjab and Haryana which are not climatically suited for the cultivation of rice has caused a serious depletion of water table in these states. Finally, the author has also shown how the calculation of MSP, based on cost of production so as to include imputed costs does not reflect the true opportunity cost of land in these states since cultivation of other alternative crops do not generate the same levels of profit as rice/wheat. Thus, the author has argued that faulty policies and failure of government to tweak the policies as per changed demand and supply conditions have resulted in distorting the cropping pattern in the states where MSP is being implemented.

Kumar and Mittal (2006) have studied the productivity trends in Indian agriculture. During the post Green Revolution period, in the initial years (between 1960s and mid 1980s), the agricultural sector saw increasing returns due to greater and more intense use of HYV seeds, chemical fertilizers, irrigation, and mechanization. However, during the second phase (after mid 1980s), though the trends in using greater inputs continued, there was a marked decline in productivity growth. The authors hence felt the need to investigate into the causes of this downward trend in agricultural productivity, especially that of individual crops. The Total Factor Productivity Growth (TFPG) estimates for major crops were used to analyze the trends in agricultural productivity of these crops over time and across states. A total of ten inputs [human labour, bullock labour, machine labour, farm yard manure (FYM), nitrogen, phosphorus, and potassium fertilizers, irrigation, plant protection and land] were used to construct the total input index. Data pertaining to costs was collected from the Directorate of Economics and Statistics (DES) which had compiled it under the "Comprehensive Scheme for the Study of Cost of Cultivation of Principal Crops." The cost share of each input was calculated by dividing the individual input cost by the total production cost. This data was then used to compute the TFP for major crops in different states. Further, the data for quantity and price of inputs and crop output were compiled for the years for which such data was available (for the period 1971 – 2000). The analysis of the TFP growth of major crops in India during that period revealed the following:

Many crops like coarse cereals, horticultural crops, sugarcane, fibres, pulses and oilseeds had not benefitted from the technological advances made during the Green Revolution. In fact, even those crops and regions which had reaped the benefits of Green Revolution had reached saturation point. While all crops had benefitted from the technological changes in some parts of the country, the gains in pulses and oilseeds was restricted to a few states. The TFP of paddy and wheat was notably the highest since these two crops were the focus of the Green Revolution. However, even though the TFP of wheat continued to grow in Punjab and Haryana, the TFP of rice in these two states started declining. On the other hand, in the second phase, the TFP of paddy showed an increasing trend in all the eastern states. To sustain high TFP growth rates, there has to be a continuous increase in input levels. But this is not sustainable. Overall, the decline in public sector investment, research, and extension led to stagnation in the agricultural sector in the post Green Revolution years. Another important issue pointed out by the authors pertained to excessive irrigation, deep percolation and seepage losses due to ineffective drainage systems. This according to the authors could cause problems like water logging and soil salinity in irrigation project areas. Thus, they concluded that TFP growth was retarded across the country due to exhaustion of soil nutrients and the depletion of ground water in the Indo Gangetic Plains (IGP) had resulted in degradation of land and other environmental problems.

Ray (2007) has studied the impact of availability of credit on cropping pattern in West Bengal. According to him, the adoption of new technological inputs is greatly constrained by the availability of credit. While the nationalisation of banks has greatly increased the availability of institutional credit, the beneficiaries are mostly large farmers with easy access to banking facilities. On the other hand, the millions of small and marginal farmers who are remotely located are largely dependent on non-institutional credit. This hampers their ability to adopt new technology and they continue to remain subsistence farmers. Easy availability of credit enables farmers to adopt better technology and inputs, shift to high value cash crops and thus enables them to earn higher levels of income.

Both secondary and primary data relating to area under crops, credit, etc. have been used in this study. The secondary data was collected from various Government publications. For field level survey, data relating to the research problem have been collected from 160 farm households belonging to six villages spread over the three agro-climatic zones. The credit availability was used as a criterion to classify farm households into four categories viz., farm households with credit (both institutional and non-institutional credit), farm households with only institutional credit, farm households with only non-institutional credit and farm households without credit. After the classification of farmers into above categories, the selection of farm households was made at random. The primary data was collected both by questionnaire and interview method. Various statistical and econometric techniques were employed for the analysis of data. The percentage of area under non-foodgrains to the gross cropped area (NFA) or the ratio of area under non-foodgrains to the area under foodgrains (NFA/FA) was used as an index of cropping pattern change. To examine the impact of credit on the change in cropping pattern across the sample farm households, regression analysis was done.

The findings of the study revealed that availability of credit has a significant impact on the change in cropping pattern, especially the small and marginal farmers. These farmers also earn more returns due to factors like closer supervision of cultivation, exclusion of costs of family labour etc., apart from the availability of credit. Moreover, it was also found that the profit from the cultivation of non-food grains was higher than from the cultivation of food grains. Yet, factors like food security, high cost of cultivation, non-availability of credit at the right time and in right quantity, mixed crop-livestock farming system etc., are proving to be obstacles in the process of shifting the cropping pattern in a big way towards non-food grains. The study also found that there was statistically significant effect where the own funds of farmers plus non-institutional credit was supplemented by institutional credit or where own funds of farmers plus institutional credit was supplemented by non-institutional credit, rather than when own funds of the farmers was supplemented by only institutional credit or only non-institutional credit. Thus, it was found that all small and marginal farmers with access to credit prefer to cultivate non-food grains. Such a shift from food grains cultivation has enhanced the profitability not just for the small farmers but for all categories of farmers. The changing cropping pattern has also had significant impact on employment generation. It should be noted that even non-institutional credit played an important role in changing the cropping pattern in the study area.

Acharya et al (2012) have studied the cropping pattern of Karnataka. The variables like area, production, and productivity of various crops was estimated using the compound growth function. The study was based on secondary data compiled for a period of 26 years from 1982-83 to 2007-08 from the relevant government departments. It was found that in the cultivation of cereals, the cropping pattern showed a movement away from coarse cereals to rice and maize. While rice production had increased due to increase in its productivity (as per the post green revolution trend all over India), maize production increased due to increase in area as well as productivity. Pulses showed a good amount of increment in area (due to remunerative prices), production, and marginal improvement in productivity due to institutional efforts at improving seed quality and varieties. As far as oilseeds are concerned, the growth in all three variables was very modest. While the growth in production of commercial crops was seen to be insignificant, the growth rate in area, production, and productivity of horticultural crops was highly significant.

Chand and Paruppurathu (2012) have studied the temporal and spatial growth in Indian agriculture. According to them, growth in agricultural sector has been uneven in India with respect to both time and place. The green revolution technologies introduced in the late 1960s played an active role in increasing the growth rate from below 1% to 3% within a short span. During this period, the widespread dispersal of technology helped in maintaining the high growth rate kick started during the initial stages of the green revolution period. Later on with greater diversification towards horticultural and cash crops, crop growth became more broad based. But due to the diversion of resources away from agriculture during the post-reform period as well as sluggish investment (both public and private) there was a decline in the growth rate of many major crops and the agricultural sector in general. The use of primary inputs in the sector also slowed down, which resulted in the yield levels of many crops stagnating or even declining up to 2004-05. After 2005, there was a remarkable strategic change which focused on hiking both public and private investment as well as improving the terms of trade favourably for the agricultural sector. As a result, there was substantial increase in agricultural credit as well as prolific increase in the distribution of good quality seeds. Another favourable factor for increasing farm production was remunerative prices of farm products. Agricultural growth spurred by rewarding prices is welcome so far as it improves the income levels of the farmers. However, whether such growth is sustainable, to what extent the farmers can be provided with incentives to continue with the highly risky profession of agriculture, and how efficiently the resources are used in the agricultural sector will decide the future trajectory of growth in this sector.

Mandal and Bezbaruah (2013) compiled primary data from 342 randomly selected farms from flood prone villages of Assam in order to establish the factors determining their cropping pattern. The data was collected from four non-contiguous districts of the Brahmaputra and Barak river valleys of Assam with varying degrees of exposure to floods - high, occasional and low flood levels. Their study revealed that the cropping pattern in Assam had generally shifted from kharif to rabi cropping given the very high levels of precipitation during the monsoons which invariably destroyed the crops. The farmers in the regularly flooded areas found that the rich alluvial soil left behind by the floods could be taken advantage of to the fullest by intensive cultivation in the flood free months. This could also be one of the reasons for crop diversification in the high risk areas. The areas with occasional flood risks and hence greater uncertainties, however, did not show greater crop diversification. Thus, the authors concluded that crop diversification in Assam was a strategy adopted not for minimizing risks. However, since the farmers in regularly flooded areas had experienced a rise in income due to crop diversification, the authors could conclude that crop diversification played a significant role in increasing farm income. The authors have also argued that access to irrigation and institutional credit enables farmers to go in for crop diversification.

In his paper, **Saha (2013)** has studied the crop diversification and/or crop specialization that took place at the state level between 1990-91 and 2008-09. The study was undertaken with the objective of exploring the trends and levels of crop diversification in the country as also to identify the major emerging crops in the various states. For this purpose, the secondary data from the Statistical Abstract of India (1991) and the official website of the Ministry of Agriculture and Cooperation, Government of India was collected and analysed. The Harfindahl-Hirschman Index was used to calculate the magnitude of diversification. For the purpose of analysis selected twelve crops (Rice, Jowar, Bajra, Maize, Ragi, Wheat, Pulses, Oilseeds, Cotton, Sugarcane, Coconut and Fruits & Vegetables) were grouped into 3 categories- food crops, commercial crops and horticultural & plantation crops. It was found that except for Bihar, Karnataka, Tripura and Punjab, almost all the states experienced an increase in the percentage share of area under commercial crops and/or horticultural and plantation crops and a decline in the percentage share of area under food crops. The four states which are an exception saw an increase in the percentage share of area under food grains due to increase in population, increasing demand for food and food habits of the people. Such a picture clearly revealed that food crops were not solely important and both commercial and horticultural crops had become important in the country, may be due to profitability and change in people's taste and preference.

During 2008-09, Karnataka, Maharashtra, Goa, Kerala, Rajasthan and Gujarat were the most diversified states, while states like West Bengal, Assam, Mizoram, Manipur and Tripura showed lower levels of crop diversification. Tamil Nadu, Meghalaya, and Andhra Pradesh also showed higher levels of crop diversification. Thus, Western and South- Western regions showed higher levels of crop diversification due to greater dominance of horticultural and commercial crop and Eastern and North-Eastern region experienced lower levels of diversification due to the dominance of rice and fruits and vegetables. Moreover, while Meghalaya, Goa, Nagaland, Maharashtra, Andhra Pradesh etc., moved towards greater crop diversification states like Sikkim, Madhya Pradesh, Haryana, Bihar, Punjab, Gujarat etc., exhibited a trend towards crop specialization. However, the crops in which these states moved towards specialization, are quite different. Sikkim specialized in fruits and vegetables, Madhya Pradesh in oilseeds, and Bihar in food crops etc. Only three states, namely Karnataka, Jammu & Kashmir and Arunachal Pradesh reported no change in their cropping pattern.

Due to dietary habit, huge domestic demand and traditional food crop farming, suitable geographical conditions and Government procurement system, rice emerged as the top ranking crop in the study. Oilseeds also came out as one of the major emerging crops. This was facilitated primarily due to the Government's Technology Mission on Oilseeds (1986) which initiated augmentation of oilseed production as also a higher tariff barrier on imported edible oil. Fruits and vegetables with increasing level of affordability, health consciousness as well as tireless promotion by National Horticultural Board, also appeared as an important emerging crop. Percentage area under 'fruits & vegetables' was considerably higher in hilly states and few others like Kerala, Bihar and West Bengal. Pulses were a major emerging crop in Western and South Western states as well as in Madhya Pradesh, though its primacy reduced in 2008-09 as compared to 1990-91. Western and South-Western states exhibited a high percentage share of area under oilseeds. Due to diversification towards high-value crops, coarse cereals like Jowar and Bajra were seen to lose importance. Thus, the southern and western states of India exhibited crop diversification to a greater extent thus benefiting the farmers in those regions. As such the study finds some spatial similarity as most socio-economically more developed states also belong to these regions. The study also found that less developed states like Meghalaya, Rajasthan etc., were also moving progressively towards diversification.

The author has argued that though urbanization and its collateral benefits like improved roads and marketing infrastructure played a big role in crop diversification, one cannot ignore the role of geographical conditions in the selection of crops for cultivation. Thus, while low water availability has propelled the cultivation of bajra, oilseeds and pulses in Rajasthan, the hilly terrain of Meghalaya is best suited for cultivation of fruits and vegetables and such crop specialization in this category is taking place here. The author has also placed equal emphasis on factors like technological support, quality input supply, insurance cover and establishment of modern storage-processing centres.

Ayalew and Sekar (2015) have studied the profitability of production of coarse cereals (maize, sorghum,, millets, barley, etc.) in India. For this purpose secondary data pertaining to costs, returns and profitability of coarse cereals' cultivation across various states in India for the period 1980-91 to 2011-12 was collected from relevant government publications. Cost concepts and farm business income measures were used for the purpose of analyzing the above data. The authors have discussed the nutritive value of coarse cereals in providing food security to the subsistence farmers in Asia and Africa (as compared to the superior cereals like rice and wheat). According to them, the gluten free and low carbohydrate nature of these grains is making them popular with the calorie conscious peoples also. Moreover, the demand for these cereals is also increasing due to the new uses these cereals are put to in industrial sector as well as for animal feed. While the production of maize has increased in India during recent times, the cultivation of other coarse cereals has not increased at the same rate primarily due to lack of remunerative prices for these crops. The authors have pointed out that coarse cereals have to compete with other more remunerative crops in different states like pulses, oilseeds, cotton or sugarcane; in some cases, coarse cereals even compete with each other. Their profitability analysis has showed how the increase in yield reduces the cost of production and thus results in greater profitability for the farmer.

In their literature review, **Kumar and Gupta (2015)**, refer to Acharya's description of crop diversification as a tactic to maximize the use of land, water, and other natural resources for the overall agricultural development and to provide the farmers with viable options to grow different crops in different agro-climatic conditions. According to them, in India crop diversification is viewed as a shift from traditionally grown less remunerative crops to high value more remunerative crops. They further assert that crop diversification also takes place due to governmental policies and thrust on some crops over a given time.

They quote Jorge and Valdes that there is need for agricultural diversification in India as many parts of country have witnessed a huge number of farmer suicides and crop diversification can be effectively used to reduce the risks faced by the farmer both in production and in pricing. They point out that Indian agriculture is also critically influenced by the several restrictions and opportunities offered by the WTO regime which requires India to import food products from abroad at subsidized prices on one hand which might have severe ramifications for Indian agriculture sector; while it also authorizes the production of high-value horticulture and livestock products to meet the ever rising consumption demand by the more affluent foreign as well as domestic consumers on the other hand. They further show that Indian agriculture oversees a greater emphasis being laid upon the cultivation of wheat and paddy which involves some serious social, economic, and ecological implications such as decline in the rate of growth of productivity, fall in agricultural self-employment, excess utilization of groundwater resources and deteriorating soil fertility as brought out by Chand. Thus, as concluded by various studies, they emphasize that agricultural diversification towards horticulture and livestock products can prove to be an expedient solution, thus deepening the employment opportunities while augmenting the incomes of the farmers, scaling down the spatial and temporal irregularities, containing the depletion of natural resources; and also increasing exports.

According to the authors, the growth spurt experienced by Indian agricultural sector during mid 1960's was due to the introduction of high yielding variety seeds, better irrigation facilities and adoption of mechanization in the farming sector. Thereafter, the growth of agricultural output was mainly fuelled by total factor productivity growth or yield growth; wherein, yield witnessed relatively higher growth rates than acreage during the following two decades. Also, the change in the pattern of cropping played a crucial role in agricultural growth in India during the same period. Another noticeable fact was that the agricultural sector performance during eighties had been impressive due to the extension of green revolution technologies in terms of enhanced investments in irrigation facilities and rural infrastructural development. Consequent to these efforts was a sharp growth in productivity, which was reflected by the massive increase in the yield of crops, though a declining trend had been observed for area expansion. On the contrary, during the post-reform period, there had been a change in the cropping pattern, i.e., the share of non-food grains crops such as oilseeds, vegetables, horticultural crops, spices and sugarcane increased as compared to food grain crops. Following the economic reform in India, it was realized that the changing pattern of crop was primarily attributable to the relative price changes among various crops and crop diversification, which took place after the economic reforms.

The result of their analysis shows that the main determinants of crop diversification in India included irrigated area as percentage of gross cropped area, consumption of fertilizer, cropping intensity, agricultural export, education, direct institutional credit for agriculture and size of average land holdings. Size of small holdings is found to be positively associated with the crop diversification. However, small farmers suffer due to lack of access to price support, cold storage facility, transport facility, market facility, agriculture credit facility and crop insurance facility. Therefore, according to the authors, policy supports in terms of price protection, insurance coverage, expenditure on agricultural research & education, subsidized inputs and technology should be extended to them.

Nayak (2016) studied the structure and nature of cropping pattern, crop diversification, crop concentration, productivity level and inter-districts disparity in the state of Odisha based on the secondary data collected for the period 1980 – 2005. The study has used Herfindahl index, location quotient, Gini coefficient and panel data regression for analysis. The study revealed that most of the districts in Odisha experienced a lateral movement towards crop specialization and crop diversification was seen only in tribal-dominated / technologically less-developed districts. The study observed a reduction in inequality during the study period and concluded that districts in Odisha converged as far as agricultural productivity was concerned. The study revealed that Odisha was basically a mono-crop (rice) state. The reasons behind increasing preference for production of rice were irrigation facilities and provision of minimum support price (MSP) by the government for this crop. An assured and increasing price of rice vis-à-vis other crops resulted in a higher preference for rice cultivation. Thus, there has been a move towards specialization rather than diversification as a result of agricultural development in the state. The crop concentration index showed that out of 30 crops grown in Odisha, the focus was only on following 7 crops: Rice, Maize, Ragi, Niger, Mustard, Til, Groundnut and Turmeric. In all the 13 districts, the value of concentration index for rice was higher than for rest of the crops grown in Odisha in all the five sub-periods from 1980 to 2005.

Dandekar and Bhattacharya (2017) have studied the cause of distress in the agrarian sector and high suicide rates of farmers in Yavatmal district in Maharashtra as well as Sangrur district in Punjab. While high levels of indebtedness figured as the foremost factor for rising suicides, the authors identified other factors which included faulty cropping pattern, rising input costs, aspirational consumption and absence of non-farm sources of income. In fact, one can say that faulty cropping pattern coupled with factors like climate change and lack of irrigation have led farmers to the brink year after year. The cultivation of Bt cotton in Yavatmal which is entirely dependent of rainfall has been disastrous for farmers; there has been crop failure year after year due to several reasons like lack of timely rainfall after sowing or excessive rainfall after sowing or hailstorms before harvest. Similarly, the cultivation of paddy which requires 4000 – 5000 litres of water to cultivate one kg of rice has resulted in deleterious effects on the water table in Sangrur district. The small farmers are particularly hard hit since they have to dig deeper bore wells every year without being sure whether they will find enough water to sustain them for the foreseeable future and the cost of such digging is directly proportional to the depth of the well and not the size of the land holding. The author has pointed out that farmers have abandoned indigenous cropping patterns which were not only suitable for their respective regions but also sustainable in terms of fodder and soil rejuvenation.

Mohan (2017) studied the cropping pattern in Andhra Pradesh for the period 1969-71 to 2004-05. The study conducted across three regions viz., Coastal Andhra Pradesh, Telangana, and Rayalaseema considered various factors affecting cropping pattern like percentage of gross irrigated area in the gross cropped area, number of tractors, rainfall, fertilizer application etc. Regression analysis was done to arrive at the correlation of the variables with crop substitution. The study revealed a shift in the cropping pattern away from cereals like rice and sorghum towards more high value crops. Among the crops which found favor with the farmers included maize as a leading replacement for rice. Other crops which witnessed a positive growth in production across regions included pulses (bengal gram, red gram and chick pea), sugarcane, oilseeds (sunflower), tobacco, and fruits and vegetables. The author has suggested that a shift in the cropping pattern away from rice may have been caused due to lack of irrigation. The author also suggests that farmers' opinion have brought about a change in the cropping pattern from low value cereals crops to high value commercial crops.

2.4 REPORTS

In their paper, **Sawant, et al (1999)** have made a detailed analysis of the agricultural economy of Maharashtra with reference to its irrigation development, land use pattern, cropping pattern, trends in cropping intensity, average productivity of important crops, sources of output growth etc. According to the report, while the share of agriculture in the net state domestic product of Maharashtra fell from 36% in 1961-62 to 18.7% in 1992-93, the proportion of labour force engaged in agriculture was 60% even in 1991; the share of the state's rural labour force employed in agriculture (main workers only) was as high as 83%, nearly half of the agricultural workers being labourers. The study period covered the post green revolution period between 1967-68 and 1992-93 for the state level analysis and from 1967-68 to 1990-91 for the district level analysis. Further, the entire study period was split into two periods: Period I from 1967-68 to 1979-80 and Period II from 1980-81 to 1992-93 or 1990-91 as the case may be. Since the years 1971-72, 1972-73, 1986-87 and 1991-92 were the worst drought years in Maharashtra, these four years have been omitted for state level analysis and the first three years have been omitted for district level analysis. The districts covered included twenty five districts excluding the Greater Bombay district and all the seven administrative divisions in the State as they existed in 1981.

In all 24 major crops and four major crops categories were included in the state level analysis. They were: (i) cereals (ii) pulses (iii) oilseeds and (iv) all crops. The district level analysis was, however, restricted to only four major crop categories and in addition, covered two crops, namely, sugarcane and cotton. The fourth category i.e. of 'all crops' covered 26 major crops, at the State level and only 25, i.e., excluding safflower, at the district level and represented gross value of output of crops covered at 80-81 prices. The series was specially generated to examine aggregate growth performance of the crop sector at the state and district level, using the price base of 1980-81. For generating gross value of output series, farm harvest prices of 13 major crops as provided in the State's Season and crop Reports were used. For the remaining crops, prices prevailing in the major wholesale markets of the relevant commodity in the state were used. State level crop statistics i.e., areas, production and yield per hectare of crops and crop aggregates were drawn from the official publications of the Directorate of Economics and Statistics, Government of India whereas the district level crop statistics were taken from the various issues of Season and Crop Reports of the

Maharashtra State. Additionally, the data relating to land utilisation, crop pattern, irrigation, farm harvest prices, livestock census etc. were also drawn from the Season and Crop Reports.

The findings of the report are discussed below:

According to the report, aggregate crop output growth was over 5% in Period I, but fell drastically in Period II to around 2.36%. The main cause for such a fall was a decline in crop yields during this period, specifically the yields of cereals and sugarcane. While the growth rate in the yield of cereals fell from 5.92% in Period I to an all time low of 1.75% in Period II, the growth rate in the yield of sugarcane actually went from a high of 3.82% in Period I to a negative growth rate of -1.33% in Period II. This fall in the yield levels took place in spite of a progressive increase in the rates of expansion of many key inputs like fertilisers, pesticides, electricity etc. from the pre1981 to the post 1981 period thus indicating a fall in the growth of total factor productivity in the agricultural sector. While unfavourable rainfall conditions were only partly responsible for the decline in yield growth rates, the decline in the total factor productivity could be attributed to the several other reasons according to the authors. These include a lack of development in seed technology for cereals like rice, jowar and maize, especially grown under rain fed conditions; non introduction of new varieties for sugarcane which is an important cash crop; lack of incremental irrigation to cereals; inefficiency in the use and management of inputs, particularly for heavy-input using crop like sugarcane. Thus, a fall in the output and yield growth rates of cereals and sugarcane (which constitute around 68% weight in the state's all crop index) would have created a serious dent on the agricultural sector. But the increase output growth for pulses and oilseeds after 1981 helped offset the above decrease. Moreover, cotton production grew steadily at 2% while a few high value vegetable and fruit crops rendered support to the growth in the agricultural sector. It should be noted that except for cotton and pulses, the growth in output for all other crops took place due to increase in area. Thus, changes in cropping pattern played a pivotal role in supporting agricultural output growth after 1981. The major beneficiaries of these changes were oilseeds, other minor high value crops, pulses and sugarcane in that order. It must also be brought to light that changes in cropping pattern was alone not responsible for continued moderate growth in crop output post-1981. Use of new technological advances in the form of short duration HYVs, fertilisers, pesticides etc., spread from cereal crops to other crops like green gram, black gram, groundnut, sunflower, soybean etc., during the eighties which led to significant growth in their yield per hectare. Rainfall also plays a significant role in the development of agricultural sector in Maharashtra with only 15% of the cropped area being irrigated by 1994. The increasing diversion of irrigation to sugarcane crop during the eighties was accompanied by a decrease in the yield of sugarcane per hectare in almost all the areas growing the crop.

In conclusion, the report throws light on the future growth prospects of the agricultural sector. According to the authors, since yield levels of all major cereal and non-cereal crops have plateaued since late 1980s, an increase in the crop output levels could only be achieved by focusing on achieving integrated and efficient management of all inputs, conventional and non-conventional. Instead of targeting use of specific inputs like seeds, fertilisers or pesticides in isolation, the balanced use of fertilisers, organic manures and integrated pest management should be the future approach. Moreover, the demands of commercialisation in agriculture requires technological development to cover both cereals and non-cereals and devise varieties for more heterogenous environments in the rainfed farming areas of the state. This would require the evolution of farming systems and cropping sequences/mixes etc., for promoting rapid rise in the aggregate land productivity rather than aiming at large increases in the yields of a few individual crops through highly input-intensive technologies. According to the report, these two proposed components of the future technology development strategy are not only highly mutually compatible but would reduce progressively the trade-off between the goals of accelerated agricultural growth and environmental conservation.

Kalamkar (2007) has analyzed the agricultural growth and the factors impacting output growth in the state of Maharashtra for almost 40 years from 1961-62 to 1997-98. The study period was divided into three segments (1961-62 to 1971-72, 1971-72 to 1981-82, and 1981-82 to 1997-98). The author found that the there was a significant rise in the gross cropped area (25 lakh hectares) during the study period, a major portion of which was due to an increase in area sown more than once. It was also found that the farmers in Maharashtra had shifted from subsistence farming to commercial crops. This was because crop diversification was taking place towards sugarcane, maize, and fruits and vegetables at the expense of food grains. Thus, all crops recorded an increase in area except jowar, bajra, and wheat. The increase in production and productivity of these crops was pronounced in the second period, while the commercial crops showed evidence of growth in the third period. The growth in yield resulted in increasing production of kharif jowar, paddy, bajra, rabi jowar, wheat, and cotton while expanding area was the prime cause of increasing production in gram, tur, and sugarcane. The growth in the use of inputs like high yielding variety seeds, irrigation, and chemical fertilizers had caused the growth in yield of the major crops. This was in keeping with the trends all over the country.

Jha et al (2009) has studied crop diversification in Indian agriculture and also examined the viability of high value commodities in accelerating agricultural diversification in the country. The study took into account different types of definitions of agricultural diversification; while the first definition is based on a concentration index, the second one is based on the percent of gross cropped area under non-food crops. The study also considered income-based, output-based and resource based agricultural diversification. Thus, income or output diversification was studied at the country level as well as state and resource diversification was examined at the level of country, state and district. After studying resource diversification at the country level as also involving states; one of the relatively progressive states, Haryana was chosen purposively to study diversification at the levels of state involving districts of the state. Lastly, an average farm was chosen to study diversification at the micro- level. The reference period of the study largely deals with the post 1980s but varies across the analysis depending on the availability of data. The authors believe that diversification and concentration are two sides of the same coin; i.e., if production of a commodity is concentrated in a few states, the study presumes that diversification in the production of that commodity across various regions has not taken place. The percent share of a commodity during the reference period was based on the share of states in the aggregate production of a commodity.

While the share of agriculture in India's GDP has been steadily declining over the years, the share of livestock and fisheries has shown prominent structural change which has caused their share in the GDP to rise. The data analyzed does not reveal any notable improvement in the diversification indices during the study period. In fact, data from certain states showed a trend towards crop specialization. In fact, the production basket of a commodity showed lower levels of diversification, i.e., states were moving towards specialization in the production of a commodity as per the resource endowment and institutional arrangements for that commodity in that particular state. In fact, the authors discovered that even within commodity groups, the dispersal of acreage varied. For example, in the case of coarse cereals, while the percent area under sorghum and barley showed a decline, the area under maize and bajra showed increase in acreage during the study period. Again, various states exhibited specialization in particular crops. The overall picture which the authors got was that the area under horticultural crops had shown remarkable increase, while the area under oilseeds and fine cereals had remained mostly unchanged. However, this did not mean that the supply of fine cereals would be affected. This was because at the micro-level, the diversification trends were not the same as those observed at the macro level. Haryana's example showed that farms in particular regions were moving towards specialization of those crops which were more remunerative. The study also showed that acreage under pulses and coarse cereals showed a declining trend since 1970's; however, that trend stopped in the 90's. Even the acreage of commercial crops had not changed much recently. Thus, the shifts in cropping pattern in specific regions/states was caused by the favourable institutional framework and remunerative prices obtained by the farmers.

In his report **Kannan (2011)** has discussed in detail the cropping pattern of various states including Maharashtra, Karnataka, Punjab and Himachal Pradesh between 1960-61 and 2004-05. With regard to Maharashtra, the author states that while Maharashtra is one of the economically most developed states in India, it is not counted among the advanced states in the country in terms of agricultural production. This is primarily because agricultural production in Maharashtra is highly unstable with significant regional variation in the performance of various regions across the state. One of the critical reasons for this is that 83 per cent of the cropped area in the state is cultivated under rainfed conditions. Even though Maharashtra receives the highest amount of rain during south-west monsoon, its timeliness and spread across months as well as across different regions is highly unpredictable. The author refers to Narayanamoorthy and Kalamkar in quoting that except for 10 districts of the 34 districts in the state, the normal rainfall of all other districts is less than the state's average normal rainfall. Nearly a third of the cropped area falls under rain-shadow region where the rains are scanty and erratic and dry land cultivation is the common practice in these areas. Thus, while irrigation assumes a high level of significance for agriculture in Maharashtra, and the state also has one of the largest irrigation sectors in the country both in terms of the number of large dams and the live storage capacity, the proportion of gross area irrigated to gross cropped area stood at 18 per cent as against about 43 per cent at the national level during 2006-07. The low level of irrigation as well as the unreliable rainfall discourages farmers to take up intensive cultivation in the state. Kannan has further stated that despite poor irrigation facility, the intensive cultivation of crops like sugarcane and horticultural crops resulted in the area cultivated increasing from 3.18 per cent in 1962-62 to 15.65 per cent in 2004-05. Kannan goes on to discuss the changes in the cropping pattern in the state and states that while area under cereal crops declined mainly because of substantial reduction in area under jowar, the total area under pulse crops has increased even though the productivity of pulse crops has been lower in the state primarily due to the non-availability of alternative crops suitable to rainfed conditions. He further shows that though area under groundnut decreased significantly, the total area under oilseed crops showed a marginal increase in the study period primarily due to the impressive increase in area under soybean since early 1990s. Finally, he shows that the share of sugarcane area in Gross Cropped Area has increased from 0.78 per cent in TE 1962-63 to 3 per cent in 2000-01, but fell to 1.98 per cent in TE 2004-05. According to him, continued support to the sugar industries from the state government encourages farmers to cultivate this water intensive crop. He suggests the strict enforcement of rules to discourage the cultivation of sugarcane under flood or conventional method of irrigation considering the severe water scarcity in the state. This is especially because of the fact that out of the total irrigated area of 3.86 million hectares available during TE 2000-01, food grain crops such as paddy, wheat, jowar and bajra together accounted for only 38.05 per cent, while sugarcane alone accounted for 16.87 per cent, and pulses and oilseeds together accounted for about 14.0 percent with only about a quarter of the area under groundnut being irrigated. Thus, Kannan refers to Rath and Mitra in showing that the net returns per unit water generated by sugarcane is very low. He points out to the World Bank report in 2002 which has estimated that nearly two-third of the irrigation water available in the state is used only by sugarcane.

Kannan has further made a detailed analysis of the area, production and productivity of principal crops in the state. With reference to maize, he shows that unlike other coarse cereals, the area, production and productivity of maize has increased significantly during the overall period at 9.44% (1990-91 to 1999-00), 12.09% (2001-02 to 2004-05) and 2.42% (1990-91 to 2004-05) respectively. Except in Ahmednagar and Solapur districts where the growth in productivity was negative, all the other major maize growing districts had experienced an increase in area and production. Most of the poultry farms are located around the metropolitan cities like Pune and Nashik and maize is the main feed source for poultry which accounts for about 70% in total production cost of broiler. Hence, increase in area was due to the ready demand for this crop in those areas while the increase in productivity was due to the readily available new seed and inputs at the market.

With reference to Soybean, Kannan states that Maharashtra is the second largest soybean growing state in the country accounting for about 25% of the area and 33% of India's production with Amravati, Nagpur and Latur divisions as the main regions where this crop is mostly grown. According to Kannan, the area, production, and productivity of soybean increased significantly at 15.48% (1990-91 to 1999-00) , 18.01% (2001-02 to 2004-05) and 2.19% (1990-91 to 2004-05) respectively. Except for Bhandara district, all other major soybean growing districts had recorded substantial increase in area and production during the study period. Farmers in Vidarbha are especially shifting in a big way from cotton, jowar, tur and other traditional crops to soybean due to its higher yield and remunerative price.

With reference to sugarcane, Kannan states that Maharashtra accounted for about 22% of the national production of sugarcane in 2006-07. Sugarcane had been repeatedly cultivated in Western Maharashtra over the four decades since the green revolution. However, he shows that area under sugarcane had decreased at the rate of 1.06% as also its production by 0.29% during the study period. The sugarcane productivity was almost stagnant during the period 1990-91 to 2004-05. This is because of sugarcane monocropping due to which not only the soil fertility has deteriorated over the years, but productivity also stagnated or declined due to certain pests and diseases associated with cultivation practices.

Kannan and Sundaram (2011) have authored a report on the trends in India's Agricultural Growth. In order to ascertain the trends in the agricultural sector at the national and state levels, secondary data pertaining to area, production, input use and value of output was collected for a period of four decades (1967-68 to 2007-08). It was found that the since the total area under cultivation had remained relatively unchanged, increasing demand for food due to higher levels of urbanization and population had led to increasing crop intensity as well as replacement of food crops by commercial cops. The fall in the area under food grains, mainly due to declining area under coarse cereals was taken up for cultivation of more lucrative crops like oilseeds, horticultural crops and non-food crops. While area under rice remained more or less constant, area under wheat cultivation showed an increasing trend for the study period. It was also proven conclusively in the report that technology and institutional support for rice, wheat and plantation crops were instrumental in influencing the cropping pattern across states.

Vishandass and Lukka (2013) have authored a Discussion Paper on Pricing, Returns, Costs and Productivity in Indian agriculture for the Commission on Agricultural Costs and Prices (CACP). The CACP was established in January 1965 along with the Food Corporation of India (FCI). The CACP was mandated to recommend minimum support prices (MSPs) to incentivize the cultivators to adopt modern technology, and raise productivity and overall grain production in line with the emerging demand patterns in the country. On the other hand, as and when the market prices fell below the MSP, the FCI was required to fix the floor price by procuring grain at MSP. In 1985, NAFED came into being with a mandate to provide price support operations for pulses and oilseeds, whenever their market prices went below the MSPs announced by the Government. As on date the 23 commodities for which the CACP recommends the MSP are as follows: 7 cereals (paddy, wheat, maize, sorghum, pearl millet, barley and ragi), 5 pulses (gram, tur, moong, urad, lentil), 7 oilseeds (groundnut, rapeseed-mustard, soyabean, sesamum, sunflower, safflower, nigerseed), and 4 commercial crops (copra, cotton, raw jute and sugarcane). While cost of production is one of the key factors in determining MSPs, the pricing policy of CACP takes into consideration several other factors which include overall conditions in the domestic and international markets, price parity between crops, effect of MSPs on consumers, terms of trade between agriculture and non-agricultural sector etc. Further, the sustainable practices adopted in the production of various crops are also taken into account in the process of recommending their respective MSPs. However, the Commission also recognizes that since MSPs are only indicative in nature, the profitability of a crop is determined by its market price which is actually accrued to the farmers. As such, this study was undertaken with the intention of understanding the process of fixing MSPs as also to discover the true levels of profitability of specifically those crops for which MSP was recommended. The paper also looks at the relationship between costs and productivity, the hypothesis being that with rising productivity, real costs go down and the probability is that it will lead to greater competitiveness and higher returns to farmers. The study revealed that inverse relationship between real cost and yield levels holds good for 18 out of 21 crops analyzed (bajra, jowar and lentil being aberrations), real costs (CoP) could be reduced by 5 to 10 percent (in cases of maize, tur, soyabeans, barley, nigerseed, ragi, urad, R & M, and safflower), and between 2 to 5 percent (in cases of paddy, groundnut, cotton, wheat, gram, moong, sesamum, sunflower and sugarcane) if their respective yield levels increase by 10 percent. Thus, the real cost of production can be contained by improving land productivity. It was further revealed that MSP covered nearly 90 percent of C_2 cost for very few crops like sugarcane, barley, paddy, and wheat while in the case of lentils, sunflower or tur, the MSP barely covered 50 percent of the C_2 cost. Since C_2 cost covers both explicit and implicit costs of the farmers, it becomes evident that farmers would prefer to cultivate the crops belonging to the first group (paddy-wheat, sugarcane) over oilseeds or pulses. Moreover, the study also showed that gross returns per hectare as percentage of paid out cost plus family labour (A_2+FL), was the highest in the case of sugarcane at Rs. 82800/ha. This was followed by cotton at Rs. 29100/ha and wheat at Rs. 24300/ha. It should be kept in mind that the gestation period for sugarcane (from sowing to harvest) is also higher at over 10 months as compared with 3 to 6 months for other crops.

Bhadwal, et al. (2014) have authored a report for The Energy and Resources Institute based on a study in Jalna district of Maharashtra. While climate change is playing havoc with all kinds of ecosystems, dry lands are especially vulnerable and the populations which are dependent on the primary sector are hard hit. The authors have undertaken this study with the objective of understanding the impact of climate change and extreme events like drought on agriculture and water resources, particularly in nine villages in the dry lands of Jalna district in Maharashtra. This report is based on the results of a two-year Indo-Norwegian research and capacity development project, 'Extreme Risks, Vulnerabilities and Community-Based Adaptation in India (EVA): a pilot study' (2012–14). For this study, the authors have reviewed relevant secondary data and consulted various stakeholders in the respective communities as also the block and district level officers. The impacts which climate change have had on the agro-ecosystem so far as well as the impacts it is likely to have in future were highlighted. The impact of other factors like socio-economic and land use changes on the agro-ecosystem was also recognized. The important findings of the report included the following:

There has been a shift in the cropping pattern of Jalna district away from cereals and pulses. While bajra was the major kharif crop up to early 2000s, and rice was cultivated over a small area in the early 2000s, it has been replaced by maize over time. However, a large proportion of the area continues to be under jowar and bajra which are suitable climatically in the region. Under the National Horticultural Mission, the cultivation of fruit crops like mango and sweet orange was given impetus. Similarly, the policies favouring diversification towards oilseeds led to the widespread cultivation of soybean and it showed an 88% increase in production between 2000 and 2010. Among cash crops, cotton showed 52% growth during the same period with a very modest area covered by sugarcane. Another area of good performance was in rabi pulses with area under it doubling during the study period. It was also found that the productivity of almost all crops (including sugarcane, cotton and maize) had increased. The adoption of better varieties of crops as well as farm management practices was instrumental in this respect. Thus, it was seen that the adoption of appropriate policies has guided the shift in the cropping pattern of Jalna towards crops like cotton, oilseeds and pulses which are suitable for growing in its dry lands.

The ICRISAT report authored by **Pramanik et al (2015)** analyzed the changes in cropping pattern in Akola villages (Kanzara and Kinkhed) over a period of four decades, between 1975 and 2013. The report found that the cropping pattern in the villages had changed significantly from one based on cotton to one based on soybean. The chief motivation for such a shift was the possibility of alternating kharif soybean with wheat or chickpea in the rabi season thus boosting their income levels. It was also found that availability of seed subsidy, supplementary irrigation in rabi season, and lower labor requirements for soybean/chickpea/wheat coupled with extremely volatile cotton prices had facilitated such a change.

Sharma et al (2018) in their study for **NABARD AND ICRIER** focused on the sustainability of the current cropping pattern in India considering the fact that water is increasingly becoming a scarce commodity. This paper calls for focusing on increasing agricultural productivity per cubic meter of water supplied and /or consumed rather than obsessing over increasing agricultural productivity per hectare of land. Ideally, allocation of resources should happen in the most efficient manner in a market economy through the pricing mechanism. But populist measures like free water and free power in various regions of the country have led to a distortion in the allocation of water, an already scarce resource. Not only has this distortion favoured large farmers, it has also led to hazardous environmental effects like depletion of ground water reserves. Thus, out of the 78 per cent of fresh water being diverted to agriculture, only 48 per cent of the gross cropped area has been brought under irrigation in the country. Out of this, paddy and sugarcane crops together occupy one-fourth of the gross cropped area and consume over 60 per cent of the total irrigation water supplied to agriculture, thus depriving most of the other crops of irrigation.
This paper asserts that the objective of agriculture development should not be of raising productivity per unit land but increasing productivity per unit water, especially irrigation water.

In a first of its kind, this study attempts to develop maps and charts for water productivity of major Indian crops. Through a better understanding of water usage, the report aims at helping policy and investment decisions which will lead to improvement in the usage of agricultural water. For this purpose, the cropping patterns adopted with regard to 10 major crops covering more than 60 per cent of gross cropped area across states were studied. The study is spread across all the 640 districts and provides detailed analysis for dominant districts and states. The water productivity calculated for the 10 major crops include cereals (rice, wheat, maize), pulses (chickpea, tur), oilseeds (groundnut, rapeseed-mustard), commercial crops (sugarcane, cotton) and horticultural crop (potato). Physical water productivity (crop output per unit of total consumptive water used (TCWU)), Irrigation water productivity (crop output per unit of irrigation water applied by farmers) and Economic water productivity (value of crop output produced per unit of TCWU as well as irrigation water applied) were analyzed for the crops from these perspectives. These parameters were then mapped to indicate the suitability of crops in various regions with respect to availability of water. The findings of the study showed that the physical water productivity (PWP) as well as irrigation water productivity (IWP) of rice, wheat and sugarcane was significantly lower than their corresponding land productivity across major states. The perverse relation between land productivity and irrigation water productivity was especially pronounced with respect to rice and sugarcane in Punjab and Maharashtra respectively.

Punjab reported the highest land productivity of rice (4t/ha). In Punjab and Haryana, the PWP was also high to the tune of 0.57 kg/m^3 and 0.4 kg/ m^3 respectively. But the inefficient use of irrigation water was seen from the fact that IWP in both these states was quiet low at 0.22 kg/m^3. The existing almost free electricity policy in agriculture in Punjab and Haryana has led to indiscriminate groundwater exploitation (depleting water table at the rate of almost 70 to 120cm/year according to the World Bank report, 2010) and indiscriminate use of water in agriculture. The high land productivity owing to assured irrigation, added with effective and assured procurement policy for paddy further encourage farmers to cultivate this crop despite the rising water sustainability issues. In contrast to Punjab and Haryana, states like Chhattisgarh and Jharkhand which displayed high irrigation water productivity have low irrigation coverage (32 per cent and 3 per cent respectively) and subsequently lower land productivity. The under developed procurement policy for paddy and low power supplies to agriculture in these states further resulted in lower profitability levels of rice cultivation in these states, despite the hydrological suitability of the region. Thus, the study found that there exists a serious misalignment in rice cropping patterns with respect to the water resource availability in India.

For sugarcane, Tamil Nadu reported the highest level of land productivity (105.3 t/ha) as well as PWP (14.01 kg/m^3). As in the case of rice, a perverse relation existed between land productivity and IWP in sugarcane also. The tropical belts of Uttarakhand, Uttar Pradesh and Bihar reported higher levels of IWP but lower levels of land productivity At the same time, the sub-tropical belts of Tamil Nadu, Karnataka, Maharashtra and Andhra Pradesh had high land productivity but lower levels of IWP values. This indicated the stated mismatch between sugarcane cropping pattern and water resource availability, which needs to be corrected by suitably adjusting the price of power and irrigation water, and by promoting more efficient technologies (such as drip) for irrigating sugarcane crop in these regions. The sugar licensing policy of preferring cooperatives sugar factories over private ones was one of the major reasons for the shift in the sugarcane growing belt from Bihar and eastern Uttar Pradesh towards the water stressed sub-tropical belts of Maharashtra, Karnataka and Tamil Nadu. But this is not in line with water resource endowment of the region.

The study concluded that at the present level of water stress existing in the country there was a need to re-calibrate the cropping patterns in line with their IWP (particularly for water guzzler crops like rice and sugarcane), and not remain obsessed with only their land productivity. Otherwise, the country will move towards unsustainable agriculture from water availability point of view, raising risks for the farmers, and promoting extreme inequity in the use of scarce water resources.

2.5 THESES

Pune district was selected for the doctoral thesis by **Patil (2012**) due to various reasons. One of them was that the study region falls into separate geographical regions having diversified rainfall relief characteristics. Moreover, irrigation is an influencing factor in the study region. The research was undertaken to make an in-depth and comprehensive study of agriculture land use in Pune district. Among its various objectives, the study intended to identify crop combination and diversification in the study region, establish relationship between selected variables and suggest measures for better agricultural land use in Pune district. The study was based on both primary and secondary sources of data. The published sources of relevant government departments were used for secondary data. Primary data was obtained for three sample villages through questionnaires. The data for general land use and agricultural land use was taken for the years 1980-81, 1985-86, 1990-91, 1995-96, 2000-01 and 2005-06. The population data was taken for census year of 1981, 1991 and 2001. The spatial distribution of agricultural crops and their temporal variations were studied for the period from 1980-81 to 2005-06 and to identify the possible causes responsible for agricultural land use pattern. The temporal variations in agricultural land use were studied for twenty-five years (1980-2005) with an interval of five years in the study region. The questions in questionnaires consisted of crop land use, farmers' education, income from various sources and problems regarding agriculture and allied sectors. Besides this, information from Talathi, Gramsevak and Sarpanch were gathered. The village level land use data was collected for the year 2008-09 and 2009-10. The obtained data was then mapped by using suitable method as diagrams and graphs for showing land use pattern. For delineating crop region, Doi's crop combination technique was applied to identify the crop combination regions and Gibbs-Martin Index was applied for diversification region. Further, the relationship between selected variables was established using correlation coefficient, multiple regression and Factor Analysis techniques. Ten crops were considered for computing crop combination regions in the study region by applying Doi's method. Six crop combination regions, namely, monoculture, two, three, four, seven and eight crop combinations were identified.

The study gave the following insights into Pune's cropping pattern:
In this study the author has attempted to delineate agricultural regions by applying crop ranking, crop combination, crop diversification methods and Factor Analysis technique. It was found that jowar, rice, bajara and fodder crops were first ranking crop. Following them fruits and vegetables and sugarcane occupied large area in the region. A high level of crop diversification was seen in ten talukas while moderate crop diversification was seen in three talukas. As the areas under high diversification covered 63.99 percent of the cropped area, it showed that the study region displayed a good level of agricultural development. The author has identified the relationship between eighteen land use variables which include eight crops and factors like net sown area, fallow land, irrigated land, rainfall, population etc. Moreover, Factor Analysis technique revealed that the talukas of Shirur, Indapur, Baramati and Daund were found to be most developed in the study region due to fertile soil types, irrigation facility and hence higher net sown area brought under sugarcane and other cash crops which have also shown higher yields.

Tupe (2014) studied agricultural land use and village wise cropping pattern in Akole tehsil of Ahmednagar district where agriculture is a predominant activity. The study area is well known for rice production but sugarcane, jowar, bajra, wheat, pulses, oilseeds, cotton, floriculture, fruit crops, vegetable crops and fodder crops are also prominent crops cultivated in the region. Besides this, there are many crops locally grown which depend on prevailing environmental conditions. The author has undertaken the study with several objectives, chiefly among them being the study of changes in cropping pattern from 1990-91 to 2010-11 in the study region. According to the author, irrigation facilities, modern techniques, geographical conditions, government policies and economic factors mostly affect the land use and cropping pattern. The secondary data sources used for the period of 1990-91 to 2010-11 (20 years) was taken from various governmental publications as well as other published and unpublished works.

Statistical Techniques used for analyzing the data were:

1. Crop combination Method (Weaver‟s 1954)

2. Crop Concentration (Jasbir Sing 1976)

3. Crop Diversification (Bhatia‟s 1965)

It was observed in the study area that the adoption of farm technology was increasingly found in the irrigated areas. Intensive agricultural systems were being accepted all over the study area. The shift from rice, cereals, pulses, groundnut and sugarcane coincided with the irrigation development in all villages. Thus, irrigation had made significant contribution to the change in the cropping pattern even though agro-climatic conditions continued to dominate the cropping pattern in the region. Rice and fodder cultivation prevailed in western heavy rainfall zone. The southern, middle and eastern part, facilitated by assured irrigation and fertile soils were also suitable for growing several crops. It was made possible due to the increase in lift and canal sources of irrigation and also the special efforts made by co-operatives, particularly sugar factories. Farming equipments, labour and other facilities i.e. fertilizers, seeds, insecticides, electricity and credit were also increasingly available. Area under rice, other cereals, other oilseeds, cotton and vegetable crops decreased during 1990-91 to 2000-01 and area under bajra, cereals, sugarcane, fruit, vegetables and fodder crops decreased during period in 2000-01 to 2010-11. It was observed that the shift from food grains to sugarcane was noteworthy in areas facilitated by perennial sources of irrigation while shift from cash crops to cereals, flowers and rice was observed in the areas having only seasonal sources of irrigation. Every circle of the Tahasil showed characteristics of multi crop combination. The 13 crop combination area was highly identified in cropping pattern because of a number of favourable conditions for these crops. It was clear that there was a tendency of specialization of 3 major crops i.e rice, vegetable crops and pulses. The cropping pattern in Akole circle showed dynamic nature in combination pattern especially in the eastern and central part of the circles as compared to Rajur, Kotul and Samsherpur circles which showed less variation from year 1990-91 to 2010-11. Rajur and Kotul circles are mainly under the tribal area and therefore used less of modern techniques. The spatial variations in the degree of crop concentration was found to be the result of the interaction of different combined factors such as physiographic, climatic, technological, hydrological and socio-economic on the study area. The crop concentration index was divided into four subclasses i.e. absence of concentration, low, medium, and high concentration, using **natural break** in concentration index of each individual crop. The different crops were concentrated in different areas based on these favorable factors. Among all crops, the dominant crops were rice, wheat, bajra, cotton, vegetable crops, pulses, fruit crops etc. These played an important role in view of their export potential as well as domestic requirements. The natural or physio-climatic condition and socio-economic factors were the fundamental factors responsible for the concentration in the study area. The index of diversification indicates the generalization of relationship between the relative strength and number of crops grown. In Akole Tahasil in the study of 191 villages, diversification index indicated that the eastern part of study region had very high crop diversification between 1990-91 to 2010-11. The highest diversification was found only in Akole circle because of relatively gentle topographic conditions, favorable soils and higher irrigation facilities of Pravara river basin. Some part of Samsherpur circle also increased the diversification area during 2010-11 because of construction of Nilwande dam and available irrigation facilities for this circle. The high diversification area was also available in the southern part of Kotul circle because of presence of Mula River. In Rajur circle, crop diversification was very little because it is in tribal area and faces unfavorable topographical condition. But, because of land improvement program, the diversification index had changed from very little diversification to little or high diversification.

Joshi (2015) has studied the cropping pattern of Maharashtra for the period 1991-2012. During these past two decades, the agriculture sector of Maharashtra underwent wide ranging changes in terms of ownership of land, cropping pattern, cultivation practices, productivity and intensity of cultivation. In earlier periods, the choice of cropping pattern was guided by agronomic considerations and consumption needs of the farmers. But in the recent past mainly market forces determined the trends in cropping pattern. Changes in cropping pattern are also determined by technological, infrastructural and institutional environment. Hence, the author of this study wanted to explore the changing pattern of crops in Maharashtra. The study also investigates the forces responsible for change in the cropping pattern. Further, it verifies the impact of new economic policy on the cropping pattern of Maharashtra if any. The various objectives crafted for completing the task of the research among others included studying the cropping pattern and trends of growth in the production of major crops in the state; to identify technological and non-technological variables and investigate the causes responsible for differential performance in growth of different crops as well as the inter district disparity in output growth in the state between 1991 and 2012. The study was undertaken with the intent to test the following hypotheses:

1. The cropping pattern under different regions of study is not same.

2. There is increasing tendency of changing cropping pattern in Maharashtra.

Crop wise aggregate data on area, output and yield of 32 crops for 36 major districts was obtained from publication of Government of Maharashtra. Detailed facts and figures relating to Area, Production and Productivity of the principal crops in Maharashtra state were obtained from the Economic Survey of Maharashtra. The data was divided into two phases starting from 1991-1992 to 2001-2002 and 2002-03 to 2012-13. This period was selected to know the impact of economic reforms on cropping pattern of Maharashtra if any. In the study, statistical and econometric tools were used for data analysis. Averages, compounded annual growth rate, average annual growth rate, standard deviation, coefficient of variation, log linear model, dummy variable log linear model, mean comparison test and t test were used for analyzing data and testing the hypotheses in the various chapters. Determinants of cropping pattern were analyzed using Log linear model. Case study method was also adopted for a study of cropping pattern in the Yavatmal district. The findings of the study were as follows:

In the history of growth of agricultural output, period 1991-92 to 2001-2002 marks a turning point in the Indian economy because of the introduction of new economic programme.

However, it did not boost the cereal and food grain production in Maharashtra. On the contrary, the production of food grains fell by -2.76 CAGR. However, in the latter period (2002-03 to 2012-13) the production of cereals and food grains picked up. Cotton crop output accelerated to 11.34%. An interesting feature of the millennium decade (2002-03 to 2012-13) was that agricultural growth permeated all the regions in Maharashtra. The most significant development was an acceleration of growth in sugarcane crops due to better and remunerative support prices declared by the government. Total food grains and cereals also recorded a significant acceleration but there was a minor deceleration in production of pulses. Thus, the cropping pattern went in favour of cash crops namely cotton and sugarcane in the second part of the study period. The results showed that food grain production in Maharashtra is significantly determined by area under canal irrigation and area under cultivation. But the impact of fertilizer is insignificant in accelerating production of food grain In the case of pulses none of the variables is significant. This is because pulses are basically rain fed crops. Therefore, production of pulses was not picking up despite better supportive prices. The results also showed that irrigation is an important determinant of cotton crop production, oilseeds crop production and sugarcane crop production. The latter requires constant water throughout the year. Hence it consumes lot of potential of other crops. Region level analysis showed that production of Pulses, Oilseed and Sugarcane crops was increasing in entire Maharashtra in the recent years due to remunerative supportive prices declared by central and state governments and increasing need of cash requirements of the farmers. But this trend was creating threat to food grain crops.

Kalaskar (2015) has authored "An Economic Appraisal of Agricultural Development in Yavatmal district of Maharashtra" covering a period from 1980-81 to 2011-12 in Maharashtra. Among others, the objectives of the study included studying the changes in land use and cropping pattern as well as the growth rates in area, production and productivity of major crops. Accordingly, relevant secondary data (and also other aspects like inputs, livestock etc.) for the study period was compiled and analyzed.

The findings of the study revealed the following:

The land use pattern as well as the cropping pattern of Yavatmal district had undergone several structural changes during the study period; for example, both the gross sown area and the net sown area showed a declining trend for the period. Among cereals, wheat showed an increase in the area cultivated during the study period while paddy, jowar and bajra showed a declining trend. Accordingly, the production of wheat and maize showed an increasing trend as compared to the three other cereal crops. For pulses, while the area under pulses showed an increase during the study period, the production and productivity of red gram, black gram and total pulses showed an increasing trend. With respect to oilseeds and commercial crops, an increase in area, production and productivity was found, especially with reference to soybean and cotton. The results of the statistical analysis showed that the variables like irrigated area, area under commercial crops, availability of credit through cooperatives, etc. have greatly influenced the cropping pattern and thus the agricultural development of Yavatmal.

Najan (2015) studied the changes in cropping pattern in South East part of Ahmednagar district from the period 1970-2010. According to him, land use and cropping pattern studies are of particular importance in view of the rapidly increasing population and consequential pressure on the existing land. These phenomenal changes are noticed more principally in the cropping pattern and importance is given to various crops from time to time. The cropping pattern of Ahmednagar district showed modification since 1973-74 from food grain crops to non-food grain crops. Accordingly, various objectives were formulated including the examination of factors contributing to changes in cropping pattern. The entire investigation was based on primary and secondary sources of data.

Primary data was obtained from twenty-three villages through questionnaires**.** The systematic purposive sampling method was chosen for selection of the sample villages. The selection of these sample villages was based on administrative revenue circles in the study region. There are a total of twenty three revenue circles in the study region So total twenty three villages were selected covering aspects like spatial-temporal analysis of cropping pattern, problems faced by farmers related to agriculture. The questionnaires covered various aspects like general land use, crop land use, family background of the farmers, education, income, problems related to agriculture etc. Besides this, second questionnaires were filled from particular tahasil, gramshevak or sarpanch of the villages to get additional information of sample villages. **Secondary data** was collected from various government departments and publications as required. The data collected was analyzed by applying suitable statistical methods and presented through tables, maps and diagrams. The data obtained for the period of 1970-71 and 2010-11 was calculated as percentage to the total geographical area. The percentage was categorized in different groups. The volume of change in these categories for forty years was analyzed and mapped. For the calculation of crop combination of the region Rafiullah maximum positive deviation method was used. The years 1970-71 and 2010-11 were selected for demarcation of crop combination and ten crops selected for delineation of crop combination. For the computation of crop diversification regions Jasbir Singh's formula was applied.

The findings of the study are summarized below:

Food crops occupied 84.88 percent of the total cropped area in 1970-71 and it dropped to 83.63 per cent in 2010-11. This decrease of 1.25 percent in food crop cultivation has been attributed by the author to the change in the attitude of farmers. This is because the share of cultivation of non food crops increased from 15.12 percent to 16.37 percent over the last four decades. The decrease in area under food crop cultivation was equivalent to the increase in area cash crops like fruits, vegetables, spices, fiber and sugarcane. Though oilseeds and food crops were also found to be significant crops, the area under cultivation for these crops had decreased during the study period.

Kamble (2016) has studied the economic efficiency of farmers in Pune district. Pune district is primarily an agricultural district with very good irrigation. However, it has the lowest level of resources used efficiently in agriculture sector. The inefficiency is the result of lack of scientific irrigation and cropping pattern. According to various studies, many irrigation projects are yet to reach even 50 per cent of the irrigation potential. A number of irrigation projects are being implemented to improve irrigation. But agriculture productivity of Pune district is very low in comparison to state average. A lot of irrigation projects are provided by government at subsidized rate but, there is no adequate water supply for agriculture in the district and therefore rate of return and income of farmers have been declining year after year. Standard of living of small and marginal farmers is very low due to their low agricultural income. Hence the author has undertaken a study on economic efficiency of the farmers. The objectives of the study included the identification of land use pattern of farmers in the form of change in cropping pattern, assessment of use of irrigation facilities by farmers in Pune and to ascertain the economic efficiency of small and marginal farmers as compared with large farmers. As such the following hypotheses were to be tested by the study:

1) Farmers are unable to use their land in the form of change in cropping pattern.

2) The resources are used inadequately with reference to irrigation facilities in crop cultivation.

3) Small and marginal farmers have less economic efficiency than large farmers.

4) Majority of farmers lack the basic factors of crop cultivation in farming.

The study was based on primary data as well as secondary data collected from a cross sectional enquiry of the sample farmers. The data for each farm in the sample involved inputs and outputs. The outputs were used in the analysis of crop inputs. (Crop inputs included land, irrigation facilities and basic factor etc.). The study area consisted of 10 Tahsils covering 49 villages of which average 5 villages (dispersion of 1 village) were taken from each Tahsil and on an average 8 farmers (dispersion of l or 2 farmers) from each village were identified. Thus at least two farmers were selected from each category. Marginal (104) small (109) medium (84) and large (88) farmers were taken for analysis. Total 385 farmers were selected as sample**.** For data analysis researcher used statistical software like SPSS (Statistical Software for Social Science, version 23.0) and MS- Excel. Using statistical software, researcher computed descriptive statistics from different datasets collected.

The major findings of this study were:

A large proportion of the land under cultivation was taken up by sugarcane/onion/jowar cultivation. These crops increased farmers' economic efficiency but not to the same extent all over the study area. Land use pattern under crops had not changed significantly and quantity of production of per acre had not increased in entire study period. Optimum use of land, by cultivating different crops is necessary to increase the level of economic efficiency. The small and medium types of farmers had the highest proportion of net sown area as compared to large types of farmers but did not have large quantity of land. On the other hand, the highest quantity of available land was with large type of famers, but a large proportion of their land remained fallow due to lack of irrigation. Therefore, farmers were not able to make optimum use of available land by mixing the crops.

There was statistically significant relationship between source of irrigation and crop cultivation. Inefficient use of sources of irrigation reduces production efficiency of the crop cultivation. Canal resource of irrigation was not available throughout the year for crop cultivation. Water available through canal at fixed interval depended on the availability of water in dam. Meanwhile other water resources had to be used instead of canal source for crop cultivation to enhance the productivity. A maximum number of farmers depended upon other sources of irrigation like river, rainfall etc. and minimum farmers had canal source for irrigation. Open-well and tube-well was one of the major sources of irrigation in study area. But this source of water depended upon rainfall in the study area. Rainfall was very low in the last ten years therefore, supply of water was not satisfactory for the farmers.

Consequently, farmers were not able to use adequate water resources for crops cultivation in Pune district.

Each and every year the level of income of the sample family members had seen some changes. But family members were not willing to reveal their real income or they had not maintained proper record of income. Therefore, there was not much variance in level of income. Large farmers were more economically sound than the other types of farmers. Maximum land holding was by large farmers, therefore, they had more income, whereas small and marginal farmers had less economic efficiency than medium and large farmers.

2.6 RESEARCH GAP

BOOKS:

1. Expert Consultation on "Crop Diversification in the Asia Pacific region" talks about the **importance of crop diversification** for **solving various issues** in the agricultural sector like **loss in soil fertility** while at the same time **addressing the issue of food security**.

2. In Agricultural Growth and Productivity in Maharashtra (Trends and Determinants), Kalamkar has **highlighted the role of irrigation in enhancing the productivity of crops** in Maharashtra given that a little over 20 percent of the agricultural land in Maharashtra is irrigated.

3. In Patterns of Structural Transformation and Agricultural Productivity Growth with Special Focus on Brazil, China, Indonesia and India, Lele, et al., have discussed the **importance of crop diversification, providing food security to the millions of marginal farmers and the need for developing sustainable agricultural practices to overcome the problems of depletion of ground water levels, salination and soil degradation.**

4. Mitra has studied the **trends in cost of production relative to crop yield and examined the behaviour of prices relative to cost of major crops in India**.

5. Rana has written about Cropping Systems and in the chapter on Crop Diversification he has talked about the **need for crop diversification** as necessary to protect the farmers from price **risks arising from reliance on mono cropping**, as also **for sustainability**.

JOURNAL ARTICLES/RESEARCH PAPERS

1. Acharya et al have studied the cropping pattern of Karnataka and the variables like **area, production, and productivity of various crops was estimated for a period of 26 years.**

2. Ayalew and Sekar have studied the **profitability of production of coarse cereals** based on the **data pertaining to costs, returns and profitability of coarse cereals' cultivation** across various states in India for the period 1980-91 to 2011-12.

3. Chand in the Commentary on Minimum Support Price (MSP) in Agriculture has written about the **distorting effects of MSP on the cropping pattern in the country** due to faulty policies and failure of government to tweak the policies as per changed demand and supply conditions in the states where MSP is being implemented.

4. Chand and Paruppurathu have identified various causes for the renaissance of the agricultural sector between 2005 and 2012 chiefly among them being **hiking of both public and private investment** as well as **improving the terms of trade favorably** for the agricultural sector. Another favourable factor for increasing farm production according to them was **remunerative prices of farm products** though the **sustainability of such a trend** was found questionable by them.

5. Dandekar and Bhattacharya have shown that while **high levels of indebtedness figured as the foremost factor for rising suicides**, other factors which included **faulty cropping pattern, rising input costs, aspirational consumption, climate change, lack of irrigation and absence of non-farm sources of income** were also prominent reasons for farmers' suicides in Yavatmal and Sangrur.

6. Dantwala has argued that the **cropping patterns followed in different states showed that they are not suitable with regard to their comparative advantage in yields** because the

farmers' decisions were based on the revenue obtained from growing different crops instead of on their yield potential. Though this is a broad-based discussion of cropping pattern with reference to revenue, no direct correlational study has been made.

7. Kumar and Mittal studied the **productivity trends in Indian agriculture** and they concluded that **Total Factor Productivity** (using ten inputs for constructing the index) growth was **low across the country** due to exhaustion of soil nutrients. **The unsustainability of continuously increasing input levels coupled with the decline in public sector investment, research, and extension** led to stagnation in the agricultural sector in the post Green Revolution years.

8**.** According to Kumar and Gupta, **the main determinants of crop diversification** in India included **irrigated area as percentage of gross cropped area, consumption of fertilizer, cropping intensity, agricultural export, education, direct institutional credit for agriculture and size of average land holdings**.

9. Mandal and Bezbaruah concluded that **crop diversification** in Assam was a strategy adopted not for minimizing risks, but it played a **significant role in increasing farm income**. The authors have also argued that **access to irrigation and institutional credit enables farmers to go in for crop diversification.**

10. Mohan has suggested that a **shift in the cropping pattern away from rice may have been caused due to lack of irrigation in Andhra Pradesh**. The author also suggests that **farmers' opinion have brought about a change in the cropping pattern** from low value cereals crops to high value commercial crops.

11. Nayak studied the structure and nature of **cropping pattern, crop diversification, crop concentration, productivity level and inter-districts disparity** in the state of Odisha. He found that the **reasons for increasing preference for production of rice as a monocrop** in the state were **irrigation facilities** and **provision of minimum support price (MSP)** by the government for this crop.

12**.** Ray's study revealed that **availability of credit** has a **significant impact** on the **change in cropping pattern** (shift to non-food grains) especially among the small and marginal farmers in West Bengal.

13. In his paper, Saha concluded that **dietary habits and increasing demand for food** due to increasing population led to **crop specialization in food grains** while **geographical conditions led to crop specialization** in places where topography was primarily important. He has also shown that the more **economically developed states** of the southern, western, and south-western parts of India also **exhibited greater crop diversification** favouring commercial and horticultural crops and oilseeds.

REPORTS

1. Bhadwal et al have shown that the **adoption of appropriate policies** has **guided the shift in the cropping pattern of Jalna** towards crops like cotton, oilseeds and pulses which are suitable for growing in its dry lands.

2. Jha et al have studied **crop diversification in Indian agriculture** and concluded that the shifts in cropping pattern in specific regions/states was **caused by the favourable institutional framework and remunerative prices obtained by the farmers**.

3. Kalamkar has analyzed the agricultural growth and the factors impacting output growth in the state of Maharashtra (1961-62 to 1997-98) and found that the growth in the use of inputs like **high yielding variety seeds, irrigation, and chemical fertilizers had caused the growth in yield of the major crops**.

4**.** Kannan in discussing the cropping pattern of Maharashtra (1960-61 and 2004-05), has highlighted that the increase in **area, production and productivity of maize and soybean** was due to **increasing demand from poultry industry, availability of new seeds and inputs**, and **higher remunerative prices obtained by farmers** for these crops while the area, production and productivity of **sugarcane has stagnated or declined** due to **erosion of soil fertility and certain pests and diseases**.

5. Kannan and Sundaram proved conclusively in their report that **technology and institutional support** for rice, wheat and plantation crops were **instrumental in influencing the cropping pattern** across states.

6. The ICRISAT report found that **higher income levels** were found to be a primary cause for shifting the **cropping pattern from cotton to soybean** in Akola villages**. Availability of seed subsidy, supplementary irrigation in rabi season, and lower labor requirements** for soybean/chickpea/wheat coupled with extremely volatile cotton prices were also relevant factors causing the change.

7. According to Sawant et al., the **use of new technological advances in the form of short duration HYVs, fertilizers, pesticides etc**., led to significant growth in the yield of green gram, black gram, groundnut, sunflower, soybean etc., during the eighties while the **decline in the total factor productivity in the agricultural sector** during the same period could be attributed to a **lack of development in seed technology for cereals** like rice, jowar and maize, especially grown under rain fed conditions and **non-introduction of new varieties for sugarcane** which is an important cash crop among others.

8. Sharma et al., in their report have shown that **populist measures like free water and free power in various regions of the country have led to a distortion in the allocation of water**, **an already scarce resource and thus influencing the cropping pattern**. Thus, rice in Punjab and sugarcane in Maharashtra (due to preference to cooperatives) are profitably cultivated by large farmers.

9. Vishandass and Lukka undertook a study to discover the **true levels of profitability of specifically those crops for which MSP was recommended** as also the **relationship between costs and productivity**, the hypothesis being that with rising productivity, real costs go down and the probability is that it will lead to greater competitiveness and higher returns to farmers thus influencing the cropping pattern.

THESES

1. Joshi's analysis of the cropping pattern of Maharashtra for the period 1991-2012 showed that an **acceleration of growth in sugarcane crops** took place due to **better and remunerative support prices** declared by the government while **food grain production** in the state is significantly **determined by area under canal irrigation and area under cultivation.**

2. Kalaskar has studied the changes in land use and cropping pattern as well as the growth rates in area, production and productivity of major crops in Yavatmal. The results of the statistical analysis showed that the **variables like irrigated area, area under commercial crops, availability of credit through cooperatives, etc. have greatly influenced the cropping pattern** and thus the agricultural development of Yavatmal.

3. Kamble has studied the economic efficiency of farmers in Pune using variables like size of land holdings, income levels, irrigation facilities etc., and concluded that there was statistically **significant relationship between source of irrigation and crop cultivation**.

4. Najan found that the cropping pattern of Ahmednagar district showed modification since 1973-74 from **food grain crops to non-food grain crops** due to the **change in the attitude of farmers.**

5. Patil has identified the relationship between **eighteen land use variables** which included eight crops and factors like net sown area, fallow land, irrigated land, rainfall, population etc. in order to study the cropping pattern and **extent of crop diversification** in Pune district. He also found that some talukas were most developed in the study region due to **fertile soil types, irrigation facility and hence higher net sown area brought under sugarcane and other cash crops which have also shown higher yields**.

6. According to the Tupe, **irrigation facilities, modern techniques, geographical conditions, government policies and economic factors** mostly affect the land use and **cropping pattern of Akole tehsil**.

It can be seen that a large body of work exists with reference to cropping patterns and the variables affecting cropping patterns. However, the studies are so varied in the temporal and spatial contexts that it is difficult to club them together based on variables used for analysis. As such, the factors affecting cropping pattern as brought out by each author has been highlighted in this section. It was seen that most of the works regarding cropping pattern were undertaken with the objective of establishing correlation between cropping pattern and a set of variables like geographical conditions, income levels of farmers, size of land holdings, irrigation availability, credit availability, other crops cultivated etc. Some other studies were undertaken with the objective of ranking the crops or studying the extent of diversification of crops in particular regions. While prices procured by farmers for their produce sometimes formed a part of the study, it was not considered a prime variable in determining the cropping pattern. **Thus, there has been no study with exclusive reference to the influence of prices obtained by farmers on Pune's cropping pattern.** Since the farmer undertakes farming activities as a source of livelihood, the researcher felt the need for analyzing cropping pattern only with regard to prices procured by farmers. This fact becomes even more relevant nowadays as agriculture is getting more and more commercialized.

2.7 CONCLUSION

The above literature review and the research gap shows that several research works have been published pertaining to cropping pattern and its influencing factors. However, an exclusive focus on prices procured by farmers for their output as a factor influencing cropping pattern was not found. Hence, this study will attempt to analyze the correlation between Pune's changing cropping pattern with reference to specific cash crops viz., sugarcane, maize and soybean and the prices procured by farmers for these crops.

REFERENCES

BOOKS

Expert Consultation. (2000). *Crop Diversification in the Asia Pacific Region.* Food and Agriculture Organization of the United Nations. Thailand.

Kalamkar, S.S. (2011). *Agricultural Growth and Productivity in Maharashtra*. Allied Publishers, New Delhi.

Lele, U. Agarwal, M. Goswami, S. (2018). *Patterns of Structural Transformation and Agricultural Productivity Growth (With Special Focus on Brazil, China, Indonesia and India).*

Mitra, K. A. (1996). *Agricultural Output Cost Pricing Analysis: Issues in the context of economic liberalization in India*. Gokhale Institute of Politics and Economics, Pune.

Rana, S.S. and Rana M.C. (2011). *Cropping System.* Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur.

JOURNAL ARTICLES / RESEARCH PAPERS

Acharya, S. P. Basavaraja, H. Kunnal, L. B. Mahajanashetti, S. B. and Bhat, A. R. S. (2012). Growth in area, production and productivity of major crops in Karnataka. *Karnataka J. Agric. Sci.,25 (4) : (431-436).*

Ayalew, B. Sekar, I. (2015). Profitability of Coarse Cereals Production in India. International Letters of Natural Sciences. Vol 39. pp 10-19. SciPress Switzerland. Online: 2015-05-12.

Chand, R. (2003). Minimum Support Price in Agriculture: Changing Requirements. *Economic and Political Weekly July 19, 2003* pp: 3027-3028.

Chand, R. and Parappurathu, S. (2012). Temporal and Spatial Variations in Agricultural Growth and Its Determinants. *Economic & Political Weekly Supplement*. June 30, 2012 Vol XLVII Nos 26 & 27. pp 55-64.

Dandekar, A. Bhattacharya, S. (2017). Lives in Debt: Narratives of Agrarian Distress and Farmer Suicides. *Economic and Political Weekly*. Vol XXI, No 21, pp 77-84.

Dantwala, M. L.. (1986). Prices and Cropping Pattern. *Economic and Political Weekly*, April 19, 1986. pp 694-695.

Kumar, P. and Mittal, S. (2006). Agricultural Productivity Trends in India: Sustainability Issues. *Agricultural Economics Research Review*. Vol. 19 (Conference No.) 2006 pp 71-88.

Kumar, S. and Gupta, S. (2015). "Crop diversification in India: Emerging trends, determinants and policy implications". *International Journal of Current Research, 7, (6), 17188-17195.*

Mandal, R and Bezbaruah, M.P.. (2013).Diversification of Cropping Pattern: Its Determinants and Role in Flood Affected Agriculture of Assam Plains. *Ind. Jn. of Agri. Econ. Vol.68, No.2, April-June 2013.* Pp 169-181.

Mohan, G. (2017). Determinants of Cropping Pattern Changes in Andhra Pradesh, India. *Asian Journal of Agricultural Extension, Economics &Sociology*. 20(3): 1-15, 2017; Article no.AJAEES.36892. ISSN: 2320-7027.

Nayak, D.K. (2016). Changing Cropping Pattern, Agricultural Diversification and Productivity in Odisha – A District-wise Study *Agricultural Economics Research Review*. Vol. 29 (No.1) January-June 2016 pp 93-104 DOI: 10.5958/0974-0279.2016.00022.7

Ray, S. K. (2017). "Economics of Change in Cropping Pattern in Relation to Credit: A Micro Level Study in West Bengal". *Ind. Jn. of Agri. Econ. Vol.62, No,2 April-June 2007.* pp 216-231.

Saha, J. (2013). "Crop Diversification in Indian Agriculture with Special Reference to Emerging Crops". *Transactions | Vol. 35, No. 1, 2013* | pp 139-147.

REPORTS

Bhadwal, S., Ghosh S., Joshi, P.K., Mahtta, R. and Barkved, L. (2014). "*Assessment of potential impacts on dryland ecosystems of Jalna District, Maharashtra, India*". Final report on WP2.1: Extreme Risks, Vulnerabilities and Community-based Adaptation in India (EVA): A Pilot Study, CIENS-TERI, TERI Press, New Delhi, India

Jha, B. Kumar, N. and Mohanty, B. (2009). "*Pattern of Agricultural Diversification in India*". Institute of Economic Growth, University of Delhi Enclave

Kalamkar, S.S. (2007). "*Agricultural Development and Sources of Output Growth in Maharashtra State*," Working Papers id:860, eSocialSciences.

Kannan, E. (May 2011). "*Determinants of Stagnation in Productivity of Important Crops (Consolidated Report)*". Agricultural Development and Rural Transformation Centre. Institute for Social and Economic Change, Bangalore. Research Report XI/ADRTC/127.

Kannan, E. and Sundaram, S. (2011). "*Analysis of Trends in India's Agricultural Growth".* Institute for Social and Economic Change. Working Paper 276.

Pramanik, S. Dhumale, A.B. Duche, V.D. Khan, P.E. and Deb, U. (2015). "*Rapid Changes In Cropping Pattern in Akola Villages: Extent, Determinants and Policy Implications"*. International Crops Research Institute for the Semi-Arid Tropics, (ICRISAT) India.

Sawant, S.D. Kulkarni, B.N. Achutan, C.V. and Satyasai, K.J.S. (1999). "*Agricultural Development in Maharashtra: Problems and Prospects*". Occasional Paper – 7. NABARD, Mumbai.

Sharma, B. Gulati, A. Mohan, G. Manchanda, S. Ray, I and Amarasinghe, U. (2018). "*Water Productivity Mapping of Major Indian Crops*". NABARD and ICRIER. Mumbai and Delhi.

Vishandass, A. and Lukka, B. (2013). "*Pricing, Costs, Returns and Productivity in Indian Crop Sector during 2000s"*. Commission for Agricultural Costs and Prices. Discussion Paper No. 7.

THESES

Joshi, V. J. (2015). "*An analytical study of changing cropping pattern in Maharashta for the period of 1991 to 2012*". Tilak Maharashtra Vidyapeeth. http://hdl.handle.net/10603/106318

Kalaskar, P. (2006). "*Economic appraisal of agricultural development of Yavatmal district in Maharashtra*". Mahatma Phule Krishi Vidyapeeth http://krishikosh.egranth.ac.in/handle/1/96801

Kamble, C. P. (2016). "*A study of economic efficiency of farmers in agriculture in Pune district_2001 to 2010*". Savitribai Phule Pune University. http://hdl.handle.net/10603/175043

Najan, R. E. (2015). "*Changes in cropping pattern in South East part of Ahmed Nagar district from the period 1970-2010*". Savitribai Phule Pune University. http://hdl.handle.net/10603/77999

Patil, S. G. (2012). "*Spatio temporal analysis of agricultural land use pattern in Pune district*". Tilak Maharashtra Vidyapeeth. http://hdl.handle.net/10603/5666.

Tupe, B.K. (2014). "*Landuse and cropping pattern changes: a case study of Akole tahsil in Ahmednagar district*". Savitribai Phule Pune University. http://hdl.handle.net/10603/99860

CHAPTER 3
RESEARCH METHODOLOGY

3.1 INTRODUCTION

The economist Thomas Malthus had stated in his theory that while agricultural production increased at a mathematical rate (1, 2, 3, 4, 5, etc.), population grew at an exponential rate (1, 2, 4, 8, 16, 32, etc.). He predicted that at some point of time in the future the earth's resources would not be able to provide for the food requirements of the world population. While he made this prediction more than 200 years ago and fortunately his prediction has not come true so far, between 2018 and 2050 (when the population is expected to reach 9.3 billion), the world food demand is going to increase phenomenally, while the extent of arable land will shrink considerably (Fan, 2012). Added to this fact that the availability of water will be highly constrained and climate change has become the norm, there is going to be tremendous stress on agricultural production to increase productivity with the available resources. The world will have to come up with sustainable agricultural practices in order to tackle the problem of increasing food demand vis a vis the resource constraints faced by the agricultural sector. Adopting sensible cropping patterns which are not only economically viable but also suited to the local climatic conditions is one such practice. This will enable the optimum use of water, an increasingly scarce resource and also help retain soil fertility by restricting indiscriminate use of fertilizers.

Maharashtra has witnessed this phenomenon wherein cropping patterns changed from food crops to cash crops like sugarcane and cotton after the green revolution. While this trend yielded profits initially, in the last two decades, sugarcane cultivation has become not only unprofitable in economic terms, but is also proving unsustainable in environmental terms. A water intensive crop like sugarcane being cultivated in the semi-arid regions of Maharashtra diverts irrigation from other areas and crops. On the other hand, the demand for other cash crops like maize is growing not only among health-conscious people for consumption, but also for poultry feed, industrial starch etc. Despite the fact that Maharashtra's climate is more conducive to producing maize, the full potential of this crop has not been realized in this state. Instead, for the first time in fifteen years, maize was imported by the state owned The Project & Equipment Corporation of India Limited (PEC) in Pune in 2015 due to increased demand for poultry feed and starch. Soybean is another important cash crop for diversification given its immense potential in the processed food industry. Soybean has already been adopted in Vidarbha by many farmers who have moved away from the riskier cotton crop. This study will be analyzing the cropping pattern in Pune district with respect to selected cash crops viz. maize, soybean and sugarcane and suggest an alternative cropping pattern which will not only be commercially viable, but also environmentally sustainable.

3.2 THEORETICAL FRAMEWORK

This study is an attempt to analyze the trends in the production and productivity of selected cash crops in Pune district. It is also an attempt to study the impact of Farm Harvest Prices on the production of these crops. As such the theoretical framework is divided into two sections. The first section elaborates on the various theories pertaining to agricultural production and productivity and how the same can be improved. The second section pertains to theories on agricultural pricing which attempt to explain the volatility / cyclicality in the latter.

(i) Theories on Agricultural Production and Productivity

In the 1950s, economists widely believed that agriculture did not contribute much to economic growth; that the marginal productivity of labour in agriculture was zero; and that economic growth could be kickstarted by transferring labour from agriculture to industry with no loss to the agricultural sector even without employing additional resources. It was also widely believed that "traditional agriculture" in developing countries was not responsive to economic incentives. Arthur Lewis in **"Economic Development with Unlimited Supplies of Labour"** in 1954 introduced the dual economy model of development. In this model, the economy is divided into two sectors, the agricultural (subsistence) sector and the industrial (capitalist) sector. The agricultural sector is thought to be labour intensive using poor techniques of production and having very low productivity. According to this model, the surplus agricultural labourers, farmers etc., existing in the agricultural sector have zero marginal productivity and hence act as a source of unlimited supply of labour which can be easily transferred to the industrial sector. Lewis did not deem it necessary to increase the labour productivity in the agricultural sector in order to offset this transfer of labour. He believed that the labour remaining in the subsistence sector would be able to provide for the food demand of the industrial sector even without employing additional resources. Further, the fixing of the wage rate in the industrial sector at a rate higher than the institutional wage rate prevailing in the agricultural sector would serve to attract endlessly the surplus labour from the agricultural sector. This would lead to greater and greater employment, savings and investment levels in the industrial sector which would boost economic growth. This theory of dual development was further extended by Ranis and Fei (1961) who combined Lewis' theory with Rostow's (1956) three "linear stages of growth" theory and thus presented a more comprehensive dual economy model of development. They have presented three stages of development based on the marginal productivity of labour in agriculture. In the first phase the surplus agricultural labour with low marginal productivity gets reallocated to the industrial sector. Due to the reallocation of surplus labour, marginal productivity of labour in the agricultural sector begins to rise (assisted by public and private investment) and the shortage point is reached. This marks the beginning of phase two when excess labour from agriculture is completely absorbed. Finally, at the end of this process, the economy enters phase three with the complete commercialisation of agricultural labour market. The Ranis-Fei model was thus a balanced growth model which believed in the simultaneous development of both the agricultural and industrial sectors (Ercolani and Wei).

In direct contrast to this understanding of the "traditional" agricultural sector, Schultz believed that the development of agricultural sector was primarily important for kickstarting economic growth. In "Transforming Traditional Agriculture", Prof. T. W. Schultz (1964) postulated that farmers practicing traditional agriculture were poor and their productivity was low, but they were efficient in the allocation of resources at their disposal. According to Schultz, the term "traditional" was not meant to infer cultural values like thrift or industriousness. It meant the cultivation of the same crops year after year using the same factors of production since the farmers realized that there were no significant inefficiencies in the allocation of factors. Schultz believed that while differences in land quality were least important, differences in physical capital stocks played an important role in enhancing productivity. Further, Schultz argued that simply injecting more capital into agriculture would not yield the desired result. The most important factor in increasing the growth rate of agriculture was increasing the capability of farmers in terms of knowledge and education (Lundahl). Thus, according to Schultz, investments in non-traditional inputs which would incentivize farmers was at the core of boosting agricultural growth (Alston and Pardey).

After his seminal work, "The Economics of Agricultural Development" more than fifty years ago, John W. Mellor in his book "Agricultural Development and Economic Transformation" (2017) has emphasized the role of improving agricultural growth rate in the process of achieving economic growth. According to Mellor, "The rapid growth of small commercial farmer dominated agriculture accelerates the economic transformation and is essential to the rapid decline in dominantly rural poverty". (pp:1). Further, according to him, "Government has a prominent role if small commercial farmer dominated agriculture is to grow rapidly" (pp:2). According to Mellor, the government should make explicit efforts towards the development of the agricultural sector in terms of increased investment expenditure and building institutions. He believed that though the agricultural sector was predominantly private in nature, it required government services like rural roads, electrification, education and institutions including research and extension along with other services like provision of statistics and market analysis. Only then will the rapid growth of the sector be enabled and rural poverty levels can be brought down significantly.

The production/productivity theory most pertinent to this study is the Theory of Diminishing Marginal Productivity. Marginal Productivity is the addition to the total output (marginal output) caused by the employment of one additional unit of input. According to this theory as additional inputs are employed in the production process, the marginal output will grow at an increasing rate up to a point. After that, additional inputs will lead to increase in output at a decreasing rate. And beyond a certain point, further employment of inputs might actually cause marginal productivity to fall. This theory can be explained in terms of variable proportions or returns to scale. In the case of Law of Variable Proportions, the proportion between fixed and variable factors employed changes due to additional employment of labour (variable factor) keeping land/capital constant (fixed factor). As more and more labour is employed on the same piece of land/capital, the three stages of returns to the factor can be observed. This phenomenon generally pertains to the short run when the fixed factor cannot be changed. The Law of Returns to *Scale* on the other hand explains the three stages of returns when *all the factors* are increased simultaneously in the same proportion. This phenomenon pertains to the long run when it is possible to employ additional fixed factors of production. In this study it has been observed that while more and more irrigation and fertilizers are being applied to increasing area of land, the yield levels of sugarcane increased dramatically in the initial stages. However, nearly four decades of monocropping has increased soil salinity to such an extent that decreasing/negative returns to scale can be witnessed with respect to sugarcane cultivation in Maharashtra.

(ii) Theories on Agricultural Pricing

The cobweb theory explains the fluctuations in the case of commodities with long production periods. It is a dynamic analysis theory which basically assumes that the current production of the commodity is dependent on the price existing in the previous period. Thus, the farmers will decide on the sown area under a particular crop depending on the price that crop commanded in the previous harvesting season. Further, the current price of the crop will determine the area under cultivation for the crop in the next period and so on. As such, the price elasticity of supply plays a significant role in determining output. A higher price will provide greater incentive to the farmers to cultivate that particular crop and accordingly its output will be higher while a lower price in the current period will disincentivize the farmers and it will lead to a fall in the output of that crop in the next period. Thus, price acts as the link in the price transmission mechanism of agricultural products (Xie and Wang). The conditions to be fulfilled for the cobweb hypothesis as enunciated by Ezekiel include the following:

(a) production is entirely determined by producers' response to price under conditions of pure competition,

(b) at least one full period is required before production can be changed, and

(c) the price is set by available supply.

In his study on the impact of price movements on acreage, Dharm Narain found cyclical pattern in the movement of both acreage and relative prices of sugarcane. He concluded that the two-way causation noticed in the cobweb phenomenon was pertinent to the price-area relationship in sugarcane. Thus, in spite of government interference in sugarcane pricing, the oscillatory movements characterized by the cobweb may continue to persist, albeit in a modified form. The cobweb theorem has been criticized for its implicit assumption of a reversible long run supply curve though the hypothesis concerns itself with the analysis of short run supply. Akerman tried to prove this inconsistency by demonstrating the inability of short run supply curves to explain conditions involving growing disequilibrium. However, Nerlove has shown that using adaptive expectations, the cobweb theorem's ability to explain fluctuations involving growing disequilibrium was substantially enhanced. Another criticism pertaining to the cobweb theorem is that the periodicity of cycles observed in the real world is quite dissimilar to that proposed by the theorem (Jha and Maji)

In empirical studies of impact of grain price on grain production using cobweb model and VEC model in China, Xie and Wang (2017) have shown that "…changes in grain production in China are affected by fluctuations in agricultural product prices, that the production change lags behind the price change, and that there is a long-term equilibrium relationship between grain yield and agricultural product price" (pp:1). Further, "The VEC model estimates that the price fluctuation of agricultural products will affect the sown area and its yield, that the degree of influence in different lag periods is diverse” (pp:11). The authors concluded that their study revealed a “divergent cobweb” state causing production to move away from the equilibrium point (pp:11).

However, in recent times, the rational expectations model which emphasizes the importance of storage for explaining price dynamics is being expounded as a better fit than the explanation given by endogenous dynamics which adopts the cobweb logic of rule-of-thumb expectations. This has been underlined by the fact that both the linear cobweb model as also the explanation of endogenous dynamics do not generate price series that are consistent with the stylised facts on agricultural prices, namely positive serial correlation and positive skewness (Gouel).

Most of the third world countries are primarily agrarian even in today’s times. Developing the agricultural sector in these countries is of prime importance to kickstart the engine of economic growth. The challenges faced by the agricultural sector in increasing production and productivity are manifold given the rising population, decreasing availability of land for cultivation due to increasing urbanization, competitive pricing demanded by globalization, and climate change. Further, water has increasingly become a scarce resource and the optimum utilization of irrigation combined with the adoption of an appropriate cropping pattern (in keeping with the geographical conditions) has become the need of the hour. A lot of the issues facing the agricultural sector today in India is due to the adoption of faulty cropping pattern during the Green Revolution. While the technologies adopted during the Green Revolution paid rich dividends initially, the law of diminishing returns has set in, particularly with reference to the cultivation of rice and sugarcane in Punjab and Maharashtra. The continued cultivation of these water intensive crops has caused immense environmental damage as well as widened inequalities in these states. As such, the government has a vital role to play in ensuring the adoption of sensible cropping patterns by the farmers in keeping with the geographical and climatic conditions and ensure equitable distribution of irrigation. Of course, aggressive government investment in the agricultural sector, improving the quality of inputs, and providing credit and insurance facilities as well as extension services will have to be undertaken on a war footing. Only then can the agricultural sector reach higher levels of growth rate and this in turn will help boost the non-agricultural sector leading to higher economic growth.

Regarding agricultural pricing, the Indian agricultural sector is susceptible to huge fluctuations in prices and hence the CACP is mandated with the task of recommending the MSP for 22 important crops in the country. The calculation of MSP itself is subject to a huge controversy since the Swaminathan Commission recommendations are not being fulfilled by the government. The cost + 50% MSP being proposed by the government only caters for the imputed value of labour and not for the imputed value of land and other fixed assets. As such, the MSP being recommended by the CACP is not considered highly remunerative. Further, studies conducted on the efficacy of MSP have shown that a majority of the farmers in India are not aware of the MSP. The rest of the farmers do not receive information about MSP in time; if at all they do receive information about the MSP, it is after the sowing is done. The MSP being recommended by the CACP already has a lag effect of 2-3 years (since it takes as much time to collect data on costs across the country) and as such is not an accurate indicator to the farmer regarding market trends. **While assured MSP has distorted cropping pattern in Punjab and Haryana in favor of rice and wheat, this study shows how assured prices for sugarcane (FRP) has distorted the cropping pattern in Maharashtra in favor of sugarcane and the consequent economic and environment damages arising out of it.**

This study is an attempt to analyze the production and productivity of selected cash crops in Pune district as also to ascertain the economic efficiency and environmental sustainability (as a secondary objective) of Pune's cropping pattern. Since economic efficiency entails remunerative prices obtained by farmers for their crops, the impact of prices on cropping pattern forms the core of the study.

3.3 RESEARCH PROBLEM

Pune lies predominantly in the scarcity zone of Maharashtra state with agricultural sector being mostly rainfed. Hence rabi crops dominate the cropping pattern. The area under rabi crops is 49.3 per cent, while that under kharif crops is 27.3 percent and 10 percent area is under sugarcane. The area under summer crops is negligible while area under fruit and vegetables crops is 2.7 and 9.3 percent respectively (C-DAP report, 2012). It must be further noted that the entire sugarcane crop is cultivated under irrigated conditions (Directorate of Economics and Statistics, 2012-13). The research questions which hence arise are:

1. Is the current cropping pattern in Pune district commercially viable and environmentally sustainable?
2. What are the crops which can be considered for diversification from the current cropping pattern?
3. Are the crops being considered profitable and sustainable?

3.4 SIGNIFICANCE OF RESEARCH

The cropping pattern of India was traditionally based on subsistence farming and constituted coarse cereals like barley, pearl millets, sorghum, maize etc. After the Green Revolution in the late 1960s, the productivity of refined cereals, primarily rice and wheat increased exponentially. This led to bumper harvests of these food grains which soon found their way into the consumer plate, replacing coarse cereals. This trend continued to be fueled by rising income levels and a consequent change in consumer preferences. However, coarse cereals continue to provide food security to the millions of subsistence farmers in India. Moreover, due to the health benefits of consuming coarse cereals which are rich in nutrition and fiber, these cereals are increasingly finding favor with diabetes-prone Indians.

Maize is one of the coarse cereals traditionally cultivated in Pune district along with other coarse cereals like jowar and bajra. Maize is a sturdy crop, suited for the dry climatic condition found in maximum parts of Pune. The demand for maize in Pune has been increasing during recent times primarily due to its use as poultry feed and Pune has a thriving poultry industry. Some proportion of maize production is utilized in grain-based distilleries for manufacture of alcohol. As a result, the area under maize production has been growing in Pune, particularly in talukas like Indapur, Baramati, Khed, Daund, Haveli, Ambegaon etc. which get low rainfall. It is cultivated mostly in the rainfed areas and is replacing traditional crops like jowar and bajra as an important cash crop for the farmers. The area under maize in the district increased from 16,000 hectares (ha) in 2009 to 24,700 ha in 2013; an increase of 11.4% CAGR (Pune District Marketing Strategy Supplement, 2016).

However, maize production dropped by up to 40 per cent in 2015-16 due to 14 per cent deficit in monsoon rains. Maize production had dropped to 23.67 million tons in 2014-15 too from the record 24.26 million tons in the previous year (Economic Times, 2016). This decline in production sharply hit maize exports for the corresponding periods. Due to the fall in maize production for the second straight year due to drought, the government allowed the state-owned PEC to import 5,00,000 tons of maize at zero duty to meet starch and poultry industry demands (economictimes.indiatimes.com, 2016). As per Global Agricultural Information Network's India Grain and Feed Annual report (2016), after a gap of more than 15 years, India commercially imported corn in 2015/16 due to domestic shortages and relatively cheap international corn. Given its economic potential, incentivizing maize production will reap rich dividends for the farmers as well as for Pune's economy.

Soybean is also on its way to becoming a very important crop in the cropping pattern of Maharashtra. An analysis of the crop's data at the state level and district level shows that soybean is fast becoming a highly favoured crop for cultivation. According to Kajale and Bodkhe (2016), in 1993-94 only 1.78 percent of the Gross Cropped Area (GCA) was under this crop, in 2011-12 it had increased to almost 13 percent of the GCA. "The area and production of the crop have grown 600 times and 399 times respectively during 1984-85 (1987- 88 in case of production) and 2013-14. Almost 90 percent of the acreage under total oilseeds is contributed by soybean" (Kajale et al, 2016, pp:24). As regards Pune, the decade wise growth rates for the period 2000-01 to 2013-14 has seen tremendous increase in area (21.81%) and production (24.84%) of soybean in Pune district. However, the share of soybean acreage of Pune division is only 1.8% of the total area under soybean in Maharashtra (Kajale et al, 2016, pp:22). Considering the fact that the productivity of soybean is second highest in Pune at 2.49% after Kolhapur at 3.57% and Pune is one of the four districts in Maharashtra where the productivity of soybean is around 2500 kg/ha makes its desirability for cultivation evident (Kajale et al, 2016, pp:23). The high prices of soybean and soybean oil continue to provide an incentive to the farmers for its cultivation. The high profitability of this crop has resulted in shifting of area under kharif crops like jowar, rice, groundnut and in some cases even sugarcane and cotton to soybean.

However, the growth rates of area, production and productivity of soybean slowed down in the state and district level in the post 2000 period. The primary reason for this was that the proportion of irrigated area allocated to soybean has been consistently declining in the post 2000 period in Maharashtra. While 1.3 percent of the area under soybean was irrigated in 1999-00, this figure fell to 1 per cent in 2004-05 and further to 0.5 per cent in 2005-06. An abysmally low 0.4 per cent of the area under soybean was irrigated in 2014 (Kajale et al, 2016, pp:24). Thus, while area under soybean cultivation has been expanding, the area under irrigation has not kept up proportionately. If this trend continues, the production and productivity of the crop will be severely affected, especially in times of scanty rainfall. This will ultimately affect farmers' incomes. Though Pune district has a higher percentage of net irrigated area to net sown area as compared to other parts of Maharashtra, the productivity of soybean needs to be enhanced considerably. This becomes vital due to the fact that rising population and income levels are causing the demand for edible oil to rise consistently and the need to fulfil this demand is increasingly being met by imports.

As seen in Chapter 1, Pune district being located in the scarcity zone of the state is not suitable for the water guzzling sugarcane crop. Added to this environmental aspect is the fact that the productivity of sugarcane in Maharashtra has been stagnating over the last two decades. While area and production of sugarcane increased, the productivity (yield per hectare) could be maintained only through the application of greater amounts of fertilizers (Kshirsagar, 2008). Due to the support prices mandated by the government, farmers are undertaking sugarcane cultivation since they are assured of the prices they will receive. This leads to a glut of sugar production in the market and sugar prices fall even below the production costs leading to huge losses for the sugarcane mills. Since this results in non-payment of arrears to farmers, the government steps in and fixes a floor price for sugar below which the it cannot be sold thus making Indian sugar prices globally uncompetitive. The issue of overproduction is difficult to solve by increasing exports of sugar not only due to the uncompetitive prices prevailing in the Indian market but also because there is very low global demand for the low quality of sugar being produced in India (businessinsider.in, 2018). The government is subsidizing the sugar industry by thousands of crores of rupees every year by providing funds to the mills to clear their arrears as well as undertaking the maintenance of huge buffer stocks (economictimes.indiatimes.com, 2018). Thus, an extremely unprofitable and environmentally unsustainable crop is being supported by faulty government policies.

This study assumes significance since the issue of adopting an appropriate cropping pattern which is both remunerative to the farmers and is also environmentally sustainable needs to be addressed urgently. An attempt is made to ascertain the economic efficiency and sustainability quotient of the three selected crops and suggest optimum reallocation of land between the three crops.

3.5 RESEARCH METHODOLOGY

Research methodology is a way to systematically solve the research problem. It not only includes the research methods but also the logic behind the methods used in the context of the research study. It explains why a research study has been undertaken, how the research problem has been defined, in what way and why the hypothesis has been formulated, what data have been collected and what particular method has been adopted for the data collection, why a particular technique has been used for analyzing the data etc. (Kothari, 2004). The following paragraphs proceed to explain the details of the research methodology in studying the selected research problem.

3.5.1 TYPE OF RESEARCH

The present study began as a **descriptive work** wherein the researcher studied the historical cropping pattern of India and Maharashtra in general and the cropping pattern of Pune in particular as it is today. For this purpose, the researcher undertook extensive literature survey on this subject. Several works of eminent economists were studied and the theses published in this regard explored. While prices procured by farmers for their produce sometimes formed a part of the study, it was not considered a prime variable in determining the cropping pattern. As such, the research work took an **explanatory** form with the researcher identifying the research problem and formulating a hypothesis to address the problem.

3.5.2 SCOPE OF RESEARCH

The researcher selected Pune district for the study since it has a sizable agrarian economy, a flourishing poultry industry, thriving dairy sector as well as it is a fast-expanding metro second only to Mumbai. The district is also a hub for the automobile industry and Information Technology (IT) sector. The challenges posed by climate change and rapid urbanization to agriculture in such a dynamic environment makes for an interesting study. After a general analysis of the cropping pattern of the district, three cash crops were selected for detailed analysis. These three cash crops, namely, sugarcane, maize and soybean were selected for their high economic value as well as the environmental impact of their cultivation. The data pertaining to the area, production and yield of these three cash crops was collected for the period from 1991-92 to 2017-18. Such a length of time is quite sufficient to show the cropping pattern trends. The selection of the period was also driven by the consideration to analyze changes in cropping pattern in the post liberalization era. Thus, this study will focus on the trends in the production and productivity of selected cash crops, namely, sugarcane, maize and soybean in Pune district for the period 1991-92 to 2017-18.

This study will be focusing primarily on the economic aspects of the cultivation of the crops. The sustainability of cultivating these crops will be dealt with as a secondary issue for the purpose of this study. The years 2014 and 2015 were witness to severe drought in India. Maharashtra was also seriously affected. At the same time, sugarcane cultivators harvested a bumper crop; they faced no water shortage for crushing cane. The ethical aspects of sugarcane cultivation are not within the purview of this research work. However, given the fact that the sugar lobby is extremely powerful in Maharashtra, any attempt at regulating the sector is bound to be met with stiff resistance.

3.5.3 OBJECTIVES OF RESEARCH

Once the scope of research was finalized, the researcher arrived at the following objectives to be achieved for the study:

i. To review the cropping pattern in Pune district.
ii. To analyse the area, production, and yield of selected cash crops in the period between 1991-92 and 2017-18 in Pune district.
iii. To analyse the trends in prices of selected cash crops in the study period.
iv. To study the impact of pricing on cropping pattern with respect to the selected cash crops.
v. To suggest policy measures for changing the cropping patterns with a view to achieving commercial viability and sustainability in agriculture in Pune district.

3.5.4 HYPOTHESIS

After undertaking the review of literature related to cropping patterns, the researcher found that the prices procured by the farmers for their produce was sometimes included as one among several variables, but the impact of prices alone on cropping pattern has not been studied. This fact becomes even more relevant nowadays as agriculture is getting more and more commercialized and the cropping pattern post green revolution has been shifting in favor of cash crops vis a vis foodgrains.

Null Hypothesis (Ho)

The null hypothesis is the statement that there is no statistically significant difference or relationship between variables. Any differences that are observed are due to chance. It is a statement of "no effect" or "no difference."

Alternate Hypothesis (Ha)

The alternate hypothesis (Ha) is the opposite. The alternate hypothesis states that there is a statistically significant difference or relationship between variables.

Taking all these factors into consideration the researcher formulated the following hypotheses:

Ho1: The area under maize cultivation in Pune district is not significantly related to the Farm Harvest Prices procured by the farmers for maize.

Ha1: The area under maize cultivation in Pune district is significantly related to the Farm Harvest Prices procured by the farmers for maize.

Ho2: The production of maize in Pune district is not significantly related to the Farm Harvest Prices procured by the farmers for maize.

Ha2: The production of maize in Pune district is significantly related to the Farm Harvest Prices procured by the farmers for maize.

Ho3: The area under soybean cultivation in Pune district is not significantly related to the Farm Harvest Prices procured by the farmers for soybean.

Ha3: The area under soybean cultivation in Pune is significantly related to the Farm Harvest Prices procured by the farmers for soybean.

Ho4: The production of soybean in Pune district is not significantly related to the Farm Harvest Prices procured by the farmers for soybean.

Ha4: The production of soybean in Pune district is significantly related to the Farm Harvest Prices procured by the farmers soybean.

Ho5: The area under sugarcane cultivation in Pune district is not significantly related to the Farm Harvest Prices procured by the farmers for sugarcane.

Ha5: The area under sugarcane cultivation in Pune district is significantly related to the Farm Harvest Prices procured by the farmers for sugarcane.

Ho6: The production of sugarcane in Pune district is not significantly related to the Farm Harvest Prices procured by the farmers for sugarcane.

Ha6: The production of sugarcane in Pune district is significantly related to the Farm Harvest Prices procured by the farmers for sugarcane.

3.5.5 SAMPLING

Pune district has been chosen for the study **purposively**. This is because Pune is the third largest district in terms of Real Gross District Value Added (at current and 2011-12 prices) as well as Per Capita Gross District Value Added at Current Prices. While Mumbai and Thane occupy the top slots with a District GVA of Rs.3,62,185 lakh crores and Rs.2,66,168 lakh crores respectively (at constant prices), Pune comes a close third with a District GVA of Rs.2,09,808 lakh crores (Economic Survey of Maharashtra, 2019-20). However, the value of income generated in Pune by the agricultural sector far outstrips that of Mumbai and Thane. While Mumbai generated agricultural income of Rs.3,19,451 lakhs, and Thane generated agricultural income of Rs.86,991 lakhs for the year 2013-14 (at current prices), the corresponding figure for Pune was Rs.8,82,700 lakhs. (District Socio Economic Reviews).

After studying the value of agricultural income generated by all the 31 districts in Maharashtra (for which the District Socio Economic Reviews have been uploaded on the mahades website), it was found that Pune has the highest agricultural income in entire Maharashtra except for Nashik which is an outlier with agricultural income double that of Pune at Rs.15,26,322 lakhs. Further analysis showed that Pune and Nashik are very similar in terms of geographical area at 15,62,000 ha and 15,53,000 ha respectively. However, the Gross Cropped Area (GCA) in Pune is higher at 10,81,000 ha (2017-18) while the corresponding figure for Nashik is 7,45,000 ha (2016-17). The Total Irrigated Area in Nashik is also very less at around 2,00,000 ha (2016-17) as compared to Pune at 5,80,000 ha (2018-19). However, the contribution of district GVA to Maharashtra GVA is higher for Pune at 11.4% as compared to a mere 4.84% for Nashik. A broad overview of the cropping pattern for the two districts also revealed that while Pune had more than 1 lakh hectares under sugarcane which is considered a high value cash crop, Nashik had only half that area (42,500 ha) under cotton. Thus, in spite of having more irrigation facility and more area under a high value cash crop, the low level of agricultural income in Pune district was a puzzle. As such, the researcher decided to undertake a study of the cropping pattern of Pune district with the primary objective of ascertaining its economic viability. Further, the **selection of the three cash crops** viz., maize, soybean and sugarcane was done **purposively** since these three crops are the dominant cash crops in Pune district. While horticultural crops also dominate the scene in the district, a comparative study of area, production and yield of horticultural crops vis a vis sugarcane would not be possible. As such, maize and soybean were selected for the study as they provide a one to one basis for analysis vis a vis sugarcane in terms of area, production, yield, as well as sustainability quotient.

3.5.6 DATA COLLECTION

In order to prove the hypothesis, the researcher collected secondary data from the relevant authorities. The data regarding the present cropping pattern of Pune district **with special reference to irrigation** was obtained from the Department of Agriculture in the report titled "Pradhan Mantri Krishi Sinchayee Yojana" (PMKSY). This report has been compiled by "Action for Agricultural Renewal in Maharashtra" (AFARM), an Association of Civil Society Organizations engaged in the field of Rural Development in Maharashtra. The report is a District Irrigation Plan which presents holistic irrigation development perspective of the district outlining medium to long term development plans integrating three components viz., water sources, distribution network and water use applications incorporating all usage of water like drinking and domestic use, irrigation and industry. The researcher contacted the office of AFARM to enquire about the period for which the data was collected for the purpose of creating the report. The office of AFARM confirmed that the data refers to the period 2014-15 which they obtained from the Department of Agriculture. The researcher was keen in obtaining data pertaining to cropping pattern with reference to irrigation and hence used this report to highlight relevant facts. The researcher had earlier contacted the Agricultural Commissionerate (Central Building, Pune Station) in order to obtain crop wise irrigation statistics for the district. However, the researcher was informed that the statistics department had stopped compiling crop wise irrigation statistics since 2002. The researcher also studied the District Socio Economic Review reports from 2009 to 2016 published by the Department of Economics and Statistics. These reports carried crop wise irrigation statistics of 2002-03. The latest District Socio Economic Review (2017) includes latest crop wise irrigation statistics for 2016-17, however, the information contained is incomplete. The Department of Agriculture at Shivajinagar then provided the researcher with the PMKSY report which though not providing crop wise irrigation statistics in detail, however, gave a fair idea of the irrigation usage for various crop categories in the district. Hence, this report has been used as the sole source of data for crop wise irrigation statistics.

The researcher then collected data regarding area, production and productivity (APY) of the selected crops for the period 1991-92 to 2017-18. The website of the Department of Agriculture however, has published district wise, crop wise statistics only from 2000 onwards. The central government website data.gov.in had district-wise crop production statistics (APY) only from 1997 onwards. The researcher visited the office of the Department of Economics and Statistics (Shukrawar Peth) to find out whether previous years' data was available. But this office also confirmed that only the data available on the website of the Department of Agriculture was available with them also. The researcher then contacted the Maharashtra State Agricultural Marketing Board (MSAMB) to get data on farm harvest prices for the selected crops for the period. The MSAMB could provide data only from 1995 onwards and that too only for maize and soybean. The researcher was instructed to contact the Sugar Commissioner office in Shivajinagar to obtain information regarding cane prices procured by farmers. The researcher then turned to the Economic and Political Weekly Research Foundation (EPWRF). For a nominal payment, the researcher could obtain data on area, production, yield and farm harvest prices for maize, soybean and sugarcane from 1991 onwards. There were certain gaps in this data also; the data for maize (APY) was not available for the year 2005-06 which was taken from the government website data.gov.in. **However, the data for soybean (APY) was not available for the year 1995-96 from any source**. The data on FHP of soybean was also not available for the period 1998-99 to 2003-04. This was then taken from the data given by MSAMB. However, with respect to sugarcane, the data for the period after 2005 was not available with the EPWRF. Moreover, the data on sugarcane prices was with reference to the prices of raw sugar and not the prices received by the farmers from the mills.

As such, the researcher took an appointment with the sugar commissioner who then instructed the statistics officer to extend full cooperation for the study. The researcher was provided with the Statistical Diary 2017, an annual publication of the Maharashtra Rajya Sahakari Sakhar Karkhana Sangh Ltd. This diary provided information regarding the recovery rate linked Statutory Minimum Prices (SMP) / Fair and Remunerative Prices (FRP) as mandated by the government for the farmers to be paid by the sugarcane mills as well as the range of actual prices paid by the mills from 1982-83 onwards. The SMP/FRP is the base rate fixed for a minimum recovery rate of sugarcane. The mills are mandated to pay a premium for every 0.1% increase in the recovery rate. This data however, pertained to the state of Maharashtra. In order to confirm that the actual prices paid by the mills to the farmers were in fact according to the support prices mandated by the government in Pune district, the researcher obtained the Cane Arrears Reports available with the Statistics Department of Sugar Commissioner's office for the last seven years (2010-11 to 2016-17). It was observed that the recovery rate linked FRP to be paid to the farmers was lesser on average by 20% in order to provide for the Harvest and Transport (H and T) costs undertaken by the mills. The mills thus pay a rate equal to the FRP net of H and T but not the FRP as worked out by the recovery rate. It was also observed that the recovery rate of the sugar mills in Pune district was on average 1.7 % higher than the minimum recovery rate prescribed for fixing the FRP. Hence, for the purpose of this study, the FRP - adjusted for a higher recovery rate and the H & T costs - will be used for studying the price trends of sugarcane.

The researcher has also used the various pricing policy reports issued by the Commission on Agricultural Costs and Prices (CACP) in order to analyze price trends of the selected cash crops at the macro level. In this regard also, **the MSP for soybean as recommended by CACP was not available for the year 2012-13 and the FHP for soybean at Pune was not available for the years 1991-92 and 1992-93.**

3.5.7 DATA ANALYSIS

The data collected regarding the general cropping pattern of Pune with special reference to irrigation was analyzed using simple averages and percentages. The data pertaining to the share of various crop categories viz. cereals, coarse cereals, pulses, oilseeds, fruits and vegetables in rainfed and irrigated areas during kharif, rabi and summer seasons as well as the production, productivity and cost of cultivation of the various crop categories in rainfed and irrigated conditions was depicted using tables, pie charts and bar graphs. For a more detailed analysis of the cropping pattern of Pune district, 13 crops were selected, viz., rice, wheat, jowar, bajra, maize, tur, udid, moong, gram, groundnut, soybean, safflower, and sugarcane. The area, production and productivity of these crops for the years 2000-01, 2007-08 and 2016-17 were analyzed in order to get a picture of the cropping trends in the district. The data gathered from the various sources mentioned in the preceding paragraph was used and the percentage change in the area, production and productivity in 2007-08 over 2000-01 as well as in 2016-17 over 2000-01 was calculated. Line graphs were used to depict the trends in the area, production and productivity of the selected crops over the three time periods as well as to show the percentage change in the three parameters over the three time periods.

The analysis of the area, production, yield and farm harvest prices of the three selected cash crops, viz., maize, soybean and sugarcane for the period from 1991-92 to 2017-18 was done as follows:

To begin with, the price trends at the macro and micro levels were compared. For this purpose, the MSP recommended by CACP and the FHP at Pune for each of these crops were analyzed using trend lines.

In the next step, the entire data was divided and into nine trienniums as following: 1991-92 to 1993-94; 1994-95 to 1996-97; 1997-98 to 1999-2000; 2000-01 to 2002-03; 2003-04 to 2005-06; 2006-07 to 2008-09; 2009-10 to 2011-12; 2012-13- to 2014-15; 2015-16 to 2017-18. The average area, average production, average yield and average FHP for each triennium was calculated. Bar graphs were used to depict the area, production, yield and prices of the crops for the trienniums. The percentage change in the average area, average production and average yield was calculated triennium over triennium and the impact of changes in area and / or yield on production was studied.

For a more detailed analysis, the correlation coefficient was calculated between:

1. Average Area and Average Farm Harvest Prices

2. Average Production and Average Farm Harvest Prices

3. Average Yield and Average Farm Harvest Prices

In case of sugarcane, the Fair and Remunerative Prices adjusted for H & T cost and increased yield levels of Pune have been calculated.

For calculating the Correlation, Pearson’s Correlation Coefficient formula was used as follows:

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

where,

r = the correlation coefficient

x_i = the i^{th} reading of the first variable

$\bar{x}$ = the mean of the first variable

y_i = the i^{th} reading of the second variable

$\bar{y}$ = the mean of the second variable

The closer the value of the coefficient to +1, the correlation between the variables is positive, that is, they tend to move in the same direction. As the value of the coefficient moves to −1, a negative correlation between the variables is established, that is, they tend to move in the opposite directions.

Linear Regression Analysis

Finally, a simple regression analysis model was used to establish the strength of the correlation between the variables and which also provided for the testing of the hypotheses. Simple linear regression is a statistical method that allows us to summarize and study relationships between two continuous (quantitative) variables:

- One variable,
- denoted *x*, is regarded as the predictor, explanatory, or independent variable.
- The other variable, denoted *y*, is regarded as the response, outcome, or dependent variable.

Regression analysis helps understand how the dependent variable changes when one of the independent variables varies and allows to mathematically determine which of those variables really has an impact. Technically, a regression analysis model is based on the sum of squares, which is a mathematical way to find the dispersion of data points. The goal of a model is to get the smallest possible sum of squares and draw a line that comes closest to the data. **Simple linear regression models the relationship between a dependent variable and one independent variable using a linear function**. If we use two or more explanatory variables to predict the dependent variable, we deal with multiple linear regression. If the dependent variable is modeled as a non-linear function because the data relationships do not follow a straight line, we use nonlinear regression instead. For this study, simple regression analysis was done in Microsoft Excel. The Regression Analysis Output in Excel consists of three tables which are explained as under:

1. Table of Regression Statistics

Multiple R: This is the **correlation coefficient** of the two variables and it shows how closely or strongly they move in relation to each other. Since this is a linear regression analysis, a linear relationship is assumed between the two variables. The value of Multiple R can vary from +1 to −1. As the value of Multiple R moves closer to +1, a strong positive relationship between the two variables is established. As the value of Multiple R moves closer to −1, a strong negative relationship is established between the two variables. A value of 0 indicates no relationship between the variables. The correlation coefficient is also known as Pearson's correlation coefficient or Pearson's r. The formula has already been explained in the previous section.

R Square: This is represented as r^2. It is the **Coefficient of Determination** and as such shows the goodness of fit of the data to the model. The value of R square shows the percentage of variation in the Y-values around the mean that is explained by the X-values. Hence, it will show how many points fall on the regression line and is **calculated as the summation of the squared deviations of original data from the mean.** A value of 95% or more is considered a good fit, since it would mean that 95% of the values fit the model.

Adjusted R Square: This value is used only when analyzing multiple regression output and is not relevant for simple linear regression output.

Standard Error: This is not the same as the standard error in descriptive statistics. It is denoted by the letter S, and is expressed in the units of the dependent variable. As such, it is an absolute number and needs to be compared with the values of the dependent variable. It shows the typical distance of the data points from the regression line. The smaller the value of this standard error in comparison with the data values, the greater is the precision of the model. It is calculated as the square root of the Mean Square Residual. It can be understood as the standard deviation of the error term. The standard error is also used to get the confidence interval for the predicted values.

Observations: This simply means the number of observations.

2. ANOVA Table

The first column of the table shows the breakup of the total variances into Regression and Residual. While the Regression represents the explained sum of squares, the Residual is the error or the unexplained sum of squares.

df : Degrees of freedom are the number of independent values that a statistical analysis can estimate. It is the number of values that are free to vary as we estimate parameters. Degrees of freedom encompasses the notion that the amount of independent information we have limits the number of parameters that we can estimate. Typically, the degrees of freedom equal the sample size minus the number of parameters we need to calculate during an analysis. It is usually a positive whole number. Degrees of freedom is a combination of how much data we have and how many parameters we need to estimate. It indicates how much independent information goes into a parameter estimate. In this vein, it's easy to see that we want a lot of information to go into parameter estimates to obtain more precise estimates and more powerful hypothesis tests. Hence, more degrees of freedom are preferred.

Sum of Squares – As mentioned earlier, the sum of squares shows the values for the three variances, namely, regression, residual, and total. The formulae for calculating these variances are as given below:

Sum of Squares (Total) : Σ**(Y – Y bar)**^{2}

It is a summation of the squares of the variances from the mean.

Sum of Squares (Residual) : Σ **(Y – Y predicted)**^{2}

It is a summation of the squares of errors in the predicted values, that is, it is the squared summation of the difference between the observed values and predicted values.

Sum of Squares (Regression) : Σ (Y predicted – Y bar)^2

It is a summation of the squared differences between the predicted values and the mean. This shows the goodness of fit of the line with the data. The closer its value to the Total Sum of Squares, the better is the goodness of fit. SS Regression can also be described as the difference between SS Total and SS Residual. Also it should be noted that SS Regression / SS Total yields a value equal to R-Square which is nothing other than proportion of variances explained by the independent variables.

Mean Square – The SS Regression and SS Residual are each divided by their df in order to arrive at the respective Mean of Squares.

The F statistic in the fifth column is calculated by dividing the Mean Square Regression by the Mean Square Residual. Further, the Significance F in the next column is calculated from the F value. The value of Significance F is generated by Excel from the corresponding F distribution of the F statistic. The F value can vary from 0 to any large number and is similar to z value, t value etc. The value of Significance F shows whether the null hypothesis can be rejected or not. If any or all of the coefficients in the regression output are actually zero, the Significance F will be equal to or greater than the alpha (0.05) level. Thus, the Significance F showing values as low as possible (zeroes in four decimal places) would show that the null hypothesis can be rejected and that the independent variable has a significant impact on the dependent variable.

3. The Coefficients Table

Regression analysis aims to ascertain the relationship between the variables being studied. These relationships among variables can be expressed mathematically to make it easier to comprehend. One such relationship between variables is a linear or straight line relationship. In linear regression analysis, this relationship is expressed mathematically as Y = a +bX.

In this equation:

- Y is the dependent variable written on the left-hand side. Its value depends on the changes in the variable X.

- X is the independent (also called explanatory) variable appearing on the right-hand side of the equation. Changes in X causes changes in Y.

- b is the slope of the regression line. The value of the slope shows the amount of change in Y for a one unit change in X.

- a is the vertical intercept, that is, it shows the point at which the regression line intercepts the Y axis.

In the Linear Regression Analysis model, the values of a and b are represented by the coefficients in the output table. Thus, the **coefficient for the Intercept (a) shows the value of Y when X = 0 and the coefficient for the X variable (b) shows the change in Y for every unit increase in X.**
The basis of running a regression model is to ascertain whether the independent variables are actually having an impact on the dependent variable. Hence, the null hypothesis is always formulated so as to state that each independent variable has no effect on the dependent variable. The purpose of formulating such a hypothesis is obviously to reject it.

The Standard Error is the third column in the coefficients table. The value of standard error for the Y variable is to be compared with the value of the Y coefficient. As the standard error shows the extent to which the prediction could be wrong, the value of the standard error should be small with reference to its coefficient. Thus, a smaller value of standard error will mean a better fit of the data to the model. Also, the value of the coefficient is probably different from 0 when its value is large as compared to its standard error. The standard error is used to help get a confidence interval for the coefficient values.

The t value or t statistic is calculated by dividing the coefficient by its standard error. As mentioned in the preceding paragraph, the larger the coefficient when compared to its standard error, the better the data fit to the model. Thus, a higher t value will indicate greater reliability of the coefficient value. However, the t value is not very useful on its own. But, it is useful in calculating the P value.

P-values

The P value shows whether the value of the coefficient is reliable or not. P value is also understood as "the probability of an error". Hence, its value should be as small as possible. The cutoff level for the P value is generally a predetermined level, for instance, 1%, 5% or 10% depending on the nature of the data under study and the different types of errors that are anticipated. Usually, a cutoff of 5% is the norm. The P value is the probability that the coefficient of the independent variable in the regression model is not reliable or that the coefficient in the regression output is zero. The P value is calculated from the t statistic using the Student's t distribution and generated by Excel. While the P value and Significance F are similar in interpretation, the difference lies in the fact that the P value applies to each corresponding coefficient while the Significance F applies to the model as a whole.

95% Confidence Interval – The coefficient of the independent variable shows the extent of impact the independent variable has on the dependent variable. The Confidence Interval represents the range within which the real value of the coefficient being estimated falls in. This Interval should not include a zero. Otherwise, the coefficient will not be statistically significant at the designated alpha level (5%). Thus, the 95% confidence interval shows the extent to which the value of the coefficient can vary. In Excel, the Confidence Interval is shown in two columns, the Lower 95% and the Upper 95%.

Residuals

This table is generated by Excel by checking on the option for the same while generating the Regression Analysis Output. It shows the predicted values of the dependent variables and the variance from the actual values which are called the Residuals.

Residual = Observed value - Predicted value

A **residual plot** is a graph that shows the residuals on the vertical axis and the independent variable on the horizontal axis. If the points in a residual plot are randomly dispersed around the horizontal axis, a linear regression model is appropriate for the data; otherwise, a nonlinear model is more appropriate.

TREND ANALYSIS

The next step was to forecast the total area under cultivation of the three crops viz. maize, soybean and sugarcane. For this purpose, the data regarding the total area under the cultivation of these three crops was taken for the period 1991-92 to 2017-18. A TREND analysis was done on Excel to forecast the total area under these three crops in the next five years. The data obtained for the 5th year i.e. 2023-24 was then used to set the objective for the OPTIMIZATION model which has been explained next.

OPTIMIZATION MODELLING

Using the input from TREND forecasting, the objective for the OPTIMIZATION model was set. The variables to be changed were the area and the production of the three crops. For setting the constraints, the area under maize and area under soybean were both set at => area under sugarcane. For the yield levels, the constraints for maize and soybean were set at world yield levels, while that for sugarcane was slightly reduced from current levels. The model has been explained in more detail in chapter 6.

3.6 BRIEF DESCRIPTION OF TERMINOLOGY

In order to make the meaning of the terms as unambiguous as possible, the following terms have been defined:

1. Area: This refers to the size of land under cultivation for a particular crop / crop category. In this study, the area under cultivation is measured in hectares (ha).

2. Production: The quantity of crop produced from the area under its cultivation is the production of the crop. This is measured in quintals or metric tons depending on the source of data. A quintal is equal to 100 kilograms while a metric ton is equal to 1000 kilograms.

3. Productivity/Yield: While total factor productivity takes into consideration the productivity of all farming inputs like land, labor, capital, irrigation, technology, fertilizers, etc., this study will be focusing only on the productivity of land. This factor is measured in kilograms per hectare (kg/ha). Thus, the production in quintals or tons is converted into kilograms (using appropriate conversion rate) and then divided by the area in hectares to arrive at the productivity of the crops.

4. Farm Harvest Prices: The average of the prices prevailing during the peak marketing season immediately after the harvest of the crop is referred to as the Farm Harvest Prices. This price has been used with respect to maize and soybean in the study. It has been confirmed from MSAMB that these prices are the actual rates received by the farmers.

5. Statutory Minimum Price (SMP) / Fair and Remunerative Price (FRP): The recovery rate linked SMP/FRP has been used to study the price trends of sugarcane. As already mentioned, since the actual rates paid by the mills vary from year to year, the SMP/FRP adjusted for the higher recovery rate in Pune and the H & T costs incurred by the mills will be used to study the price trends. The calculation of FRP includes several considerations like the cost of cultivation, sufficient margins to the cultivators, availability of sugar to consumers at reasonable prices, recovery rate of sugarcane etc. For this study, the minimum FRP recommended (linked to basic recovery rate) has not been used. Instead, the SMP/FRP recommended by CACP based on the average recovery rates of the previous years at all India level has been used. However, such data is not available (SMP/FRP based on all India averages) between 1991-92 and 1998-99 in the CACP reports. Hence, the data for SMP/FRP from 1999-00 onwards has been used for studying the trends at macro level and comparing it with the FRP obtained by farmers in Pune.

6. Recovery rate: This is the proportion in weight of sugar produced by crushing sugarcane. Thus, if 10 kg of sugar is produced by crushing 100 kg of sugarcane, the recovery rate is 10%.

7. Minimum Support Prices (MSP): The MSP is the floor price recommended by the CACP which is then declared by the Government as the price below which procurement is not to take place. While cost of production is an important consideration in the calculation of MSP, several other factors like demand and supply, intercrop price parity and international prices are taken into consideration while recommending the MSP. In fact, ensuring the rational utilization of resources like land and water is also being factored in during recent times due to the burning issues of climate change and sustainability. A report by Niti Aayog, "Evaluation Report on Efficacy of Minimum Support Prices on Farmers" shows that 50% to 100% farmers across major states in India are either not aware of the MSP or receive information about it only after sowing (pp.72). As such, the MSP is not seen to play an influential factor in deciding the cropping pattern. Hence, this work is focused on the influence of FHP on cropping pattern rather than the MSP. However, to give a perspective of the trends in FHP, a

comparison is made between the MSP (declared at the national level) and FHP (at the district level) of the selected cash crops.

3.7 CHAPTER SCHEME

The entire thesis has been organized into the following sections:

Chapter 1: Introduction

In this chapter an overview is given regarding the subject of cropping pattern including its meaning, types and importance in sustainable agricultural practices. The cropping pattern of India and Maharashtra is then analyzed beginning from the pre-green revolution period and covering the green revolution, post green revolution and post reform periods, finally followed up by the renaissance in the agricultural sector in recent times. Thereafter, an in-depth study of the crop profiles of the three selected cash crops viz. maize, soybean and sugarcane has been undertaken. The origin, morphology, species, nutritional value, global production scenario, domestic outlook and future trends / recent developments have been explored in detail.

Chapter 2: Review of literature

An extensive review of literature including books, theses, journal articles, reports etc. was undertaken by the researcher in order to study the work already undertaken in this field. The review included works by eminent economists like S. S. Kalamkar, Ramesh Chand, Elumalai Kannan and Narayanamoorthy. The gaps existing in the literature were identified and the novelty of the study being undertaken was highlighted. A detailed bibliography is appended at the end of the thesis.

Chapter 3: Research Methodology

The section explains in detail the type of research, scope, objectives, the hypotheses of the study, the methods used for data collection, and the tools used for statistical analysis. Various terms have been defined in order to make their meaning as unambiguous as possible.

Chapter 4: District Profile and Irrigation Scenario

A general description of the Pune district is given in this section and includes facts regarding the geographical location, topography, climatic conditions, soil slope, etc. Thereafter, the cropping pattern of Pune as it is today has been analyzed with specific reference to irrigation. The share of various crop categories viz., cereals, coarse cereals, pulses, oilseeds and fruits and vegetables in irrigated and rainfed areas for the various crop seasons, viz., kharif, rabi, summer and annual have been analyzed. Also, the production, productivity and cost of cultivation of the various crop categories in irrigated and rainfed areas has been analyzed. Finally, the block-wise crop water demand for the district up to 2020 as estimated by the PMKSY report has been presented.

Chapter 5: Pune's cropping pattern

In this chapter, trends in selected 13 important crops in the district, viz., rice, wheat, jowar, bajra, maize, tur, udid, moong, gram, groundnut, soybean, safflower, and sugarcane were analyzed. The trends in the area, production, and yield of these crops is depicted using line graphs while percentage changes in the area, production and productivity of these crops for the years 2000-01, 2007-08 and 2016-17 has been analyzed in order to get a picture of the cropping trends in the district.

Chapter 6: Data Analysis and Interpretation

The analysis of the area, production, yield and farm harvest prices of the three selected cash crops, viz., maize, soybean and sugarcane for the period from 1991-92 to 2017-18 has been done in this section. The entire data has been divided in to nine trienniums for ease of analysis. The percentage change in the four parameters for the crops (between TE1993-94 and TE2005-06 and between TE2005-06 and TE2017-18) has been calculated and bar graphs presented in order to depict the trends regarding the production of the crops. Correlation analysis has been shown between area, production, and yield each with the FHP. Simple regression analysis between area, production and FHP is done in order to test the hypotheses. Trend analysis is done to forecast the area under production of the three crops over the next 5 years. Finally, Optimization modelling is done to provide an alternative cropping pattern which would be both economically feasible and environmentally sustainable.

Chapter 7: Findings, conclusions and suggestions

In the last section, the main findings of the study regarding Pune's cropping pattern have been highlighted. Conclusions regarding the hypotheses have been presented. Suggestions regarding alteration in cropping pattern have been put forth to make agriculture economically feasible and environmentally sustainable in Pune district.

3.8 LIMITATIONS OF THE STUDY

The unavailability of crop wise irrigation statistics at the district level is a huge drawback in arriving at a precise picture of the cropping pattern in Pune district; the PMKSY report gives a very broad idea about the crop wise availability of irrigation. The data regarding area, production, productivity and farm harvest prices has been sourced from the EPWRF and as such it is a secondary source. Minor aberrations in the data may exist as data from remotely located areas may not have been collected. Finally, the prices paid by the sugarcane mills to the farmers cannot be estimated exactly because there are more than a dozen mills in Pune and each one of them pays a different rate according to their costing policies. As such, an average of the rates for the district can be estimated at best. However, given the fact that the government mandated SMP/FRP is paid by the mills to the farmers (even though postponed/ paid in instalments some of the times), the SMP/FRP has been used Similarly, the Farm Harvest Prices for maize and soybean are also the average of the prices prevailing during the peak season after harvesting. As such, the incomes earned by farmers at the micro level is bound to vary. Moreover, the data for Farm Harvest Prices for soybean is not available for the first two years viz., 1991 and 1992. But since soybean was not being cultivated in a big way in Pune till the beginning of the previous decade, this lack of data is not a huge constraint in the analysis. Again, the data has been compiled from several sources like MSAMB, data.gov.in., Sugar Commissionerate's office and website, Department of Economics and Statistics, and Economic and Political Weekly Research Foundation. The methodology adopted by every source is likely to be different, and hence there may be minor variations in the data. The need to use so many sources arose in order to fill the gaps in the data available with each source.

3.9 CONCLUSION

In this chapter, the theoretical framework for the study has been elaborated followed by the formulation of the Research Problem and the Significance of Research. The section on Research Methodology explains the various aspects of the study including type of research, scope of the study, objectives of research, selection of sampling method, etc. This provides the foundation for the data analysis which has been done in the next three chapters. The 4th chapter gives a brief description of the District Profile of Pune and how irrigation is being applied to various crop categories in Pune district This is followed by an analysis of Pune's cropping pattern for thirteen important crops (5th chapter) between 2000-01 and 2016-17 and the analysis of cropping pattern of selected cash crops, viz., maize, soybean and sugarcane (6th chapter) between 1991-92 and 2017-18 in Pune district.

REFERENCES

BOOKS

Ercolani, M. G., & Wei, Z. (2010). *An empirical analysis of the Lewis-Ranis-Fei theory of dualistic economic development for China*. Department of Economics, University of Birmingham.

Mellor, W. J. (2017). *Agricultural Development and Economic Transformation*: *Promoting Growth with Poverty Reduction*. Palgrave Studies in Agricultural Economics and Food Policy. ISBN 978-3-319-65258-0. A Palgrave Macmillan imprint published by Springer International Publishing, Switzerland. https://doi.org/10.1007/978-3-319-65259.7.

JOURNAL/CONFERENCE PUBLICATIONS

Alston J. M. and P. G. Pardey (2017), Transforming Traditional Agriculture Redux, Working Paper Series No 260, African Development Bank, Abidjan, Côte d'Ivoire.

Fan, S. (2012). Can we free the world of hunger and Malthus's shadow forever? *The Crawford Fund for International Agricultural Research*, Australia. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwjOrZ703ufeAhVBto8KHUaZDDMQFjABegQIBRAC&url=https%3A%2F%2Fageconsearch.umn.edu%2Fbitstream%2F152407%2F2%2FFan2012.pdf&usg=AOvVaw3Dz6tYYeVifnEEF9xfbbRv

Gouel, C. (2012). Agricultural price instability: a survey of competing explanations and remedies. *Journal of Economic Surveys*, Wiley, 2012, 26 (1), pp.129-156. 10.1111/j.1467-6419.2010.00634.x. hal-01001218

Jha, D. and Maji, C.C. (1971). Cobweb Phenomenon and Fluctuations in Sugarcane Acreage in North Bihar. *Indian Journal of Agricultural Economics*. Vol XXVI, No. 4. Oct-Dec 1971.. pp 415: pp 421. ISSN:0019-5014. Indian Society of Agricultural Economics, Bombay.

Kshirsagar, K. G. (2008). *Impact of Organic Farming on Economics of Sugarcane Cultivation in Maharashtra.* Gokhale Institute of Politics and Economics, Pune. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiD9rnboujeAhXHeisKHe1zB54QFjAAegQICxAC&url=http%3A%2F%2Fwww.indiaenvironmentportal.org.in%2Ffiles%2Fw15kgk.pdf&usg=AOvVaw1QzlOv197bb7FkvPaU-VrQ

K., M. L. , R., W. , N., W. , P., B. , & S., S. (2016). Maize Utilization in India: An Overview. *American Journal of Food and Nutrition*, *4*(6), 169-176. Retrieved from: http://pubs.sciepub.com/ajfn/4/6/5

Kajale, J. S. and Bodkhe, N. (2016) Soybean Sector in Maharashtra: Bring Hope, Not Distress. *Agricultural Situation in India*. Directorate of Economics and Statistics.

Kothari, C. R. (2004). *Research Methodology, Methods and Techniques*. New Age International Publishers. New Delhi.

Lundahl, M. (1987) 'Efficient but Poor', — Schultz' Theory of Traditional Agriculture, Scandinavian Economic History Review, 35:1, 108-129, DOI:10.1080/03585522.1987.10408083 https://doi.org/10.1080/03585522.1987.10408083

Mason, O. J. (2012). Performing Regression Analysis Using Microsoft Excel. *International Journal of Arts and Commerce*. Vol 1. No. 5.

Narayanamoorthy. (2013). Profitability in Crops Cultivation in India: Some Evidence from Cost of Cultivation Survey Data. *Indian Journal of Agricultural Economics*. Vol.68, No.1, Jan.-March 2013.

Orlov, L.M. (1996). Multiple Linear Regression Analysis using Microsoft Excel. Handout published by Chemistry Department, Oregon State University.

Xie, H. and Wang, B. (2017). An Empirical Analysis of the Impact of Agricultural Product Price Fluctuations on China's Grain Yield. *Sustainability*, 2017, 9, 906. www.mdpi.com/journal/sustainability. Doi:10.3390/su9060906.

REPORTS

Bisaliah, S. (1986). *Soyabean Development in India*. CGPRT Centre. Retrieved from:https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwjCwsGsq-feAhXEOY8KHdQwA0IQFjAAegQIChAC&url=http%3A%2F%2Feprints.icrisat.ac.in%2F12155%2F1%2FRP-04796.pdf&usg=AOvVaw17gvnCsE6wSFPD24avaVoX

Comprehensive District Agricultural Plan: 2012-13 to 2016-17. (2012) Department of Agriculture, Government of Maharashtra. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiJ9JmO0tPeAhXFO48KHThhDfIQFjAAegQICBAC&url=http%3A%2F%2Fkrishi.maharashtra.gov.in%2FSite%2FUpload%2FPdf%2Fpune_cdap.pdf&usg=AOvVaw2krcvsuhWc3XUk9-Cf8WB0

District Socio Economic Reviews (Pune, Mumbai, Thane, Nashik). Directorate of Economics and Statistics, Planning Department, Government of Maharashtra, India.

Economic Survey of Maharashtra (2019-20). Directorate of Economics and Statistics, Planning Department, Government of Maharashtra, Mumbai.

Evaluation Report on Efficacy of Minimum Support Prices (MSP) on Farmers (DMEO Report No.231). (Jan 2016). NITI Aayog.

India Grain and Feed Annual. (2016). GAIN Report Number: IN6033. Retrieved from:https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_New%20Delhi_India_2-26-2016.pdf.

India Sugar Annual. (2018). GAIN Report Number: IN8047. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiihtba-efeAhVJO48KHZe6BpAQFjAAegQICxAC&url=https%3A%2F%2Fgain.fas.usda.gov%2FRecent%2520GAIN%2520Publications%2FSugar%2520Annual_New%2520Delhi_India_4-19-2018.pdf&usg=AOvVaw0OZAXNzf9qI57y9m86rZqj

Maize in India. (2014). India Maize Summit – 2014. FICCI, KPMG, NCDEX. Retrieved from:http://ficci.in/spdocument/20386/India-Maize-2014_v2.pdf.

Price Policy for Sugarcane: the 2012-13 Sugar season. Commission for Agricultural Costs and Prices. Ministry of Agriculture, Government of India. Retrieved from: https://cacp.dacnet.nic.in

Price Policy for Sugarcane: the 2014-15 Sugar season. Commission for Agricultural Costs and Prices. Ministry of Agriculture, Government of India. Retrieved from: https://cacp.dacnet.nic.in

Pune District Marketing Strategy Supplement (MSS). (2016). Maharashtra Agricultural Competitiveness Project. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwib5e-tlejeAhWMr48KHQfBCNgQFjAAegQICRAC&url=http%3A%2F%2Fmacp.gov.in%2Fsites%2Fdefault%2Ffiles%2Fuser_doc%2FPune%2520MSS_0.pdf&usg=AOvVaw2AfgvxeQ0F0Q_MGywTBOBh

WEBSITES

Directorate of Economics and Statistics. Ministry of Agriculture and Farmers Welfare, Government of India.

http://eands.dacnet.nic.in/LUS_2012-13/lus_2012-13.xls.

http://economictimes.indiatimes.com/news/economy/agriculture/government-allows-duty-free-import-of-maize-up-to-five-lakh-tonnes/articleshow/50465727.cms. 06 Jan 2016.

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=13&cad=rja&uact=8&ved=2ahUKEwjsloWytefeAhUaeisKHbqJBt8QFjAMegQICBAB&url=https%3A%2F%2Fwww.reuters.com%2Farticle%2Fus-brazil-soy-usa%2Fbrazil-to-pass-u-s-as-worlds-largest-soy-producer-in-2018-idUSKBN1IC2IW&usg=AOvVaw2PnytOWOlHmHJPxNEW1qI4. 12 May 2018

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=14&cad=rja&uact=8&ved=2ahUKEwjctK7o7efeAhXLtI8KHQZ_Dd8QFjANegQIChAB&url=https%3A%2F%2Fwww.investopedia.com%2Farticles%2Finvesting%2F101615%2F5-countries-produce-most-sugar.asp&usg=AOvVaw3LJi0R5NMDHubWA6vR-yO. 15 Nov 2018

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=15&ved=2ahUKEwjJ3sPA9uneAhWJq48KHRQMBIkQFjAOegQIDBAB&url=https%3A%2F%2Fwww.businessinsider.in%2Findia-could-soon-become-the-worlds-largest-sugar-producer-but-heres-why-thats-a-problem%2Farticleshow%2F65657844.cms&usg=AOvVaw1TCkYIOeqo5cVBZGv3H00P. 03 Sep 2018

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwik7srB9-neAhXEMI8KHaxXC38QFjAAegQIChAB&url=https%3A%2F%2Feconomictimes.indiatimes.com%2Fnews%2Feconomy%2Fagriculture%2Findia-to-consider-sugar-export-subsidy-proposal-next-week%2Farticleshow%2F65868276.cms&usg=AOvVaw3bIab2vso-KDsgWi70wRER19 Sep 2018

CHAPTER 4
DISTRICT PROFILE AND IRRIGATION SCENARIO

4.1 INTRODUCTION

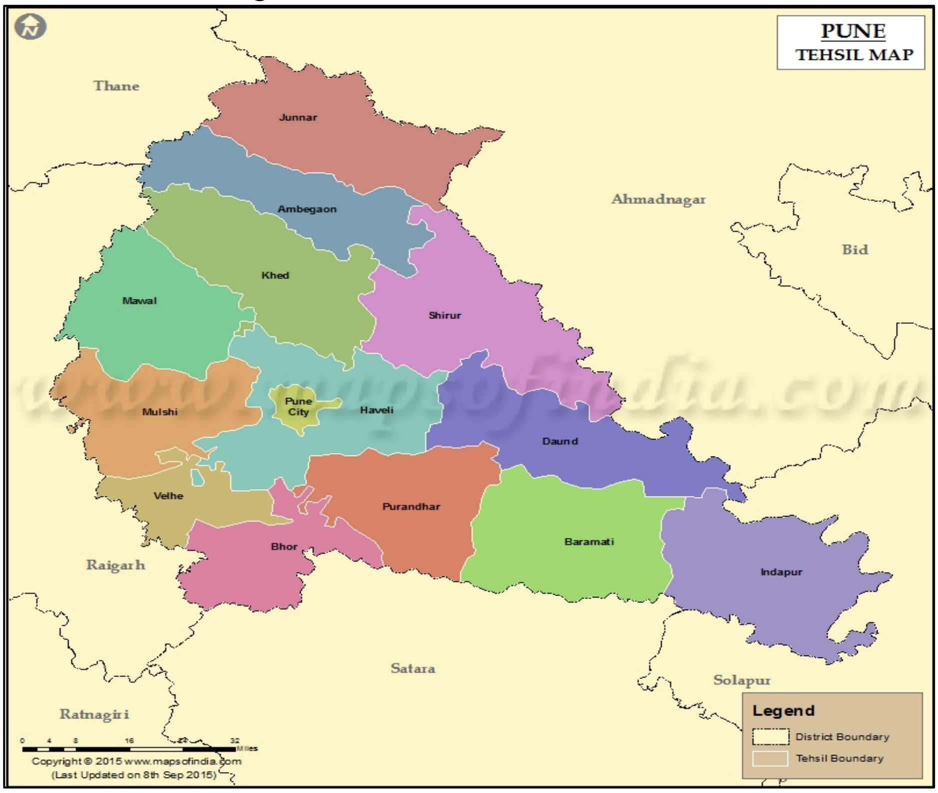
In this chapter, an analysis of Pune's cropping pattern has been done with respect to irrigation. The District Socio Economic Reviews contain crop wise irrigation statistics from the year 2016-17 onwards. An analysis of these statistics reveals very discouraging trends. While sugarcane continues to be completely irrigated (100% of 1,30,621 ha), the irrigation statistics for maize available for the three years 2016-17, 2017-18, and 2018-19 reveal that there has been a steady decline in irrigated area under maize from 33.67% to 28.76% and finally to 21% respectively. Maize is cultivated throughout the year as kharif, rabi and summer crop in Pune. As such, maize crop requires both productive as well as protective irrigation. With respect to soybean, the data available for only one year 2018-19 shows that hardly 10% of the area under soybean is irrigated. Thus, decreased irrigation to maize and soybean is affecting the productivity of these crops (as will be brought out in subsequent chapters), while increasing irrigation to greater area under sugarcane cultivation is proving wasteful due to stagnation in sugarcane yield levels.

Water being a scarce resource, the importance of its optimum use across various crop categories cannot be adequately stressed. In this chapter an attempt has been made to analyze the crop wise irrigation statistics in Pune. The data presented in this chapter also provides insight into the production and productivity of rainfed and irrigated crops. This will give insight into the current usage of irrigation across crop categories under the present cropping pattern and provide a basis for suggesting an alternative cropping pattern for optimum usage of irrigation. **All the data regarding crop wise irrigation statistics are taken from a single source, the Pradhan Mantri Krishi Sinchayee Yojana report and pertains to the year 2014-2015.** This is because the crop wise irrigation statistics have not been compiled since 2002 by the Department of Agriculture. The District Socio Economic Reviews from the year 2009 to 2015 were scrutinized for the required data. However, the crop wise irrigation statistics given in those reports are all pertaining to the year 2002-03. It is only in the latest District Socio Economic Reviews (2016-2017 onwards) that this data has been freshly surveyed and included. However, the data in these publications is incomplete and for a lot of crops it is not available. Hence, the data from the PMKSY report has been used for the purpose of analysis.

4.2 DISTRICT PROFILE

Pune is the second largest district of Maharashtra state with respect to area. The district has a geographical area of 15,642 sq.km., which is 5.08% of the total area of the state. It is located in the western region of the state and is situated between latitudes 17°54'N and 19°24'N and longitudes 73°29'E and 75°10'E. Pune district shares its boundaries with Ahmednagar district in the north and east, Satara and Solapur districts in the south and south east respectively and Thane and Raigarh districts in the north west and west respectively. It is divided into 14 talukas namely Pune city, Haveli, Khed, Ambegaon, Junnar, Shirur, Daund, Indapur, Baramati, Purandhar, Bhor, Velhe, Mulsi and Maval for administrative purposes. It is geographically located in the Bhima and Nira basins. The district is in the shape of a triangle wherein the base lies in the Sahyadri mountains on the west and the apex is in the extreme South-east corner near the river Nira. The district is divided into three zones viz., based on factors like height from sea level, rainfall, soil pattern etc. The Sahyadri ranges are spread from North to South in the district.

Figure 4.01: Location of Pune district



Source: www.mapsofindia.com

4.2.1 DEMOGRAPHY

The population of Pune district grew at a rate of 35.9 per cent from 72,24,224 in 2001 to 94,29,408 in 2011. The average growth rate for the state was 15.99 per cent and for Pune city it was 8.4 per cent. The density of population in the district is 603 inhabitants per square kilometre. While the male population was around 49.24 lakhs, the female population was 45.05 lakhs. The district has a literacy rate of 87.19 percent; however, while male literacy is high at 92.72 percent, female literacy is at a low of 81.13 percent. The average family size of the district is 4 persons. For every 1000 males, there were 919 females in 2011 (District Socio Economic Review, 2018, pp3).

4.2.2 LIVESTOCK

Livestock are domesticated animals raised in an agricultural setting to produce labour and commodities such as meat, eggs, milk, fur, leather and wool. Animal husbandry is that branch of agriculture which involves the breeding, maintenance and slaughter of livestock. Such activities have traditionally been a part of agriculture since the settlement of civilizations into farming lifestyles. Nowadays, animal husbandry along with dairy and fisheries provide an important alternative source of income to the small and marginal farmers. It also acts as an insurance cover for the poor during drought and famine as well as provides cheap nutrition and proteins to them. Pune district has a large number of milching animals like cows, buffaloes, goats etc. apart from a thriving poultry industry. Livestock of the Pune district is divided largely in to four types, namely poultry, small animals, large animals and draft animals. The poultry of the district is a flourishing industry with a total of 1,85,37,999 which is a considerable size. In the small animals category, ducks, pigs, sheep and goats are counted with their total count being 7,09,016. The large animals count is 10,37,025 which is substantial. The draft animal total of the district comes to 2,02,142. Pune city has the least number of poultry units due to the dense population and lack of space availability. Shirur taluka has the highest number of poultry birds at a count of 27,20,328. The blocks of Ambegaon and Junnar also show significant number of poultry birds. Livestock of small animals like goats and sheep are large in Baramati, Indapur, Shirur, Junnar and Daund. The total count of draft animals in the district is 2,02,142 of which the number of bullocks is 1,80,269, followed by 20,407 he-buffaloes, 1118 donkeys, 318 horses and 30 camels. The bullock and he-buffalo power available in the district are predominantly used for agricultural operations whereas horses, donkey and camel are used for enhancing income from other supplementary activities. Total number of cow count both indigenous and hybrid variety is 7,63,261 and buffalo count is 2,94,171. Though there is huge scope, presently, the scarcity of water and availability of green fodder across the year inhibits animal husbandry and dairy business of the district. As the cropping pattern of the district is shifting towards cash crops which are more remunerative, the production of fodder is not taken up. The nutritive value of feed and fodder to make fodder production more remunerative is critical to bridge the gap between demand and supply (District Socio Economic Review, pp 223-229).

4.2.3 AGRO-ECOLOGY, CLIMATE, HYDROLOGY AND TOPOGRAPHY

As can be seen from Table 4.01, Pune district is divided into six agroecological zones namely AES-I to AES-VI. The first AES-I is the Ghat section, characterized by high rainfall and shallow soils which covers the western parts of Velha, Bhor, Mulshi, Khed, Junnar, Ambegaon and Maval. This part of the district receives annual rainfall ranging from 3000-5000 mm. The average monthly rainfall of this area is 750 to 1250 mm. The second AES-II covers sub mountainous region with medium rainfall having laterite soils. This also consists of the western parts of Velha, Bhor, Mulshi, Khed, Junnar, Ambegaon and Maval blocks of the district. This zone receives annual rainfall of 1750 to 2500 mm. The zone AES-III is sub mountainous with assured rainfall and medium soil. This zone includes the western parts of Purander, Haveli, Bhor, Eastern parts of Maval, Mulshi and Central parts of Khed, Ambegaon, Junnar. This area receives average monthly rainfall of 250 to 425mm. The next zone AES-IV is a plain area with assured rainfall and medium soil. This consists of Central part of Haveli, Khed, Purandar, Ambegaon and Junnar with annual rainfall of 950-1250mm. and average monthly rainfall from 238 to 313mm. The AES-V is a scarcity zone with low rainfall and light to medium soils covering parts of Purandar, part of Baramati, Daund, Haveli, Indapur, Shirur, Ambegaon and Khed. This area receives average monthly rainfall of 188mm. The last zone AES-VI is also a scarcity zone characterized by light to medium soils and rainfall. This covers parts of Shirur, Baramati, Indapur, Daund blocks. These blocks receive less than 750 mm rainfall annually.

4.2.4 CLIMATE AND RAINFALL

Pune district experiences four distinct seasons. It gets the south-west monsoon from June to September. October and November are the autumn months followed by winters from December to February. The cycle ends with summers from March to May. While the mean minimum temperature of the district is around 12°C and mean maximum temperature is around 39°C, the normal annual rainfall over the district varies from about 468mm to 4659 mm. The eastern part of the district around Daund (468mm), Baramati (486mm), and Jujuri (494mm) receives minimum rainfall. Moving towards the west, precipitation increases and around Khandala (4659 mm) in the western ghat receives maximum rainfall. Rainfall analysis also indicates occurrence of drought prone area in eastern, southern, south-eastern, central and north western part around Indapur, Baramati, Jujuri, Daund, Talegaon-Damdhare, Alandi, Shirur and Bhor covering about 50% area of the district (krishi.maharashtra.gov.in).

Table 4.01: Agro-Ecology, Climate, Hydrology and Topography of Pune district

Sr. No.	Agro-Ecological Zone Type	Type of Terrain	Name of Block	Normal Annual Rainfall (mm)	Average Monthly Rainfall (mm)
1.	AES - I	Ghat area, High rainfall, shallow soils	Western part of Velha, Bhor, Mulshi, Khed, Junnar, Ambegaon and Maval	3000-5000	750-1250
2.	AES - II	Sub-mountain, medium rainfall, lateritic soil	Western part of Velha, Bhor, Mulshi, Khed, Junnar, Ambegaon and Maval	1750-2500	425-625
3.	AES - III	Sub-mountain, assured rainfall, medium soil	Western part of Purandar, Haveli, Bhor, Eastern part of Maval, Mulshi and Central parts of Khed, Ambegaon and Junnar	1000-1700	250-425
4.	AES - IV	Plain area, assured rainfall, medium soil	Central part of Khed, Haveli, Ambegaon, Purandar and Junnar	950-1250	238-313
5.	AES - V	Scarcity, low rainfall, light to medium soil, Non command area	Purandar, part of Baramati, Daund, Haveli, Indapur, Shirur, Ambegaon and Khed	Less than 750	188
6.	AES - VI	Scarcity, low rainfall, light to medium soil, Command area	Parts of Shirur, Khed, Ambegaon and Junnar, Baramati, Indapur, Daund, Haveli	Less than 750	188

Source: pmksy.gov.in

4.2.5 TOPOGRAPHY AND AGRO-CLIMATIC CONDITIONS

Pune district generally has dry climate except for the monsoons. The summer is moderately high and temperature varies from 36°C to 42°C. The average annual rainfall is 905 mm. There is wide variations in temperature and rainfall conditions within Pune district because it is part of the tropical monsoon land. Whereas the western regions in the district are cool, the eastern regions are hot and dry. There are four distinct agroclimatic zones (Zone 3 to Zone 6) in Pune district.

1. Zone – 3: Western Ghat Zone: This zone includes Lonavala and Khandala and covers 1.16 lakh ha area of the district, the least among the four zones.

2. Zone – 4: Sub-Mountain Zone (Transition Zone-1 with red to reddish brown soils): This zone covers the western parts of Bhor, Velhe and Mulshi, central parts of Mawal, and western strip of Khed, Ambegaon and Junnar talukas of Pune district. This zone ranks third among the four zones with an area coverage of 3.08 lakh ha.

3. Zone – 5: Western Maharashtra Plain Zone (Transition Zone-II with Greyish Black Soils): This is a wider strip running parallel to the eastern side of Transition Zone-I and extends towards east up to the line where the Scarcity Zone starts. This zone ranking second in terms of area coverage (covering 3.14 lakh hectares) extends to the central part of Bhor, western part of Haveli and eastern parts of Maval, Khed, Ambegaon and Junnar talukas in Pune district.

4. Zone – 6: Scarcity Zone (with kharif cum rabi cropping): A large section in mid-western Maharashtra is traditionally known as the famine area of the State. It comprises of Pune, Ahmednagar, Nasik and Dhule districts (excluding the portions covered under plain Zone). Areas of Purandar, Baramati, Indapur, Daund, Shirur, Junnar, Ambegaon, Khed, Haveli and Bhor talukas of the district are part of this zone that constitutes the largest agroclimatic zone covering 8.21 lakh ha.

(krishi.maharashtra.gov.in)

Figure 4.02: Agro-Climatic Zones of Pune District

Source: macp.gov.in

4.2.6 SOIL TYPE

Different types of soils can be found in Pune district. In the western region of the district the soils are brown in colour and less fertile. On the other hand, the eastern part has comparatively deep soils with black colour and are more fertile. The richest alluvial soil track is found in the valley of Bheema river. The rivers Velu and Ghod are on the left side of Bheema and the rivers Indrayani, Bhama, Mula-Mutha etc. are on the right side. Each tahsil of the district has minimum one river. Therefore, the agro-climatic condition of the district is favourable. The soils of Pune district can be classified into 5 types viz., Black (45 percent), Red (5 percent), Alluvial (8 percent), Sandy (12 percent) and Sandy loams (30 percent). Since the district falls partly in the Western Ghat section and partly in the Deccan Plateau, the physiography of the district comprises of four major land forms: (1) The hills and ghats (2) The foothills (3) The plateau and (4) The plains (krishi.maharashtra.gov.in).

4.2.7 DRAINAGE NETWORK

The district has three major drainage systems namely:

(1) The Bhima river (355 km) and the Ghod river (196 km) forms the total Bhima-Ghod river system in the northern, north-eastern and eastern part of the district.

(2) The Mula-Mutha river system (242 km) provides drainage for the central part of the district.

(3) The Nira river (231 km) provides drainage in the south, south-east and eastern part of the district.

Other important rivers include Andhra, Karna, Shivganga, Pushpavati, Pauna and Indrayani. These rivers are characterized by semi-dendritic drainage pattern and their drainage density is quite high. The district is divided into 71 watersheds based on the geo-morphological setting and the drainage pattern.

(krishi.maharashtra.gov.in)

4.2.8 SOIL SLOPE

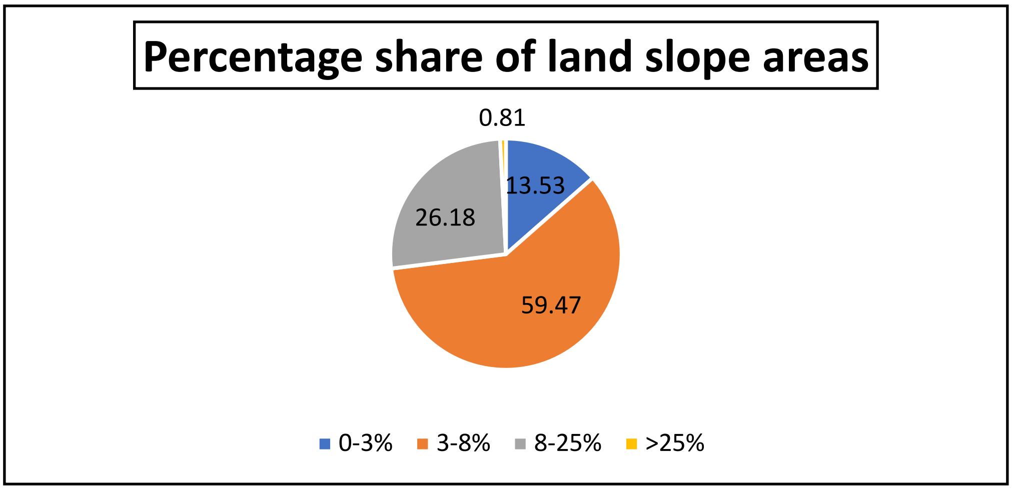
Slope and Topography describes the shape and relief of the land. Slope is the percentage change of elevation over a certain distance. The angle of slope affects the type, depth and moisture content of soil. It also affects the rate of soil erosion. The extent of farm mechanization depends on the slope. The slope also affects the infiltration, rate of precipitation and consequently water retention capacity of the soils. The greater the slope, the lesser is the soil retention capacity. The sloping land also enhances the subsurface runoff since such soils are sandy soils with greater porosity. Thus, the slope of land manipulates erosion, water infiltration rate, water retention capacity, subsurface runoff etc, key factors that impinge on crop productivity and production.

Table 4.02: Soil Slope of Pune district

Sr. No.	Land Slope	Area (in ha)	Percentage share
1.	0-3%	119799	13.53
2.	3-8%	526571	59.47
3.	8-25%	231821	26.18
4.	>25%	7191	0.81
	Total	885383	100

Source: krishi.maharashtra.gov.in

Figure 4.03: Soil slope of Pune district



Source: Table 4.02

Of the 8,85,383 ha of the district surveyed, 1,19,799 ha area has 0- 3% slope which is highly suitable for agriculture purpose, 5,26,571 ha area has 3-8% slope and is moderately suitable for agriculture whereas 2,31,821 ha area with slope of 8- 25% is least suitable for agriculture. The remaining land of 7,192 ha with slope greater than 25% is totally unfavourable for agriculture. Blocks like Shirur, Baramati, Indapur, Daund have plain fields with the least variation of sloping conditions having slope lesser than 25% which are used for agriculture. Velha block mainly comprises of hilly terrain and undulated area. This region shows maximum erosion due to higher degree of slope. The western part of Pune district comprising of Junner, Ambegaon, Maval, Mulshi, Velha, Bhor etc have more sloping and undulated lands as compare to the eastern part of district comprising of Indapur, Baramati, Daund, Shirur etc. Naturally the slope of land influences the intensity of runoff. Higher the slope greater will be the runoff. As a consequence, there is more soil erosion and with the loss of the fertile layers, crop yield is severely hampered (krishi.maharashtra.gov.in)

4.2.9 LAND USE PATTERN

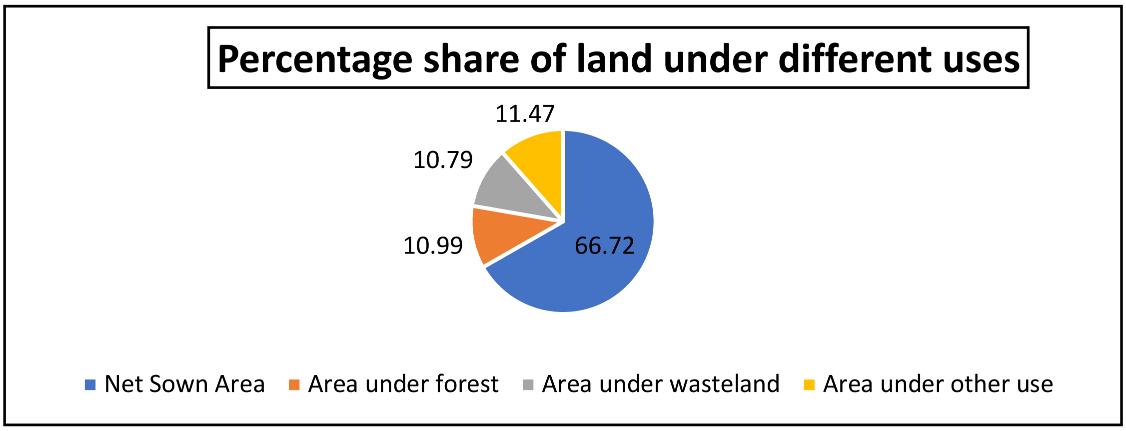
Land use involves management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats such as arable fields, pastures forest etc. It also has been defined as "the total of arrangements, activities, and inputs that people undertake in a certain land cover type". In the context of agriculture the land use pattern is regrouped in different classes namely Agriculture area and Non-Agricultural area which consists of area under forest, wasteland and other miscellaneous use. Pune has 13 blocks covering 1877 villages with total geographical area of 15,62,018 ha. It has gross agricultural area of 11,72,951 ha and net sown area of 10,42,282 ha. The district comprises of forest on 1,71,809 ha and wasteland of 1,68,696 ha. The area under other use is 1,79,231 ha. This area is mainly used for rural and urban habitation, industries, roads and area under rivers and nallas etc. The district includes a total 1,71,809 ha forest which mainly covers the western part i.e., Sahayadri ranges of the district. The district consists of remarkable area under waste land i.e., 1,68,696 ha of which the maximum portion lies in Haveli block (29,170 ha) and minimum (4,863) ha in Velha block. Land under other use is seen to the maximum extent in Haveli block (40,038 ha), Maval block (38,894 ha) and Mulshi block (29,529 ha) since these cover big urban habitations like Pune and Pimpri Chinchwad and the major industrial belt of the district (krishi.maharashtra.gov.in)

Table 4.03: Land use pattern of Pune district

Sr. no.	Type of land use	Area (in ha)	Percentage share
1.	Gross Cropped Area	1172951	75.09
2.	Net Sown Area	1042282	66.72
3.	Area under forest	171809	10.99
4.	Area under wasteland	168696	10.79
5.	Area under other use	179231	11.47
6.	Total (1877 villages)	1562018	100

Source: krishi.maharashtra.gov.in

Figure 4.04: Land Use Pattern of Pune District



Source: Table 4.03

4.2.10 CROPPING INTENSITY

Instead of cultivating a single crop, when farmers resort to cultivating 2-3 crops from the same piece of land in one year, then the cropping intensity for that land is said to be high. From Table 4.3, it can be seen that the area sown more than once in Pune district thus works out to

(1172951-1042282) = 130669 ha.

Cropping intensity for a region is calculated using the following formula:

Cropping intensity = (Gross cropped area/Net sown area) x 100

Thus, when a larger portion of the net area is cropped more than once in an agricultural year, it depicts a higher level of cropping intensity. It also shows that the productivity per unit of arable land is higher in an agricultural year.

From the above table it is seen that the cropping intensity of the district is around 113%. ((1172951/1042282)*100).

In case of India, higher average cropping intensity is seen in the northern plains like in Punjab (176%), Himachal Pradesh (169%), West Bengal (157%), Haryana (145%), and Uttar Pradesh (143%). The average cropping intensity is lower in dry, rainfed regions like Rajasthan, Gujarat, Maharashtra and Karnataka (110%-125%). The relevant figures for Maharashtra and India are 127% and 130% respectively (krishi.maharashtra.gov.in).

4.3 IRRIGATION SCENARIO IN PUNE

The climate of Pune region is majorly dry and arid and as such the district falls under the classification of scarcity zone of the state. Agriculture in Pune is dependent mainly on rainfall and hence the cropping pattern is dominated by rabi crops. While rabi crops cover 60 per cent of the cropping area, 26 per cent is covered by kharif crops. Sugarcane and horticultural crops occupy around 10 percent of the cultivated area each (C-DAP, 2012-13 to 2016-17). The district comprises three cropping seasons, which includes kharif, rabi, summer and annual crops of which the kharif season begins in June or July and ends in September or October whereas rabi starts from September or October and ends in February or March. The crops cultivated in the rabi season are primarily foodgrains with 60 per cent of the area under rabi jowar and 19 per cent under wheat. The other dominant crop in the rabi season is gram which also happens to be the main pulse crop in this region. Rabi oil-seeds are negligible. Pune's cropping pattern can be divided into four types:

A) Paddy based

B) Bajra based

C) Sugarcane belt

D) Fruits and vegetables

(PMKSY, 2015)

The district grows a wide range of crops viz cereals, coarse cereals, pulses, oil seeds, fruits and vegetables etc., across all seasons of the year. The crop category and types of crops grown in the district is presented below.

Table 4.04: Cropping Pattern of Pune district

Sr. No.	**Crop Category**	**Type of crops**
1.	Cereals	Wheat, paddy
2.	Coarse cereals	Sorghum (jowar), pearl millet (bajra), maize etc
3.	Pulses	Pigeon pea, gram, green gram (*moong*), *udid* etc.
4.	Oilseeds	Sunflower, groundnut etc.
5.	Fibre	Cotton
6.	Vegetables	Tomato, onion, okra, potato, cabbage, cauliflower, peas, beans, cucumber, leafy vegetables like coriander, fenugreek etc.
7.	Fruits	Mango, banana, grapes, sapota (*chikku*), pomegranate etc.
8.	Others	Sugarcane

Source: pmksy.gov.in

The cereals mainly grown in the district are wheat and paddy. The blocks like Mulshi, Maval, Bhor, Velha, Junnar, Khed etc. grow cereals on a large scale in kharif season whereas blocks like Purandar, Daund, Baramati, Indapur grow them in rabi season. During summer none of the blocks grow cereals. In case of coarse cereals, the district grows bajra, jowar, maize etc.

The Junnar, Khed, Shirur, Ambegaon, Haveli blocks are the highest growers of coarse cereals in kharif season and Indapur, Shirur, Baramati, Daund, Purandar lead in cultivating coarse cereals in rabi season.. Area under coarse cereals during summer season is negligible. The pulses are grown in Shirur, Junnar, Purandar, Baramati, Indapur, Daund etc blocks on large scale in both kharif and rabi seasons. During summer season none of the blocks cultivate pulses. The key pulse crops grown in the district are pigeon pea, green gram (moong), udid, bengal gram etc. Junnar, Ambegaon, Shirur, Khed, Indapur etc are major vegetable growing blocks in the district. These blocks take up vegetables in both kharif and rabi seasons. Sugarcane is also cultivated on substantial area in the district and blocks like Indapur, Baramati, Daund, Shirur are the prominent areas in sugarcane cultivation. The vegetable and sugarcane producing belt of the district is placed along the main river basin of Bhima. This belt has also very good access to markets like Pune, Mumbai, Nashik, Ahmednagar etc (PMKSY, 2015). The cereals, pulses and oil seed crops are mainly dependent on precipitation and hence are rainfed crops. Sometimes these crops are supported with protective irrigation during dry spells of the season. The crops like sugarcane, vegetables and fruits are provided with regular watering during their life cycle. The average frequency of irrigations is 10 to 12 days. However, it comes down to 6 to 8 days during summer season. The fruit crops especially in its early age and then during flowering and fruiting stages of productive age are supplied with frequent watering. The district uses both ground water and surface water sources for irrigation. The overall picture of the district shows that out of total 10,42,282ha cultivated area 3,75,053 ha i.e. 35.98 % is under irrigated crops whereas 6,67,229 ha i.e. 64.02 % is grown on rain water. Out of the total area (3,75,053 ha) under irrigation, 62,995 ha area is under irrigated horticultural crops and 1,13,947 ha area (out of the 1,19,957 ha under summer crops) is under sugarcane cultivation.

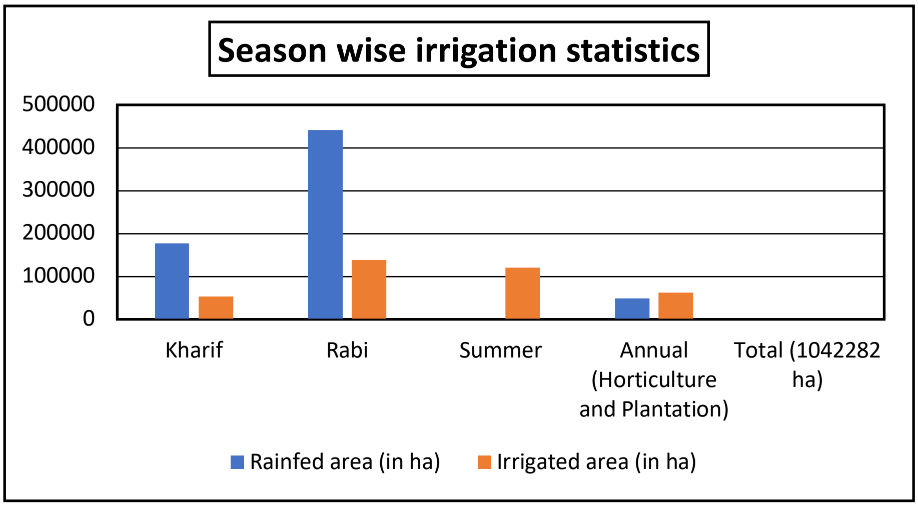
Thus, it can be seen that the irrigation of the district is skewed in favour of sugarcane and horticultural crops. Though occupying around 10% of the total cultivated area (1,11,829 ha out of 10,42,282 ha), nearly 56% of the area under horticultural production is irrigated (62,995 ha out of 1,11,829 ha). Again, out of the 1,19,957 ha under summer crops, 1,13,497 ha is under sugarcane. This also forms around 10% of the total cultivated area of 10,42,282 ha, but is 100% irrigated. On the other hand, the rabi crop season which is the main cropping season of the district occupies nearly 56% of the total cultivated area (5,80,620 ha out of 10,42,282 ha), but only 24% of the area is covered by irrigation (1,38,928 ha out of 5,80,620ha).

Table 4.05: Season wise irrigation statistics of Pune (2015)

Sr. no.	Crop season	Rainfed area (in ha)	Irrigated area (in ha)
1.	Kharif (2,29,876 ha: 22% of total area)	176703(77%)	53173 (23%)
2.	Rabi (5,80,620: 56% of total area)	441692(76%)	138928(24%)
3.	Summer (sugarcane 1,13,497 ha: 10% of total area)	0	119957(100%)
4.	Annual: Horticulture and Plantation (1,11,829 ha: 10% of total area)	48834(44%)	62995(56%)
	Total (1042282 ha)	667229 (64.02%)	375053(35.98%)

Source: pmksy.gov.in

Figure 4.05: Season wise irrigation statistics of Pune



Source: Table 4.05

Out of total 6,18,395 ha seasonal rain-fed area highest area i.e. 4,41,692 (71.42%) is seen during rabi season followed by kharif season with 1,76,703 ha (28.58%) area. The summer season does not grow any rain-fed crop in the district. In case of total 3,12,058 ha seasonal irrigated crops maximum 1,38,928 ha (44.52%) are seen in rabi season, followed by 1,19,957 ha (38.44%) and 53,173 (17.03%) in summer and kharif seasons respectively.

Table 4.06: Seasonal irrigated and seasonal rainfed area statistics of Pune (2015)

Sr. No.	Crop season	Seasonal Rainfed area (in ha)	Seasonal Irrigated area (in ha)
1.	Kharif	176703 (28.58%)	53173 (17.03%)
2.	Rabi	441692 (71.42%)	138928 (44.52%)
3.	Summer	0	119957 (38.44%)
	Total	618395	312058

Source: pmksy.gov.in

Table 4.07: Crop wise season wise irrigation statistics of Pune (2015)

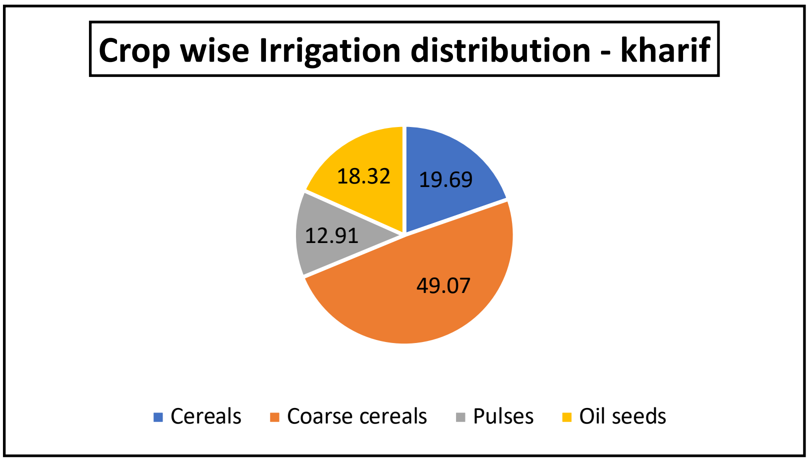
Crop Type	Irrigated Kharif (area in ha)	Irrigated Rabi (area in ha)	Irrigated Summer crop (area in ha)	Irrigated Horticulture and Plantation Crop (area in ha)	Total (area in ha)
Cereals	10471	39135			49606
Coarse cereals	26092	76779	1240		104111
Pulses	6864	20199			27063
Oil seeds	9746	2815	5220		17781
Fibre	0				
Any other crops (sugarcane)			113497	62995	176492
Total (area in ha)	53173	138928	119957	62995	375053

Source: pmksy.gov.in

From the above table it is seen that among irrigated crops, annual crops like sugarcane and horticultural crops occupying 176942 ha (113497 + 62995) out of the total irrigated area of 375053ha form the lion’s share, nearly 47% of the irrigated area.

In kharif season out of total 53,173 ha irrigated area, maximum i.e. 26,092 ha (49.07%) area is seen under coarse cereals whereas only 6,864 ha (12.91%) area is under pulses. The proportion of irrigated cereals and oil seed crops in kharif season found to be 10,471 ha (19.69%) and 9,746 ha (18.32%) respectively.

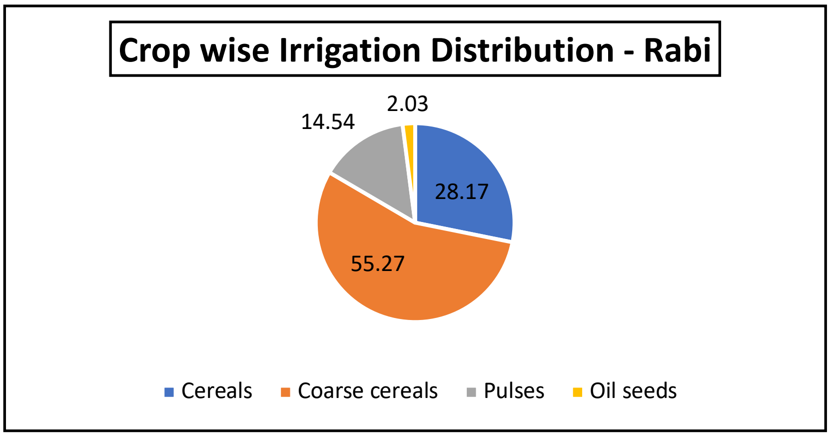
Figure 4.06: Crop wise Distribution of Irrigated Area – Kharif season of Pune



Source: Table 4.07

In rabi season out of total 1,38,928 ha irrigated area, maximum i.e.76,779 ha (52.26%) area is seen under coarse cereals whereas only 2,815 ha (2.03%) area is under oil seed crops. The proportion of irrigated cereals and pulses in rabi season is found to be 39,135 ha (28.17%) and 20,199 ha (14.53%) respectively

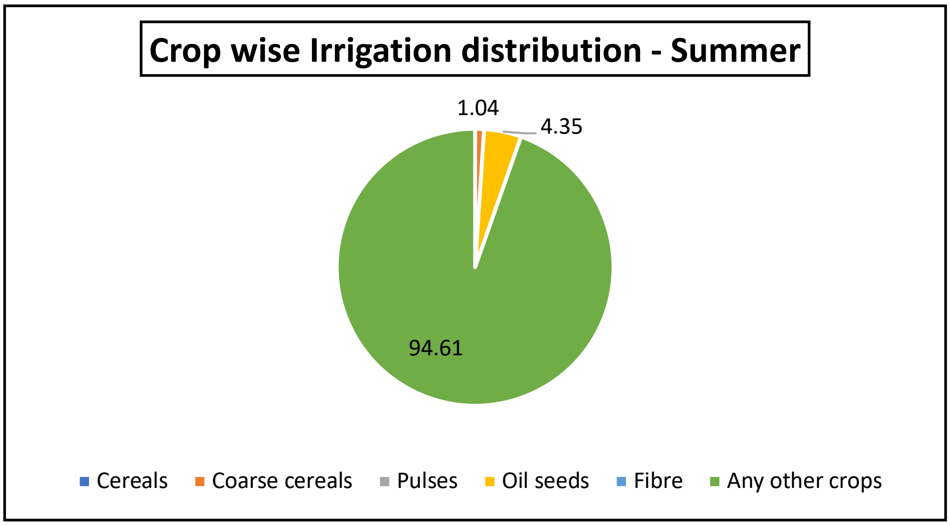
Figure 4.07: Crop wise Distribution of Irrigated Area – Rabi season of Pune



Source: Table 4.07

Similarly in summer season out of total 1,19,957 ha irrigated area 1,13,497 ha (94.61%) area is under sugarcane followed by only 5,220 ha (4.35%) and 1,240 ha (1.03%) area under oil seed crops and coarse cereals respectively.

Figure 4.08: Crop wise Distribution of Irrigated area – Summer season of Pune



Source: Table 4.07

Table 4.08: Crop wise season wise statistics for rainfed area of Pune (2015)

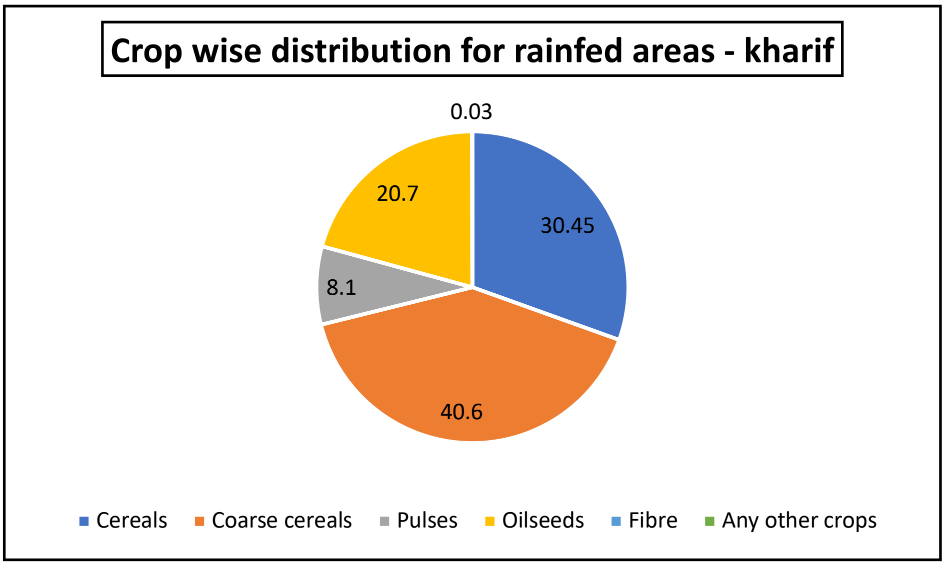
Crop Type	Rainfed Kharif (Area in ha)	Rainfed Rabi (Area in ha)	Rainfed Horticulture and Plantation (Area in ha)	Total (Area in ha)
Cereals	53822	27255		81077
Coarse cereals	71757	365551		437308
Pulses	14462	42961		57423
Oilseeds	36602	5925		42527
Fibre	60			60
Any other crops			48834	48834
Total	176703	441692	48834	667229

Source: pmksy.gov.in

From the table 4.08 it can be seen that no summer crops are cultivated in the rainfed areas, while other crops like horticulture and plantation occupy a small proportion (around 7%) of the total rainfed area (48834 ha out of 667229 ha).

Among the rainfed areas during the kharif season it is seen that coarse cereals (71757 ha) and cereals (53822 ha) occupy a large share of the area (40.6% and 30.56% respectively), while oilseeds (36602 ha) occupy 20.7% and pulses (14462 ha) 8.7%. Fibre occupies a negligible (60 ha) 0.03%.

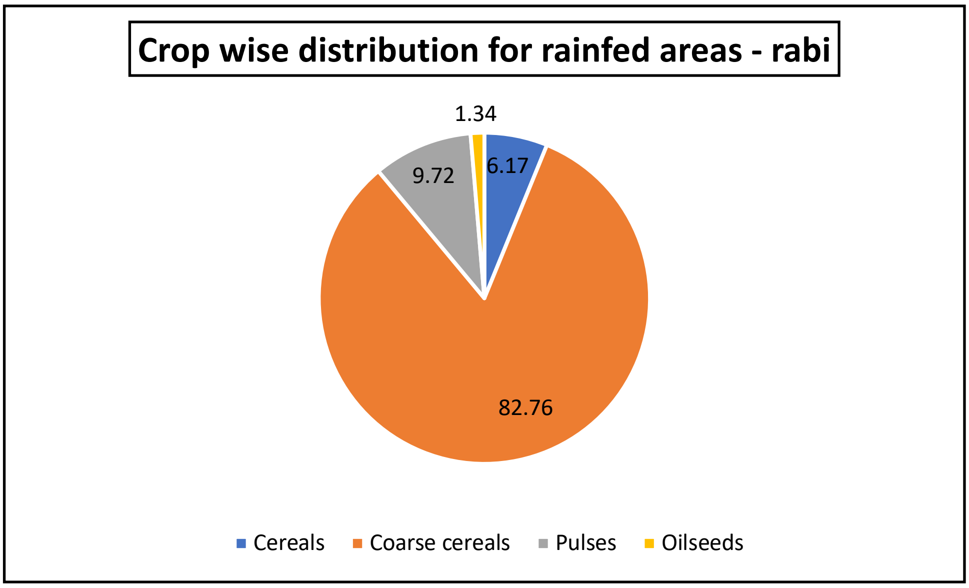
Figure 4.09: Crop wise distribution for rainfed areas – kharif season of Pune



Source: Table 4.08

It can be also be observed that in the rainfed areas during the rabi season, coarse cereals occupy a lion's share of 82.76% of the total area (365551 ha). Pulses (42961 ha), cereals (27255 ha) and oilseeds (5925 ha) follow at 9.72%, 6.17% and 1.34% respectively.

Figure 4.10: Crop wise distribution for rainfed areas – rabi season of Pune



Source: Table 4.08

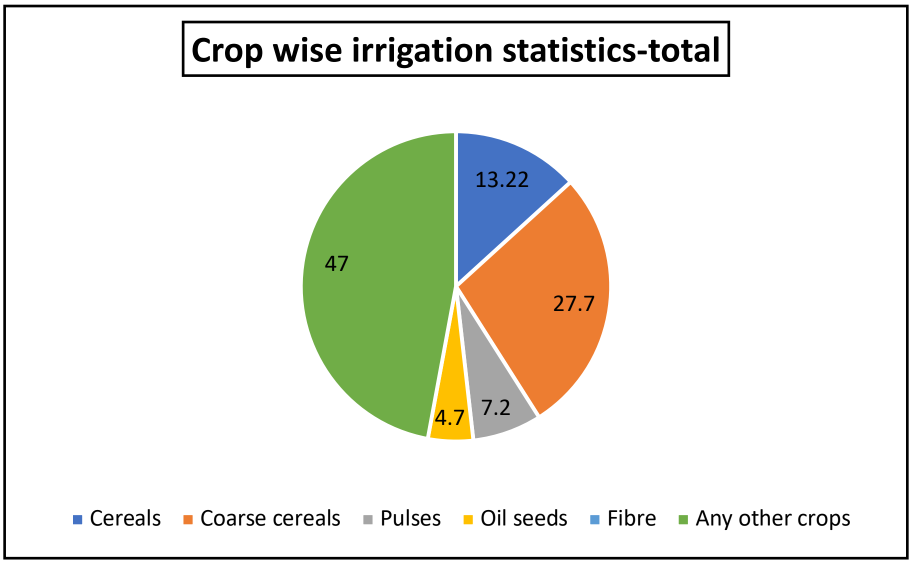
Table 4.09: Crop wise statistics for irrigated and rainfed areas of Pune – Total (2015)

Crop Type	**Total Irrigated (area in ha)**	**Total Rainfed (area in ha)**	**Total (area in ha)**
Cereals	49606	81077	130683
Coarse cereals	104111	437308	541419
Pulses	27063	57423	84486
Oil seeds	17781	42527	60308
Fibre		60	60
Any other crops	176492	48834	225326
Total (area in ha)	375053	667229	1042282

Source: pmksy.gov.in

The above table (Table 4.09), summarizes the cropping pattern of rain fed and irrigated areas of Pune district. As seen earlier, other crops like sugarcane and horticultural crops occupy nearly 47% of the total irrigated area (176492 ha out of 375053 ha), while 27% of irrigated area is under coarse cereals (104111ha) and 14% of irrigated area is under cereals (49606 ha) are covered. Pulses (27063 ha) and oilseeds (17781 ha) cover 7.2% and 4.7% of the total irrigated area.

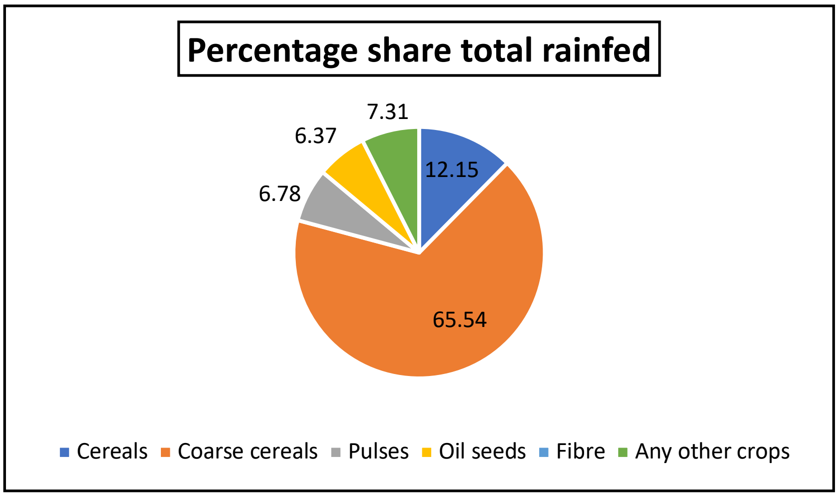
Figure 4.11: Crop wise irrigation statistics of Pune - total



Source: Table 4.09

Among the rain fed areas it is seen that coarse cereals (437308 ha) are cultivated in the maximum amount of area (around 65%) while cereals (81077 ha) cover around 12%. Pulses (57423 ha), oilseeds (42527 ha) and other crops (48834 ha) cover small proportions of the rainfed areas at 6.78%, 6.37% and 7.31% respectively.

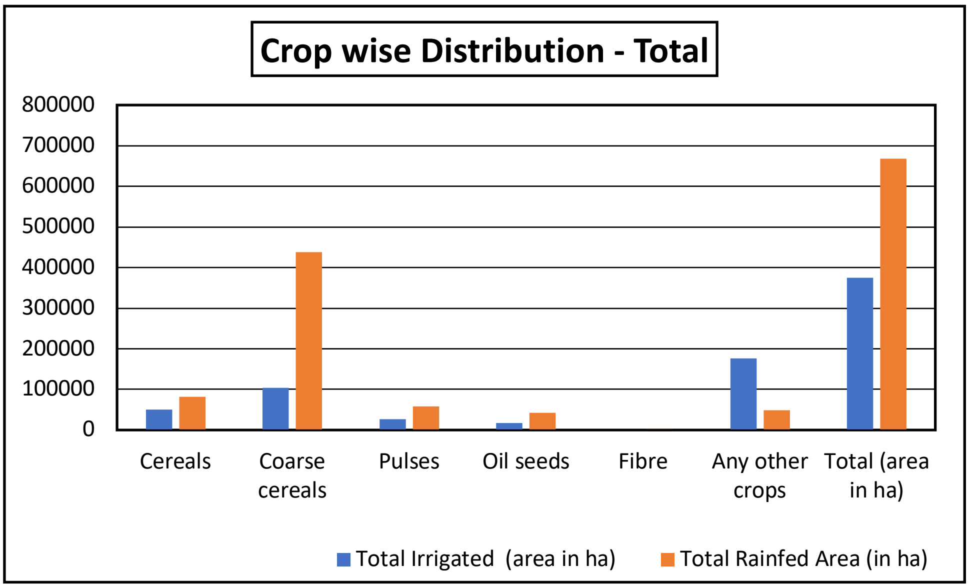
Figure 4.12: Crop wise distribution for rainfed areas of Pune -total



Source: Table 4.09

It is also seen that while sugarcane and horticultural crops occupy around 20% of the total cultivated area (225326 ha out of 1042282 ha), 78% of these crops are covered by irrigation (176492 ha out of 225326 ha). It has already been mentioned that out of this, sugarcane is 100% irrigated. On the other hand, coarse cereals occupy nearly 52% of the total cultivated area (541419 ha out of 1042282ha) but only 19.2% of the crop is covered by irrigation. Cereals occupy 12.5% of the total cultivated area, almost as much as sugarcane; however, only 38% of the crop is covered by irrigation. Pulse and oilseeds occupy 8.1% and 5.7% of the total cultivated area while 32% and 29% of these crops is covered by irrigation respectively.

Figure 4.13: Crop wise Distribution for Irrigated and Rainfed areas of Pune– Total



Source: Table 4.09

4.4 PRODUCTION AND PRODUCTIVITY OF MAJOR CROPS IN PUNE DISTRICT

Production is the process of converting inputs into output. While inputs are the resources available at the disposal of the producer, output refers to the end product/commodity. In agriculture, the resources at the disposal of the farmer are primarily his own land, labour (own/hired), irrigation, technology (seeds, fertilizers, mechanization etc.), credit etc. The optimum utilization of resources results in enhancing production, that is, more units of output are produced per unit of input. This is nothing but increasing the productivity of the inputs. In agriculture, productivity is measured generally in terms of output per hectare of land. Thus, agricultural productivity is the ratio of agricultural output to agricultural inputs. Amongst all the inputs, irrigation plays a vital role in increasing the productivity of land, especially in Pune district which falls under the scarcity zone. It is estimated that provision of irrigation during critical stages of crop growth approximately doubled the yield of crops.

Cost of cultivation of any crop is the sum total of several components on which the farmer has to spend from the cost of land preparation to harvesting of the crop. These costs incurred on a farm can be classified as cash cost or non-cash cost. Cash costs are the costs for which the farmer spends money for acquisition of material inputs like seeds, fertilizer, chemicals or labour (hired) etc. On the other hand, non-cash costs are attributable to items of cost, which do not require spending money. These may be items of cost like family labour, payments made in kind, home grown seeds, manure etc., exchange labour, depreciation, interest on operating capital etc.

Pune district grows both rainfed and irrigated crops in all three agriculture seasons. The productivity, production and cost of cultivation of cultivated crops varies from crop to crop and also season to season, since some cost components are crop and season specific. The cost of cultivation of irrigated crops is greater than the rainfed crops as the rainfed crops need limited inputs and resources that comprise the cost factor.

Table 4.10: Crop wise season wise Production, Productivity and Cost of major crops of Pune (2015)

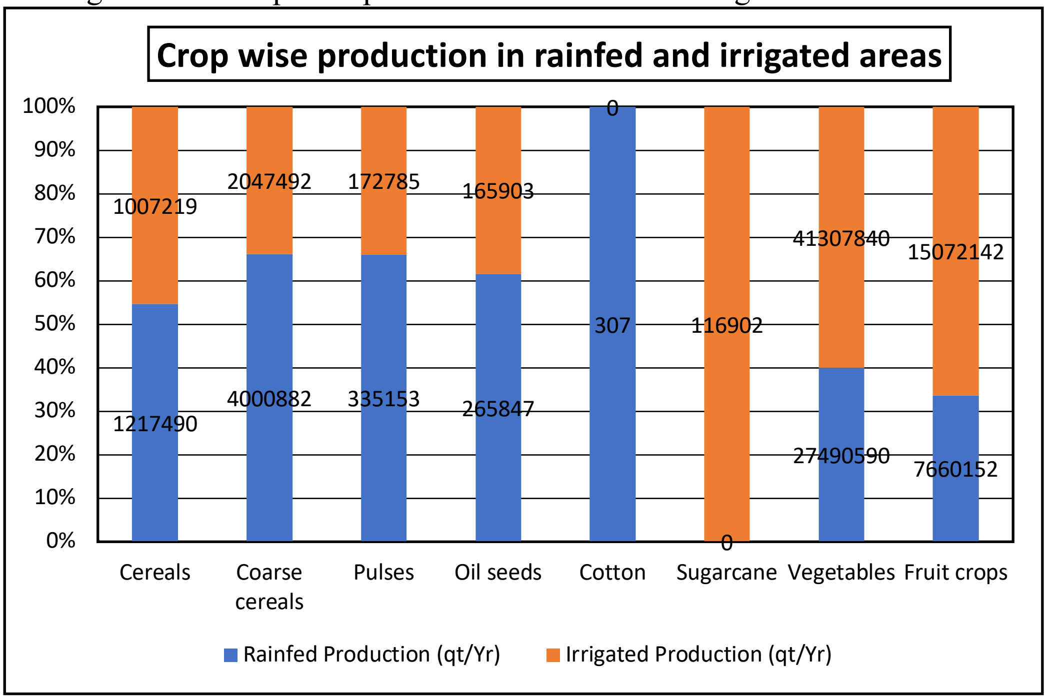
Crop Category	Rainfed			Irrigated		
	Production (qt/Yr)	**Productivity (kg/ha)**	**Cost of cultivation (Rs./ha)**	**Production (qt/Yr)**	**Productivity (kg/ha)**	**Cost of cultivation (Rs./ha)**
Cereals	1217490	1501	64542	1007219	2094	82256
Coarse cereals	4000882	995	37965	2047492	1496	55100
Pulses	335153	579	38143	172785	619	54054
Oil seeds	265847	539	32862	165903	842	50369
Cotton	307	511	69398	0	0	0
Sugarcane	0	0	0	116902	103	120540
Vegetables	27490590	76500	73125	41307840	87667	91000
Fruit crops	7669152	59710	98000	15072142	86230	313520

Source: pmksy.gov.in

Note: Production and productivity of sugarcane is mentioned in tonnes

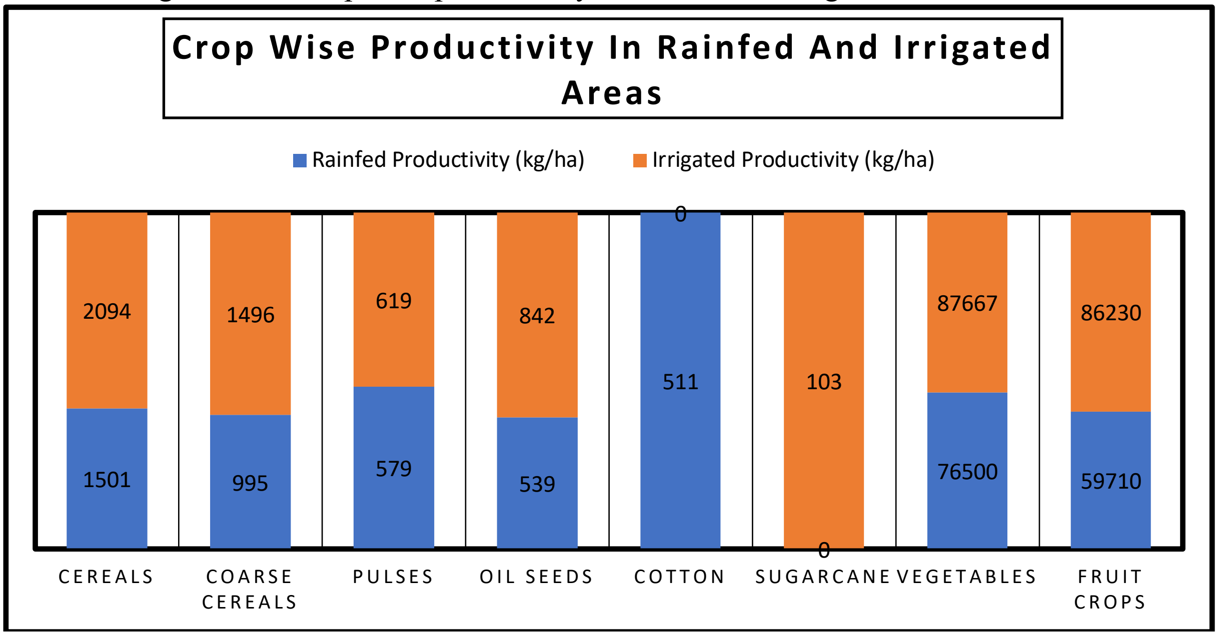
The above table indicates that the productivity, production and cost of cultivation differs from crop to crop category and even season to season. From the above table it can be seen that in case of all crop categories except fruits and vegetables, the production levels are higher in the rainfed seasons than the irrigated areas. 55% of cereals production (1217490 qt out of 2224709 qt), 66% of coarse cereals production (4000882 qt out of 6048374 qt), 65% of the pulses production (335153 qt out of 507938 qt), and 61% of oilseeds production (265847 qt out of 431750 qt) take place in the rainfed areas. However, the productivity of the crops in rainfed areas is lesser than the crops grown in the irrigated areas. The productivity of rainfed cereals and coarse cereals is 1501 kg/ha and 995 kg/ha respectively and that of irrigated cereals and coarse cereals is 2094 kg/ha and 1496 kg/ha respectively. It means the productivity of irrigated cereals and coarse cereals is 40% and 50% more than rainfed cereals and coarse cereals respectively. The productivity of rainfed and irrigated pulses does not show much difference. It is more by just 40kg/ha than rainfed pulse crop. In the case of oilseeds, the productivity of the irrigated crop shows a 56% jump over the rainfed crop (from 539 kg/ha to 842 kg/ha) The difference between rainfed and irrigated vegetables is 11167 kg/ha i.e. the productivity of rainfed vegetables is 76500 kg/ha and it is 87667 kg/ha in case of irrigated vegetables. It means productivity of irrigated vegetables is 14% more than rainfed vegetables. Again the difference in the productivity between irrigated and rainfed fruit crops amounts to 44% (86230 kg/ha over 59710 kg/ha). While the cotton crop is grown entirely in rainfed areas, the sugarcane crop is 100% irrigated.

Figure 4.14: Crop wise production in rainfed and irrigated areas of Pune



Source: Table 4.10

Figure 4.15: Crop wise productivity in rainfed and irrigated areas of Pune

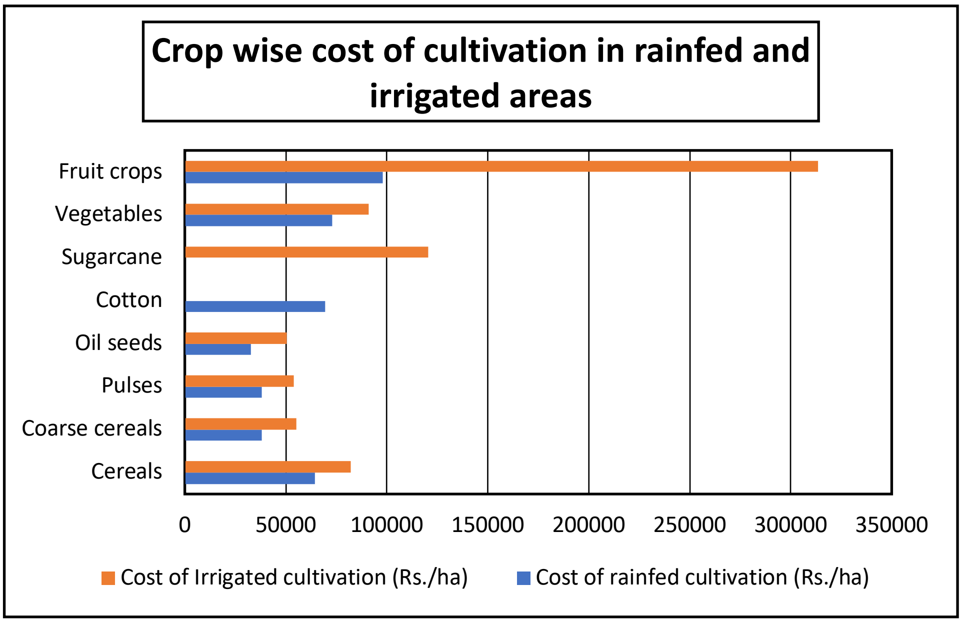


Source: Table 4.10

The cost also differs in rainfed and irrigated crops. The table 4.10 shows the difference in cost of cultivation of rainfed and irrigated cereals and coarse cereals is Rs. 17,714 and Rs. 17,135 per ha respectively. This means the cost of cultivation of irrigated cereals and coarse cereals is 27% and 45% more than rainfed cereals and coarse cereals. In the case of pulses, the difference in the cost of cultivation between the irrigated and rainfed crop is Rs. 15,911, that is, 42% and in the case of oilseeds the difference is Rs. 17,507, that is, 53%. In the case of vegetables the difference in the cost of cultivation between irrigated and rainfed crops is Rs. 17,875 and in the case of fruits, the same is a whopping difference of Rs. 215,520. This would amount to an increase of 24% and 220% respectively.

The total agriculture production of the district is estimated to be 10,08,69,704 quintals in which vegetables contribute highest share of 6,87,98,430 quintals per year followed by fruits i.e. 2,27,41,294 quintals. On the other side, the district produces least quantity of cotton and is only 307 quintal per year. Total 82,73,083 quintals of cereals and coarse cereals are produced, of which coarse cereals have a major share of 60,48,374 quintals. The production of 9,39,688 quintals of pulses and oil seeds in the district forms a very small proportion of the total agricultural produce. From table 4.11 it is seen that the average productivity of crops ranges from 511 kg/ha (of cotton) to 82,083 kg/ha (of vegetables). The average crop cultivation costs varies from crop to crop. It is seen minimum in oil seeds i.e. Rs. 41,616 per ha and maximum in fruit crops i.e. Rs. 2,05,760 per ha. The cost of cultivation of sugarcane is second highest at Rs. 1,20,540 per ha. It is Rs. 73,399/- and Rs. 46,532 per ha in case of cereals and coarse cereals respectively. The per ha cost of cultivation of pulses and oil seed crops is about Rs. 46,098 and Rs. 41,616 respectively.

Figure 4.16: Crop wise cost of cultivation in rainfed and irrigated areas of Pune



Source: Table 4.10

Table 4.11: Crop wise Area, Production, Productivity and Cost of cultivation of major crops of Pune - total

Crop Category	Total			
	Area	Production (qt/yr)	Productivity (kg/ha)	Cost of cultivation (Rs/ha)
Cereals	130683	2224709	1797	73399
Coarse cereals	541419	6048374	1245	46532
Pulses	84486	507938	599	46098
Oil seeds	60308	431750	690	41616
Cotton	60	307	511	69398
Sugarcane	113497	116902	103	120540
Vegetables	81506	68798430	82083	82063
Fruit crops	30323	22741294	72970	205760

Source: pmksy.gov.in

Note: Production and productivity of sugarcane is mentioned in tonnes

From the above table 4.11 it is also seen that cereals occupy 12.54% of the total cultivated area (130683 ha out of 1042282 ha) while coarse cereals occupy almost 52% (541419 ha). The proportion of pulses (84486 ha) and oilseeds (60308 ha) in the total area is 8% and 5.78% only. The area occupied by cotton is negligible while sugarcane (113497 ha) as well as horticultural crops (111829 ha) occupy a little over 10% of the total cultivated area each respectively.

4.5 CROP WATER DEMAND

The crop water requirement is the depth (or amount) of water needed to meet the water loss through evapotranspiration. In other words, it is the amount of water needed by the various crops to grow optimally. It always refers to a crop grown under optimal conditions, i.e. a uniform crop, actively growing, completely shading the ground, free of diseases, and favourable soil conditions. The crop thus reaches its full production potential under the given environment. The crop water requirement mainly depends on climate and crop type. The key source of water for the crops is precipitation which is supported by protective irrigation from surface storages or ground water resources. The district grows a variety of crops in different agricultural seasons. These crops are either rainfed, partially irrigated or irrigated using surface or ground water resource.

The table below (Table 4.12) reveals that the projected cropped area of the district is 10,53,761 ha by 2020 of which 4,22,652 ha will be irrigated. Considering the water requirement of proposed crops as recommended by State Agricultural Universities, the annual net water requirements of all the crops of the district have been worked out and is estimated to be 673326400 cubic meter i.e. 6.7332640 billion cubic meters (BCM) by 2020. The existing water potential of the district is 6.0056788 BCM and additional potential of 0.732384 BCM needs to be created by 2020. The table indicates that the projected sown area of Indapur block is 1,39,441 ha and its estimated water requirement is highest i.e. 1.19803145 BCM, whereas it is lowest in Velha block i.e. 0.0338638 BCM with projected irrigated area of 15,674 ha. The projected irrigated area of Shirur block is observed to be 1,46,340 ha and its potential water requirement is 0.9363295 BCM. The table also reveals that Indapur (1,39,441ha), with slightly lesser projected irrigated area than Shirur, has a higher water requirement than Shirur by 2020. This means the cropping pattern of Shirur block is comparatively rational than Indapur block. The Purandar block has the highest projected area expansion at 27036 ha and consequently it also has the highest projected water potential to be created at 0.20 BCM. The blocks of Shirur, Baramati, Indapur and Daund are projected to increase the Area Sown to a much greater extent than the rest of the district (>20000 ha) and the irrigated areas in these blocks, except Baramati, are also higher than the rest of the district (>50000 ha). However, only the Shirur block has high water potential to be created at 0.10 BCM. The crop water requirement shown in the table (Table 4.12) is estimated by considering water demand of crop necessarily through protective irrigations only, since these demands are normally in productive phase of crop cycle or at critical stages of its survival during dry spell of monsoon. The water demand during vegetative growth stages are normally compensated with soil moisture available through rain. Therefore, while calculating crop water requirement the water which is available through rain has not been considered since it is available naturally. Only the additional water requirement is considered which is meant to be provided through protective irrigation.

Table 4.12: Block wise crop water requirement for Pune district in 2020

Sr. no.	Name of the Block	Area sown (ha) existing (1)	Area sown (ha) projected (2)	Area expansion (ha) (2-1)	Irrigated Area (ha)	Water potential required (BCM) (approx.)	Existing Water potential (BCM) (approx.)	Water potential to be created (BCM) (approx.)
1.	Haveli	34092	48236	14144	28834	0.40	0.33	0.07
2.	Maval	21023	27764	6741	13767	0.13	0.87	0.05
3.	Mulshi	13396	26291	12895	20999	0.09	0.06	0.03
4.	Bhor	28659	41918	13259	12567	0.15	0.13	0.03
5.	Velha	7952	15674	7722	1774	0.03	0.02	0.01
6.	Junnar	104454	116099	11645	37771	0.74	0.70	0.03
7.	Khed	80427	98082	17655	32010	0.48	0.45	0.03
8.	Ambegaon	78609	92373	13764	25830	0.51	0.45	0.06
9.	Shirur	125563	146340	20777	77980	0.94	0.83	0.10
10	Baramati	110489	139226	28737	34422	0.81	0.76	0.05
11.	Indapur	115179	139441	24262	59602	1.20	1.17	0.03
12.	Daund	52944	77084	24140	54438	0.84	0.81	0.03
13.	Purandar	58197	85233	27036	22658	0.40	0.20	0.20
	Total		1053761	14144	422652	6.73	6.00	0.73

Source: pmksy.gov.in

According to the report prepared by Action for Agricultural Renewal in Maharashtra (AFARM) for the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY), the district has experienced fast urbanization and industrialization during the last couple of decades. The estimated data shows that so far an area of 45,000 ha of the district has been brought under urbanization and industrialization in the last 5 years. Moreover, it is predicted that approximately about 50,000 ha of agriculture area will be utilized by urban habitations or industries in the next five years. Thus altogether about 1.00 lakh ha agriculture area of the district will be excluded from agriculture. Though such a conversion of agricultural land to non-agricultural land entails lower crop water requirement for the district, it should be borne in mind that such a reduction will be compensated by the increasing domestic or industrial water demands due to urbanization.

The report further states that in the last 4-5 years area under jowar, bajra, wheat, gram, ground nut etc has been decreasing. The data reveals that approximately 2.0 lakh ha area of these crops will have declined in the next five years. The area under sugarcane is also decreasing which is one of the best indications for optimizing water demand of farming business. The proposed strategy for water management looks forward to minimize the sugarcane area by about 20,000 ha in next five years. The strategic action plan for irrigation under PMKSY for the district proposes that the decreased area of above crops should be used for cultivation of crops like maize, soybean, horticulture/fruit crops etc. which needs comparatively lesser water. Besides, the strategy also suggests that it will be made mandatory for around 40% of proposed sugarcane area to adopt drip irrigation facility so as to save about 50% water loss in its cultivation. In addition, other crops will be encouraged to grow with water saving micro- irrigation systems which will also save around 30% of its water requirements.

4.6 CONCLUSION

The district profile of Pune district shows that out of a geographical area of 15,62,018 ha, nearly two thirds of the area, that is, 10,42,282 ha is under agricultural use. The analysis of the irrigation scenario of the district indicates that agriculture continues to remain mostly rainfed in Pune. The rabi crop season is the main crop season as compared to the kharif, summer and annual crops. Pune falls under the scarcity zone and only 36% of the agricultural land is provided with irrigation. Out of this, sugarcane occupies 30% of the irrigated area under cultivation. Though the production of rainfed crops is more than that of irrigated crops, the productivity of irrigated crops is higher than the rainfed crops. However, the cost of cultivation of irrigated crops is also higher than that for rainfed crops. As has been mentioned in Chapter 1, studies in the US have shown the productivity of maize to increase by 30% on applying irrigation. As mentioned in Chapter 3 (3.3: Significance of Research), there has been a steady decline in the area under irrigation for soybean in Maharashtra post 2000. Pune district which lies in Western Maharashtra, is the largest producer of sugarcane in Maharashtra. Traditional crops like jowar and bajra have been replaced with sugarcane, groundnut, wheat, rice and horticultural crops. Being an expanding urban metro, the demands on water supply with respect to domestic use and industrial use is bound to rise. As a lion's share of water supply is used for irrigation, it is vital to use this scarce resource in the most efficient manner.

REFERENCES

REPORTS

AFARM – PUNE. (2017). *Pradhan Mantri Krishi Sinchayee Yojana.* District Superintending Agriculture Officer Pune. Retrieved from: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwj25vrGh93dAhUS3Y8KHY2QAAUQFjAAegQICRAC&url=http%3A%2F%2Fwww.pmksy.gov.in%2Fmis%2FUploads%2F2017%2F20170109010346632-1.pdf&usg=AOvVaw0OdbQYJTkd7ZgqjiRBk7WP Accessed on 29/09/2018.

Comprehensive District Agricultural Plan. 2012-13 to 2016-17. Department of Agriculture, Government of Maharashtra. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiJ9JmO0tPeAhXFO48KHThhDfIQFjAAegQICBAC&url=http%3A%2F%2Fkrishi.maharashtra.gov.in%2FSite%2FUpload%2FPdf%2Fpune_cdap.pdf&usg=AOvVaw2krcvsuhWc3XUk9-Cf8WB0

District Socio Economic Reviews of Pune. (2016, 2017, 2018). Department of Economics and Statistics, Planning Department, Government of Maharashtra, India.

WEBSITES

www.krishi.maharashtra.gov.in

www.pmksy.gov.in

www.mapsofindia.com

www.macp.gov.in

CHAPTER 5
CROPPING PATTERN OF PUNE DISTRICT

5.1 Introduction

5.2 Cropping Pattern Of Pune – Area, Production And Productivity Of Important Crops

5.3 Trends In Cropping Pattern Of Pune District

5.4 Conclusion

5.1 INTRODUCTION

The cropping system of a region consists of both the cropping pattern and all components required for the production of a particular crop and the interrelationships between them and environment. Thus, the cropping system is an important part of the agricultural economy of a region. The concept of cropping system encompasses the concepts of crop rotation and cropping pattern. Crop rotation refers to the process of growing different crops in succession on a piece of land in a specific period of time with the objective of maximizing returns without reducing soil fertility. Cropping pattern on the other hand means the proportion of area under various crops at a point of time. However, cropping pattern is a dynamic concept and changes with space and time since it is influenced by the geo-climatic, socio-cultural, economic, historical and political factors. Thus, a change in a cropping pattern from one year to the next can occur by changing the relative acreage of existing crops, and/or by introducing new crops. While the agro-ecological (soil and weather) conditions play a determining role in the cropping system adopted in the region, at the micro level, a farmer's choice of cropping pattern largely depends on the productivity of the crop as well as the monetary benefits to be obtained. However, other external factors like infrastructural facilities, technological development etc. also tend to play a role in the farmer's choice of cropping pattern. In this chapter, trends in the cropping pattern in the district since 2000-01 to 2016-17 with respect to thirteen major crops has been presented.

5.2 CROPPING PATTERN OF PUNE – AREA, PRODUCTION AND PRODUCTIVITY OF IMPORTANT CROPS

The cropping pattern of Pune has evolved over the decades and follows the trends being observed all over India and Maharashtra. Traditionally, jowar and bajra were the major crops cultivated in the district which was in keeping with the climatic conditions. With the onset of green revolution and the availability of irrigation, Pune became the second largest producer of sugarcane (an important cash crop) in the state. Though cotton (another important cash crop) was being cultivated in other parts of Maharashtra like Vidarbha, it was not cultivated in Pune. Among cereals, the cultivation of paddy and wheat has gone up considerably, however, coarse cereals continue to dominate the food grains sector. Amongst the coarse cereals, though jowar continues to occupy a major share of the cultivated area, it is fast losing ground to maize (which is emerging as an important cash crop as well), while production of bajra is also steadily decreasing. Among the pulses, moong and gram dominate the sector with tur and udid having modest production levels. In the oilseeds sector, while groundnut and safflower were the major products, soybean has taken over this sector in a big way. While groundnut cultivation is declining, safflower production has been completely stopped. Other oilseeds like nigerseed, castorseed, sesame, linseed, sunflower, rapeseed, mustard etc. are cultivated over negligible areas. Another major trend in Pune's cropping pattern is the cultivation of fruits and vegetables under larger areas over the years. However, the statistics for the same was not available for analysis. The following table shows the area, production and productivity of major crops in Pune district in 2000-01, 2007-08 and 2016-17.

Table 5.01: Area, production and productivity of major crops in Pune district in 2000-01, 2007-08 and 2016-17

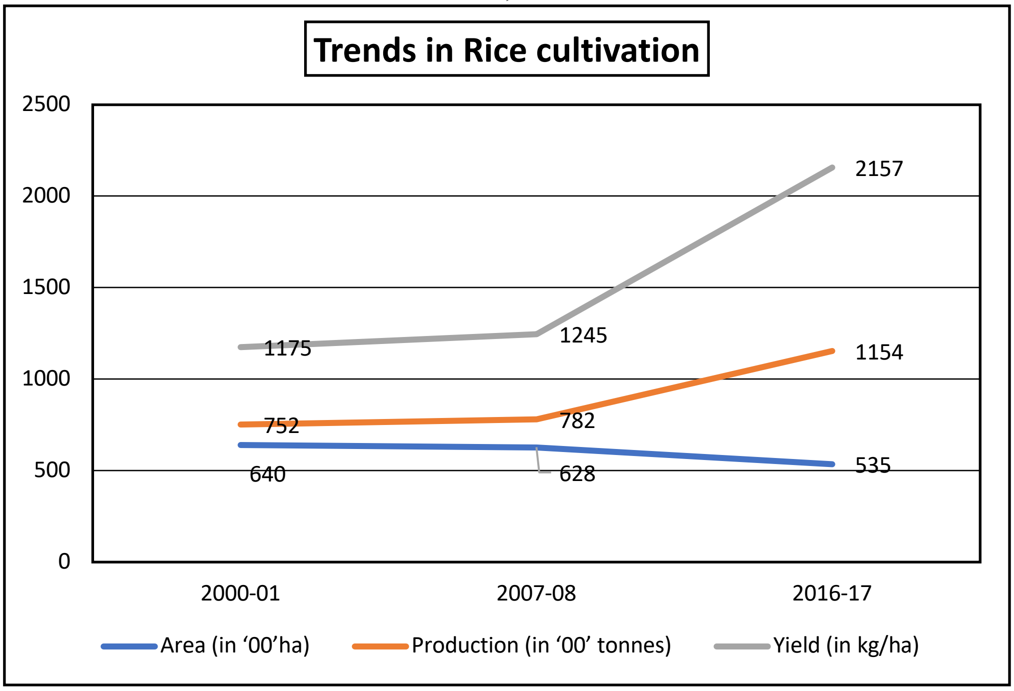
Crop name	**2000-01**			**2007-08**			**2016-17**		
	Area (in '00'ha)	**Production (in '00' tonnes)**	**Yield (in kg/ha)**	**Area(in '00'ha)**	**Production (in '00' tonnes)**	**Yield (in kg/ha)**	**Area (in '00'ha)**	**Production (in '00' tonnes)**	**Yield(in kg/ha)**
Rice	640	752	1175	628	782	1245	535	1154	2157
Wheat	555	570	1027	734	1550	2112	689	1652	2398
Jowar	4908	2052	608	4032	2179	669	2796	980	285
Bajra	1604	1046	652	1127	982	872	304	222	732
Maize	162	151	932	166	452	2722	426	1295	3040
Moong	92	35	384	71	45	629	217	63	289
Gram	536	322	601	549	376	685	805	865	1075
Tur	42	20	484	39	18	454	18	16	889
Udid	25	21	832	23	21	926	10	4	418
Soya	7	6	857	30	52	1733	180	383	2130
Groundnut	539	663	1500	506	601	1545	218	282	1665
Safflower	179	110	616	87	52	602	NA	NA	NA
Sugarcane	487	45583	94	1042	101577	97	959	90709	95

Source: Department of Agriculture, Maharashtra

Note: Yield for sugarcane is in tons/ha.

From the above table it is seen that in the food grains sector, with respect to rice, the area under production declined from 64,000 ha in 2000-01 to 62800 ha in 2007-08 and further to 53,500 ha in 2016-17.But the production increased from 75,200 tonnes to 78200 tonnes and further to 1,15,400 tonnes during the same period. Thus, the productivity of rice increased from 1175 kg/ha to 1245 kg/ha and further on to 2157 kg/ha from 2000-01 to 2007-08 and from 2007-08 to 2016-17.

Figure 5.01: Trends in the area, production and productivity of rice cultivation in Pune district between 2000-01, 2007-08 and 2016-17.

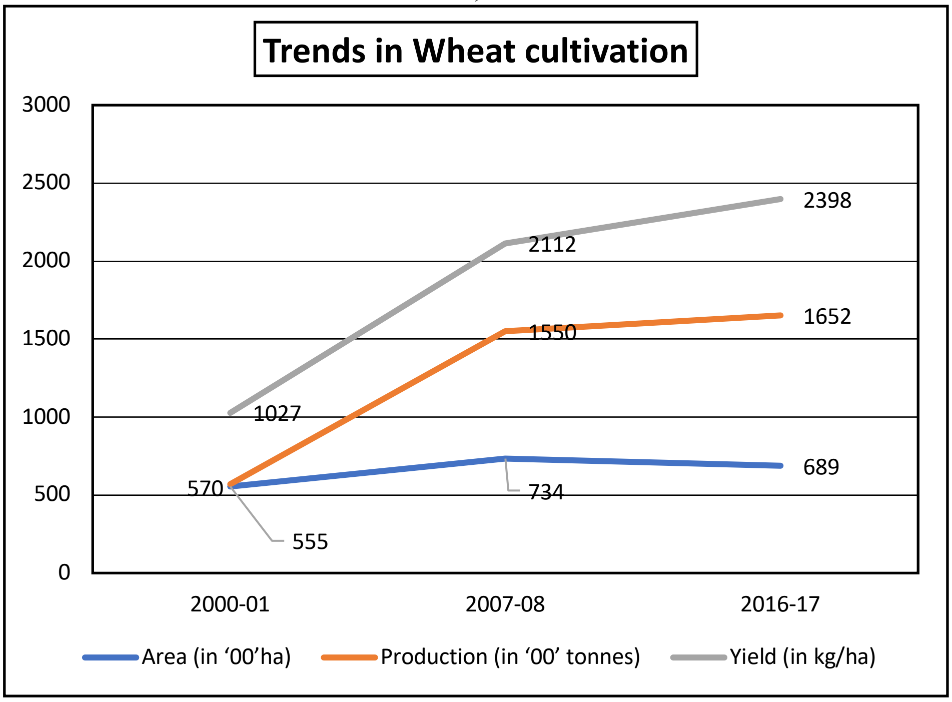


Source: Table 5.01

In the case of wheat, the area increased from 55,500 ha in 2000-01 to 73,400 ha in 2007-08 and then declined to 68,900 ha in 2016-17. But the production increased from 57,000 tonnes to 1,55,000 tonnes to 1,65,200 tonnes over the same period. The productivity of wheat thus rose from 1027 kg/ha to 2112 kg/ha between 2000-01 and 2007-08 and further on to 2398 kg/ha in 2016-17.

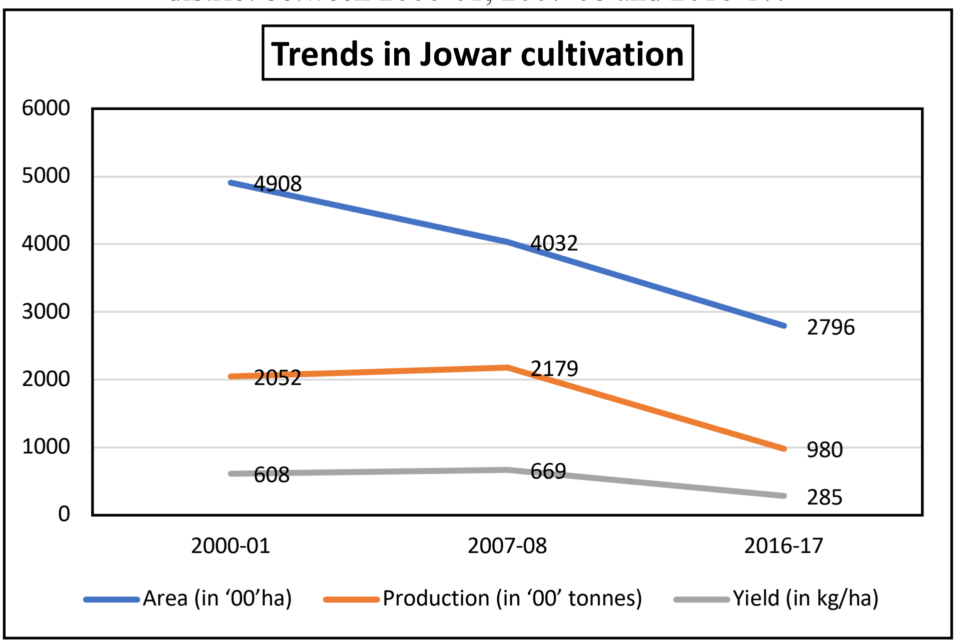
With respect to jowar, the area under production decreased from 4,90,800 ha in 2000-01 to 4,03,200 ha in 2007-08 and further to 2,79,600 ha 2016-17 The production of jowar increased from 2,05,200 tonnes to 2,17,900 tonnes between 2000-01 and 2016-17. However, it decreased after that to a mere 98,000 tonnes in 2016-17. The productivity of jowar increased from 608 kg/ha in 2000-01 to 669 kg/ha in 2007-08, but drastically decreased to 285 kg/ha in 2016-17.

Figure 5.02: Trends in the area, production and productivity of wheat cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



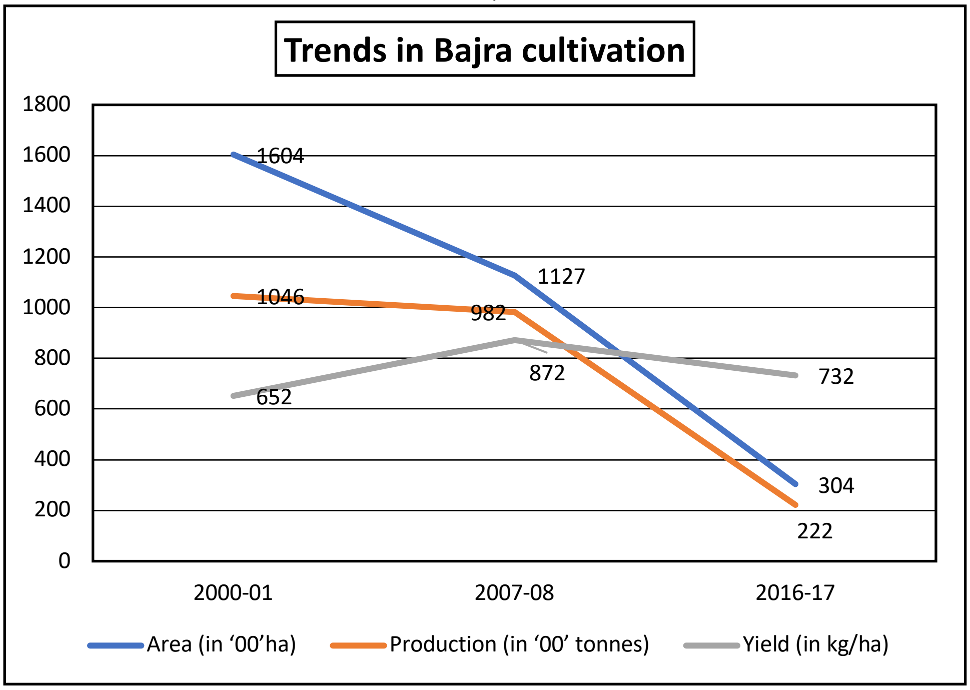
Source: Table 5.01

Figure 5.03: Trends in the area, production and productivity of jowar cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

Figure 5.04: Trends in the area, production and productivity of bajra cultivation in Pune district between 2000-01, 2007-08 and 2016-17.

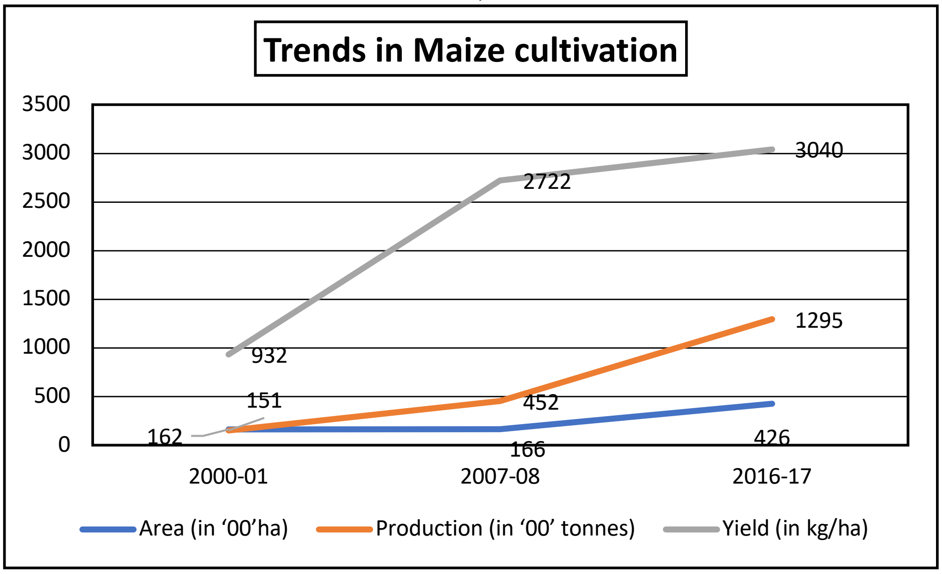


Source: Table 5.01

The area under bajra steadily declined from 1,60,400 ha in 2000-01 to 1,12,700 ha in 2007-08 and a mere 30,400 ha in 2016-17. The production accordingly fell from 1,04,600 tonnes to 98,200 tonnes and further down to 22,200 tonnes between the three periods. The productivity of bajra increased from 652kg/ha in 2000-01 to 872 kg/ha in 2007-08, but reduced to 732 kg/ha in 2016-17.

With respect to maize, the area steadily increased from a modest 16,200 ha in 2000-01 to 16,600 ha in 2007-08 and escalated to 42,600 ha in 2016-17. Accordingly, the production also increased from 15,100 tonnes in 2000-01 to 45,200 tonnes in 2007-08 and further to a whopping 1,29,500 tonnes in 2016-17. The productivity of maize showed tremendous progress from 932 kg/ha in 2000-01 to 2722 kg/ha in 2007-08 and a massive increase to 3040 kg/ha in 2016-17. Thus, among the cereals, maize production is finding favour with the farmers.

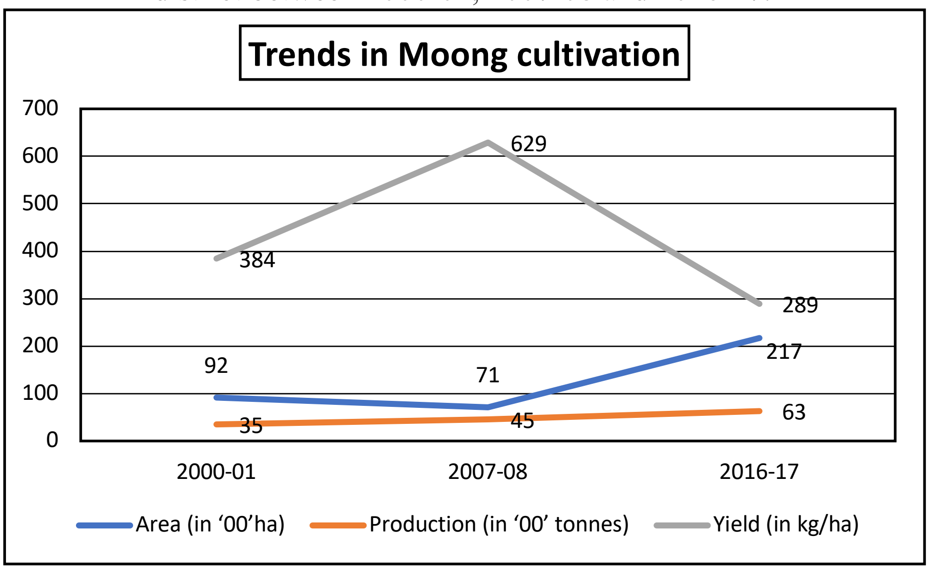
Figure 5.05: Trends in the area, production and productivity of maize cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

With respect to moong, the area under this pulse decreased from 9200 ha to 7100 ha between 2000-01 and 2007-08, but later increased to a massive 21800 ha in 2016-17. The production of moong, however, consistently rose from 3500 tonnes in 2000-01 to 4500 tonnes in 2007-08 and on to 6300 tonnes in 2016-17. The productivity of moong rose from 384 kg/ha to 629 kg/ha between 2000-01 and 2007-08, but fell to 289 kg/ha in 2016-17.

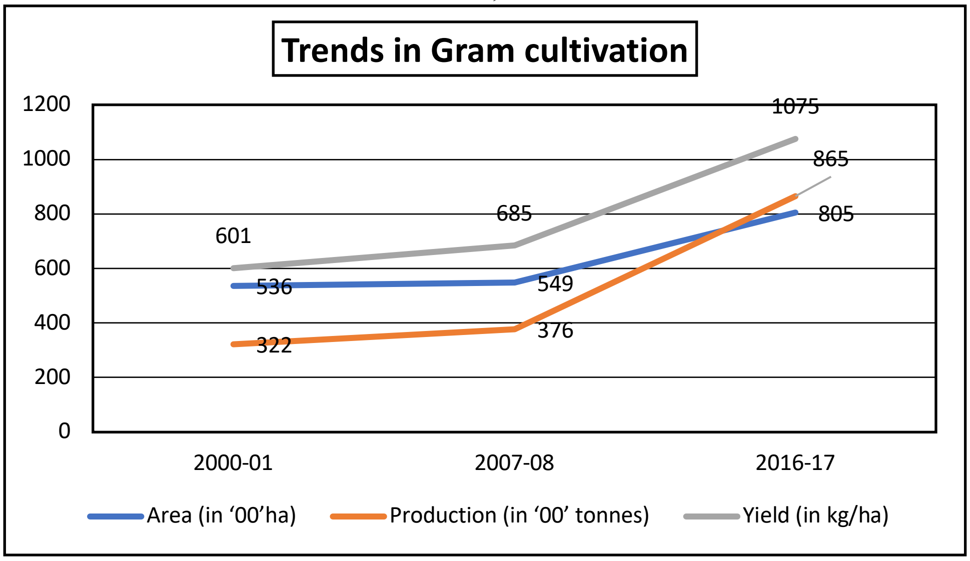
Figure 5.06: Trends in the area, production and productivity of moong cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

In case of gram, the area increased marginally from 53800 ha in 2000-01 to 54900 ha in 2007-08, but later to a massive 80500 ha in 2016-17. The production of gram increased from 32200 tonnes in 2000-01 to 37600 tonnes in 2007-08 and further to 86500 tonnes in 2016-17. The productivity of gram increased from 601 kg/ha in 2000-01 to 685 kg/ha in 2007-08, and on to a huge amount of 1075 kg/ha in 2016-17. From the above analysis it is seen that among the pulses, the cultivation of gram is showing an increasing trend in the district.

Figure 5.07: Trends in the area, production and productivity of gram cultivation in Pune district between 2000-01, 2007-08 and 2016-17.

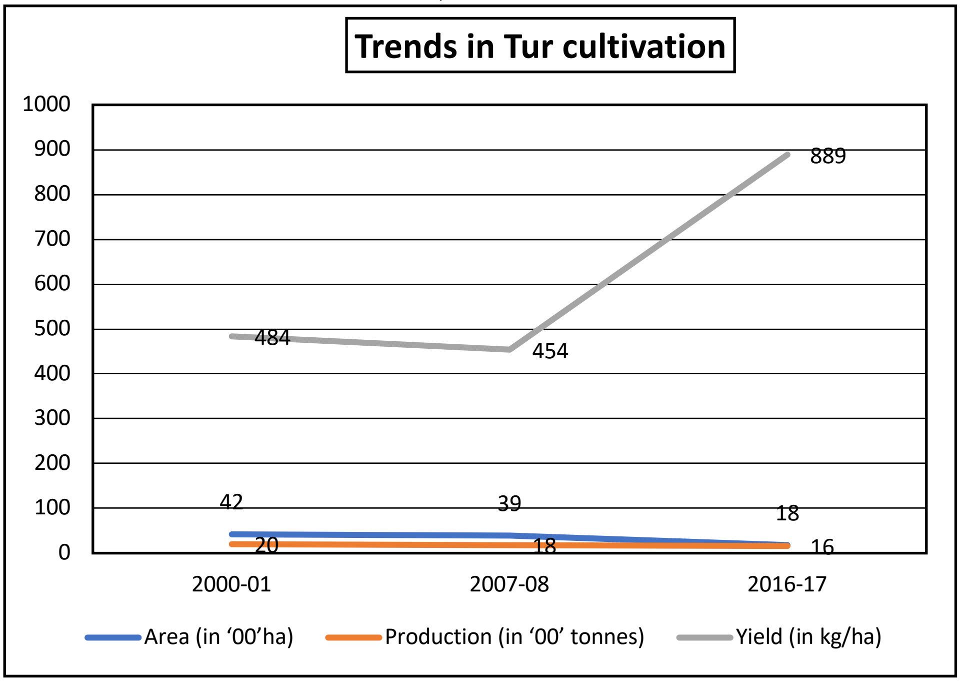


Source: Table 5.01

Among the pulses, with regard to tur, the area and production went down from 4200 ha to 3900 ha between 2000-01 and 2007-08 and further down to 1800 ha between 2007-08 and 2016-17 respectively. Similarly, production of tur reduced from 2000 tonnes to 1800 tonnes and further down to 1600 tonnes during the three time periods. The productivity of tur went down from 484 kg/ha in 2000-01 to 454 kg/ha in 2007-8, but increased to 872 kg/ha in 2016-17.

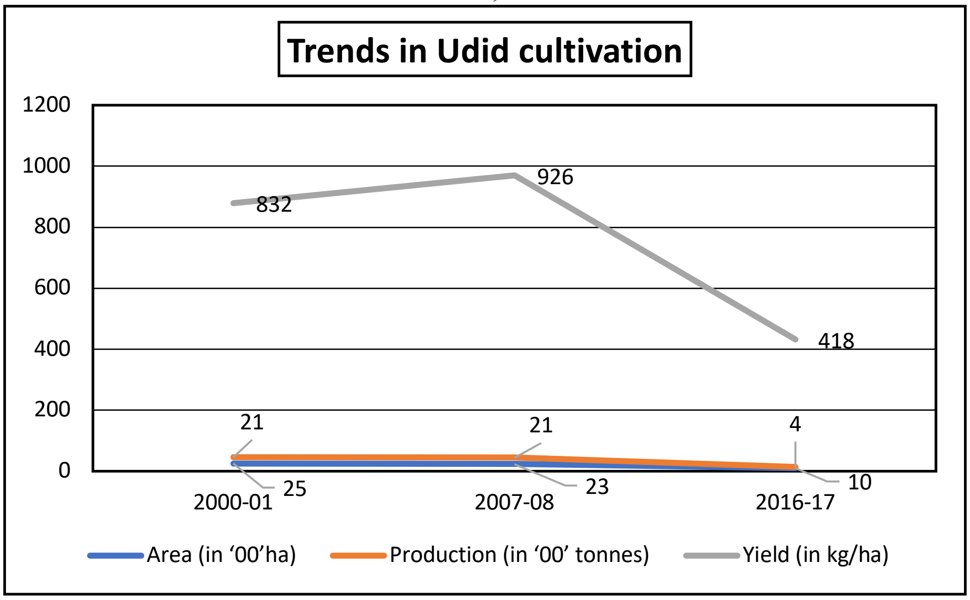
It can be seen from Fig 5.09 that the area and production under udid cultivation changed only marginally between 2000-01 and 2007-08. While the area went down from 2500 ha to 2300 ha from 2000-01 to 2007-08 while production remained unchanged at 2100 tonnes. Accordingly productivity rose from 832 kg/ha to 926 kg/ha. But in 2016-17, the area under cultivation had fallen to a mere 1000 ha and production to 400 tonnes while productivity declined to 418 kg/ha.

Figure 5.08: Trends in the area, production and productivity of tur cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

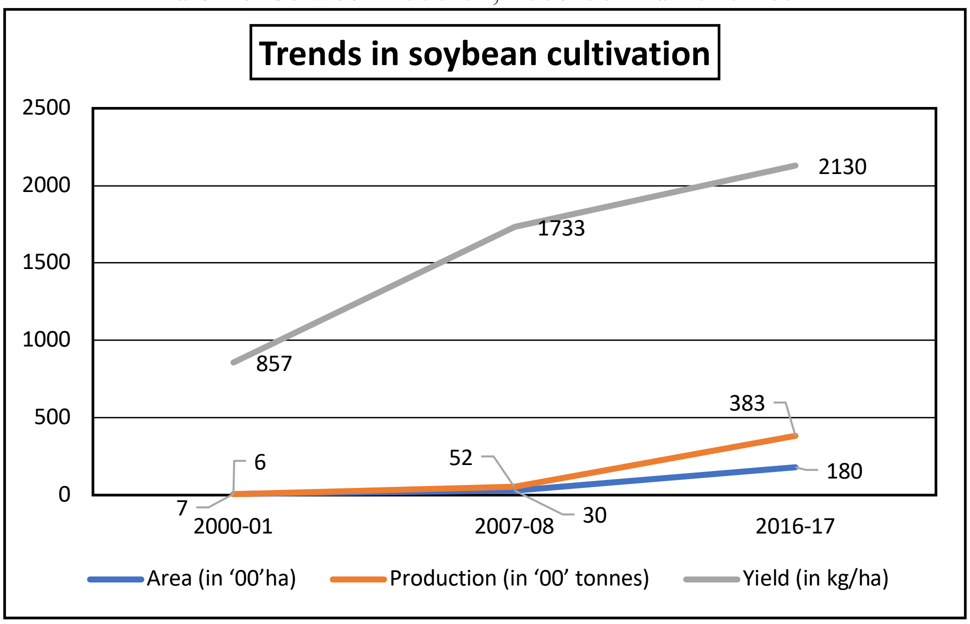
Figure 5.09: Trends in the area, production and productivity of udid cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

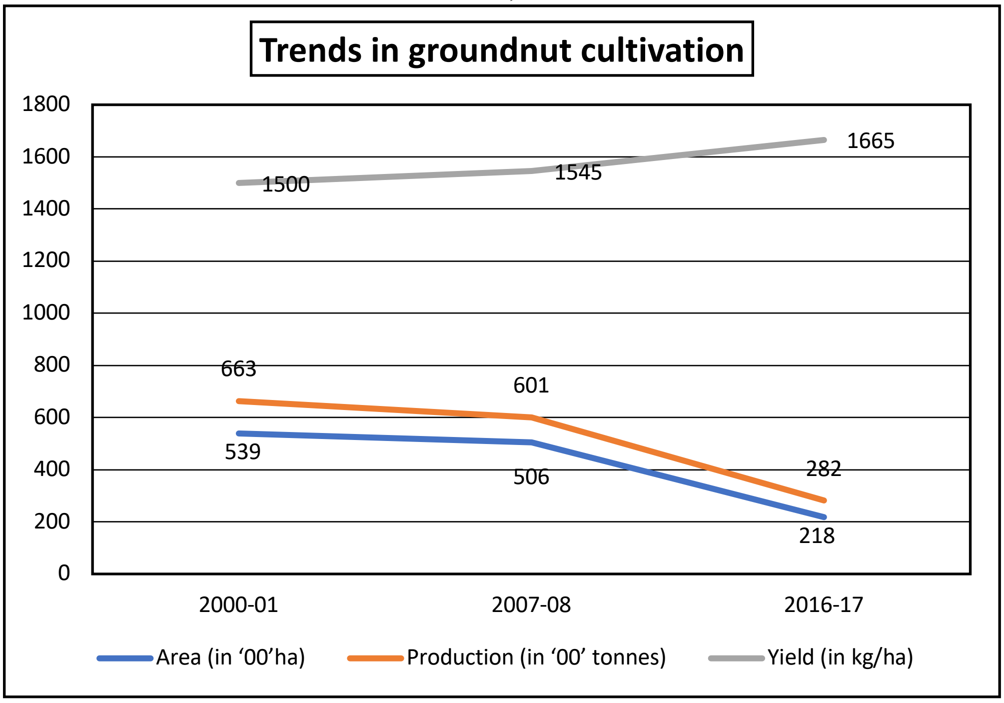
Among the oilseeds, the area under safflower went down from 17900 ha in 2000-01 to just 8700 ha in 2007-08, and by 2015-16, there was no more area under this oilseed. Thus, the production went down from 11000 tonnes to 5200 tonnes, while productivity fell from 616 kg/ha to 602 kg/ha between 2000-01 and 2007-08. Groundnut had a large area of 53900 ha under its cultivation in 2000-01 which fell to 50600 ha in 2007-08 and drastically further to 21800 ha in 2016-17. The production of groundnut fell to some extent from 66300 tonnes to 60100 tonnes and further to a low of 28200 tonnes during these three periods. The productivity of groundnut, however, marginally increased from 1500 kg/ha in 2000-01 to 1545 kg/ha in 2007-08 and to a greater extent to 1665 kg/hain 2016-17 . In the case of soybean, the cultivation of this oilseed in the district began only in 2000s with a mere 700 ha under it in 2000-01. This went up to a modest 3000 ha in 2007-08 and then rose dramatically to 18000 ha in 2016-17. The production of soybean which was a mere 600 tonnes in 2000-01, went up to 5200 tonnes in 2007-08 which then shot up to a high of 38300 tonnes in 2016-17. The productivity of soybean was always a good figure. From 857 kg/ha in 2000-01, it went up to 1733 kg/ha in 2007-08 which further escalated to 2130 kg/ha in 2016-17. Thus, in the oilseeds sector, soybean has emerged the clear favourite of the farmers.

Figure 5.10: Trends in the area, production and productivity of soybean cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



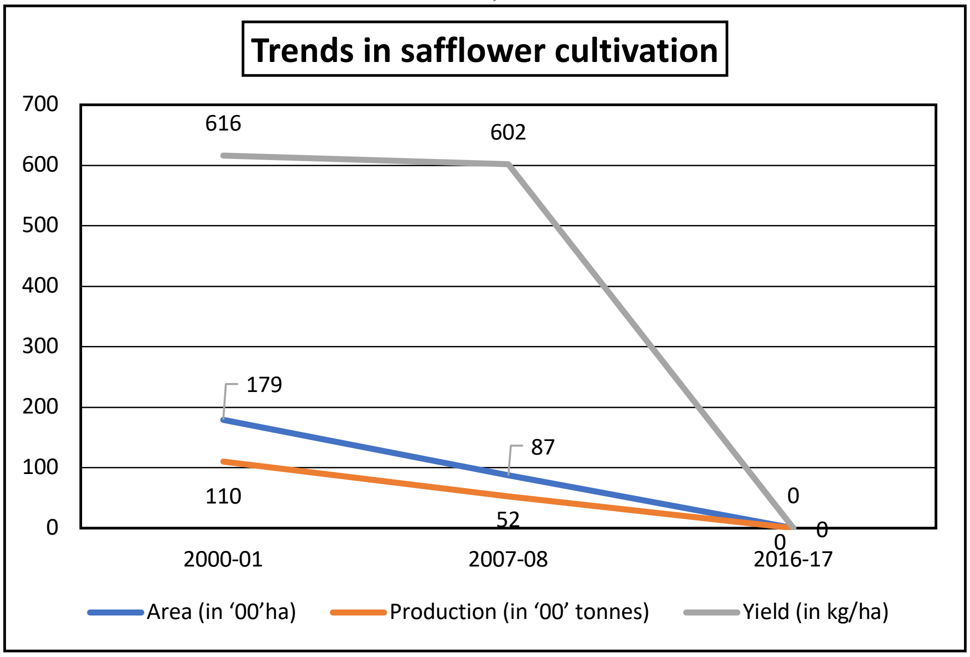
Source: Table 5.01

Figure 5.11: Trends in the area, production and productivity of groundnut cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

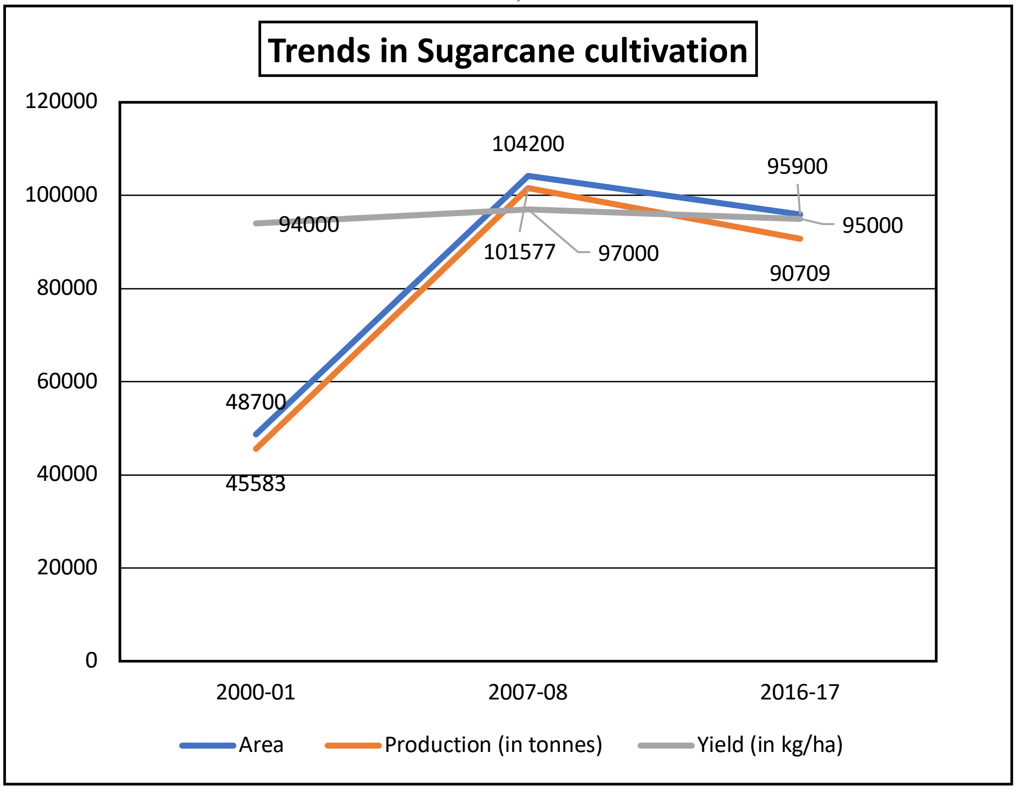
Figure 5.12: Trends in the area, production and productivity of safflower cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

Finally, the most important cash crop of the district as well as the state, sugarcane, has seen area and production expansion, but a stagnation in its productivity levels. Between 2000-01 and 2007-08, the area under sugarcane more than doubled from 48,700 ha to 1,04,200 ha, but then fell to around 96,000 ha in 2016-17. The production levels also followed the same pattern – from 45,58,300 tonnes, the production of sugarcane increased to 1,01,57,700 tonnes and then fell to 90,70,900 tonnes during these three periods. However, the productivity of sugarcane remained stagnant at 94 kg/ha, 97 kg/ha and 95 kg/ha for the same three periods respectively. The productivity as well as the popularity of sugarcane seems to be on the wane in the district.

Figure 5.13: Trends in the area, production and productivity of sugarcane cultivation in Pune district between 2000-01, 2007-08 and 2016-17.



Source: Table 5.01

5.3 TRENDS IN CROPPING PATTERN OF PUNE DISTRICT

The following table depicts the percentage change in area, production and yield of the major crops in Pune district in 2007-08 over 2000-01 and in 2016-17 over 2000-01.

Table 5.02: Percentage change in area, production and productivity of major crops in Pune district between 2000-01 and 2007-08

Crop name	2000-01			2007-08			Percentage change (in 2007-08 over 2000-01)		
	Area (in '00'ha)	Production (in '00' tonnes)	Yield (in kg/ha)	Area (in '00'ha)	Production (in '00' tonnes)	Yield (in kg/ha)	Area	Production	Yield
Rice	640	752	1175	628	782	1245	–2%	+4%	+6%
Wheat	555	570	1027	734	1550	2112	+32%	+172%	+106%
Jowar	4908	2052	608	4032	2179	669	–18%	+6%	+10%
Bajra	1604	1046	652	1127	982	872	–30%	–6%	+34%
Maize	162	151	932	166	452	2722	+2%	+200%	+192%
Moong	92	35	384	71	45	629	–23%	+28%	+64%
Gram	536	322	601	549	376	685	+2%	+17%	+14%
Tur	42	20	484	39	18	454	–8%	–10%	–6%
Udid	25	21	832	23	21	926	–8%	0%	+11%
Soya	7	6	861	30	52	1724	+329%	+767%	+102%
Groundnut	539	663	1500	506	601	1545	–6%	–9%	+3%
Safflower	179	110	616	87	52	602	-	-	
Sugarcane	487	45583	94	1042	101577	97	+114%	+123%	+3%

Source: Table 5.01

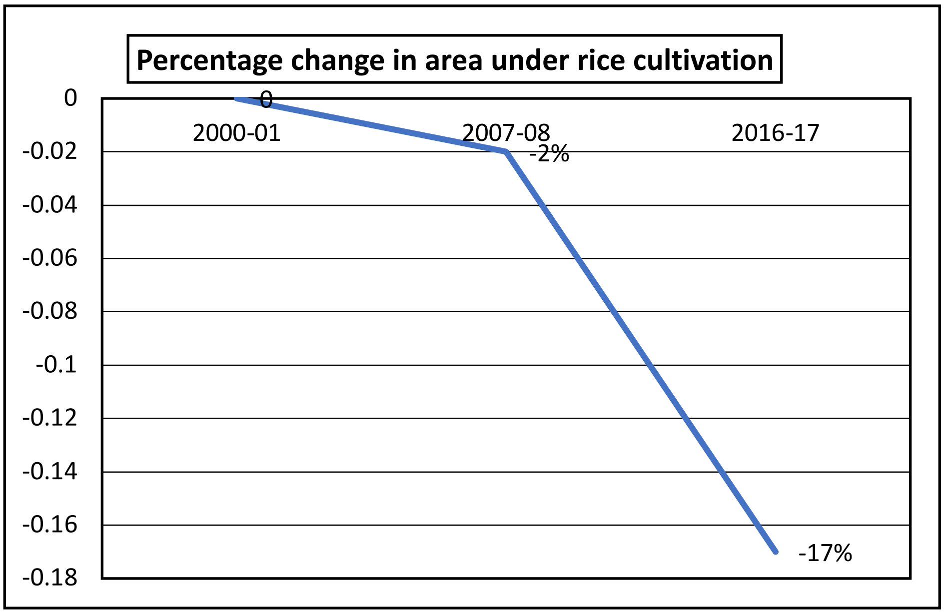
Table 5.03: Percentage change in area, production and productivity of major crops in Pune district between 2000-01 and 2016-17

Crop name	2000-01			2016-17			Percentage change (in 2016-17 over 2000-01)		
	Area (in '00'ha)	Production (in '00' tonnes)	Yield (in kg/ha)	Area (in '00'ha)	Production (in '00' tonnes)	Yield (in kg/ha)	Area	Production	Productivity
Rice	640	752	1175	535	1154	2157	–17%	+53%	+83%
Wheat	555	570	1027	689	1652	2398	+24%	+189%	+133%
Jowar	4908	2052	608	2796	980	285	–44%	–53%	–53%
Bajra	1604	1046	652	304	222	732	–82%	–80%	+12%
Maize	162	151	932	426	1295	3040	+162%	+757%	+226%
Moong	92	35	384	217	63	289	+135%	+80%	–25%
Gram	536	322	601	805	865	1075	+50%	+168%	+78%
Tur	42	20	484	18	16	889	–58%	–20%	+80%
Udid	25	21	832	10	4	418	–60%	–81%	–50%
Soya	7	6	861	180	383	2131	+2471%	+6283%	+147%
Groundnut	539	663	1500	218	282	1665	–60%	–58%	+5%
Safflower	179	110	616	NA	NA	NA	-	-	-
Sugarcane	487	45583	94	959	90709	95	+96%	+98%	+1%

Source: Table 5.01

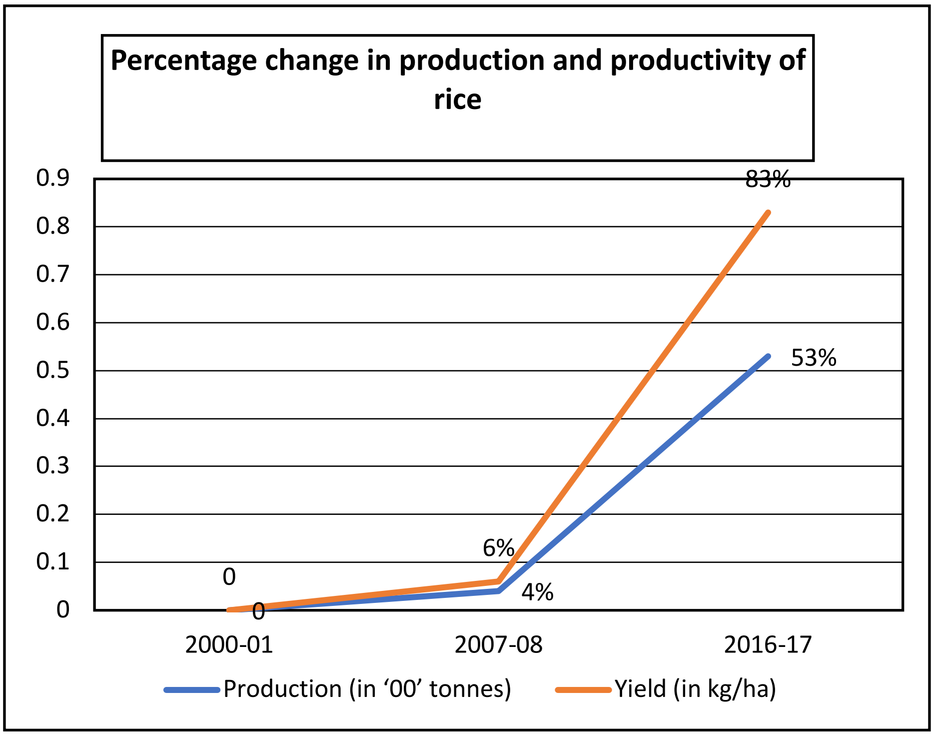
It is seen that while the area under rice declined by 2% between 2000-01 and 2007-08 and by 17% in 2016-17 over 2000-01, the production increased by 4% and 53% respectively thus resulting in the productivity of rice increasing by 6%and 83% between the two time periods. In the case of wheat, area under wheat increased by 32% and 24% in 2007-08 and 2016-17 over 2000-01. The production of wheat increased by 172% and 189% for the same periods while the productivity of wheat increased by 106% and 133% respectively between the two periods.

Figure 5.14: Percentage change in the area under rice cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



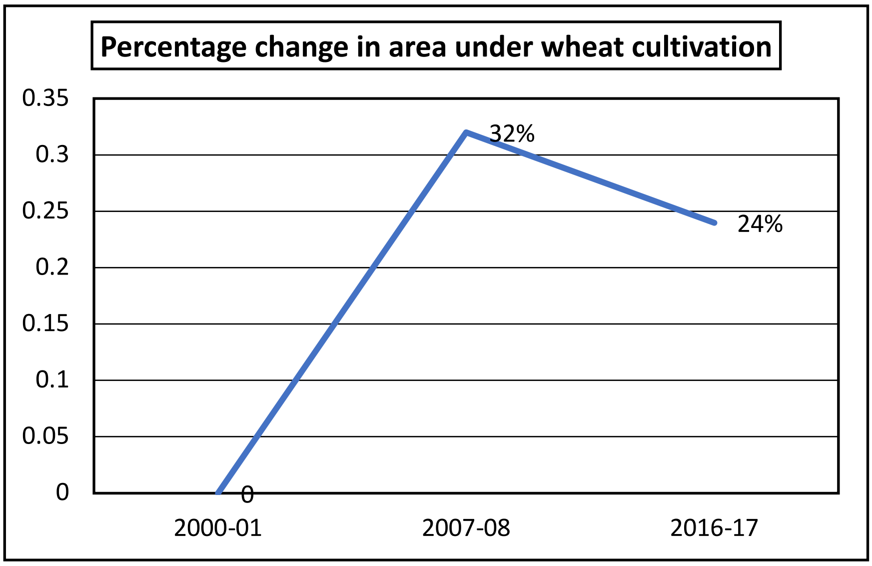
Source: Tables 5.01 and 5.02

Figure 5.14 (i): Percentage change in the production and productivity of rice cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



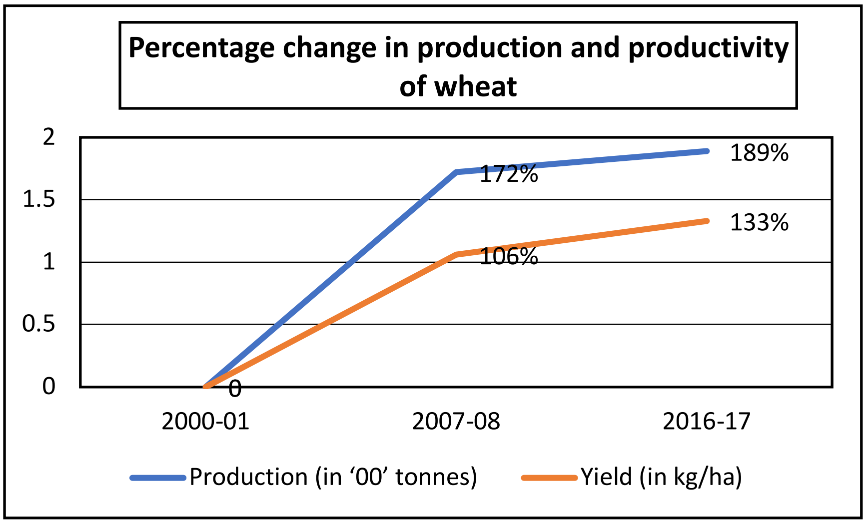
Source: Tables 5.02 and 5.03

Figure 5.15: Percentage change in the area under wheat cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

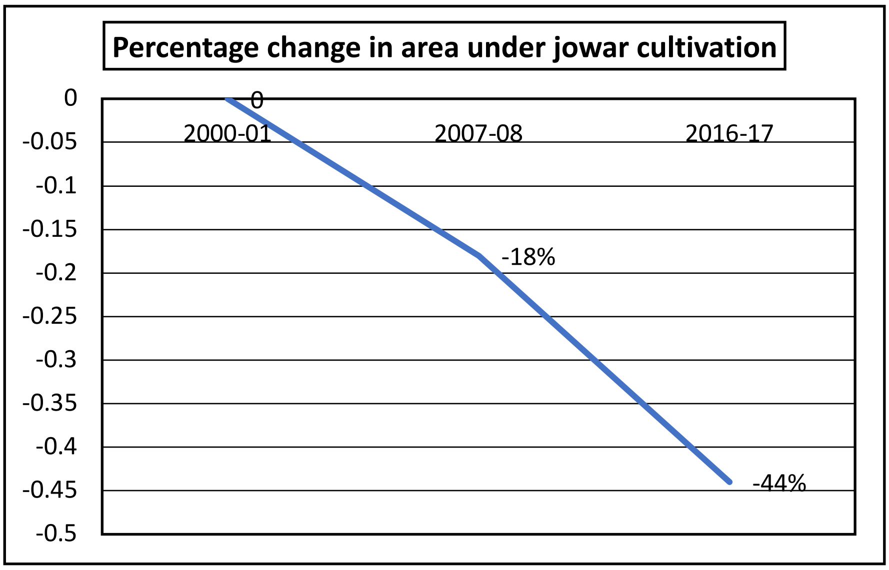
Figure 5.15(i): Percentage change in the production and productivity of wheat cultivation in Pune district in 2007-08 and 2016-17 over 2000-01



Source: Tables 5.02 and 5.03

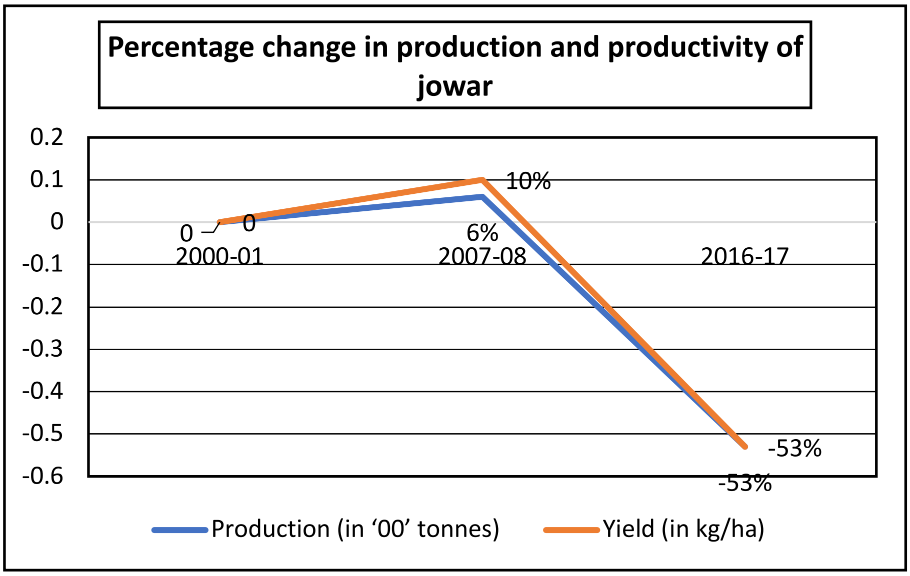
Among coarse cereals, both jowar and bajra show declining trend in area and production. In the case of jowar, the area under its cultivation fell by18% from 2000-01 to 2007-08 and by 44% from 2000-01 to 2016-17. The production increased marginally by 6% in the first time period but fell drastically by 53% during the total time period between 2000-01 and 2016-17. The productivity also shows the same trend; it increased by 10% in the first time period, but fell by a massive 53% in the total time period between 2000-01 and 2016-17. With respect to bajra, the area under bajra declined by 30% from 2000-01 to 2007-08 and by 82 % from 2000-01 to 2016-17. The production of bajra fell by 6% in the first time period and by nearly 80% in the total time period. The productivity thus increased in the first time period by 34% in the first time period but by a marginal 12% in the total time period.

Figure 5.16: Percentage change in the area under jowar cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



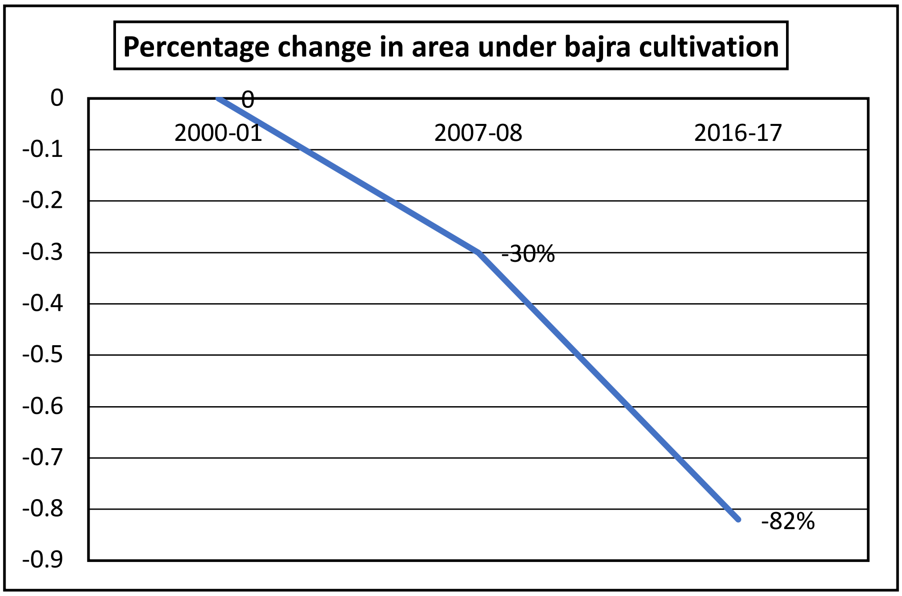
Source: Tables 5.02 and 5.03

Figure 5.16(i): Percentage change in the production and productivity of jowar cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



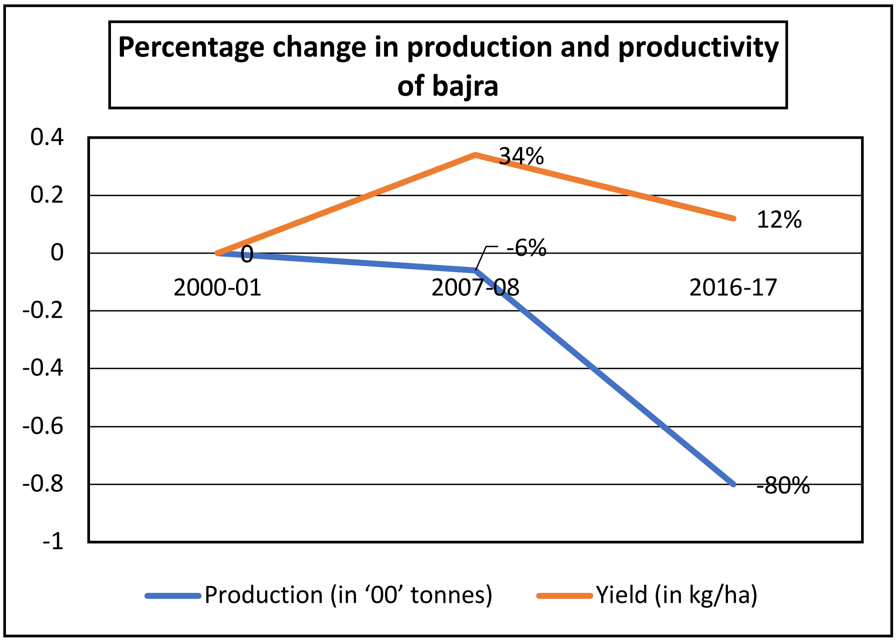
Source: Tables 5.02 and 5.03

Figure 5.17: Percentage change in the area under bajra cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

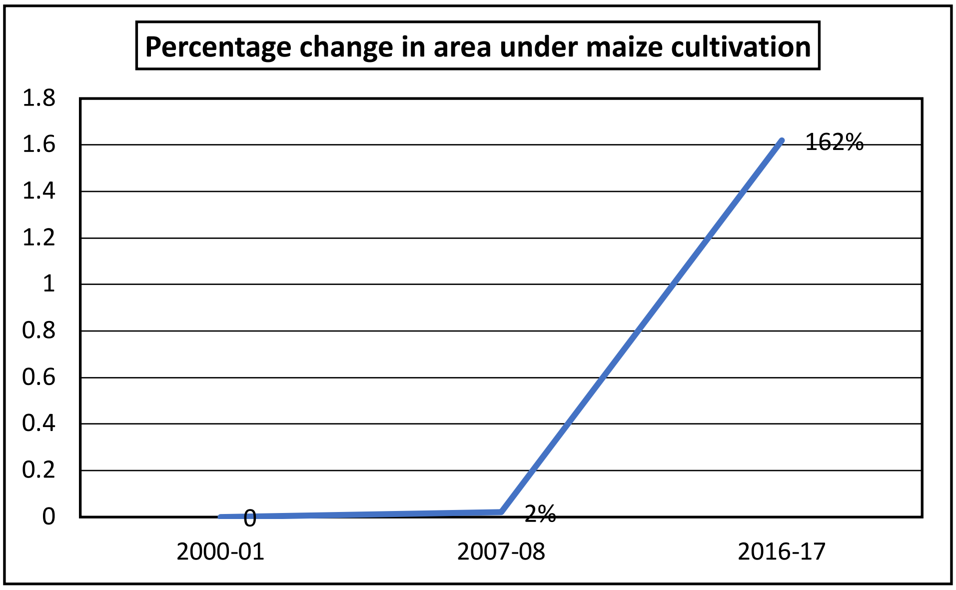
Figure 5.17 (i): Percentage change in the production and productivity of bajra cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

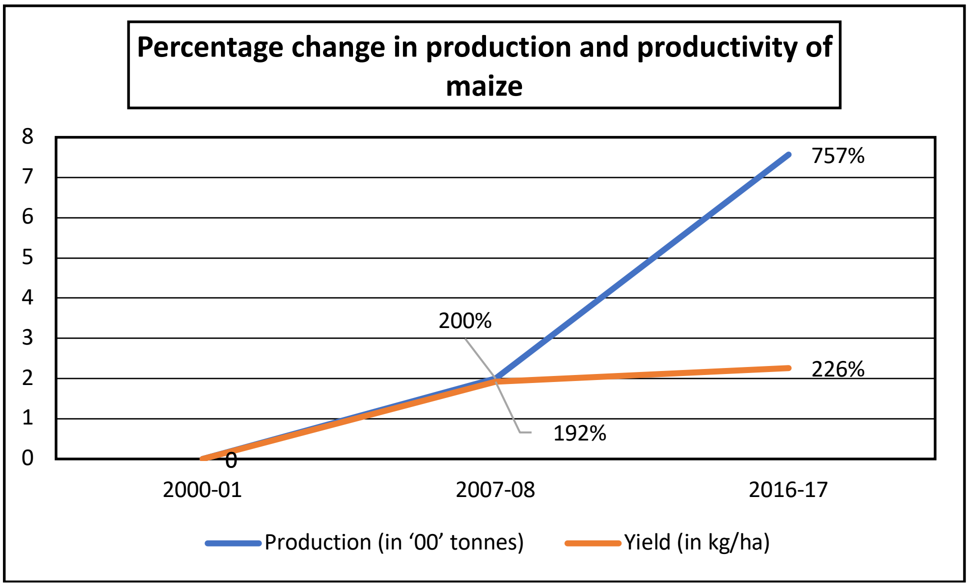
Maize production has increased by leaps and bounds – the area, production and productivity showed an increase 2%, 200% and 192% respectively between 2000-01 and 2007-08 and by 162%, 757% and 226% respectively between 2000-01 and 2016-17.

Figure 5.18: Percentage change in the area under maize cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

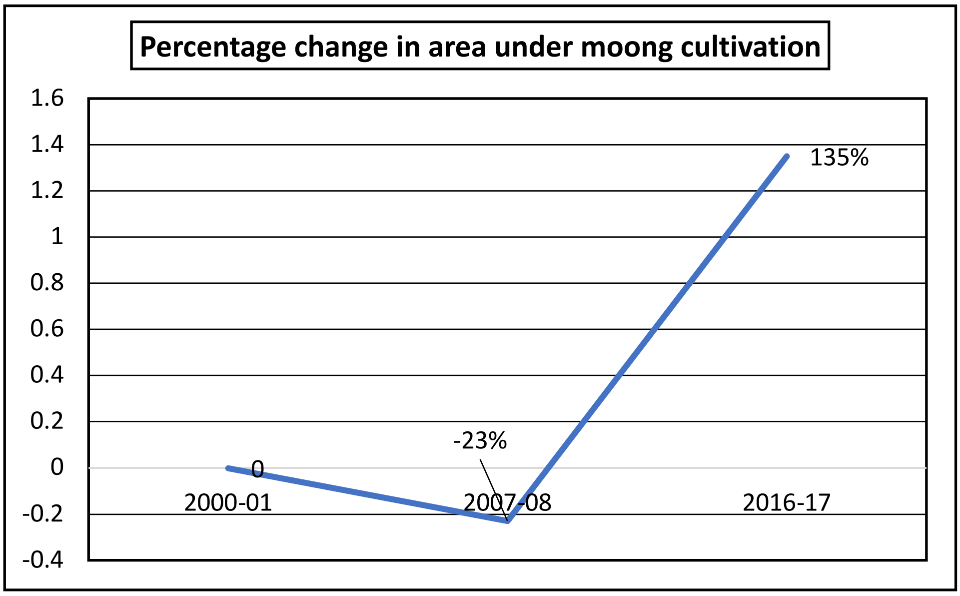
Figure 5.18(i): Percentage change in the production and productivity of maize cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

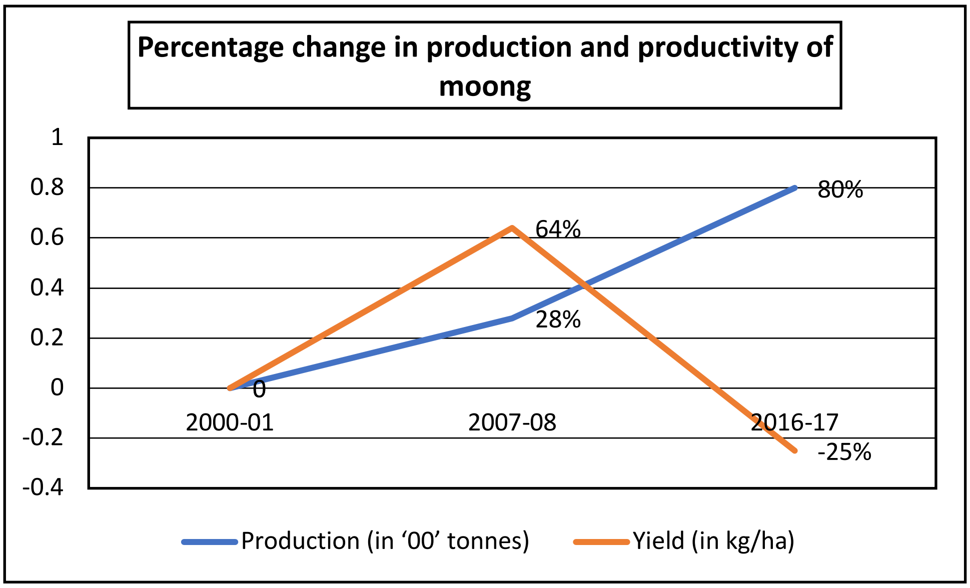
An analysis of the data shows that the production of pulses is now moving in favour of moong and gram from tur and udid. Both moong and gram have recorded increases in area as well as production. However, the productivity of moong has declined while that of gram has increased. In the case of moong, the area under cultivation fell by 23% between 2000-01 and 2007-08, but increased overall by 135% between 2000-01 and 2016-17. The production of moong increased by 28% and then by nearly 80% for the same two periods while the productivity of moong increased by 64% in the first time period, but fell by 25% between 2000-01 and 2016-17.

Figure 5.19: Percentage change in the area under moong cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

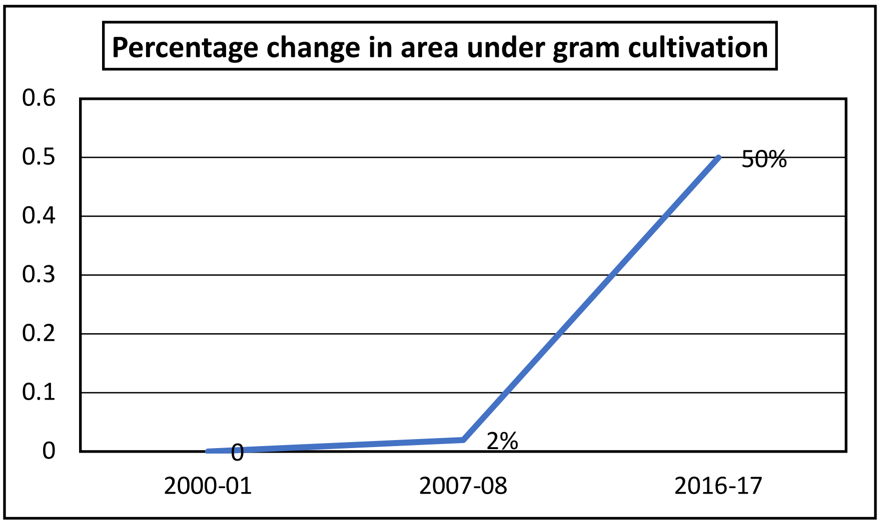
Figure 5.19(i): Percentage change in the production and productivity of moong cultivation in Pune district in 2007-08 and 2016-17 over 2000-01



Source: Tables 5.02 and 5.03

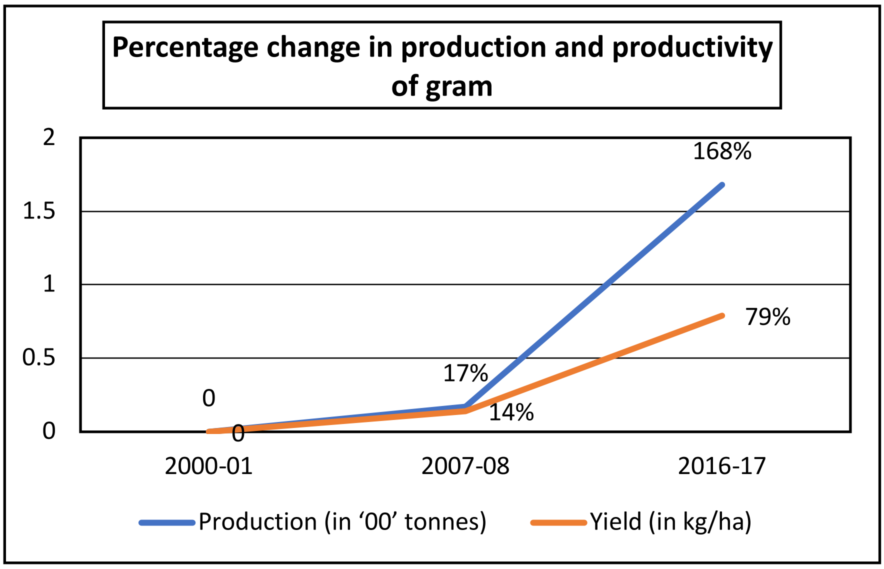
In the case of gram, the area under cultivation increased marginally by 2% between 2000-01 and 2007-08, but increased by a massive 50% between 2000-01 and 2016-17. The production of gram accordingly increased by 17% and 168% for the two time periods, while the productivity of gram showed the same trend – it increased by 14% and 78% in 2007-08 and 2016-17 over 2000-01.

Figure 5.20: Percentage change in the area under gram cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

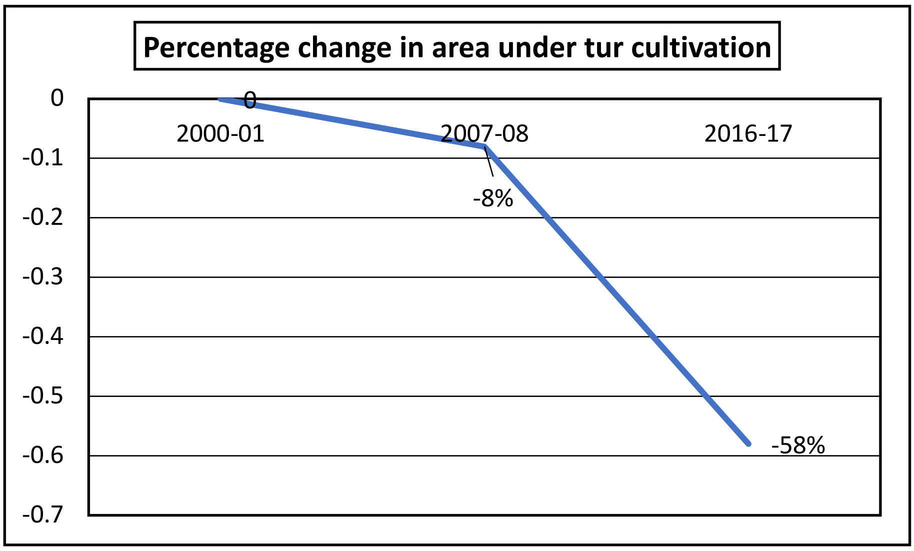
Figure 5.20(i): Percentage change in the production and productivity of gram cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

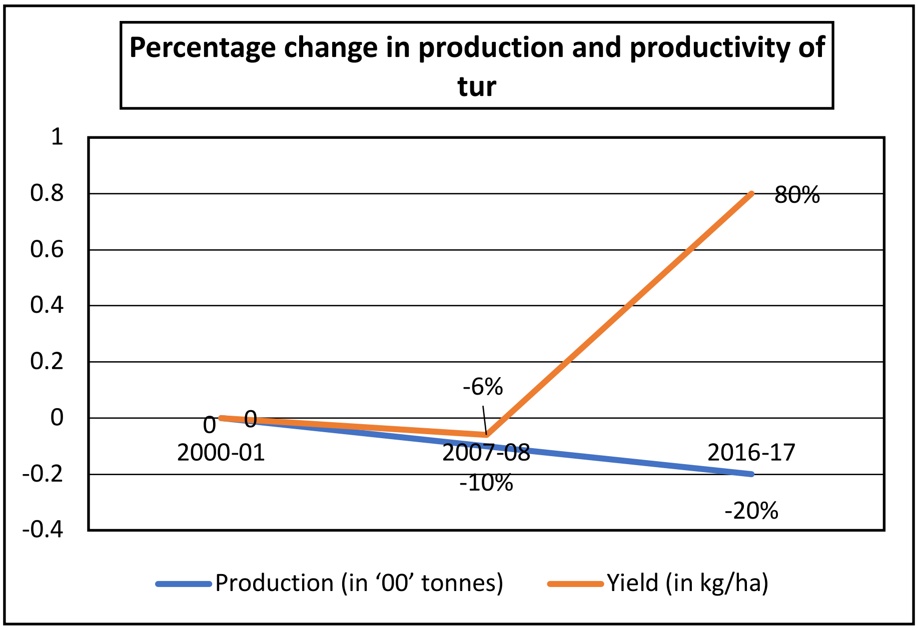
With respect to tur, the area under cultivation fell by 8% between 2000-01 and 2007-08 and by a drastic 58% between 2000-01 and 2016-17. The production of tur declined by 10% and 20% for the two time periods while the productivity of tur declined by 6% in the first time period, but showed an increase of 80% for the total time period between 2000-01 and 2016-17.

Figure 5.21: Percentage change in the area under tur cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

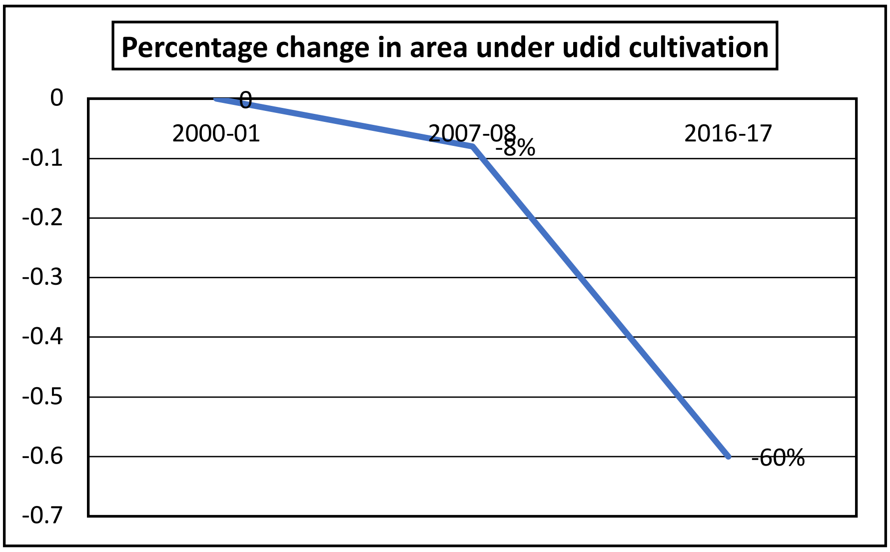
Figure 5.21 (i): Percentage change in the production and productivity of tur cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

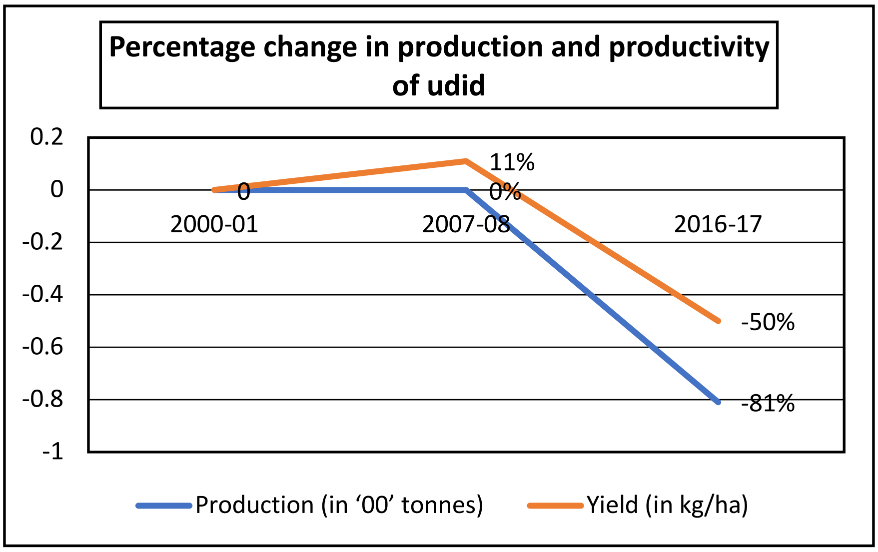
With respect to udid, area under cultivation declined by 8% between 2000-01 and 2007-08 and declined drastically by 60% between 2007-08 and 2016-17. While production was constant in the first period, it declined by 81% between 2007-08 and 2016-17. The productivity thus showed a marginal increase of 11% in the first period and declined by 50% in the second period.

Figure 5.22: Percentage change in the area under udid cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

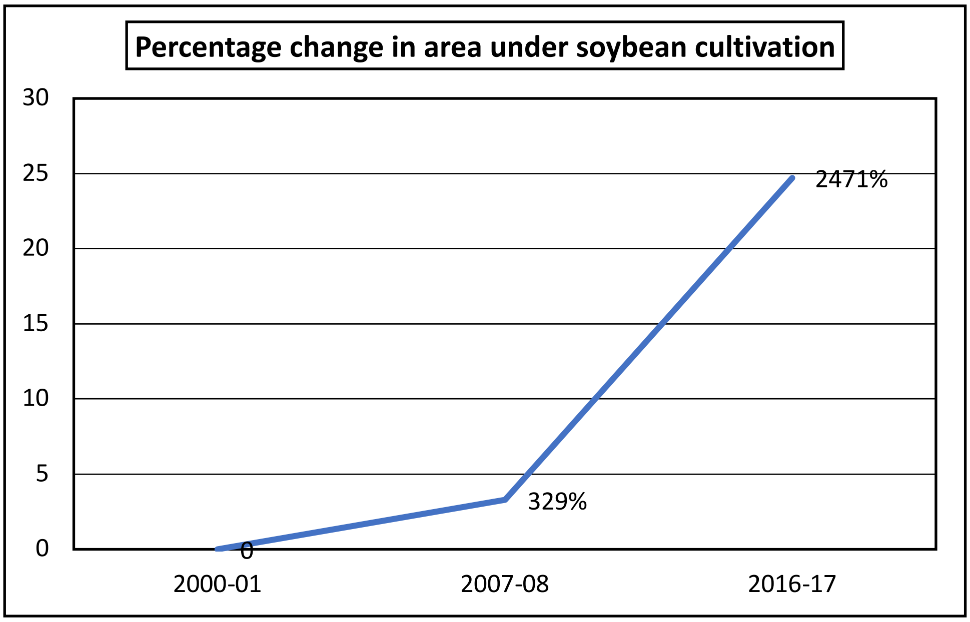
Figure 5.22(i): Percentage change in the production and productivity of udid cultivation in Pune district in 2007-08 and 2016-17 over 2000-01



Source: Tables 5.02 and 5.03

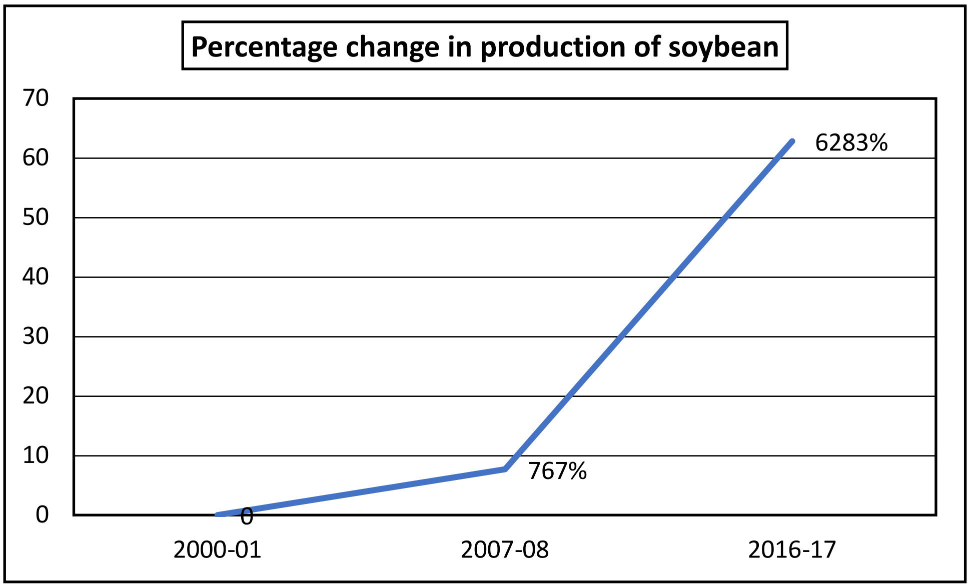
Among the oilseeds, groundnut which was traditionally cultivated as a kharif crop and is also grown as a summer crop in recent times, has seen a decline in area by 6% between 2000-01 and 2007-08 and by a huge amount of 60% overall between 2000-01 and 2016-17. The production of groundnut accordingly fell by 9% and 58% during the corresponding periods while the productivity of groundnut increased marginally by 3% in the first time period and by 5% in the total time period between 2000-01 and 2016-17. The production of safflower declined over the last 4-5 years and has now been completely stopped in the last two years. On the other hand, soybean has seen an exponential growth in terms of area, production and productivity. The area under soybean cultivation grew by 329% between 2000-01 and 2007-08 and by a whopping 2471% overall between 2000-01 and 2016-17. The production of soybean increased by 767% and 6283% for the corresponding periods. The productivity of soybean showed 100% growth in the first time period, and an overall increase of 147% between 2000-01 and 2016-17. It can be seen that the productivity of soybean has not increased at the same rate as production.

Figure 5.23: Percentage change in the area under soybean cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



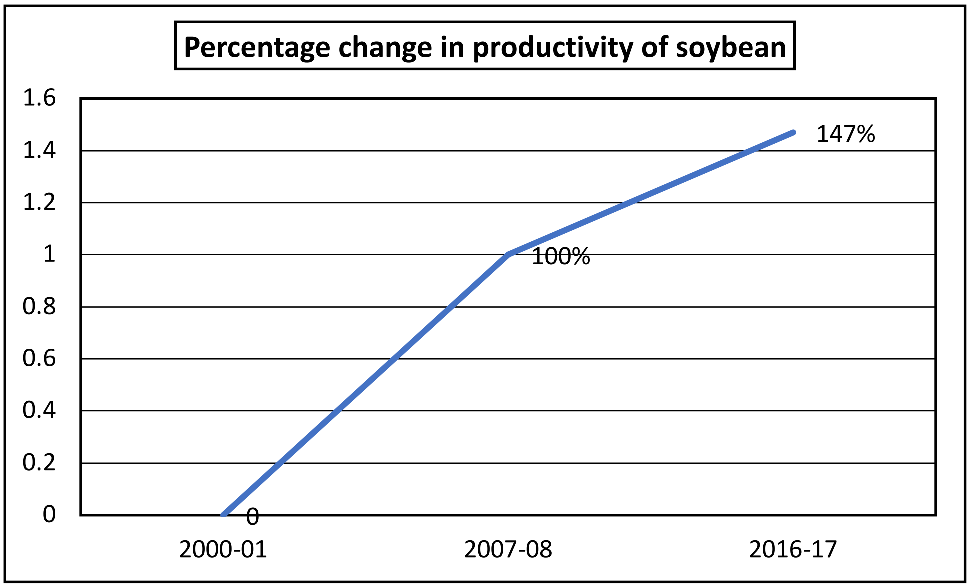
Source: Tables 5.02 and 5.03

Figure 5.23(i): Percentage change in the production of soybean cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



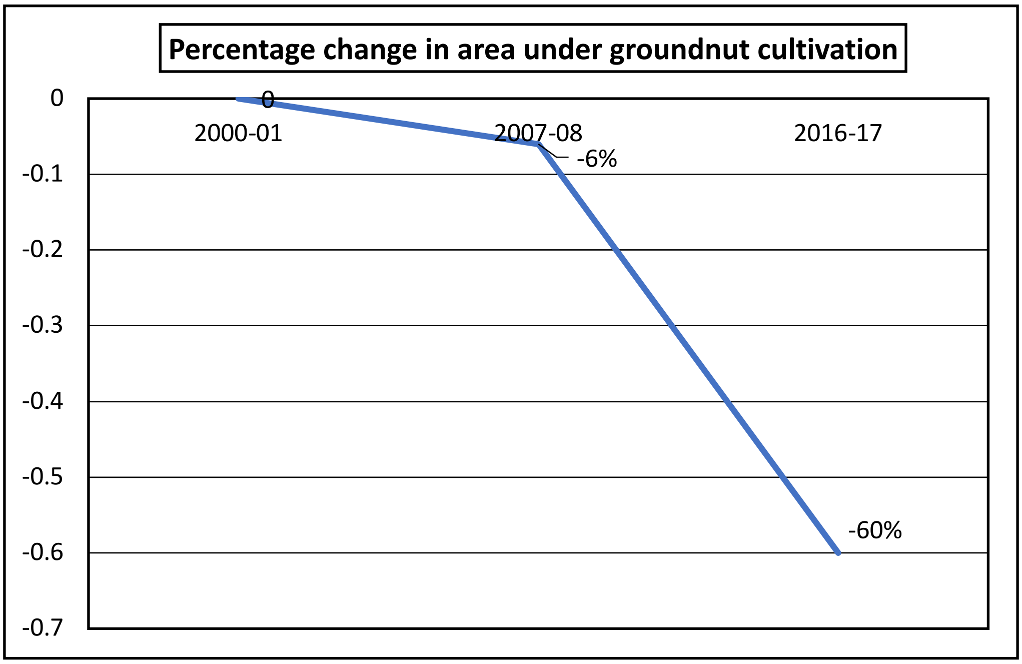
Source: Tables 5.02 and 5.03

Figure 5.23(ii): Percentage change in the productivity of soybean cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



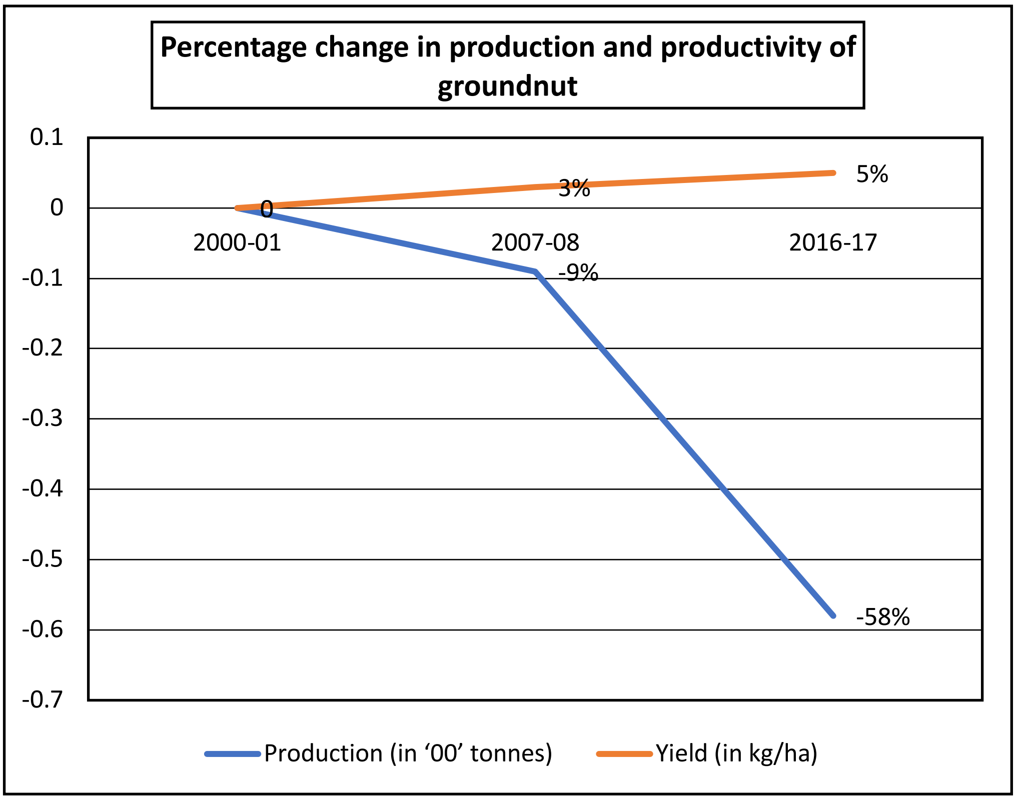
Source: Tables 5.02 and 5.03

Figure 5.24: Percentage change in the area under groundnut cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

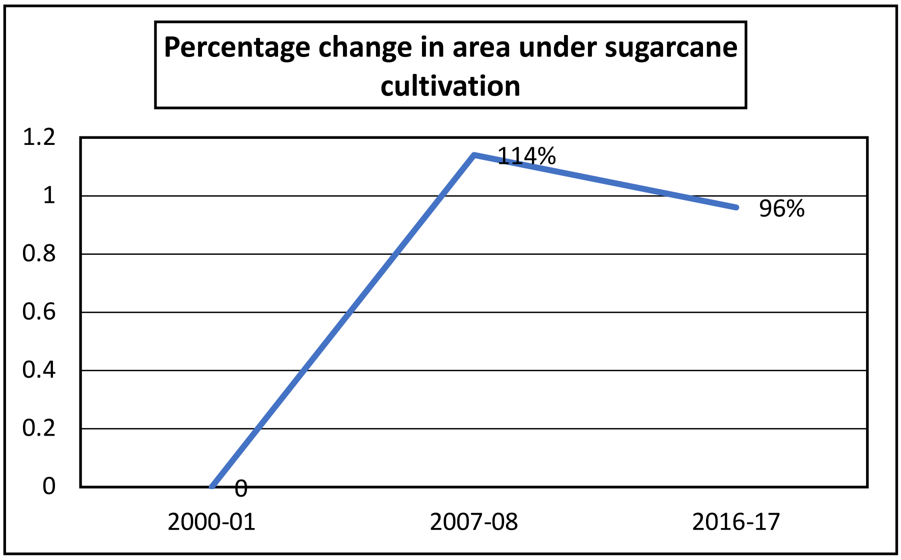
Figure 5.24(i): Percentage change in the production and productivity of groundnut cultivation in Pune district in 2007-08 and 2016-17 over 2000-01



Source: Tables 5.02 and 5.03

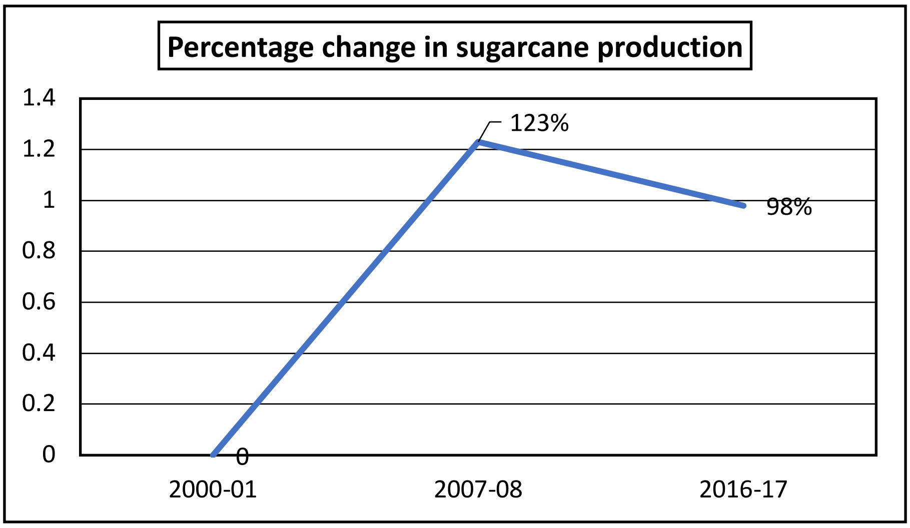
Finally, in the case of sugarcane, the area under sugarcane cultivation increased by 114% between 2000-01 and 2007-08 and by 96% in the total time period between 2000-01 and 2016-17. The production of sugarcane increased by 123% and 98% for the corresponding time periods. But the productivity of sugarcane increased marginally by 3% in the first time period and a mere 1% for the total time period between 2000-01 and 2016-17. Thus, sugarcane productivity has been stagnating for the last two decades.

Figure 5.25: Percentage change in the area under sugarcane cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



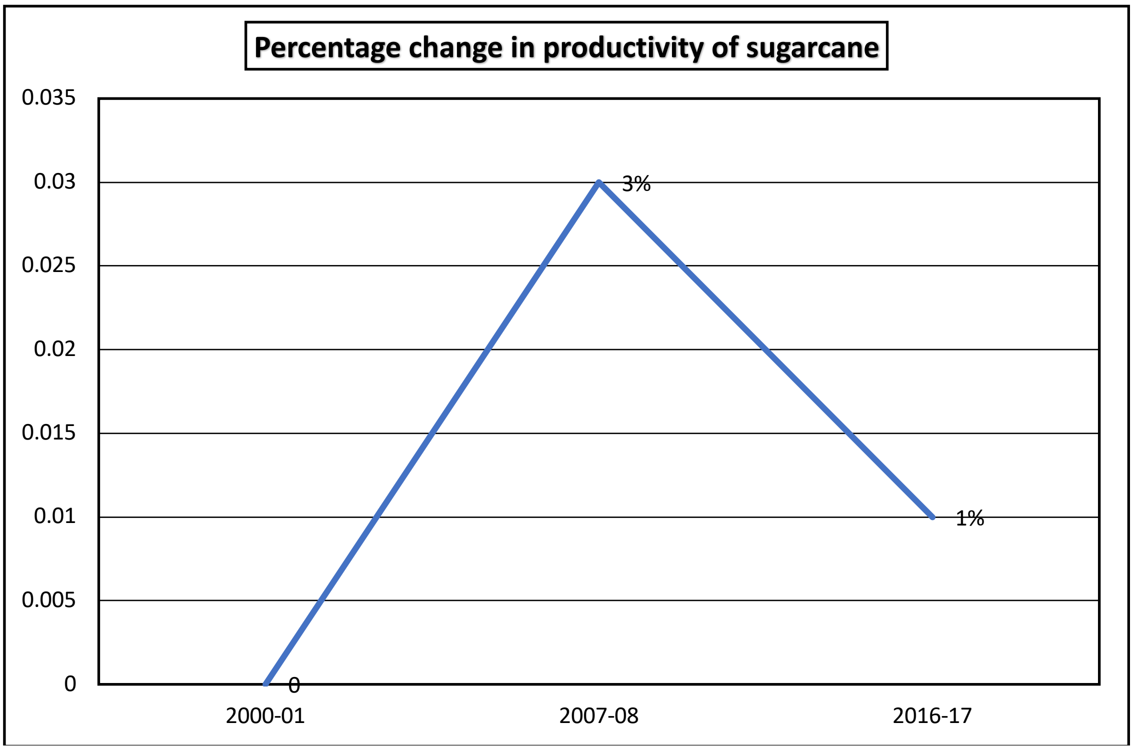
Source: Tables 5.02 and 5.03

Figure 5.25 (i): Percentage change in the production of sugarcane cultivation in Pune district in 2007-08 and 2016-17 over 2000-01.



Source: Tables 5.02 and 5.03

Figure 5.25(ii): Percentage change in the productivity of sugarcane cultivation in Pune district in 2007-08 and 2016-17 over 2000-01



Source: Tables 5.02 and 5.03

The other most important crop category is fruits and vegetables. In 2014-15, the area under production of horticulture crops was 111829 ha with an average productivity of 77,527 kg/ha. While the statistics for comparison with the year 2000-01, is not available, the fact that fruits and vegetables occupy around 10% of the total cultivated area, almost as much as sugarcane shows that it is very popular among the farmers.

5.4 CONCLUSION

Agriculture in Pune was mainly subsistence farming like much of the country before the green revolution. With the introduction of high yielding variety seeds and irrigation, the cropping pattern of the district shifted from traditional crops like jowar and bajra to more remunerative crops like rice, wheat, groundnut and sugarcane. With the productivity of most of the crops stagnating during the post-reform period, the government undertook several initiatives for giving an impetus to the sector. However, it is seen that while the productivity of rice and wheat have increased to a certain extent, the productivity of jowar and bajra have declined. Among pulses, moong and gram have shown improvement in production, but while the productivity of gram has increased, the productivity of moong has declined. Among the oilseeds, while safflower production declined gradually and has been completely stopped, groundnut production has also gone down considerably with yield stagnating. Most importantly, sugarcane area and production continued to increase but its productivity has stagnated. The two crops which have shown record increase in production and productivity are maize and soybean. The cropping pattern of Pune is showing a distinct preference for sturdy crops which are suited for the dry climatic conditions of the district and also prove to be remunerative to the farmers.

DATA SOURCES

www.krishi.maharashtra.gov.in

www.data.gov.in

CHAPTER 6
DATA ANALYSIS AND INTERPRETATION

6.1 INTRODUCTION

In the 5th chapter, the data analysis of Pune's cropping pattern has been done for thirteen important crops grown in Pune district for the period 2000-01 to 2016-17. From the analysis it is seen that the cropping pattern of the district shifted from traditional crops like jowar and bajra to more remunerative crops like rice, wheat, groundnut and sugarcane. Most importantly, sugarcane area and production continued to increase but its yield has stagnated. The two crops which have shown record increase in area and production are maize and soybean. The cropping pattern of Pune is showing a distinct preference for sturdy crops which are suited for the dry climatic conditions of the district and also prove to be remunerative to the farmers. In order to establish this statistically, this chapter will be analysing the trends in area, production, and yield for sugarcane, maize and soybean in Pune district for the period 1991-92 to 2017-18. It will also be establishing the correlation between the prices procured by the farmers for their produce with regard to these crops and the area, production, and yield for these crops. This analysis will help ascertain whether the cropping pattern in Pune district is in fact being influenced by the prices procured by the farmers for their produce. A Simple Regression Analysis has been done for studying the strength of the correlation between the variables viz., area, production, and FHP/FRP as also for the testing of hypotheses. A TREND analysis has been done to forecast the total area under these three crops in the next 5 years. Finally, an optimization model has been used to suggest the optimum cropping pattern for Pune.

6.2 PRODUCTION AND PRODUCTIVITY

(i) A production function describes the technical relationship that transforms inputs (resources) into outputs (commodities). A production function is generally expressed as:

$y = f(x)$

where y is the output and x is the input. The Cobb-Douglas production function which was based on the empirical study of the American manufacturing industry is a linear homogeneous production function of degree one wherein two inputs namely, labour and capital are taken into account. The function is expressed as follows:

$Q = AL^{\alpha}C^{1-\alpha}$

Where Q is the output, L and C are labour and capital respectively and A refers to the 'residual', also called technical change. This production function had ¼ contribution of capital and ¾ contribution of labour to the increase in output in manufacturing industry. The Cobb-Douglas production function shows constant returns to scale, the total of the values of L and C being equal to one ($\alpha + (1-\alpha)$). The coefficient of L measures the percentage increase in Q that would result from a 1 per cent increase in labour while keeping capital constant and vice versa. Though it is an easy function to estimate, the Cobb-Douglas function could represent only one stage of production at a time and that was not compatible with the neoclassical three stage production function. Economists like Halter, Carter and Hocking have introduced modifications in the Cobb Douglas function to allow for the three stages of production and variable production elasticities. However, agricultural economists continue using the Cobb Douglas production function due to its ease of use and the fact that it allows for diminishing marginal returns to each input (Debertin).

(ii) Productivity is defined as "a ratio of a volume measure of output to a volume measure of input use" (FAO). According to the United States Department of Agriculture, the total factor productivity (TFP) is the most informative measure of agricultural productivity as it takes into account all of the factors like land, labour, capital and other material resources employed in agricultural production and compares them with the total amount of crop and livestock output. Thus, if the total output grows at a faster rate than total inputs, then the TFP is supposed to be improving. Land productivity on the other hand measures the amount of output generated by a given amount of land. It is often expressed in physical terms (tonnes of output), i.e., crop yield per acre / hectare. It can also be expressed in monetary terms (returns to land). Land productivity is calculated as:

Land productivity = Volume of output / Planted Area

In general, planted area is a better concept than harvested area for calculating land productivity. However, while planted area is suitable for a monocropping system, the cultivated area including fallow land, should be used for calculating land productivity under mixed cropping systems. This becomes relevant in developing countries where farming systems are widely diversified and there is a tendency to underestimate output and yield due to lack of accounting of crops grown in mixture or in sequence and the lack of appraisal of by-products, which may be sold, consumed by the household or used in the production of other products. The measurement of land productivity is also challenging considering the differences in land quality and other related issues like land prices / rents (FAO).

For the purpose of this study, the trends in the production and productivity of the three selected cash crops viz., maize, soybean and sugarcane are being analysed for Pune district. While production of the crops is measured in metric tonnes or quintals, productivity in this study refers to crop yield per hectare. The impact of Farm Harvest Prices on production and productivity is being studied to estimate the economic efficiency of Pune's cropping pattern. It may also be highlighted that while higher remunerative prices impact area and production of crops directly, the crop yield depends on several other inputs like irrigation, seeds, fertilizers, and technology. Though logically higher prices will make it possible for farmers to use better inputs and improve yield levels, the stagnating yield levels of sugarcane in the face of ever rising FRP is a revealing contradiction. Hence, this study has restricted the analysis of yield of the crops to their correlation with FHP and the Regression Analysis between yield and FHP/FRP has not been done.

6.3 DATA ANALYSIS FOR MAIZE

For the purpose of data analysis, this study has started by studying the trends in the prices of maize at the macro level and then compared it with the district level data. The minimum support prices (MSP) recommended by the Commission on Agricultural Costs and Prices (CACP) was collected from the CACP reports for the years 1991 to 2018. The MSP recommended by the CACP is a floor price below which the procurement is not to be done. The following factors are taken into consideration in determining the MSP:

1. the cost of production
2. overall demand-supply
3. domestic and international prices
4. inter-crop price parity

5. terms of trade between agricultural and non-agricultural sectors

6. the likely impact of the price policy on the rest of the economy

7. ensuring rational utilization of production resources like land and water

Thus, pricing policy is rooted not in "cost plus" approach, though cost is an important determinant of MSPs. However, it is assumed that at the least, the MSP recommended by CACP is obtained by the farmers for their produce. On the other hand, the data obtained from Economic and Political Weekly (EPW) for the Farm Harvest Prices (FHP) obtained by farmers for their produce is the actual prices obtained by them. This has been confirmed with the office of Maharashtra State Agricultural Marketing Board (MSAMB).

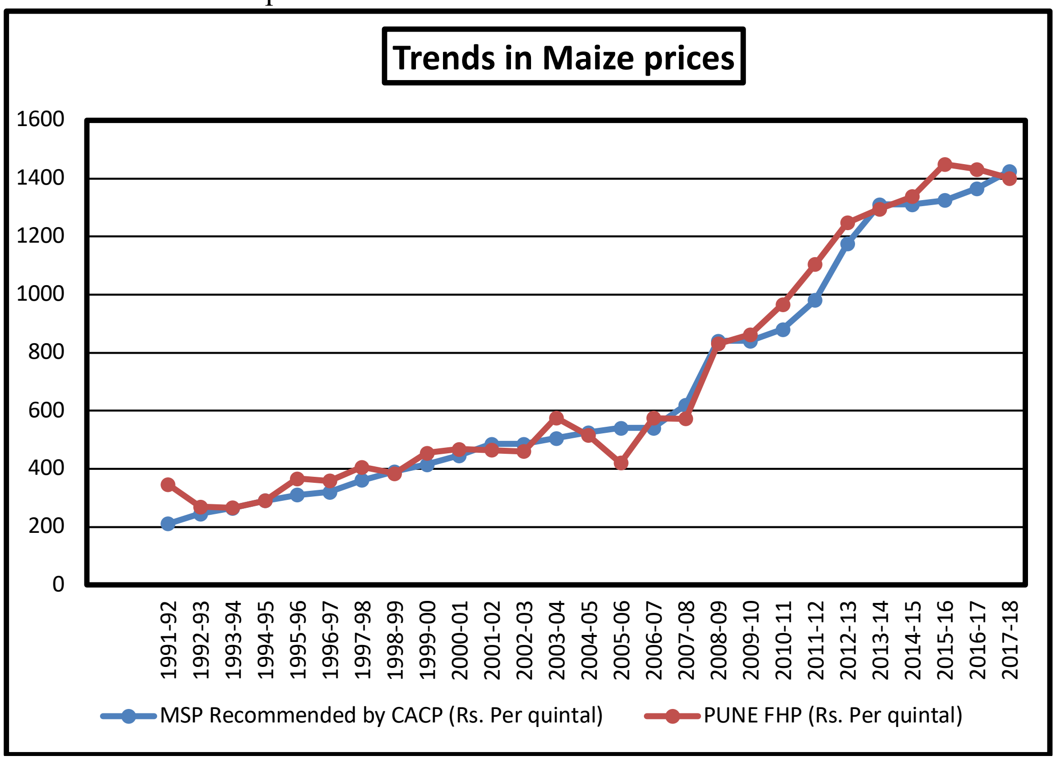
Table 6.01: MSP recommended by CACP at all India level and FHP obtained by farmers in Pune district for maize from 1991 to 2018.

YEAR	**MSP Recommended by CACP (Rs. Per quintal)**	**Pune FHP (Rs. Per quintal)**
1991-92	210.00	346.30
1992-93	245.00	268.50
1993-94	265.00	265.30
1994-95	290.00	290.25
1995-96	310.00	365.50
1996-97	320.00	358.10
1997-98	360.00	405.30
1998-99	390.00	384.00
1999-00	415.00	454.00
2000-01	445.00	468.00
2001-02	485.00	464.00
2002-03	485.00	460.00
2003-04	505.00	576.00
2004-05	525.00	515.00
2005-06	540.00	420.00
2006-07	540.00	575.00
2007-08	620.00	572.00
2008-09	840.00	830.00
2009-10	840.00	862.00
2010-11	880.00	966.00
2011-12	980.00	1104.00
2012-13	1175.00	1247.00
2013-14	1310.00	1295.00
2014-15	1310.00	1338.00
2015-16	1325.00	1449.00
2016-17	1365.00	1431.00
2017-18	1425.00	1401.00

Source: CACP reports and EPW

As can be seen from table 6.01, the FHP obtained by farmers in Pune has been in line with the MSP recommended by CACP. It is only in the two years (2005-06 and 2007-08) that there is a greater variation of the MSP from the FHP, more so in 2005-06. While the FHP has been slightly lower than the MSP in seven years (1998-99, 2001-02, 2002-03, 2004-05, 2008-09, 2013-14 and 2017-18), for the remaining nine years the FHP has been more than the MSP. Thus, we can say that the FHP obtained by farmers in Pune for maize is more or less in keeping with the macro trends.

Fig 6.01: Trends in maize prizes at macro and district levels between 1991-92 and 2017-2018



Source: Table 6.01

The trends in maize prices as recommended by CACP at the all India level and the FHP obtained by farmers for maize in Pune district are shown in the above figure (Fig. 6.01). It can be seen that the two lines, blue and red, are more or less convergent thus showing that there is very less variation in the macro and micro level prices of maize.

The next step was to analyse the data for maize at the district level. For this, the area, production and yield of maize for Pune district was compiled. The table (Table 6.02) below shows the area, production, yield, and FHP for maize in Pune district from 1991-92 to 2017-18. It can be seen from the table that area under maize saw a huge jump after 1995-96 and continuous expansion after 2009-10. However, increase in FHP was incremental up to 2007-08 after which it has shown a higher rising trend may be due to higher demand for poultry feed and human consumption.

Table 6.02: Area, Production, Yield, and FHP of maize in Pune district between 1991-92 and 2017-18.

YEAR	AREA (00 HA)	PRODUCTION (00 MT)	YIELD (KG/HA)	FHP (RS./QUINTAL)
1991-92	76.00	84.00	1105.26	346.30
1992-93	78.00	95.00	1217.95	268.50
1993-94	43.00	70.00	1627.91	265.30
1994-95	79.00	118.00	1493.67	290.25
1995-96	87.00	141.00	1620.69	365.50
1996-97	151.00	226.00	1496.69	358.10
1997-98	125.04	217.70	1741.04	405.30
1998-99	139.00	238.00	1712.23	384.00
1999-00	150.00	224.00	1493.33	454.00
2000-01	162.00	151.00	932.10	468.00
2001-02	153.00	258.00	1686.27	464.00
2002-03	149.00	285.00	1912.75	460.00
2003-04	104.00	181.00	1740.38	576.00
2004-05	153.00	337.00	2202.61	515.00
2005-06	165.00	365.00	2212.00	420.00
2006-07	183.00	425.00	2322.40	575.00
2007-08	166.00	452.00	2722.89	572.00
2008-09	174.00	422.00	2424.00	830.00
2009-10	160.00	411.00	2568.75	862.00
2010-11	253.00	722.00	2853.75	966.00
2011-12	272.00	872.00	3205.88	1104.00
2012-13	252.00	661.00	2623.02	1247.00
2013-14	319.00	919.00	2880.88	1295.00
2014-15	360.00	1334.00	3705.56	1338.00
2015-16	372.00	883.00	2373.66	1449.00
2016-17	426.00	1295.00	3040.00	1431.00
2017-18	473.00	1466.00	3100.00	1401.00

Source: EPW Time Series, MSAMB

Given the long time period, the entire period has been divided into nine trienniums as follows: 1991-92 to 1993-94; 1994-95 to 1996-97; 1997-98 to 1999-2000; 2000-01 to 2002-03; 2003-04 to 2005-06; 2006-07 to 2008-09; 2009-10 to 2011-12; 2012-13- to 2014-15; 2015-16 to 2017-18.

Table 6.02(i) shows the average area, average production, average yield and average FHP of maize in Pune district between 1991-92 and 2017-18.

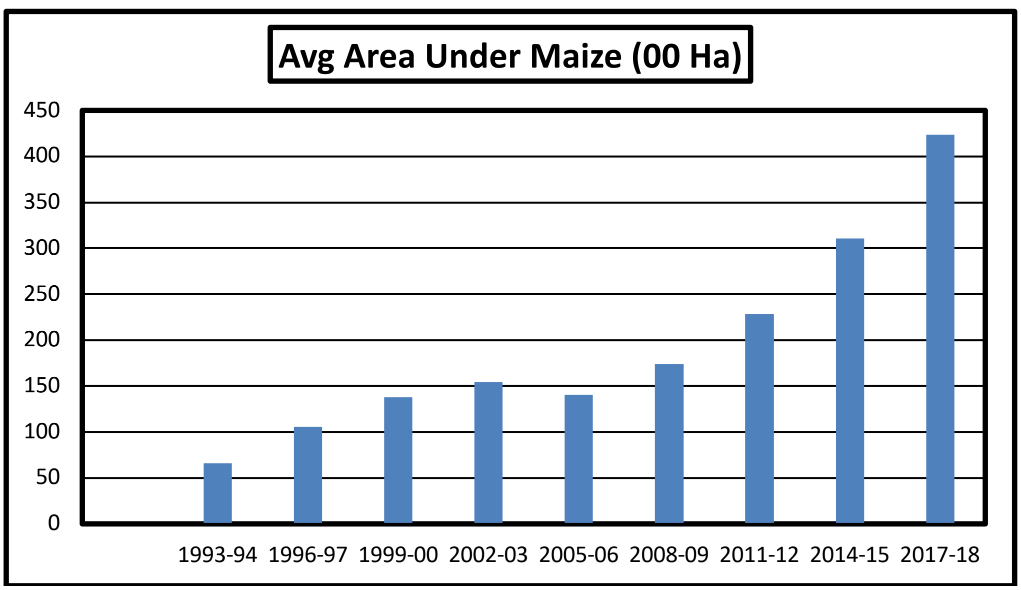
Table 6.02 (i): Average Area, Average Production, Average Yield, and Average FHP of maize for Pune district from 1991-92 to 2017-18.

TE	AVG AREA (00 hectares)	AVG PROD (00 Metric Tons)	AVG YIELD (kg/ha)	AVG FHP (Rs. per quintal)
1993-94	65.67	83.00	1317.04	293.37
1996-97	105.67	161.67	1537.02	337.95
1999-00	138.01	226.57	1648.87	414.43
2002-03	154.67	231.33	1510.37	464.00
2005-06	140.67	294.33	2051.67	503.67
2008-09	174.33	433.00	2489.77	659.00
2011-12	228.33	668.33	2876.13	977.33
2014-15	310.33	971.33	3069.82	1293.33
2017-18	423.67	1214.67	2837.89	1427.00

Source: Table 6.02.

From Table 6.02(i) it is seen that the area, production and yield of maize has been increasing by leaps and bound especially in the last decade. The same trend is observed for the Farm Harvest Prices also. These trends are depicted in the following graphs.

Fig. 6.02: Average area under maize cultivation for Pune district from TE1993-94 to TE2017-2018.

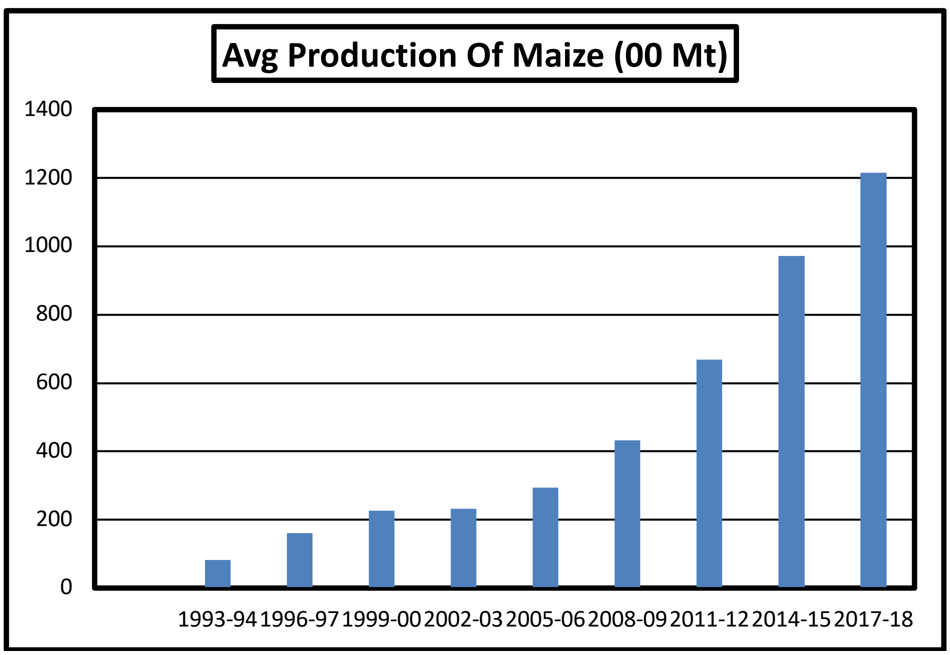


Source: Table 6.02(i)

It can be seen from Fig 6.02 that the area under maize cultivation had been increasing from TE1993-94 to TE2002-03. It dipped slightly in TE2005-06 and after that again picked up. Thus while area under maize took 15 years to double from a mere 6500 ha in TE 1993-94 to around 14000 ha in 2005-06, the increase from TE2005-06 to TE2017-2018 has been a very steep one with a three-fold increase in area from around 14000 hectares to over 42300 hectares.

Fig 6.03 shows the average production of maize for the time period 1991-92 to 2017-2018. The trend observed for area is also seen in production wherein the production of maize was increasing from TE1993-94 to TE2005-06 but at a slow rate. It increased from 8300 metric tons in 1993-94 to 29400 MT during this time period. However, production picked up after that and increased nearly four-fold from 29400 metric tons in TE2005-06 to 121400 metric tons in TE2017-18.

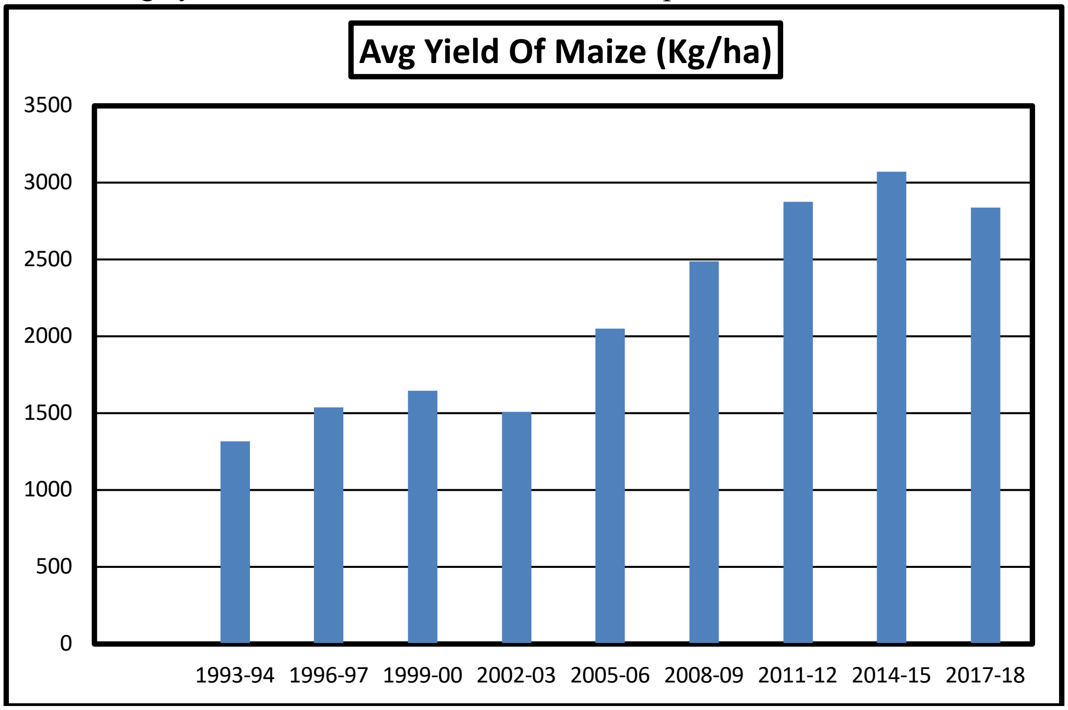
Fig 6.03: Average production of maize in Pune district between TE1993-94 and TE2017-2018.



Source: Table 6.02(i)

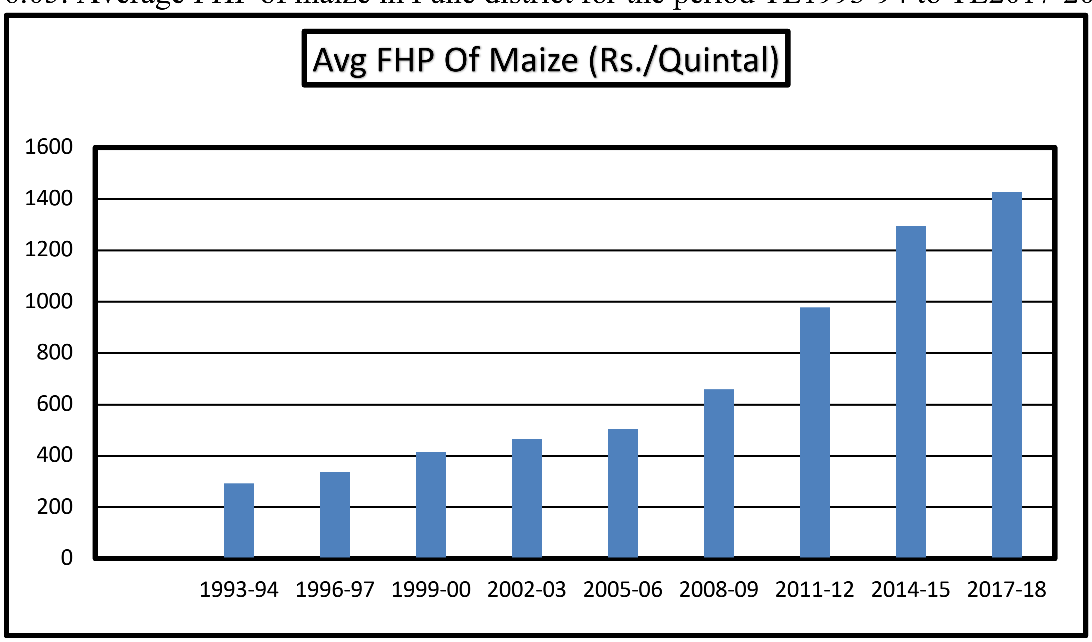
Figure 6.04 shows the average yield of maize in Pune district increasing from around 1300 kg/ha in TE1993-94 to around 1600 kg/ha inTE1999-2000. After a dip in yield levels for TE2002-03 (around 1500 kg/ha), there was an increase in yield from TE 2005-06 at around 2050 kg/ha to around 3060 kg/ha in TE 2014-15. The yield levels for TE 2017-18 has fallen again to around 2800 kg/ha.

Fig 6.04: Average yield of maize in Pune district for the period TE1993-94 to TE2017-2018.



Source: Table 6.02(i)

Fig 6.05: Average FHP of maize in Pune district for the period TE1993-94 to TE2017-2018.



Source: Table 6.02(i)

It can be seen from Fig 6.05 that the rise in average FHP of maize in Pune district was very incremental between TE1993-94 and TE2005-06 from around Rs. 290 per quintal to around Rs. 500 per quintal. But from TE2008-09 onwards, the FHP has been rising at a very fast rate, so much so that, the FHP in TE2017-18 at Rs. 1427 per quintal is almost twice that in TE2008-09 at Rs. 659 per quintal. While it took more than fifteen years to double the FHP in the initial part of the study period (1991-92 to 2005-06), the FHP doubled within 10 years in the latter part of the study period (2008-09 to 2017-18).

The percentage changes in the average area, average production, average yield and average FHP TE over TE have been shown in the following table.

Table 6.03: Percentage change in average area, average production, and average yield TE over TE for maize in Pune.

TE	% Change In Area	% Change In Prod	% Change In Yield
1993-94	-	-	-
1996-97	60.91	94.78	16.70
1999-00	30.61	40.14	7.28
2002-03	12.07	2.10	-8.40
2005-06	-9.05	27.23	35.84
2008-09	23.93	47.11	21.35
2011-12	30.98	54.35	15.52
2014-15	35.91	45.34	6.73
2017-18	36.52	25.05	-7.56

Source: Table 6.02(i)

It can be seen from Table 6.03 that the percentage increase in average production in TE 1996-97 is 94% since both average area and average yield have increased by 60% and 16% respectively. In TE 1999-00 while average area has increased by 30%, average yield has increased only by 7%; hence average production increased only by 40%. Again, even though average area shows 12% increase in TE 2002-03, average production has increased only by 2% due to negative growth in yield. On the other hand, in TE 2005-06 average production has increased by 27% in spite of negative growth in average area primarily because of an increase in yield by 35%. Between TE 2011-12 and TE 2014-15, average production increased by 54% and 45% due to increase in area by 30% and 35% respectively; the reduction in growth of production in spite of an increase in growth in area was due to the fact that average yield grew by 15% in TE 2011-12, but it increased only by 6% in TE 2014-15. Finally, in TE 2017-18 when the yield shows a negative growth, average production shows 25% growth due to increase in area by 36% which is a reversal of the scenario in TE 2005-06.

In order to establish the correlation between the Farm Harvest Prices obtained for maize and the area, production, and yield of maize, correlation analysis was done using Pearson's correlation coefficient. The formula explaining the calculation of Pearson's correlation coefficient is already given in Chapter 3.

To begin with, the correlation coefficient between average area under maize cultivation and average FHP obtained for maize has been calculated as shown under:

Table 6.04: Calculation of correlation coefficient between area under maize and FHP obtained for maize in Pune district.

TE	AVG AREA (x) (00 HA)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	65.67	293.37	-127.82	-414.42	52969.68	16337.01	171744.24
1996-97	105.67	337.95	-87.82	-369.84	32477.72	7711.70	136779.43
1999-00	138.01	414.43	-55.47	-293.35	16272.22	3076.88	86056.40
2002-03	154.67	464.00	-38.82	-243.79	9462.91	1506.70	59432.12
2005-06	140.67	503.67	-52.82	-204.12	10780.88	2789.56	41665.13
2008-09	174.33	659.00	-19.15	-48.79	934.25	366.71	2380.17
2011-12	228.33	977.33	34.85	269.55	9393.79	1214.55	72655.21
2014-15	310.33	1293.33	116.85	585.55	68421.30	13654.01	342864.47
2017-18	423.67	1427.00	230.18	719.21	165551.10	52984.54	517267.29
	193.48	707.79			366263.86	99641.66	1430844.45
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.02(i)

Further calculations are shown as below:

366263.856 / √ (99641.6565*1430844.45)

= 366263.856 / 377586.6935

= 0.970012615

The above calculation shows that there is a very high correlation (0.97) between area under maize cultivation and the FHP obtained for maize in Pune district.

The next correlation coefficient was calculated between the production of maize and the FHP obtained for maize in Pune district for the study period.

Table 6.05: Calculation of correlation coefficient between production of maize and FHP obtained for maize in Pune district.

TE	AVG PROD (x) (00 MT)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	83.00	293.37	-393.03	-414.42	162877.95	154469.38	171744.24
1996-97	161.67	337.95	-314.36	-369.84	116261.70	98821.74	136779.43
1999-00	226.57	414.43	-249.46	-293.35	73179.80	62229.92	86056.40
2002-03	231.33	464.00	-244.69	-243.79	59652.88	59874.46	59432.12
2005-06	294.33	503.67	-181.69	-204.12	37087.16	33012.20	41665.13
2008-09	433.00	659.00	-43.03	-48.79	2099.11	1851.23	2380.17
2011-12	668.33	977.33	192.31	269.55	51835.75	36982.14	72655.21
2014-15	971.33	1293.33	495.31	585.55	290025.42	245329.43	342864.47
2017-18	1214.67	1427.00	738.64	719.21	531240.00	545590.14	517267.29
	476.03	707.79			1324259.76	1238160.65	1430844.45
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.02(i)

Further calculations are shown as under:

1324259.76 / √ (1238160.65*1430844.45

= 1324259.76 / 1331020.395

= 0.99492071

From the above calculations, it is seen that the correlation coefficient being almost +1 (0.99), there exists a very strong, positive correlation between production of maize and FHP obtained for maize in Pune district.

Next, the correlation coefficient between the yield of maize and FHP obtained for maize for Pune district was calculated.

Table 6.06: Calculation of correlation coefficient between yield of maize and FHP obtained for maize in Pune district.

TE	AVG YIELD (x) (KG/HA)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	1317.04	293.37	-831.69	-414.42	344668.95	691706.94	171744.24
1996-97	1537.02	337.95	-611.71	-369.84	226233.95	374192.24	136779.43
1999-00	1648.87	414.43	-499.86	-293.35	146635.90	249860.42	86056.40
2002-03	1510.37	464.00	-638.35	-243.79	155622.49	407496.12	59432.12
2005-06	2051.67	503.67	-97.06	-204.12	19812.51	9421.20	41665.13
2008-09	2489.77	659.00	341.04	-48.79	-16638.14	116305.62	2380.17
2011-12	2876.13	977.33	727.40	269.55	196067.95	529110.60	72655.21
2014-15	3069.82	1293.33	921.09	585.55	539339.19	848401.59	342864.47
2017-18	2837.89	1427.00	689.16	719.21	495650.00	474936.12	517267.29
	2148.73	707.79			2107392.79	3701430.86	1430844.45
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.02(i)

Further calculations are shown as under:

2107392.79 / √ 3701430.86*1430844.45

= 2107392.79 / 2301341.305

= 0.915723707

From the above calculations it can be seen that there is a strong positive correlation (0.91) between yield of maize and FHP obtained for maize in Pune district.

6.4 DATA ANALYSIS FOR SOYBEAN

For the purpose of data analysis, this section was started by studying the trends in the prices of soybean at the macro level and then comparing it with the district level data. The minimum support prices (MSP) recommended by the Commission on Costs and Prices (CACP) was collected from the CACP reports for the years 1991 to 2018.

It can be seen from Table 6.07 that the data for FHP at Pune for soybean is not available for the initial two years (1991-92 and 1992-93). The MSP recommended by CACP for soybean for the year 2012-13 is also not available. In spite of these minor aberrations, the overall trends in soybean prices at the macro and micro level reveal that the FHP obtained by farmers for soybean in Pune has been higher than the MSP recommended by CACP in 19 years out of the 28 years thus proving that it is the norm rather than the exception. In 1999-00, 2004-05, 2005-06, 2006-07, 2007-08, and 2017-18, (6 years), the FHP in Pune for soybean was markedly lower than the CACP. In 1998-99 and 2016-17 (2 years), though the FHP in Pune for soybean was lower than the MSP recommended by CACP, the difference was not a very substantial amount. Thus, it can be said that the FHP in Pune for soybean has been more favourable overall than the MSP recommended by CACP.

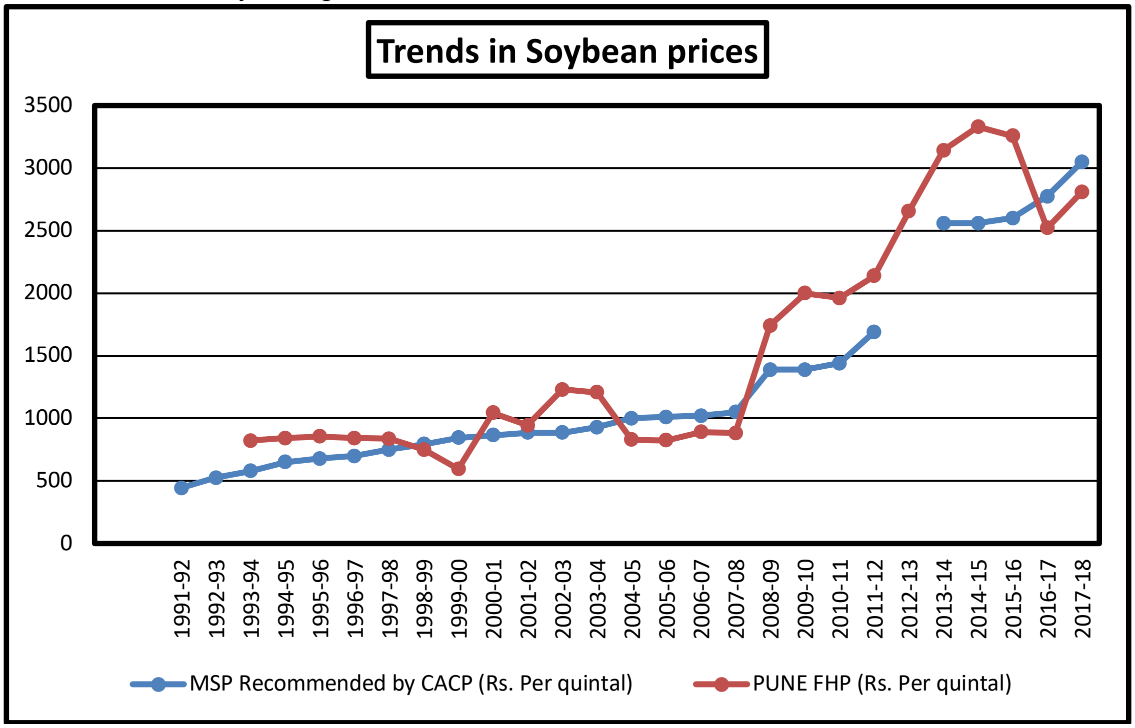
The trends in the soybean prices at the macro and micro levels are depicted in the graph below (Fig 6.06). It can be seen that for the most part, the red line depicting Pune's FHP for soybean lies above the blue line which depicts the MSP declared by CACP for soybean at the macro level. However, in the last two years (2016-17 and 2017-18), the FHP in Pune has been lower than that at the macro level.

Table 6.07: MSP recommended by CACP at all India level and FHP obtained by farmers in Pune district for soybean from 1991-92 to 2017-2018.

YEAR	MSP Recommended by CACP (Rs. Per quintal)	Pune FHP (Rs. Per quintal)
1991-92	445.00	NA
1992-93	525.00	NA
1993-94	580.00	821.25
1994-95	650.00	841.50
1995-96	680.00	855.50
1996-97	700.00	841.20
1997-98	750.00	837.20
1998-99	795.00	750.00
1999-00	845.00	596.00
2000-01	865.00	1043.00
2001-02	885.00	944.00
2002-03	885.00	1230.00
2003-04	930.00	1208.00
2004-05	1000.00	830.00
2005-06	1010.00	825.00
2006-07	1020.00	890.00
2007-08	1050.00	882.00
2008-09	1390.00	1743.00
2009-10	1390.00	1999.00
2010-11	1440.00	1962.00
2011-12	1690.00	2138.00
2012-13	NA	2653.00
2013-14	2560.00	3142.00
2014-15	2560.00	3330.00
2015-16	2600.00	3257.00
2016-17	2775.00	2521.00
2017-18	3050.00	2810.00

Source: CACP reports, EPW and MSAMB

Fig. 6.06: Trends in soybean prizes at macro and district levels between 1991-92 and 2017-2018



Source: Table 6.07

The next step was to analyse the data for soybean at the district level. For this, the area, production, yield and FHP of soybean for Pune district was compiled. The table below (Table 6.08) shows the area, production, yield and FHP for soybean in Pune district from 1991-92 to 2017-18. It can be seen that since 2008-09 there has been quantum jump in the area, production and FHP of soybean. This could be due to the deliberate promotion of oilseeds production undertaken by the government. Other factors like increased demand for edible oil which requires huge imports of the commodity could have been an influencing factor in increased cultivation of soybean. The yield levels of soybean have been high overall during the study period.

Table 6.08: Area, Production, Yield, and FHP of soybean for Pune district from 1991-92 to 2017-18

YEAR	AREA (00 HA)	PRODUCTION (00 MT)	YIELD (KG/HA)	FHP (RS./QUINTAL)
1991-92	5.00	3.00	600.00	NA
1992-93	4.00	4.00	1000.00	NA
1993-94	5.00	7.00	1400.00	821.25
1994-95	8.00	6.00	750.00	841.50
1995-96	NA	NA	NA	855.50
1996-97	3.00	5.00	1666.67	841.20
1997-98	15.00	12.00	800.00	837.20
1998-99	4.00	5.00	1250.00	750.00
1999-00	6.00	12.00	2000.00	596.00
2000-01	7.00	6.00	857.14	1043.00
2001-02	4.00	5.00	1250.00	944.00
2002-03	4.00	7.00	1750.00	1230.00
2003-04	6.00	20.00	3333.33	1208.00
2004-05	12.00	36.00	3000.00	830.00
2005-06	18.00	38.00	2111.11	825.00
2006-07	19.00	36.00	1894.74	890.00
2007-08	30.00	52.00	1733.33	882.00
2008-09	24.00	37.00	1541.67	1743.00
2009-10	33.00	47.00	1424.24	1999.00
2010-11	29.00	58.00	2000.00	1962.00
2011-12	39.00	82.00	2102.56	2138.00
2012-13	42.00	81.00	1928.57	2653.00
2013-14	69.00	268.00	3884.06	3142.00
2014-15	71.00	117.00	1647.89	3330.00
2015-16	161.00	470.00	2919.25	3257.00
2016-17	180.00	383.00	2130.00	2521.00
2017-18	202.00	409.00	2020.00	2810.00

Source: EPW Time Series data and MSAMB.

Given the long time period, the entire period has been divided into nine trienniums as follows: 1991-92 to 1993-94; 1994-95 to 1996-97; 1997-98 to 1999-2000; 2000-01 to 2002-03; 2003-04 to 2005-06; 2006-07 to 2008-09; 2009-10 to 2011-12; 2012-13- to 2014-15; 2015-16 to 2017-18. Table 6.08(i) shows the average area, average production, average yield and average FHP of soybean in Pune district between 1991-92 and 2017-18.

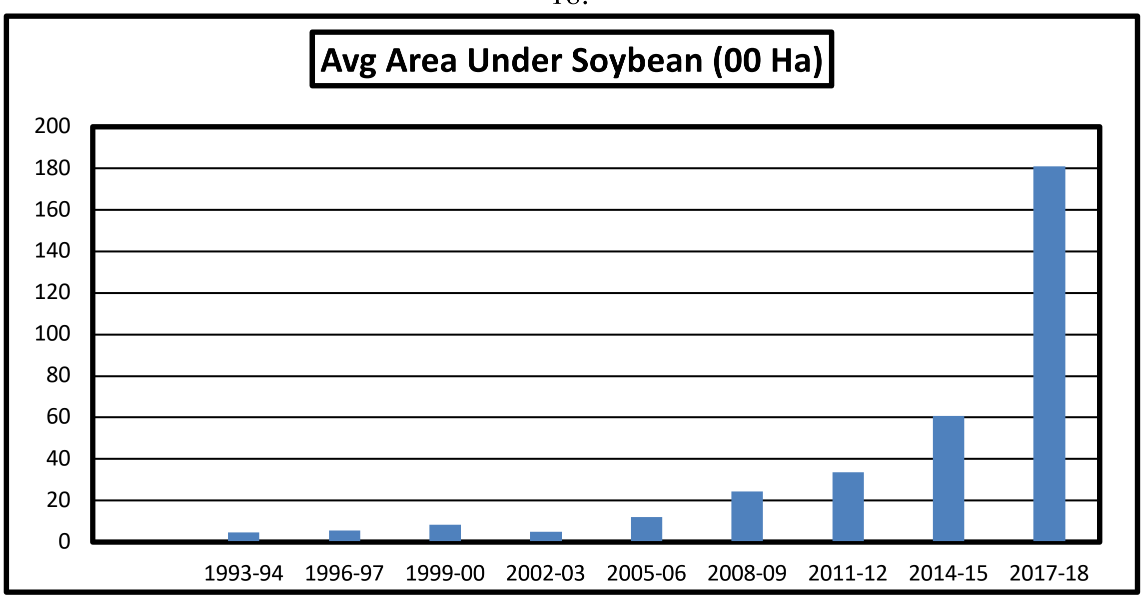
Table 6.08 (i): Average Area, Average Production, Average Yield, and Average FHP of soybean for Pune district from 1991-92 to 2017-18.

TE	AVG AREA (00 hectares)	AVG PROD (00 Metric Tons)	AVG YIELD (kg/ha)	AVG FHP (Rs. Per quintal)
1993-94	4.67	4.67	1000.00	821.25
1996-97	5.50	5.50	1208.34	846.07
1999-00	8.33	9.67	1350.00	727.73
2002-03	5.00	6.00	1285.71	1072.33
2005-06	12.00	31.33	2814.81	954.33
2008-09	24.33	41.67	1723.25	1171.67
2011-12	33.67	62.33	1842.27	2033.00
2014-15	60.67	155.33	2486.84	3041.67
2017-18	181.00	420.67	2356.42	2862.67

Source: Table 6.08

It can be seen from Table 6.08(i) that the area under soybean in Pune district has increased sevenfold in the last decade; the production of soybean has increased nearly ten times; but the Yield of soybean has not even doubled and Farm Harvest Prices of soybean have more than doubled. These trends are depicted in the following graphs.

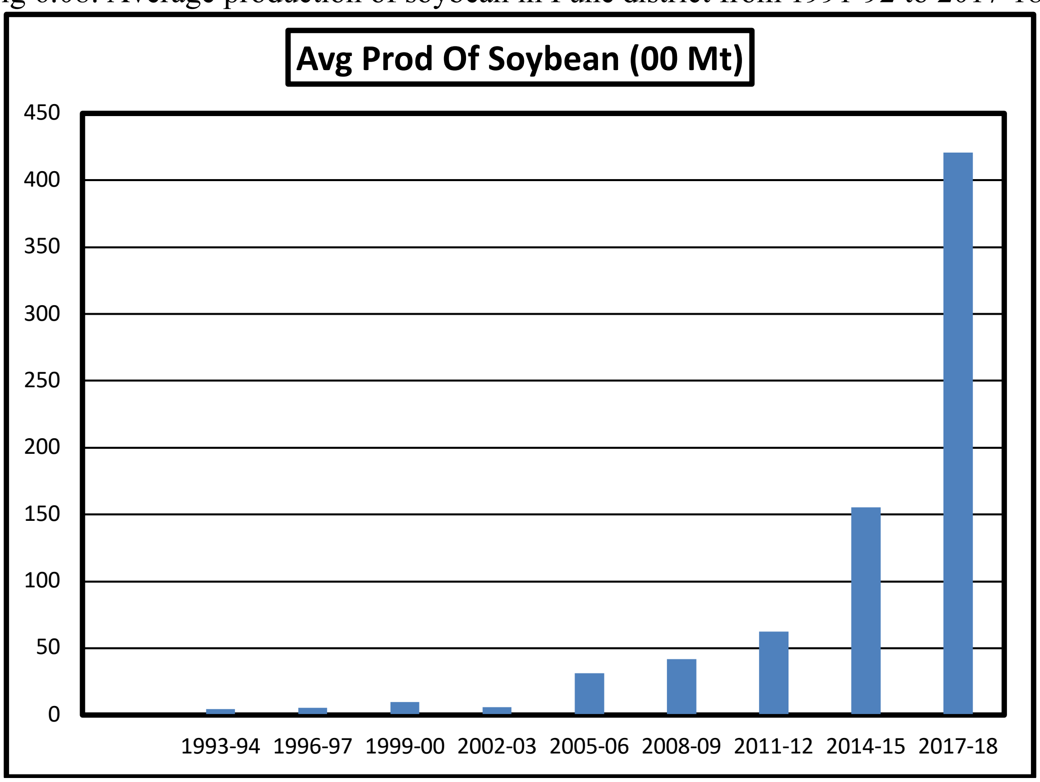
Fig 6.07: Average area under soybean cultivation in Pune district from TE1993-94 to TE2017-18.



Source: Table 6.08(i)

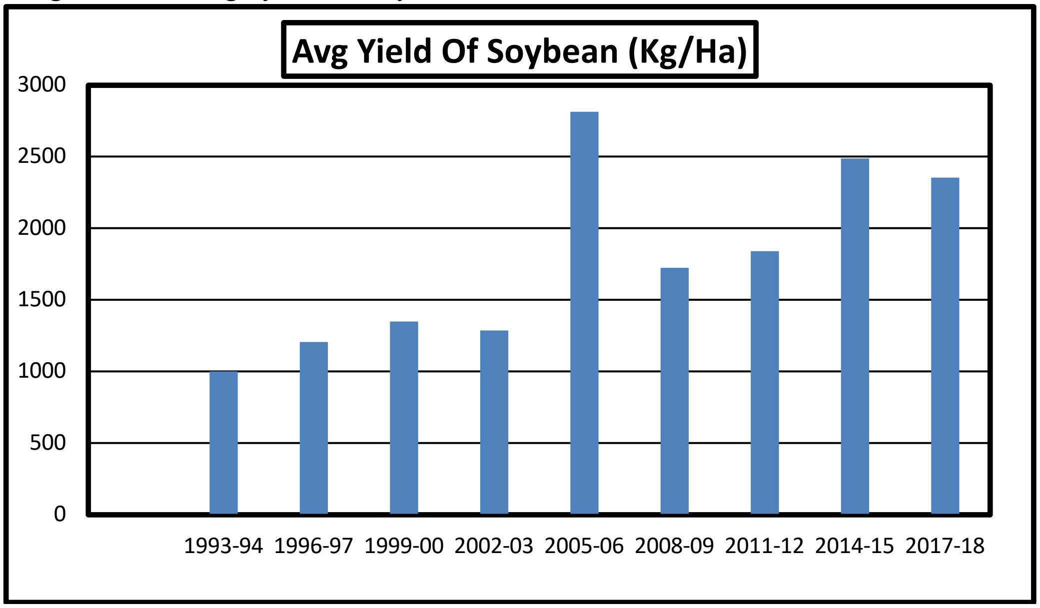
It can be seen from Fig 6.07 that there was very less area under soybean cultivation in Pune district from TE1993-94 to TE2008-09 (less than 2500 hectares). But after TE2008-09, the area under soybean has gone up more than 7 times in the last decade from just under 2500 hectares to nearly 18000 hectares. The same trend can be observed in Fig 6.08 which shows the average production of soybean cultivation in Pune district from TE1993-94 to TE2017-18. Up to TE2008-09, the production of soybean was around 400 metric tons. This shot up to over 42000 metric tons in 2017-18, an increase of around than 10 times. However, the trend is not the same with respect to yield of soybean in Pune district. Fig. 6.09 shows that the yield of soybean has seen incremental improvement over the years from around 1000 kg/ha in the first triennium to just about 2300 kg/ha in the last triennium of the study period. Thus, yield has stagnated over the years with respect to soybean cultivation in Pune district.

Fig 6.08: Average production of soybean in Pune district from 1991-92 to 2017-18.



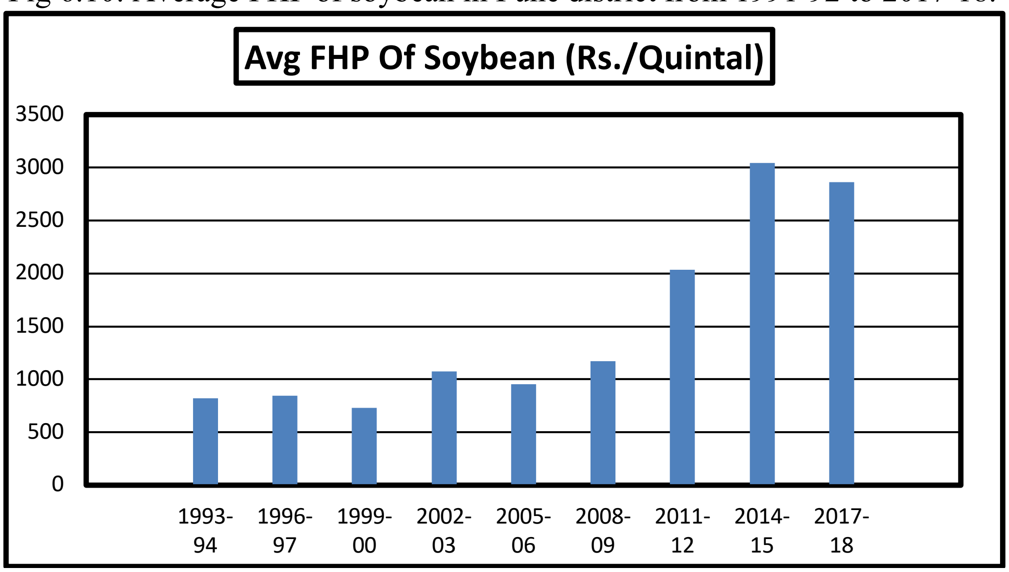
Source: Table 6.08(i)

Fig 6.09: Average yield of soybean in Pune district from 1991-92 to 2017-18.



Source: Table 6.08 (i)

Fig 6.10: Average FHP of soybean in Pune district from 1991-92 to 2017-18.



Source: Table 6.08(i)

Finally, the trends of FHP for soybean in Pune district also follows the trend of area and production of soybean. Thus, the FHP for soybean saw very little increase (between Rs. 750 and Rs. 1000 per quintal) from TE 1993-94 up to the TE2005-06. After TE2008-09, the FHP for soybean increased dramatically from Rs. 1100 per quintal to nearly Rs. 3000 per quintal in TE ending 2014-15, before falling to around Rs. 2800 per quintal in TE ending 2017-18. Thus, there has been a threefold increase in the FHP during the second part of the study period.

The percentage changes in the Average Area, Average Production, Average Yield and Average FHP TE over TE are shown in the table below (Table 6.09)

Table 6.09: Percentage change in average area, average production, average yield, and average farm harvest prices TE over TE for soybean in Pune

TE	% Change In Area	% Change In Prod	% Change In Yield
1993-94			
1996-97	17.86	17.86	20.83
1999-00	51.52	75.76	11.72
2002-03	-40.00	-37.93	-4.76
2005-06	140.00	422.22	118.93
2008-09	102.78	32.98	-38.78
2011-12	38.36	49.60	6.91
2014-15	80.20	149.20	34.99
2017-18	198.35	170.82	-5.24

Source: Table 6.08(i)

It can be seen from Table 6.09 that in TE 1996-97, average production of soybean increased by 17% due to a 17% increase in average area and 20% increase in yield over the previous triennium. The growth in average production jumped to 75% in the next triennium due to average growth increasing by over 50% though average yield increased only by 11%. In TE 2002-03, there was negative growth in all the three parameters. In TE 2005-06, the crop staged a dramatic recovery with average production posting 400% growth due to average area and average yield increasing by 140% and 118% respectively. In TE 2008-09 and TE 2017-18, average yield of soybean recorded negative yield growth rates of nearly 40% and 5% respectively. However, average production grew at a modest 32% and a huge 170% in the two periods since average area grew by a whopping 100% and 200% respectively. Finally, in the TE 2011-12 and TE 2014-15, average production posted 50% and 150% growth respectively due to the combined effects of average area increasing by 40% and 80% and average yield growing by 7% and 35% respectively.

In order to establish the correlation between the Farm Harvest Prices obtained for soybean and the area, production, and yield of soybean, correlation analysis was done using Pearson's correlation coefficient.

To begin with, the correlation coefficient between average area under soybean cultivation and average FHP obtained for soybean has been calculated as shown under:

Table 6.10: Calculation of correlation coefficient of average area under soybean and average FHP obtained for soybean in Pune district.

TE	AVG AREA (x) (00 HA)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	4.67	821.25	-32.57	-682.16	22220.83	1061.07	465346.31
1996-97	5.50	846.07	-31.74	-657.35	20864.66	1007.47	432104.15
1999-00	8.33	727.73	-28.91	-775.68	22422.89	835.64	601678.89
2002-03	5.00	1072.33	-32.24	-431.08	13898.33	1039.47	185829.65
2005-06	12.00	954.33	-25.24	-549.08	13859.18	637.09	301488.44
2008-09	24.33	1171.67	-12.91	-331.75	4281.98	166.60	110055.61
2011-12	33.67	2033.00	-3.57	529.59	-1892.78	12.77	280462.43
2014-15	60.67	3041.67	23.43	1538.25	36035.02	548.77	2366224.46
2017-18	181.00	2862.67	143.76	1359.25	195405.31	20666.72	1847570.63
	37.24	1503.41			327095.40	25975.62	6590760.56
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.08(i)

Further calculations are shown as below:

327095.4 / √ 25975.61728*6590760.56

= 327095.4 / 413762.0982

= 0.790539784

From the above calculations it is seen that the average area under soybean cultivation in Pune district has a high correlation to the FHP of soybean obtained in Pune district. The correlation coefficient being around 0.8 (and thus closer to +1) is evidence of the same.

Next, the correlation coefficient of the average production of soybean in Pune district with the average FHP of soybean in Pune district was calculated as follows:

Table 6.11: Calculation of correlation coefficient of average production of soybean and the FHP of soybean in Pune district

TE	AVG PROD (x) (00 MT)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	4.67	821.25	-77.24	-682.16	52690.77	5966.13	465346.31
1996-97	5.50	846.07	-76.41	-657.35	50226.13	5838.09	432104.15
1999-00	9.67	727.73	-72.24	-775.68	56035.67	5218.72	601678.89
2002-03	6.00	1072.33	-75.91	-431.08	32722.14	5761.93	185829.65
2005-06	31.33	954.33	-50.57	-549.08	27769.19	2557.74	301488.44
2008-09	41.67	1171.67	-40.24	-331.75	13349.72	1619.32	110055.61
2011-12	62.33	2033.00	-19.57	529.59	-10366.18	383.14	280462.43
2014-15	155.33	3041.67	73.43	1538.25	112947.70	5391.37	2366224.46
2017-18	420.67	2862.67	338.76	1359.25	460459.78	114757.84	1847570.63
	81.91	1503.41			795834.92	147494.28	6590760.56
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.08(i)

Further calculations are shown below:

795834.922 / √ 147494.284*6590760.56

= 795834.922 / 985951.0684

= 0.807174866

From the above calculations it is seen that the average production of soybean has a high correlation with the average FHP of soybean in Pune district. The value of the coefficient being 0.80 (and thus closer to +1) is evidence of the same.

Finally, the correlation coefficient of the average yield of soybean in Pune district and the average FHP of soybean in Pune district was calculated as follows:

Table 6.12: Calculation of correlation coefficient of average yield of soybean and the average FHP of soybean in Pune district

TE	AVG YIELD (x) (KG/HA)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	1000.00	821.25	-785.29	-682.16	535697.70	616684.87	465346.31
1996-97	1208.34	846.07	-576.96	-657.35	379261.11	332880.37	432104.15
1999-00	1350.00	727.73	-435.29	-775.68	337647.80	189479.87	601678.89
2002-03	1285.71	1072.33	-499.58	-431.08	215358.14	249578.75	185829.65
2005-06	2814.81	954.33	1029.52	-549.08	-565289.54	1059915.47	301488.44
2008-09	1723.25	1171.67	-62.05	-331.75	20583.94	3849.86	110055.61
2011-12	1842.27	2033.00	56.98	529.59	30173.74	3246.26	280462.43
2014-15	2486.84	3041.67	701.55	1538.25	1079155.82	492166.87	2366224.46
2017-18	2356.42	2862.67	571.13	1359.25	776304.27	326184.18	1847570.63
	1785.29	1503.41			2808892.99	3273986.49	6590760.56
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.08(i)

Further calculations are shown below:

2808892.99 / √ 3273986.49*6590760.56

= 2808892.99 / 4645219.156

= 0.604684707

From the above calculations it is seen that the average yield of soybean and the average FHP of soybean in Pune district are not highly correlated. Though there is correlation (the value of the coefficient being 0.6), it is not as high as those for average area and average production (around 0.8). This is obviously because of the stagnation in the yield levels of soybean in Pune district.

6.5 DATA ANALYSIS FOR SUGARCANE

FRP stands for Fair and Remunerative Price, which is the minimum price to be paid by the sugar mills to the cane suppliers/growers who have given their cane for crushing to the mill. Prior to 2009 the Central Government had been fixing the Statutory Minimum Price (SMP) of sugarcane, for every sugar season, as provided in Clause 3 of the Sugarcane Control Order, 1966. The following factors are taken into consideration while calculating the SMP-

- Cost of production of sugarcane
- Returns to the growers from alternative crops and the general trend of prices of agricultural commodities
- Availability of sugar to consumers at fair price
- Price at which sugar produced from sugarcane is sold by sugar producers
- Recovery of sugar from sugarcane
- The realization made from sale of by-products viz. molasses, bagasse and press mud or their imputed value

The SMP/FRP is fixed on the basis of the recommendations of the Commission for Agricultural Costs and Prices (CACP) in consultation with the various State Governments and associations of sugar industry and the cane growers. For the calculation, a minimum SMP/FRP is recommended by the CACP which is linked to a minimum recovery rate. Over and above that, a certain amount of premium is to be added for every 0.1% increase in the recovery rate. Further, it was found that the mills in Pune district deducted an average of 20% of the mandated FRP for Harvest and Transportation (H&T).

The following table (Table 6.13) shows the SMP/FRP recommended by CACP **based on the all India average recovery rates for the previous years**. **This is not the minimum SMP/FRP linked to a basic recovery rate**. **The data from 1991-92 to 1998-99 in the CACP reports gives the minimum SMP linked to a basic recovery rate and does not have data for the FRP based on the all India average recovery rates.** As such, the data from 1999-00 onwards has been taken for comparing the trends in the SMP/FRP at the macro and micro levels.

Table: 6.13: The FRP recommended by CACP based on the average recovery rates for previous years.

YEAR	**RECOVERY RATE %**	**FRP BASED ON AVG RR (Rs/quintal)**
1999-00 (LAST 5 YRS AVG)	9.92	65.47
2000-02(LAST 5 YRS AVG)	9.84	67.90
2001-02(LAST 5 YRS AVG)	9.87	72.05
2002-03(LAST 5 YRS AVG)	10.11	76.72
2003-04 (LAST 5 YRS AVG)	10.20	78.60
2004-05 (LAST 5 YRS AVG)	10.29	90.25
2005-06 (2003-04)	10.40	91.87
2006-07 (2004-05)	10.17	90.33
2007-08 (2005-06)	10.20	92.00
2008-09 (2006-07)	10.22	92.00
2009-10 (2007-08)	10.16	138.86
2010-11 (2008-09)	10.30	126.84
2011-12 (2009-10)	10.05	153.42
2012-13 (2010-11)	10.20	182.53
2013-14 (2011-12)	10.17	224.81
2014-15 (2012-13)	10.27	237.83
2015-16 (2013-14)	10.05	243.00
2016-17 (2014-15)	10.25	248.00
2017-18 (2015-16)	10.60	284.48

Source: Various CACP reports

Note: The FRP recommended is based on the all India average recovery rates for the year(s) mentioned in the brackets.

The calculation of the SMP/FRP for Pune district has been shown in the following table (Table 6.14)

Table 6.14: Calculation of Pune's FRP of sugarcane from 1991-92 to 2017-18.

YEAR	SMP/FRP per quintal (1)	Recovery rate % (2)	PUNE'S RECOVERY RATE (AVG) (3)	Premium for every 0.1% increase in R (4)	Pune's Premium (5)	Pune's recommended SMP/FRP (6) (1+5)	Less H & T @ 20% (7)	Net FRP for Pune (8) (6 - 7)
1991-92	26.00	8.50	10.20	0.29	4.93	30.93	6.19	24.74
1992-93	29.00	8.50	10.20	0.34	5.78	34.78	6.96	27.82
1993-94	30.50	8.50	10.20	0.36	6.12	36.62	7.32	29.30
1994-95	39.10	8.50	10.20	0.46	7.82	46.92	9.38	37.54
1995-96	42.50	8.50	10.20	0.50	8.50	51.00	10.20	40.80
1996-97	45.90	8.50	10.20	0.54	9.18	55.08	11.02	44.06
1997-98	48.45	8.50	10.20	0.57	9.69	58.14	11.63	46.51
1998-99	52.70	8.50	10.20	0.62	10.54	63.24	12.65	50.59
1999-00	56.10	8.50	10.20	0.66	11.22	67.32	13.46	53.86
2000-01	58.65	8.50	10.20	0.69	11.73	70.38	14.08	56.30
2001-02	62.05	8.50	10.20	0.73	12.41	74.46	14.89	59.57
2002-03	64.50	8.50	10.20	0.76	12.92	77.42	15.48	61.94
2003-04	65.50	8.50	10.20	0.77	13.09	78.59	15.72	62.87
2004-05	74.50	8.50	10.20	0.88	14.96	89.46	17.89	71.57
2005-06	79.50	9.00	10.70	0.88	14.96	94.46	18.89	75.57
2006-07	80.25	9.00	10.70	0.90	15.30	95.55	19.11	76.44
2007-08	81.18	9.00	10.70	0.90	15.30	96.48	19.30	77.18
2008-09	81.18	9.50	11.20	0.90	15.30	96.48	19.30	77.18
2009-10	129.84	9.50	11.20	1.37	23.29	153.13	30.63	122.50
2010-11	117.00	9.50	11.20	1.23	20.91	137.91	27.58	110.33
2011-12	145.00	9.50	11.20	1.53	26.01	171.01	34.20	136.81
2012-13	170.00	9.50	11.20	1.79	30.43	200.43	40.09	160.34
2013-14	210.00	9.50	11.20	2.21	37.57	247.57	49.51	198.06
2014-15	220.00	9.50	11.20	2.32	39.44	259.44	51.89	207.55
2015-16	230.00	9.50	11.20	2.42	41.14	271.14	54.23	216.91
2016-17	230.00	9.50	11.20	2.42	41.14	271.14	54.23	216.91
2017-18	255.00	9.50	11.20	2.68	45.56	300.56	60.11	240.45

Source: CACP reports and Cane Crushing Reports of Sugar Commissionerate

The above table shows the calculation for the average FRP being paid by the sugarcane mills in Pune district to the cane growers. As can be seen from the table, the average recovery rate of sugarcane in Pune is around 1.7% greater than the basic recovery rate. The premium for every 0.1% increase in recovery rate is given in column 4. The amount of premium to be paid is shown in column 5, while the total amount (basic recovery rate + premium) is shown in column 6. It was observed that the mills in Pune charge around 20% of the amount to be paid (col. 6) for Harvest and Transportation which is shown in column 7. So the final amount which they paid to the cane growers is shown in column 8 (col 6 – col 7).

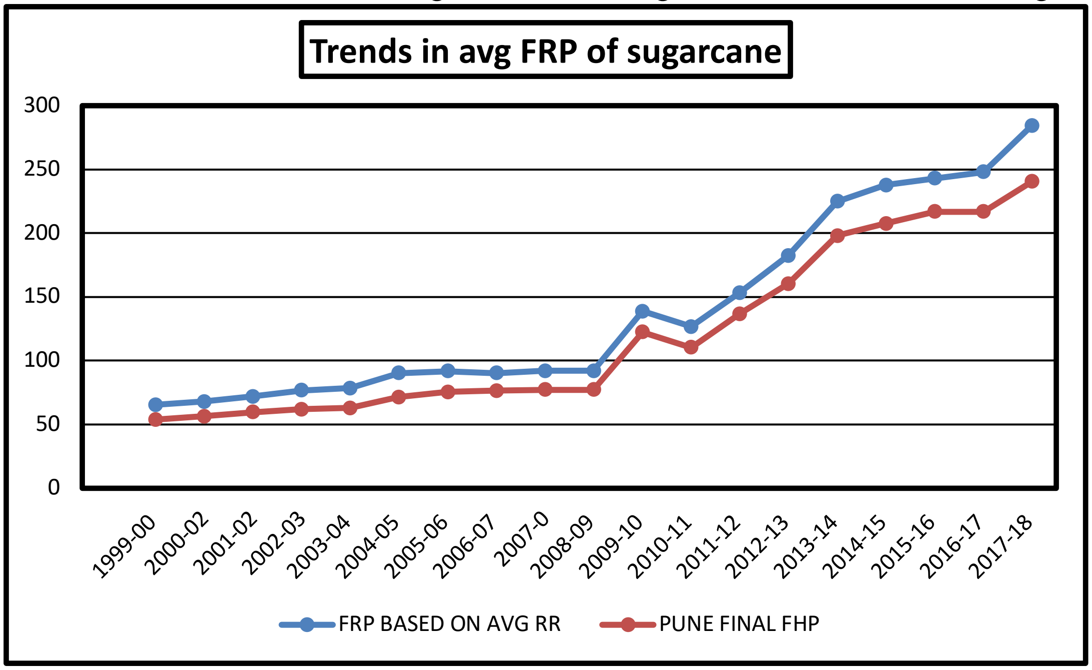
The comparison of the average FRP at all India level and for Pune has been shown in the following table (Table 6.15). It can be seen from the table that the FRP paid by the sugarcane mills in Pune district follows the same trend as that of the all India FRP recommended by CACP. However, even though the recovery rates in Pune are higher than the all India average, the rates paid by mills are lower than those recommended by CACP primarily due to the H&T costs deducted by the mills. Thus, the trend line for Pune district average FRP lies lower than that for the all India FRP. This can be seen in the figure 6.11. It can also be seen that while the gap between the two lines is almost non-existent to begin with, in the last 3-4 years (from 2013-14 onwards), the gap between the two lines has been increasing. This means that the average FRP being paid by the mills in Pune is progressively lower than the all India FRP as recommended by CACP.

Table 6.15: Comparison of average FRP of sugarcane at all India level and in Pune

YEAR	FRP BASED ON AVG RR (Rs./quintal)	PUNE FINAL FHP (Rs./quintal)
1999-00	65.47	53.86
2000-02	67.90	56.30
2001-02	72.05	59.57
2002-03	76.72	61.94
2003-04	78.60	62.87
2004-05	90.25	71.57
2005-06	91.87	75.57
2006-07	90.33	76.44
2007-0	92.00	77.18
2008-09	92.00	77.18
2009-10	138.86	122.50
2010-11	126.84	110.33
2011-12	153.42	136.81
2012-13	182.53	160.34
2013-14	224.81	198.06
2014-15	237.83	207.55
2015-16	243.00	216.91
2016-17	248.00	216.91
2017-18	284.48	240.45

Source: CACP reports and sugarcane crushing reports of Sugar Commissionerate.

Fig 6.11: Trends in the all India average FRP and average FRP in Pune district for sugarcane.



Source: Table 6.15.

The next step was to analyze the data for sugarcane at the district level. For this, the area, production, yield, and SMP/FRP of sugarcane for Pune district was compiled. The table below shows area, production, yield, and FRP for sugarcane in Pune district from 1991-92 to 2017-18 (Table 6.16). It can be seen from the table that except for the years 2003-04 and 2004-05, area and production of sugarcane were more or less maintained at the same level with incremental increases in the FRP. After 2007-08, there was continuous expansion in area and production up to 2013-14 after which there was a decline in these variables up to 2016-17. Area and production again picked up in 2017-18. These trends can be directly correlated to the movements in the FRP. Between 2008-09 and 2013-14 (except 2010-11), the FRP rose at a rising pace. The FRP increased incrementally in 2014-15 and 2015-16 while it remained unchanged in 2016-17 before finally being increased in 2017-18.

Table: 6.16: Area, Production, Yield and FRP of sugarcane from 1991-92 to 2017-18 in Pune district.

YEAR	AREA (00 HA)	PRODUCTION (00 MT)	YIELD (KG/HA)	Pune's final SMP/FRP (RS/QUINTAL)
1991-92	520.00	31303.00	60198.08	24.74
1992-93	442.00	26847.00	60739.82	27.82
1993-94	427.00	25404.00	59494.15	29.30
1994-95	526.00	35092.00	66714.83	37.54
1995-96	562.00	32989.00	58699.29	40.80
1996-97	637.00	35362.00	55513.34	44.06
1997-98	425.00	40762.00	95910.59	46.51
1998-99	409.00	39227.00	95910.00	50.59
1999-00	476.00	47775.00	10036.00	53.86
2000-01	487.00	45583.00	94000.00	56.30
2001-02	487.00	41610.00	85000.00	59.57
2002-03	535.00	46900.00	88000.00	61.94
2003-04	396.00	27560.00	70000.00	62.87
2004-05	282.00	23619.00	84000.00	71.57
2005-06	538.00	50361.00	94000.00	75.57
2006-07	782.00	68726.00	88000.00	76.44
2007-08	1042.00	101577.00	97000.00	77.18
2008-09	856.00	83328.00	97345.79	77.18
2009-10	956.00	91121.00	95314.85	122.50
2010-11	1115.00	110831.00	99400.00	110.33
2011-12	1299.00	131576.00	101290.22	136.81
2012-13	1377.00	138884.00	100859.84	160.34
2013-14	1439.00	169635.00	117883.95	198.06
2014-15	1278.00	138339.00	108246.48	207.55
2015-16	1184.00	122854.00	103761.82	216.91
2016-17	959.00	90709.00	94584.00	216.91
2017-18	1131.00	132706.00	117293.00	240.45

Source: EPW Time series data, Department of Agriculture and various CACP reports

Given the long time period, the entire period has been divided into nine trienniums as follows: 1991-92 to 1993-94; 1994-95 to 1996-97; 1997-98 to 1999-2000; 2000-01 to 2002-03; 2003-04 to 2005-06; 2006-07 to 2008-09; 2009-10 to 2011-12; 2012-13- to 2014-15; 2015-16 to 2017-18. The average area, average production, average yield and average FRP for the trienniums is given in the table below:

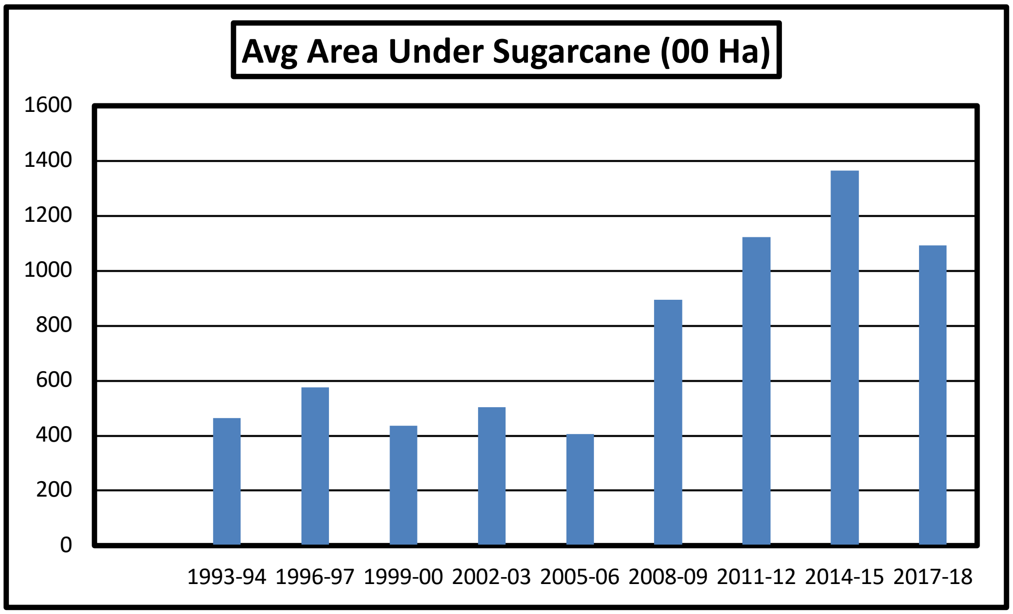
Table 6.16(i): Average area, Average Production, Average Yield, and Average FRP of sugarcane in Pune district between TE1993-94 and TE2017-18.

TE	AVG AREA (00 HA)	AVG PROD (00 MT)	AVG YIELD (KG/HA)	Pune's final SMP/FRP (Rs./quintal)
1993-94	463.00	27851.33	60144.02	27.29
1996-97	575.00	34481.00	60309.15	40.80
1999-00	436.67	42588.00	67285.53	50.32
2002-03	503.00	44697.67	89000.00	59.27
2005-06	405.33	33846.67	82666.67	70.00
2008-09	893.33	84543.67	94115.26	76.94
2011-12	1123.33	111176.00	98668.36	123.21
2014-15	1364.67	148952.67	108996.76	188.65
2017-18	1091.33	115423.00	105212.94	224.76

Source: Table 6.16.

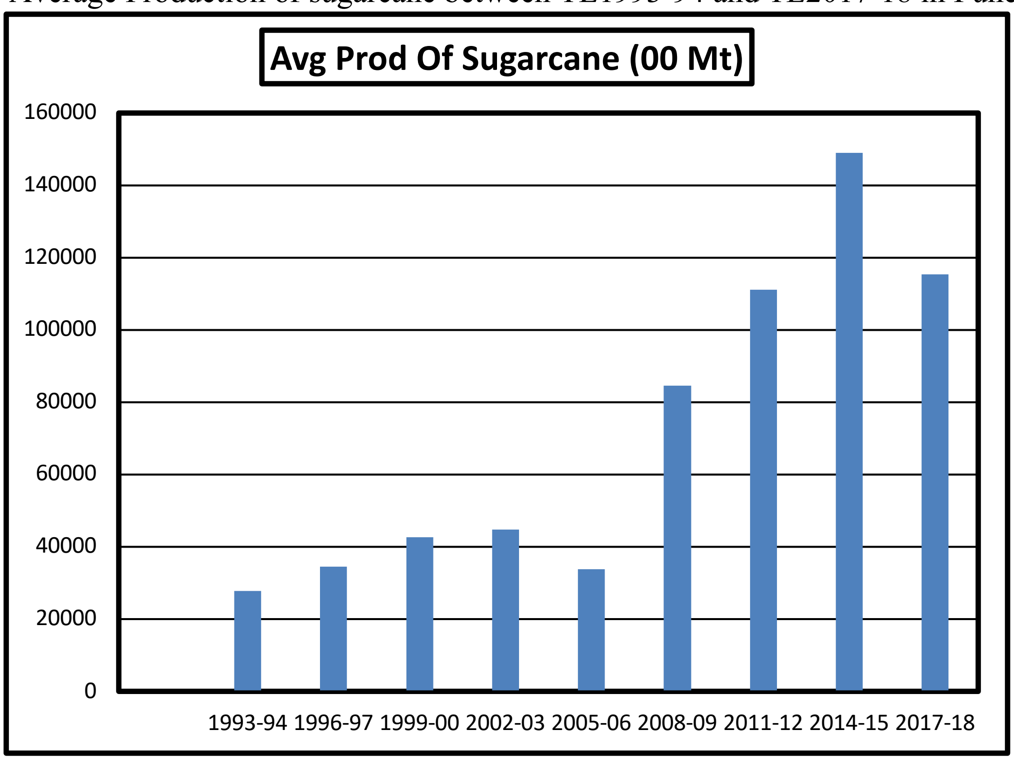
It can be seen from Table 6.16(i), that the average area of sugarcane remained more or less stable between TE 1993-94 and TE 2005-06 (between 40000 ha and 50000 ha) and has increased 1.5 times in the last ten years between TE 2008-09 and TE 2014-15 (from 90,000 ha to 1,40,000 ha) and finally saw a fall in the TE 2017-18 (around 1,00,000 ha) . The same trend has been observed for Average Production of sugarcane where production rose from around 28,00,000 metric tons in TE 1993-94 to 33,00,846 metric tons in TE 2005-06, but increased more than 1.5 times from around 85,00,000 metric tons in TE 2008-09 to around 1,50,00,000 metric tons in TE 2014-15 and finally saw a fall in TE 2017-18 to 1,15,00,423 metric tons. The Average Yield of sugarcane has seen very incremental increases from around 60,000 kg/ha in TE 1993-94 to around 80,000 kg/ha in TE 2005-06 and then on to around 1,00,000 kg/ha in TE 2017-18.. On the other hand, the SMP saw incremental increases between TE 1993-94 (Rs. 27 per quintal) and TE 2008-09 (Rs. 76 per quintal), but saw a threefold rise in the FRP between TE 2008-09 and TE 2017-18 (Rs. 224 per quintal). These trends are depicted in the following graphs (Fig 6.12 to 6.15).

Fig 6.12: Average Area under sugarcane cultivation between TE1993-94 and TE2017-18 in Pune district.



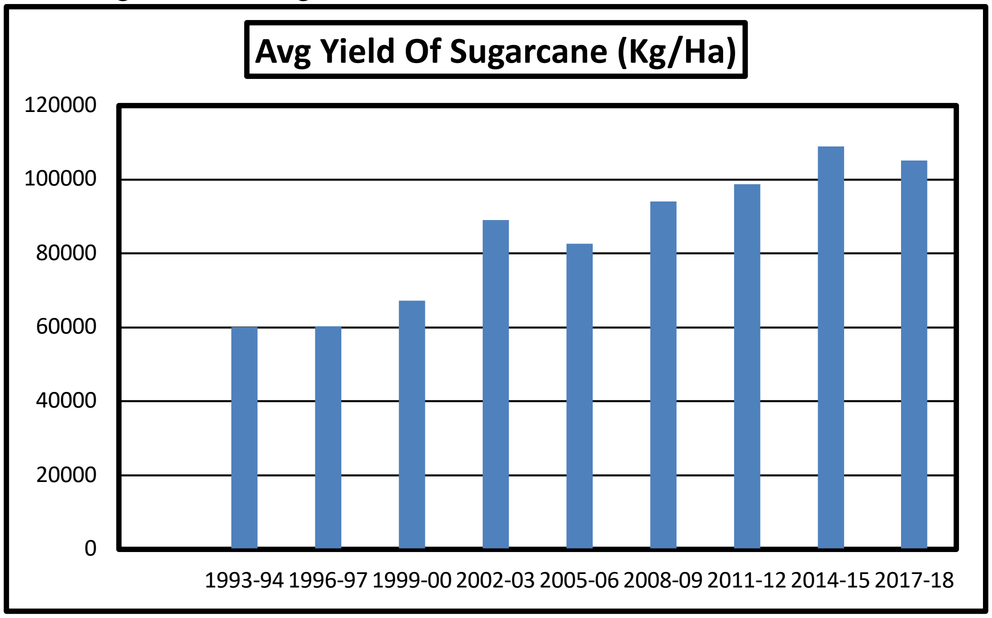
Source: Table 6.16(i)

Fig 6.13: Average Production of sugarcane between TE1993-94 and TE2017-18 in Pune district.



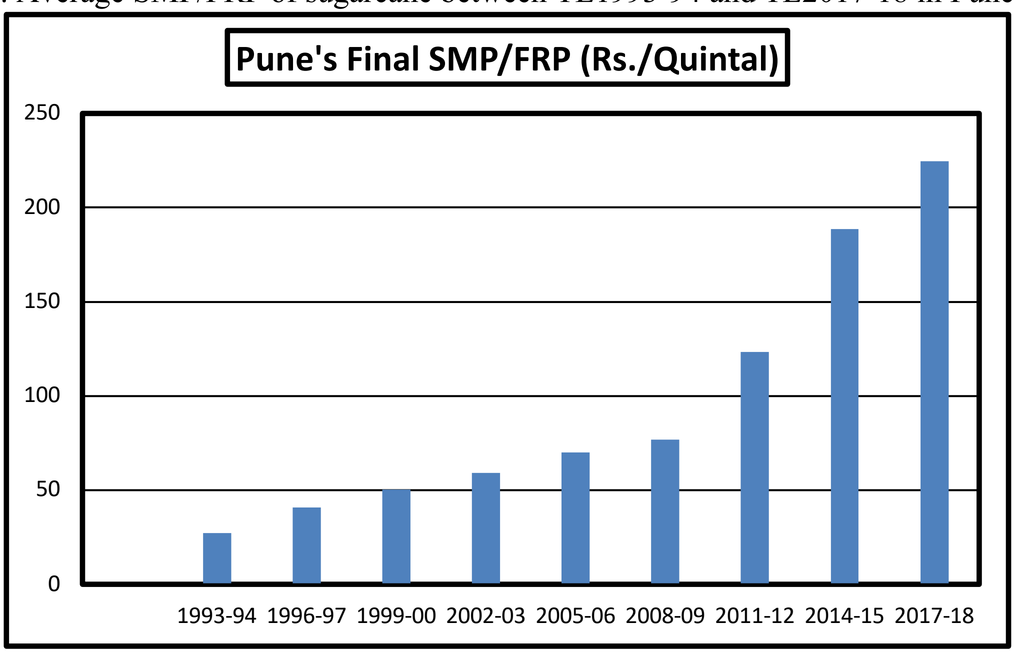
Source: Table 6.16(i)

Fig 6.14: Average Yield of sugarcane between TE1993-94 and TE2017-18 in Pune district



Source: Table 6.16(i)

Fig 6.15: Average SMP/FRP of sugarcane between TE1993-94 and TE2017-18 in Pune district.



Source: Table 6.16(i)

The percentage changes in the average area, average production, average productivity and average FRP TE over TE have been shown in the table below.

Table 6.17: Percentage changes in average area, average production, and average yield TE over TE for sugarcane in Pune district

TE	% Change In Area	% Change In Prod	% Change In Yield
1993-94			
1996-97	24.19	23.80	0.27
1999-00	-24.06	23.51	11.57
2002-03	15.19	4.95	32.27
2005-06	-19.42	-24.28	-7.12
2008-09	120.39	149.78	13.85
2011-12	25.75	31.50	4.84
2014-15	21.48	33.98	10.47
2017-18	-20.03	-22.51	-3.47

Source: Table 6.16 (i)

It can be seen from the above table (Table 6.17) that in TE 1996-97, the average production of sugarcane grew at around 24% due to a 24% increase in area over the previous triennium; the growth rate in yield was negligible. In TE 1999-00, even though there was negative growth in area under sugarcane, there was a 24% increase in production due to a 12% increase in yield. The year 2002-03 is an aberration with both average area and average yield posting 15% and 32% growth rates, but average production increasing by only 5%. The two trienniums TE 2005-06 and TE 2017-18 have seen negative growth in all the three parameters. The TE 2008-09 was a period of recovery for the crop with average production increasing by 150% due to average area increasing by nearly 120% even though yield increased only by around 14%. TE 2011-12 saw the average production of sugarcane increasing by over 30% due to growth in area by over 25% with yield growing by a mere 5%. Finally, in TE 2014-15 average production increased by 34% (almost the same as the previous triennium) even though yield growth was at over 10% due to a fall in area growth to 21% from 25% in the previous triennium.

In the next step, the correlation coefficient between Average Area, Average Production and Average Yield each with respect to Average FRP of sugarcane has been calculated using Pearson's correlation coefficient.

To begin with, the correlation coefficient between Average Area and Average FRP of sugarcane was calculated as under:

Table 6.18: Calculation of correlation coefficient between Average Area and Average FRP of sugarcane in Pune district.

TE	AVG AREA (x) (00 HA)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	463.00	27.29	-298.74	-68.41	20435.37	89246.03	4679.25
1996-97	575.00	40.80	-186.74	-54.89	10250.77	34872.10	3013.25
1999-00	436.67	50.32	-325.07	-45.37	14749.60	105673.15	2058.71
2002-03	503.00	59.27	-258.74	-36.42	9424.30	66946.77	1326.69
2005-06	405.33	70.00	-356.41	-25.69	9156.24	127026.24	660.00
2008-09	893.33	76.94	131.59	-18.76	-2468.29	17316.61	351.83
2011-12	1123.33	123.21	361.59	27.52	9951.14	130749.20	757.37
2014-15	1364.67	188.65	602.93	92.96	56046.56	363519.67	8641.12
2017-18	1091.33	224.76	329.59	129.06	42538.64	108631.28	16657.59
	761.74	95.69			170084.32	1043981.06	38145.80
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.16(i)

Further calculations are shown as follows:

170084.319 / √ 1043981.062*38145.795

= 170084.319 / 199558.2311

= 0.852304204

The above calculation shows that there is a very high correlation between Average Area and Average FRP of sugarcane in Pune district. The value of the coefficient being 0.85 (very close to +1), it can be interpreted that as the FRP increased, the area under sugarcane cultivation also increased.

Next, the correlation coefficient between Average Production and Average FRP of sugarcane was calculated as follows:

Table 6.19: Calculation of correlation coefficient between Average Production and Average FRP of sugarcane in Pune district.

TE	AVG PROD (x) (00 MT)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	27851.33	27.29	-43655.33	-68.41	2986244.69	1905788128.44	4679.25
1996-97	34481.00	40.80	-37025.67	-54.89	2032451.29	1370899992.11	3013.25
1999-00	42588.00	50.32	-28918.67	-45.37	1312127.73	836289281.78	2058.71
2002-03	44697.67	59.27	-26809.00	-36.42	976483.07	718722481.00	1326.69
2005-06	33846.67	70.00	-37660.00	-25.69	967499.35	1418275600.00	660.00
2008-09	84543.67	76.94	13037.00	-18.76	-244535.49	169963369.00	351.83
2011-12	111176.00	123.21	39669.33	27.52	1091711.81	1573656007.11	757.37
2014-15	148952.67	188.65	77446.00	92.96	7199196.58	5997882916.00	8641.12
2017-18	115423.00	224.76	43916.33	129.06	5668030.66	1928644333.44	16657.59
	71506.67	95.69			21989209.70	15920122108.89	38145.80
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.16(i)

Further calculations are shown as under:

21989209.7 / √15920122109*38145.795

= 21989209.7 / 24643167.72

= 0.89230451

The above calculation shows that there is a very high correlation between Average Production and Average FRP of sugarcane in Pune district. The value of the coefficient being very close to +1 (0.89), this can be interpreted to mean that as the FRP increased, the Average Production also rose. Finally, the correlation coefficient between the Average Yield and the Average FRP of sugarcane was calculated as follows:

Table 6.20: Calculation of correlation coefficient between Average Yield and Average FRP of sugarcane in Pune district.

TE	AVG YIELD (x) (KG/HA)	AVG FHP (y) (RS./QUINTAL)	x - x¯ (a)	y - y¯ (b)	a*b	a^2	b^2
1993-94	60144.02	27.29	-25011.39	-68.41	1710905.27	625569781.31	4679.25
1996-97	60309.15	40.80	-24846.26	-54.89	1363886.47	617336455.28	3013.25
1999-00	67285.53	50.32	-17869.88	-45.37	810810.71	319332600.38	2058.71
2002-03	89000.00	59.27	3844.59	-36.42	-140034.22	14780874.60	1326.69
2005-06	82666.67	70.00	-2488.74	-25.69	63936.73	6193841.87	660.00
2008-09	94115.26	76.94	8959.86	-18.76	-168060.33	80279003.43	351.83
2011-12	98668.36	123.21	13512.95	27.52	371880.37	182599797.12	757.37
2014-15	108996.76	188.65	23841.35	92.96	2216234.99	568409766.39	8641.12
2017-18	105212.94	224.76	20057.53	129.06	2588711.22	402304579.69	16657.59
	85155.41	95.69			8818271.20	2816806700.05	38145.80
	(AVG)	(AVG)			(TOTAL)	(TOTAL)	(TOTAL)

Source: Table 6.16(i)

Further calculations are shown as follows:

8818271.2 / √ 2816806700*38145.795

= 8818271.2 / 10365776.92

= 0.850710108

From the above calculation it can be seen that the Average Yield has a positive correlation with the Average FRP of sugarcane in Pune district. The value of the coefficient is closer to +1 than to -1, and hence shows that average yield level of sugarcane has increased with an increase in average FRP.

6.6 SIMPLE REGRESSION ANALYSIS

As explained in detail in the chapter on Research Methodology (Chapter 3), a simple regression analysis model was run in Excel in order to establish the strength of the correlation between the dependent and independent variables, fit a trend line to the data, and finally test the hypotheses stated. The Simple Regression Output summary is given in the form of three tables:

1. Regression Statistics
2. ANOVA Table
3. Coefficients Table

The Regression Statistics shows the goodness of fit of the data to the model. The ANOVA table provides the Significance F which shows whether the null hypothesis can be rejected. The Coefficients table gives the values for the regression equation and contains the P value which also enables the hypothesis testing. Since this is a simple regression, the values of Significance F and P are the same.

After running the model, a scatter diagram for the data was generated and a trend line was fitted to it. This trend line also gives the equation which can be cross verified with the coefficients for the intercept and the dependent variable.

The Residuals graph was generated from the Residuals output. The dispersal of the residuals around the horizontal axis showed the linear nature of the data.

The Simple Regression Analysis was done with respect to the following variables of the three crops, viz. maize, soybean and sugarcane in Pune district for the period 1991-92 to 2017-18.

1. Area under maize with FHP of maize
2. Production of maize with FHP of maize
3. Area under soybean with FHP of soybean
4. Production of soybean with FHP of soybean
5. Area under sugarcane with FRP of sugarcane
6. Production of sugarcane with FRP of sugarcane

The above six analyses are associated with the following six hypotheses (already stated in Chapter 3):

1. Null hypothesis 1 states that there is no significant relationship between the area under maize and FHP of maize. Alternative hypothesis 1 states that there is a significant relationship between the area under maize and the FHP of maize.

2. Null hypothesis 2 states that there is no significant relationship between the production of maize and FHP of maize. Alternative hypothesis 2 states that there is a significant relationship between the production of maize and the FHP of maize.

3. Null hypothesis 3 states that there is no significant relationship between the area under soybean and FHP of soybean. Alternative hypothesis 3 states that there is a significant relationship between the area under soybean and the FHP of soybean.

4. Null hypothesis 4 states that there is no significant relationship between the production of soybean and FHP of soybean. Alternative hypothesis 4 states that there is a significant relationship between the production of soybean and the FHP of soybean.

5. Null hypothesis 5 states that there is no significant relationship between the area under sugarcane and FRP of sugarcane. Alternative hypothesis 5 states that there is a significant relationship between the area under sugarcane and the FRP of sugarcane.

6. Null hypothesis 6 states that there is no significant relationship between the production of sugarcane and FRP of sugarcane. Alternative hypothesis 6 states that there is a significant relationship between the production of sugarcane and the FRP of sugarcane.

6.6.1 Simple Regression Analysis of Area under maize cultivation and FHP of maize in Pune district.

The data for the analysis has been taken from Table 6.02, an extract of it has been presented below for ready reference. **A Confidence Interval of 95% has been assumed; i.e., alpha is 0.05.**

YEAR	FHP (Variable X) (RS./QUINTAL)	AREA (Variable Y) (00 HA)
1991-92	346.30	76.00
1992-93	268.50	78.00
1993-94	265.30	43.00
1994-95	290.25	79.00
1995-96	365.50	87.00
1996-97	358.10	151.00
1997-98	405.30	125.04
1998-99	384.00	139.00
1999-00	454.00	150.00
2000-01	468.00	162.00
2001-02	464.00	153.00
2002-03	460.00	149.00
2003-04	576.00	104.00
2004-05	515.00	153.00
2005-06	420.00	165.00
2006-07	575.00	183.00
2007-08	572.00	166.00
2008-09	830.00	174.00
2009-10	862.00	160.00
2010-11	966.00	253.00
2011-12	1104.00	272.00
2012-13	1247.00	252.00
2013-14	1295.00	319.00
2014-15	1338.00	360.00
2015-16	1449.00	372.00
2016-17	1431.00	426.00
2017-18	1401.00	473.00

Table 6.21: Simple Regression Analysis of area under maize and FHP of maize in Pune district for the period 1991-92 to 2017-18.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.9333							
R Square	0.8710							
Adjusted R Squa	0.8659							
Standard Error	40.8648							
Observations	27.0000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1.0000	281936.9988	281936.9988	168.8316	0.0000			
Residual	25.0000	41748.2650	1669.9306					
Total	26.0000	323685.2638						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	14.1922	15.8823	0.8936	0.3801	-18.5180	46.9024	-18.5180	46.9024
X Variable 1	0.2533	0.0195	12.9935	0.0000	0.2132	0.2935	0.2132	0.2935

Source: Table 6.02

1. Regression statistics:

- Multiple R: shows the value of correlation coefficient as 0.93 thus showing very high correlation between Area under maize and FHP of maize.
- R Square: shows the coefficient of determination (percentage of variance in the dependent variable that is predictable from the independent variable), so a value of 0.87 shows that 87% of the values lie near the trend line (or that 87% of the Y values can be predicted) thus showing a good fit.
- Adjusted R Square does not apply since this is simple regression and not multiple variable analysis
- Standard Error: Lower values of S are better because it signifies that the distances between the data points and the fitted values are smaller. This is an **absolute value** and as such a value of 40 being very small in comparison with the values of the Y variable, Area, hence again shows a good fit.
- Observations**:** simply means the number of observations.

2. ANOVA Table:

- df: These are the degrees of freedom associated with the sources of variance. The total variance has N-1 degrees of freedom. In this study, it is 27-1 = 26. The model degrees of freedom corresponds to the number of predictors minus 1 (K-1). This would be 1-1 (since there is 1 independent variable in the model). But, the intercept is automatically included in the model (unless you explicitly omit the intercept). Including the intercept, there are 2 predictors, so the model has 2-1= 1 degrees of freedom. The Residual degrees of freedom is the DF total minus the DF model, 26-1 = 25.

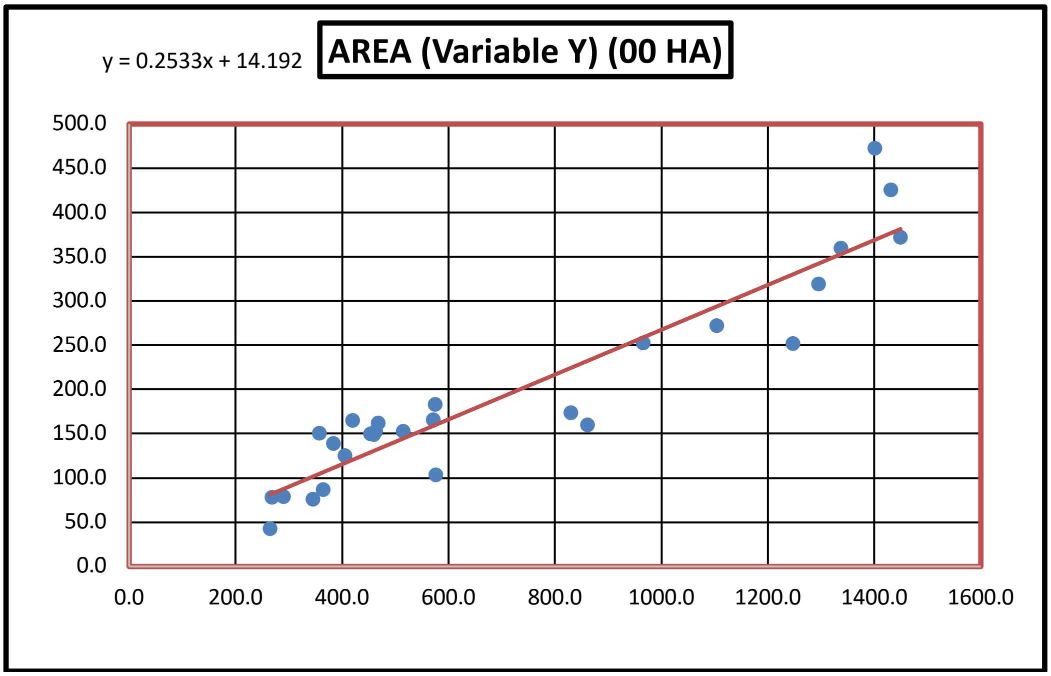
- **The important reading here is the Significance F. This value is equal to 0.0000. Since this reading is below the significance level of 0.05, it means that the null hypothesis can be rejected**.

3. Coefficients Table:

- The coefficient for the Intercept shows a value of 14.192 which is the value of Y when X = 0.
- The coefficient for X variable is 0.2533 which means that the value of Y changes by that amount for every unit increase in X.
- The Standard Error for the X variable shows 0.019 value which is very small in comparison with the value of the X coefficient 0.25. Hence, the data shows a good fit.
- The P value again shows a very small value (0.0000). It is the same as the Significance F since this is a simple regression with only one independent variable. Since it is very small, it indicates that the null hypothesis can be rejected.
- The upper and lower boundaries of the confidence interval are depicted by the upper 95% and lower 95% respectively. The value of the coefficient is shown to be 0.25, but it can vary from 0.21 to 0.29. Since this range does not include 0, we have confidence that FHP is significantly correlated to Area.

The following trend line has been obtained from the data for area under maize cultivation and FHP of maize in Pune district for the period 1991-92 to 2017-18.

Fig. 6.16: Trend line showing correlation of Area under maize cultivation and FHP of maize in Pune district between 1991-92 and 2017-18.



Source: Table 6.02

The regression equation is given as:

Y = b*X +a

The above graph shows the equation as
Y = 0.2533 * X + 14.192

These are the same values obtained in the coefficients table.

This means that the value of the dependent variable "Y" which is the area under maize cultivation can be calculated for every value of the independent variable "X" i.e., the FHP of maize by multiplying it with the value of "b" which is the slope of the trend line (0.2533) and adding the value of "a" which is the Y intercept (14.192).

The following table shows the predicted values of the dependent variables and the variance between the predicted values and the actual values. These variances are called residuals.

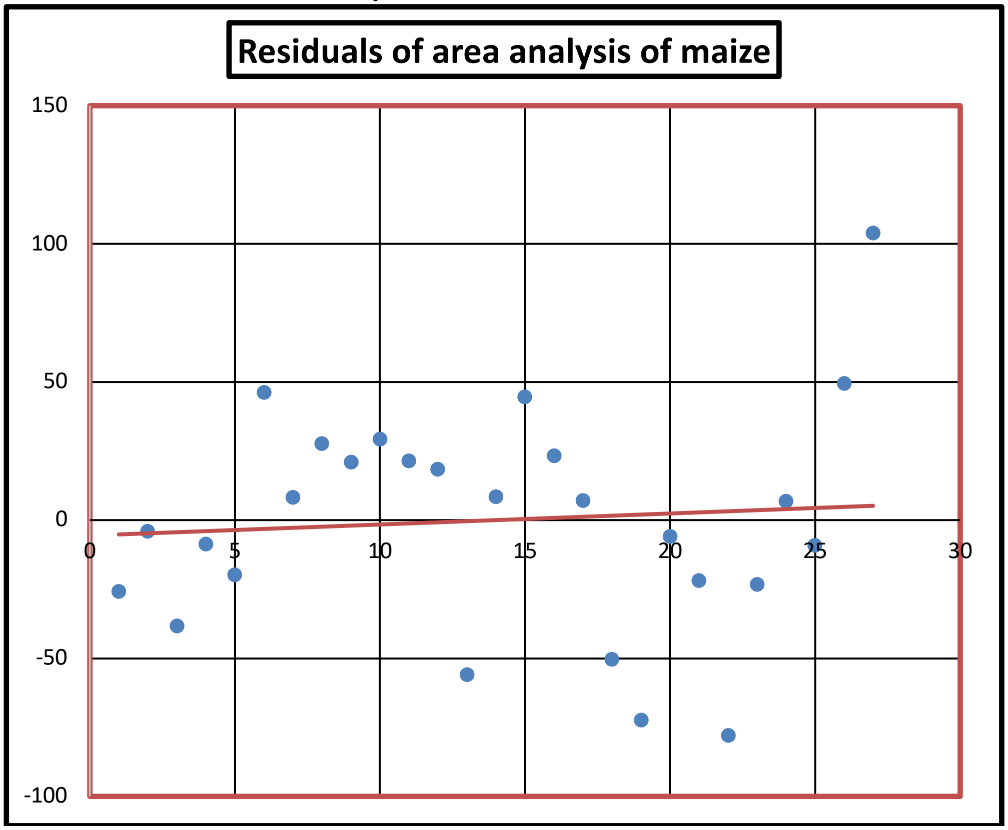
Table 6.22: Residual output for regression analysis between area under maize and its FHP

RESIDUAL OUTPUT		
Observation	***Predicted Y***	***Residuals***
1	101.9140	-25.9140
2	82.2064	-4.2064
3	81.3958	-38.3958
4	87.7159	-8.7159
5	106.7776	-19.7776
6	104.9031	46.0969
7	116.8594	8.1806
8	111.4639	27.5361
9	129.1957	20.8043
10	132.7421	29.2579
11	131.7288	21.2712
12	130.7156	18.2844
13	160.0998	-56.0998
14	144.6477	8.3523
15	120.5831	44.4169
16	159.8464	23.1536
17	159.0865	6.9135
18	224.4409	-50.4409
19	232.5469	-72.5469
20	258.8913	-5.8913
21	293.8484	-21.8484
22	330.0719	-78.0719
23	342.2309	-23.2309
24	353.1233	6.8767
25	381.2409	-9.2409
26	376.6813	49.3187
27	369.0820	103.9180

Source: Table 6.02

The residuals in the graph, Fig. 6.17, show a random pattern. A few of the readings lie above 0, while a few are negative. This random pattern is suitable for a linear trend line. (In case of U shaped or inverted U shaped patterns, a non-linear model will be the correct fit.)

Fig. 6.17: Scatter diagram showing the residuals and the corresponding trend line for regression analysis of area under maize



Source: Table 6.22

From the above analysis it can concluded that the Area under maize cultivation is significantly related to the Farm Harvest Prices of maize in Pune district. Thus, we can reject the null hypothesis Ho1 and accept the alternative hypothesis Ha1.

6.6.2 Simple Regression Analysis of production of maize and FHP of maize in Pune district.

The data for the analysis has been taken from Table 6.02, an extract of it has been presented below for ready reference. **A Confidence Interval of 95% has been assumed; i.e., alpha is 0.05.**

YEAR	FHP (Variable X) (RS./QUINTAL)	PRODUCTION (Variable Y) (00 MT)
1991-92	346.30	84.00
1992-93	268.50	95.00
1993-94	265.30	70.00
1994-95	290.25	118.00
1995-96	365.50	141.00
1996-97	358.10	226.00
1997-98	405.30	217.70
1998-99	384.00	238.00
1999-00	454.00	224.00
2000-01	468.00	151.00
2001-02	464.00	258.00
2002-03	460.00	285.00
2003-04	576.00	181.00
2004-05	515.00	337.00
2005-06	420.00	365.00
2006-07	575.00	425.00
2007-08	572.00	452.00
2008-09	830.00	422.00
2009-10	862.00	411.00
2010-11	966.00	722.00
2011-12	1104.00	872.00
2012-13	1247.00	661.00
2013-14	1295.00	919.00
2014-15	1338.00	1334.00
2015-16	1449.00	883.00
2016-17	1431.00	1295.00
2017-18	1401.00	1466.00

Table 6.23: Simple Regression Analysis of production of maize and FHP of maize in Pune district for the period 1991-92 to 2017-18.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.9302							
R Square	0.8652							
Adjusted R Squa	0.8598							
Standard Error	151.7757							
Observations	27.0000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1.0000	3696615.0461	3696615.0461	160.4721	0.0000			
Residual	25.0000	575896.8258	23035.8730					
Total	26.0000	4272511.8719						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-173.1823	58.9884	-2.9359	0.0070	-294.6711	-51.6935	-294.6711	-51.6935
X Variable 1	0.9172	0.0724	12.6678	0.0000	0.7681	1.0664	0.7681	1.0664

Source: Table 6.02

1. Regression statistics:

- Multiple R: shows the value of correlation coefficient as 0.93 thus showing very high correlation between production of maize and FHP of maize.
- R Square: shows the coefficient of determination (percentage of variance in the dependent variable that is predictable from the independent variable), so a value of 0.86 shows that 86% of the values lie near the trend line (or that 86% of the Y values can be predicted) thus showing a good fit.
- Adjusted R Square does not apply since this is simple regression and not multiple variable analysis
- Standard Error: Lower values of S are better because it signifies that the distances between the data points and the fitted values are smaller. This is an **absolute value** and as such a value of 151 being very small in comparison with the values of the Y variable, Production, hence again shows a good fit.
- Observations**:** simply means the number of observations.

2. ANOVA Table:

- df: These are the degrees of freedom associated with the sources of variance. The total variance has N-1 degrees of freedom. In this study, it is 27-1 = 26. The model degrees of freedom corresponds to the number of predictors minus 1 (K-1). This would be 1-1 (since there is 1 independent variable in the model). But, the intercept is automatically included in the model (unless you explicitly omit the intercept). Including the intercept, there are 2 predictors, so the model has 2-1= 1 degrees of freedom. The Residual degrees of freedom is the DF total minus the DF model, 26-1 = 25.

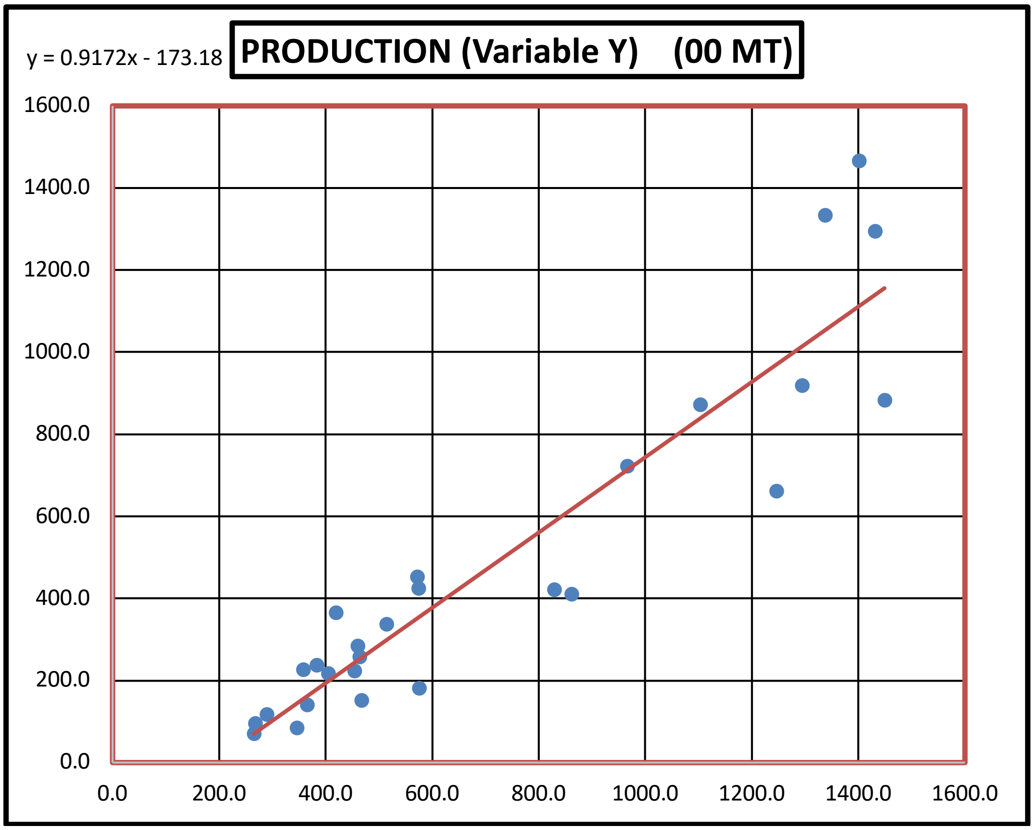
- **The important reading here is the Significance F. This value is equal to 0.0000. Since this reading is below the significance level of 0.05, it means that the null hypothesis can be rejected**.

3. Coefficients Table:

- The coefficient for the Intercept shows a value of -173.18 which is the value of Y when X = 0.
- The coefficient for X variable is 0.9172 which means that the value of Y changes by that amount for every unit increase in X.
- The Standard Error for the X variable shows 0.0724 value which is very small in comparison with the value of the X coefficient 0.9172. Hence, the data shows a good fit.
- The P value again shows a very small value (0.0000). It is the same as the Significance F since this is a simple regression with only one independent variable. Since it is very small, it indicates that the null hypothesis can be rejected.
- The upper and lower boundaries of the confidence interval are depicted by the upper 95% and lower 95% respectively. The value of the coefficient is shown to be 0.9172, but it can vary from 0.76 to 1.06. Since this range does not include 0, we have confidence that FHP is significantly correlated to Production.

The following trend line has been obtained from the data for production of maize and FHP of maize in Pune district for the period 1991-92 to 2017-18.

Fig. 6.18: Trend line showing correlation between production of maize and FHP of maize in Pune district between 1991-92 and 2017-18.



Source: Table 6.02

The regression equation is given as:

Y = b*X + a

The above graph shows the equation as
Y = 0.9172 * X - 173.18

These are the same values obtained in the coefficients table.

This means that the value of the dependent variable "Y" which is the production of maize can be calculated for every value of the independent variable "X" i.e., the FHP of maize by multiplying it with the value of "b" which is the slope of the trend line (0.9172) and adding the value of "a" which is the Y intercept (-173.18).

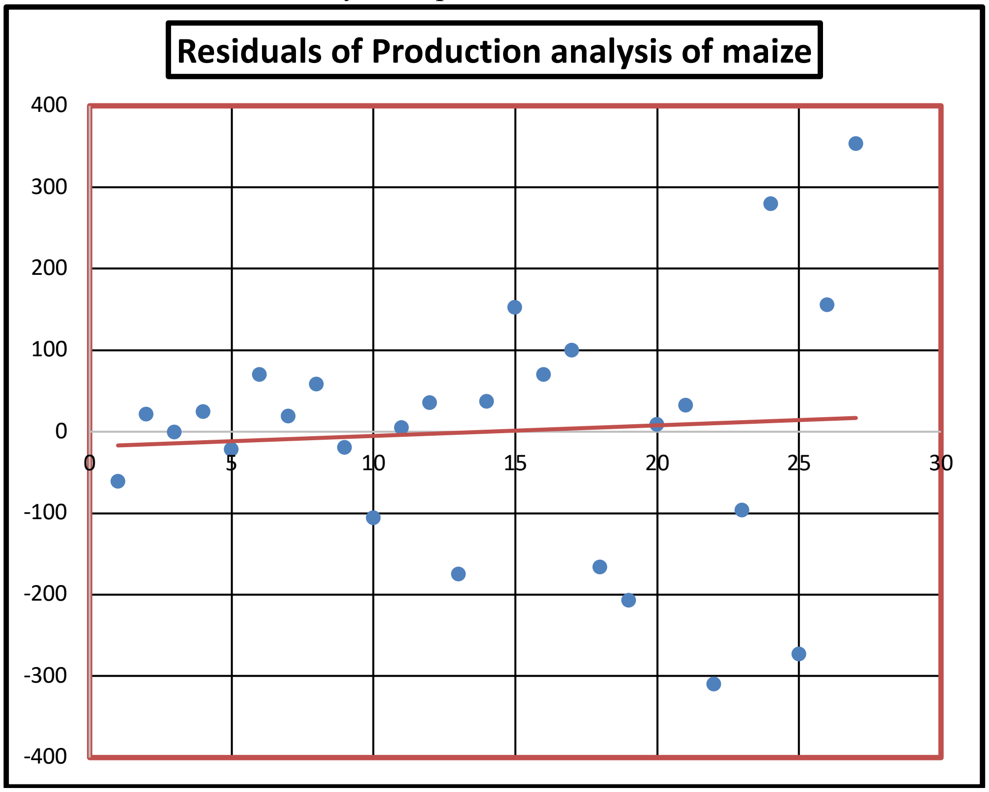
The following table shows the predicted values of the dependent variables and the variance between the predicted values and the actual values. These variances are called residuals.

Table 6.24: Residual output for regression analysis between production of maize and its FHP

RESIDUAL OUTPUT		
Observation	***Predicted Y***	***Residuals***
1	144.4567	-60.4567
2	73.0957	21.9043
3	70.1606	-0.1606
4	93.0456	24.9544
5	162.0677	-21.0677
6	155.2801	70.7199
7	198.5737	19.1263
8	179.0366	58.9634
9	243.2431	-19.2431
10	256.0844	-105.0844
11	252.4155	5.5845
12	248.7466	36.2534
13	355.1460	-174.1460
14	299.1946	37.8054
15	212.0571	152.9429
16	354.2288	70.7712
17	351.4771	100.5229
18	588.1241	-166.1241
19	617.4757	-206.4757
20	712.8683	9.1317
21	839.4470	32.5530
22	970.6119	-309.6119
23	1014.6392	-95.6392
24	1054.0804	279.9196
25	1155.8937	-272.8937
26	1139.3834	155.6166
27	1111.8663	354.1337

Source: Table 6.02

Fig. 6.19: Scatter diagram showing the residuals and the corresponding trend line for regression analysis of production of maize



Source: Table 6.24

The residuals in the graph, Fig. 6.19, show a random pattern. A few of the readings lie above 0, while a few are negative. This random pattern is suitable for a linear trend line. (In case of U shaped or inverted U shaped patterns, a non-linear model will be the correct fit.)

From the above analysis it can concluded that the Production of maize is significantly related to the Farm Harvest Prices of maize in Pune district. Thus, we can reject the null hypothesis Ho2 and accept the alternative hypothesis Ha2.

6.6.3 Simple Regression Analysis of area under soybean cultivation and FHP of soybean in Pune district.

The data for the analysis has been taken from Table 6.08, an extract of it has been presented below for ready reference. **A Confidence Interval of 95% has been assumed; i.e., alpha is 0.05.** Since the data for 1991-92, 1992-93, 1995-96 are not available, the regression analysis has been done with the data from 1996-97 to 2017-18.

YEAR	FHP (Variable X) (RS./QUINTAL)	AREA (Variable Y)(00 HA)
1991-92		5.00
1992-93		4.00
1993-94	821.25	5.00
1994-95	841.50	8.00
1995-96	855.50	
1996-97	841.20	3.00
1997-98	837.20	15.00
1998-99	750.00	4.00
1999-00	596.00	6.00
2000-01	1043.00	7.00
2001-02	944.00	4.00
2002-03	1230.00	4.00
2003-04	1208.00	6.00
2004-05	830.00	12.00
2005-06	825.00	18.00
2006-07	890.00	19.00
2007-08	882.00	30.00
2008-09	1743.00	24.00
2009-10	1999.00	33.00
2010-11	1962.00	29.00
2011-12	2138.00	39.00
2012-13	2653.00	42.00
2013-14	3142.00	69.00
2014-15	3330.00	71.00
2015-16	3257.00	161.00
2016-17	2521.00	180.00
2017-18	2810.00	202.00

Table 6.25: Simple Regression Analysis between area under soybean cultivation and FHP of soybean in Pune district for the period 1996-97 to 2017-18.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.7373							
R Square	0.5436							
Adjusted R Square	0.5208							
Standard Error	40.9184							
Observations	22.0000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1.0000	39887.1561	39887.1561	23.8230	0.0001			
Residual	20.0000	33486.2985	1674.3149					
Total	21.0000	73373.4545						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-33.0667	18.1208	-1.8248	0.0830	-70.8660	4.7327	-70.8660	4.7327
X Variable 1	0.0468	0.0096	4.8809	0.0001	0.0268	0.0668	0.0268	0.0668

Source: Table 6.08

1. Regression statistics:

- Multiple R: shows the value of correlation coefficient as 0.73 thus showing a high correlation between area under soybean cultivation and FHP of soybean.
- R Square: shows the coefficient of determination (percentage of variance in the dependent variable that is predictable from the independent variable), so a value of 0.54 shows that 54% of the values lie near the trend line (or that 54% of the Y values can be predicted) thus showing a moderately good fit.
- Adjusted R Square does not apply since this is simple regression and not multiple variable analysis
- Standard Error: Lower values of S are better because it signifies that the distances between the data points and the fitted values are smaller. This is an **absolute value** and as such a value of 40 being very small in comparison with the values of the Y variable, Area under Soybean, hence again shows a good fit.
- Observations**:** simply means the number of observations.

2. ANOVA Table:

- df: These are the degrees of freedom associated with the sources of variance. The total variance has N-1 degrees of freedom. In this study, it is 22-1 = 21. The model degrees of freedom corresponds to the number of predictors minus 1 (K-1). This would be 1-1 (since there is 1 independent variable in the model). But, the intercept is automatically included in the model (unless you explicitly omit the intercept). Including the intercept, there are 2 predictors, so the model has 2-1= 1 degrees of freedom. The Residual degrees of freedom is the DF total minus the DF model, 21-1 = 20.

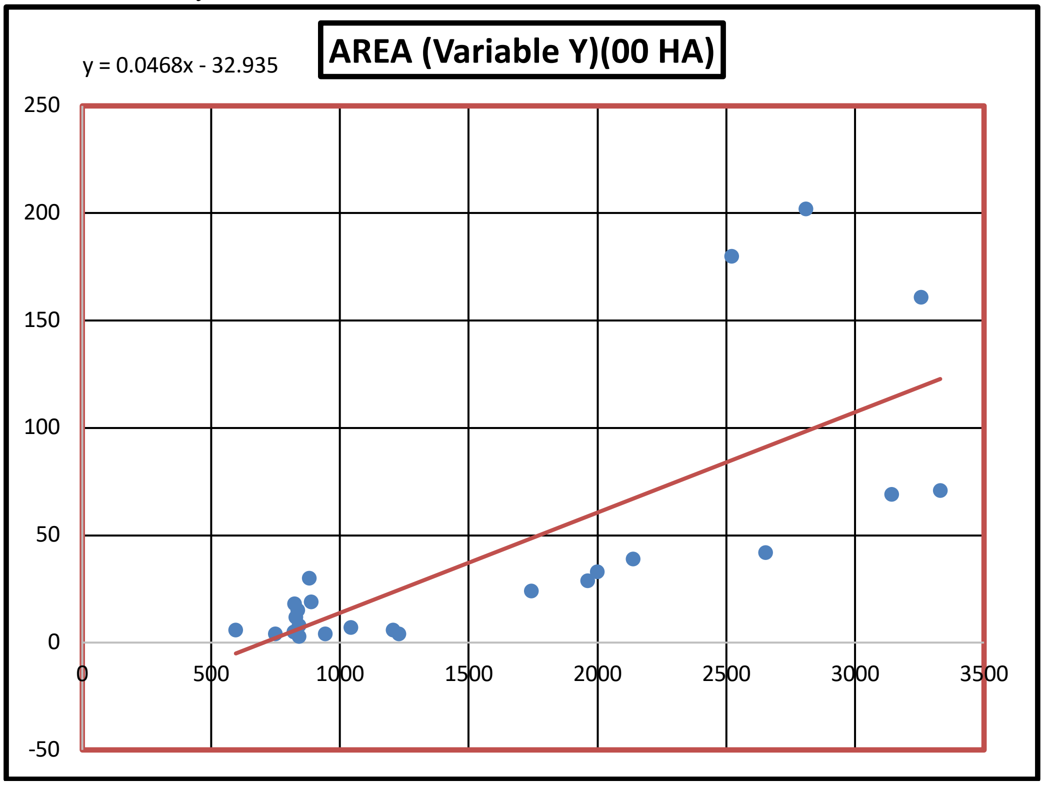
- **The important reading here is the Significance F. This value is equal to 0.0001. Since this reading is below the significance level of 0.05, it means that the null hypothesis can be rejected**.

3. Coefficients Table:

- The coefficient for the Intercept shows a value of -33 which is the value of Y when X = 0.
- The coefficient for X variable is 0.0468 which means that the value of Y changes by that amount for every unit increase in X.
- The Standard Error for the X variable shows 0.0095 value which is very small in comparison with the value of the X coefficient 0.0468. Hence, the data shows a good fit.
- The P value again shows a very small value (0.0001). It is the same as the Significance F since this is a simple regression with only one independent variable. Since it is very small, it indicates that the null hypothesis can be rejected.
- The upper and lower boundaries of the confidence interval are depicted by the upper 95% and lower 95% respectively. The value of the coefficient is shown to be 0.0468, but it can vary from 0.026 to 0.066. Since this range does not include 0, we have confidence that FHP is significantly correlated to Area.

The following trend line has been obtained from the data for area under soybean cultivation and FHP of soybean in Pune district for the period 1996-97 to 2017-18.

Fig. 6.20: Trend line showing correlation between area under soybean cultivation and FHP of soybean in Pune district between 1996-97 and 2017-18



Source: Table 6.08

The regression equation is given as:

Y = b*X + a

The above graph shows the equation as
Y = 0.0468 * X - 32.935

These are the same values obtained in the coefficients table.

This means that the value of the dependent variable "Y" which is the area under soybean cultivation can be calculated for every value of the independent variable "X" i.e., the FHP of soybean by multiplying it with the value of "b" which is the slope of the trend line (0.0468) and adding the value of "a" which is the Y intercept (-32.935).

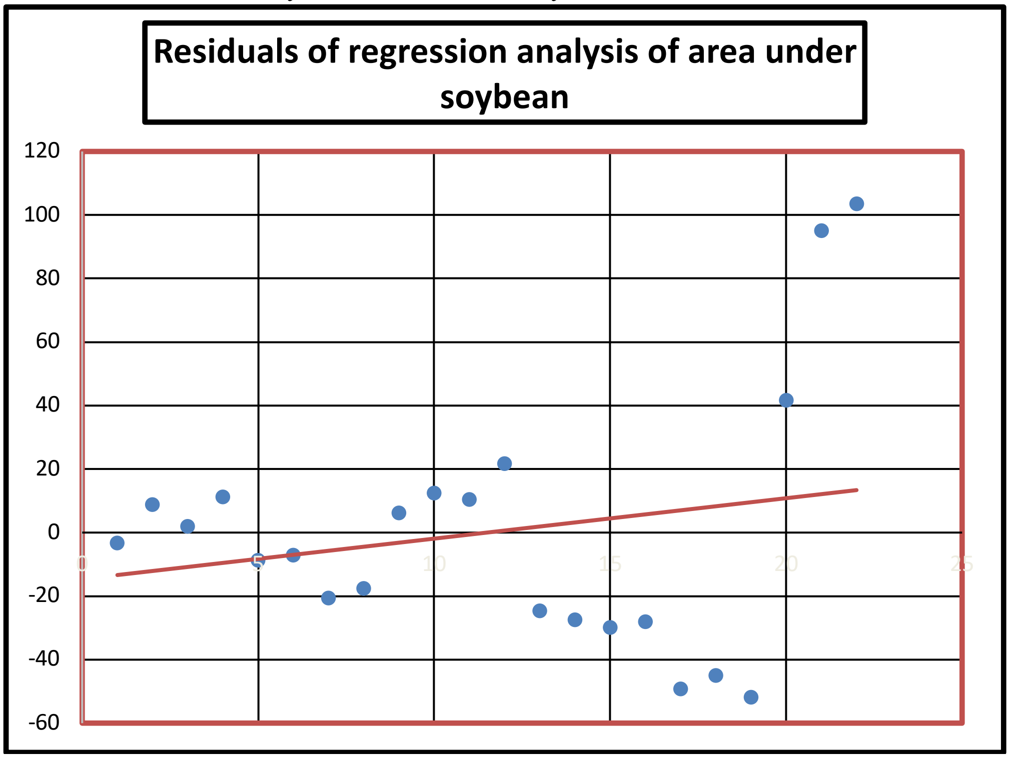
The following table shows the predicted values of the dependent variables and the variance between the predicted values and the actual values. These variances are called residuals.

Table 6.26: Residual output for regression analysis between area under soybean and its FHP

RESIDUAL OUTPUT		
Observation	***Predicted Y***	***Residuals***
1	6.3125	-3.3125
2	6.1253	8.8747
3	2.0432	1.9568
4	-5.1661	11.1661
5	15.7594	-8.7594
6	11.1249	-7.1249
7	24.5134	-20.5134
8	23.4836	-17.4836
9	5.7882	6.2118
10	5.5541	12.4459
11	8.5970	10.4030
12	8.2225	21.7775
13	48.5286	-24.5286
14	60.5127	-27.5127
15	58.7806	-29.7806
16	67.0197	-28.0197
17	91.1285	-49.1285
18	114.0201	-45.0201
19	122.8209	-51.8209
20	119.4036	41.5964
21	84.9491	95.0509
22	98.4781	103.5219

Source: Table 6.08

Fig. 6.21: Scatter diagram showing the residuals and the corresponding trend line for regression analysis of area under soybean cultivation



Source: Table 6.26

The residuals in the graph above show a random pattern. A few of the readings lie above 0, while a few are negative. This random pattern is suitable for a linear trend line. (In case of U shaped or inverted U shaped patterns, a non-linear model will be the correct fit.)

From the above analysis it can concluded that the area under soybean cultivation is significantly related to the Farm Harvest Prices of soybean in Pune district. Thus, we can reject the null hypothesis Ho3 and accept the alternative hypothesis Ha3.

6.6.4 Simple Regression Analysis of production of soybean and FHP of soybean in Pune district.

The data for the analysis has been taken from Table 6.08, an extract of it has been presented below for ready reference. **A Confidence Interval of 95% has been assumed; i.e., alpha is 0.05.** Again, the analysis is for the period from 1996-97 to 2017-18.

YEAR	FHP (Variable X) (RS./QUINTAL)	PRODUCTION (Variable Y) (00 MT)
1991-92	NA	3.00
1992-93	NA	4.00
1993-94	821.25	7.00
1994-95	841.50	6.00
1995-96	855.50	NA
1996-97	841.20	5.00
1997-98	837.20	12.00
1998-99	750.00	5.00
1999-00	596.00	12.00
2000-01	1043.00	6.00
2001-02	944.00	5.00
2002-03	1230.00	7.00
2003-04	1208.00	20.00
2004-05	830.00	36.00
2005-06	825.00	38.00
2006-07	890.00	36.00
2007-08	882.00	52.00
2008-09	1743.00	37.00
2009-10	1999.00	47.00
2010-11	1962.00	58.00
2011-12	2138.00	82.00
2012-13	2653.00	81.00
2013-14	3142.00	268.00
2014-15	3330.00	117.00
2015-16	3257.00	470.00
2016-17	2521.00	383.00
2017-18	2810.00	409.00

Table 6.27: Simple Regression Analysis between production of soybean and FHP of soybean in Pune district for the period 1996-97 to 2017-18.

SUMMARY OUTPUT							
Regression Statistics							
Multiple R	0.7597						
R Square	0.5772						
Adjusted R Square	0.5560						
Standard Error	95.4554						
Observations	22.0000						
ANOVA							
	df	*SS*	*MS*	*F*	*Significance F*		
Regression	1.0000	248754.2891	248754.2891	27.3004	0.0000		
Residual	20.0000	182234.8018	9111.7401				
Total	21.0000	430989.0909					
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	-94.2292	42.2726	-2.2291	0.0374	-182.4084	-6.0500	-182.4084	-6.0500
X Variable 1	0.1169	0.0224	5.2250	0.0000	0.0702	0.1636	0.0702	0.1636

Source: Table 6.08

1. Regression statistics:

- Multiple Rshows the value of correlation coefficient as 0.75 thus showing a high correlation between production of soybean and FHP of soybean.
- R Square: shows the coefficient of determination (percentage of variance in the dependent variable that is predictable from the independent variable), so a value of 0.57 shows that 57% of the values lie near the trend line (or that 57% of the Y values can be predicted) thus showing a moderately good fit.
- Adjusted R Square does not apply since this is simple regression and not multiple variable analysis
- Standard Error: Lower values of S are better because it signifies that the distances between the data points and the fitted values are smaller. This is an **absolute value** and as such a value of 95 being very small in comparison with the values of the Y variable, production of soybean, hence again shows a good fit.
- Observations**:** simply means the number of observations.

2. ANOVA Table:

- df: These are the degrees of freedom associated with the sources of variance. The total variance has N-1 degrees of freedom. In this study, it is 22-1 = 20. The model degrees of freedom corresponds to the number of predictors minus 1 (K-1). This would be 1-1 (since there is 1 independent variable in the model). But, the intercept is automatically included in the model (unless you explicitly omit the intercept). Including the intercept, there are 2 predictors, so the model has 2-1= 1 degrees of freedom. The Residual degrees of freedom is the DF total minus the DF model, 21-1 = 20.

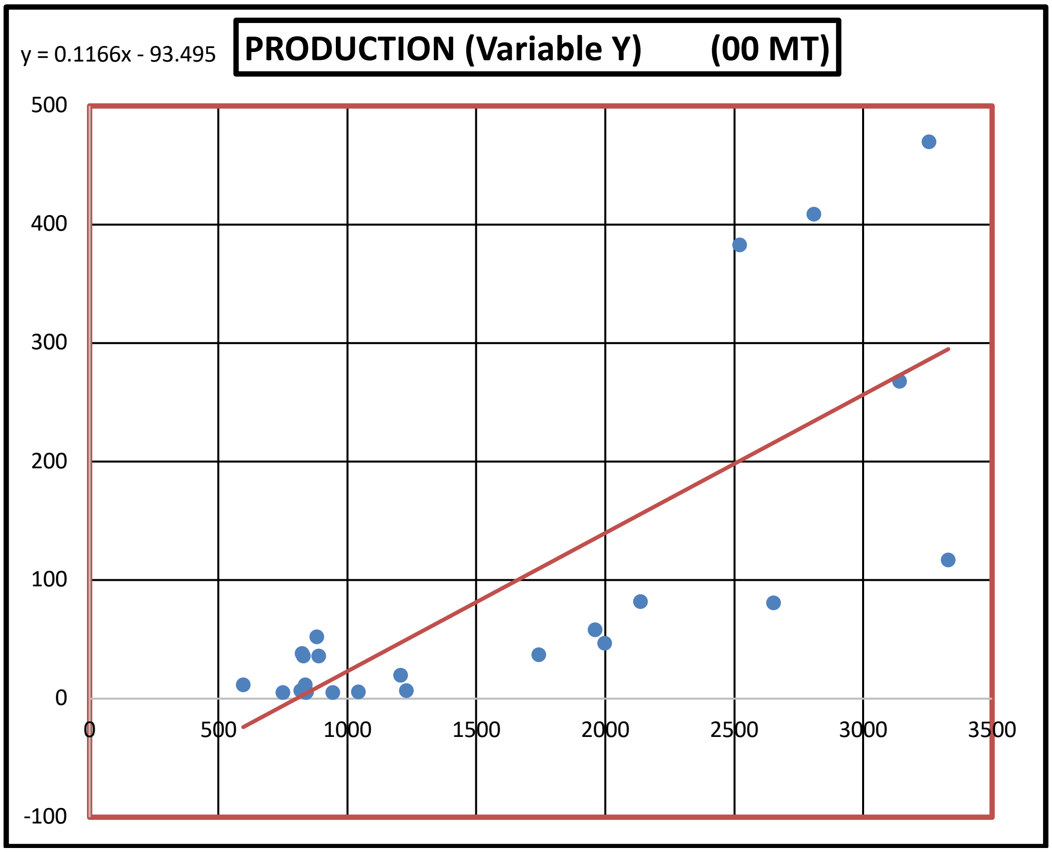
- **The important reading here is the Significance F. This value is equal to 0.0000. Since this reading is below the significance level of 0.05, it means that the null hypothesis can be rejected**.

3. Coefficients Table:

- The coefficient for the Intercept shows a value of -94 which is the value of Y when X = 0.
- The coefficient for X variable is 0.1169 which means that the value of Y changes by that amount for every unit increase in X.
- The Standard Error for the X variable shows 0.0223 value which is very small in comparison with the value of the X coefficient 0.1169. Hence, the data shows a good fit.
- The P value again shows a very small value (0.0000). It is the same as the Significance F since this is a simple regression with only one independent variable. Since it is very small, it indicates that the null hypothesis can be rejected.
- The upper and lower boundaries of the confidence interval are depicted by the upper 95% and lower 95% respectively. The value of the coefficient is shown to be 0.1169, but it can vary from 0.0702 to 0.1635. Since this range does not include 0, we have confidence that FHP is significantly correlated to production of soybean.

The following trend line has been obtained from the data for production of soybean and FHP of soybean in Pune district for the period 1996-97 to 2017-18.

Fig. 6.22: Trend line showing correlation between production of soybean and FHP of soybean in Pune district between 1996-97 and 2017-18.



Source: Table 6.08

The regression equation is given as:

Y = b*X + a

The above graph shows the equation as
Y = 0.1166 * X - 93.495

These are the same values obtained in the coefficients table.

This means that the value of the dependent variable "Y" which is the production of soybean can be calculated for every value of the independent variable "X" i.e., the FHP of soybean by multiplying it with the value of "b" which is the slope of the trend line (0.1166) and adding the value of "a" which is the Y intercept (-93.495).

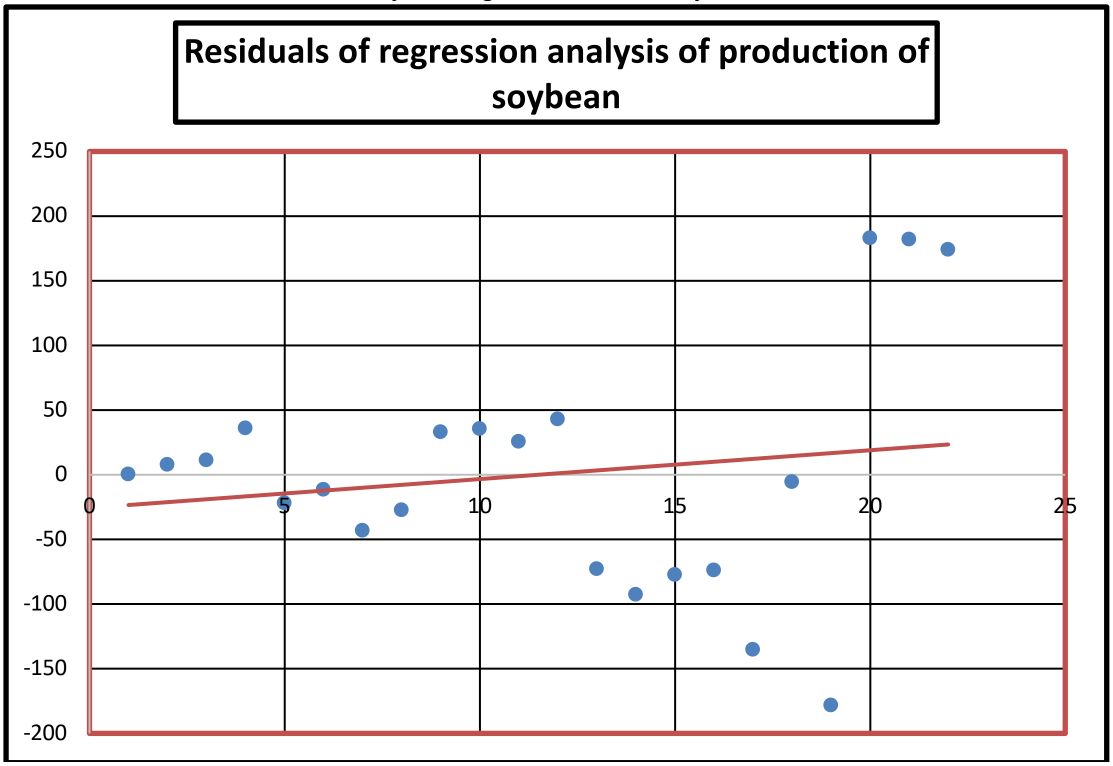
The following table shows the predicted values of the dependent variables and the variance between the predicted values and the actual values. These variances are called residuals.

Table 6.28: Residual output for regression analysis of production of soybean and its FHP

RESIDUAL OUTPUT		
Observation	***Predicted Y***	***Residuals***
1	4.1120	0.8880
2	3.6443	8.3557
3	-6.5498	11.5498
4	-24.5533	36.5533
5	27.7036	-21.7036
6	16.1299	-11.1299
7	49.5649	-42.5649
8	46.9930	-26.9930
9	2.8026	33.1974
10	2.2181	35.7819
11	9.8170	26.1830
12	8.8817	43.1183
13	109.5376	-72.5376
14	139.4655	-92.4655
15	135.1400	-77.1400
16	155.7154	-73.7154
17	215.9219	-134.9219
18	273.0889	-5.0889
19	295.0672	-178.0672
20	286.5330	183.4670
21	200.4904	182.5096
22	234.2761	174.7239

Source: Table 6.08

Fig. 6.23: Scatter diagram showing the residuals and the corresponding trend line for regression analysis of production of soybean



Source: Table 6.28

The residuals in the graph above show a random pattern. A few of the readings lie above 0, while a few are negative. This random pattern is suitable for a linear trend line. (In case of U shaped or inverted U shaped patterns, a non-linear model will be the correct fit.)

From the above analysis it can concluded that the production of soybean is significantly related to the Farm Harvest Prices of soybean in Pune district. Thus, we can reject the null hypothesis Ho4 and accept the alternative hypothesis Ha4.

6.6.5 Simple Regression Analysis of area under sugarcane cultivation and FRP of sugarcane in Pune district.

The data for the analysis has been taken from Table 6.16, an extract of it has been presented below for ready reference. **A Confidence Interval of 95% has been assumed; i.e., alpha is 0.05.**

YEAR	Pune's final SMP/FRP (Variable X) (RS/QUINTAL)	AREA (Variable Y) (00 HA)
1991-92	24.74	520.00
1992-93	27.82	442.00
1993-94	29.30	427.00
1994-95	37.54	526.00
1995-96	40.80	562.00
1996-97	44.06	637.00
1997-98	46.51	425.00
1998-99	50.59	409.00
1999-00	53.86	476.00
2000-01	56.30	487.00
2001-02	59.57	487.00
2002-03	61.94	535.00
2003-04	62.87	396.00
2004-05	71.57	282.00
2005-06	75.57	538.00
2006-07	76.44	782.00
2007-08	77.18	1042.00
2008-09	77.18	856.00
2009-10	122.50	956.00
2010-11	110.33	1115.00
2011-12	136.81	1299.00
2012-13	160.34	1377.00
2013-14	198.06	1439.00
2014-15	207.55	1278.00
2015-16	216.91	1184.00
2016-17	216.91	959.00
2017-18	240.45	1131.00

Table 6.29: Simple Regression Analysis between area under sugarcane cultivation and FRP of sugarcane in Pune district for the period 1991-92 to 2017-18.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.8262							
R Square	0.6826							
Adjusted R Square	0.6699							
Standard Error	205.1849							
Observations	27.0000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1.0000	2263386.3401	2263386.3401	53.7611	0.0000			
Residual	25.0000	1052520.8450	42100.8338					
Total	26.0000	3315907.1852						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	340.0676	69.7615	4.8747	0.0001	196.3911	483.7441	196.3911	483.7441
X Variable 1	4.4065	0.6010	7.3322	0.0000	3.1688	5.6443	3.1688	5.6443

Source: Table 6.16

1. Regression statistics:

- Multiple R: shows the value of correlation coefficient as 0.82 thus showing a high correlation between area under sugarcane cultivation and FHP of sugarcane
- R Square: shows the coefficient of determination (percentage of variance in the dependent variable that is predictable from the independent variable), so a value of 0.68 shows that 68% of the values lie near the trend line (or that 68% of the Y values can be predicted) thus showing a moderately good fit.
- Adjusted R Square does not apply since this is simple regression and not multiple variable analysis
- Standard Error: Lower values of S are better because it signifies that the distances between the data points and the fitted values are smaller. This is an **absolute value** and as such a value of 205 being very small in comparison with the values of the Y variable, area under sugarcane cultivation, hence again shows a good fit.
- Observations**:** simply means the number of observations.

2. ANOVA Table

- df: These are the degrees of freedom associated with the sources of variance. The total variance has N-1 degrees of freedom. In this study, it is 27-1 = 26. The model degrees of freedom corresponds to the number of predictors minus 1 (K-1). This would be 1-1 (since there is 1 independent variable in the model). But, the intercept is automatically included in the model (unless you explicitly omit the intercept). Including the intercept, there are 2 predictors, so the model has 2-1= 1 degrees of freedom. The Residual degrees of freedom is the DF total minus the DF model, 26-1 = 25.

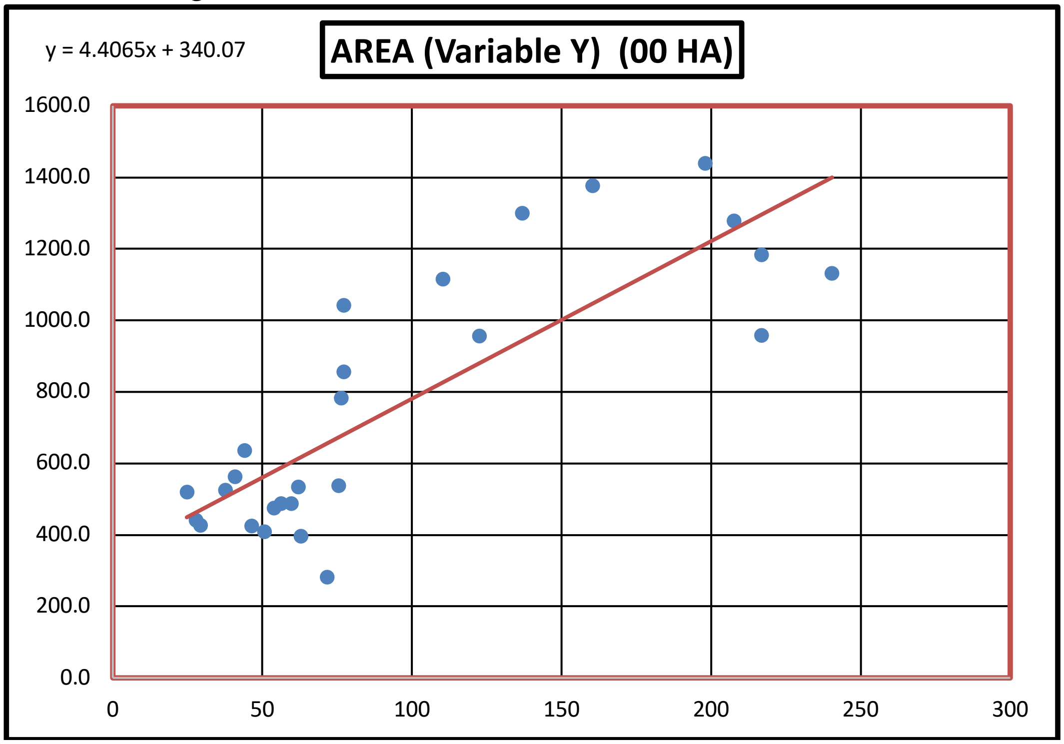
- **The important reading here is the Significance F. This value is equal to 0.0000. Since this reading is below the significance level of 0.05, it means that the null hypothesis can be rejected**.

3. Coefficients Table:

- The coefficient for the Intercept shows a value of 340.06 which is the value of Y when X = 0.
- The coefficient for X variable is 4.406 which means that the value of Y changes by that amount for every unit increase in X.
- The Standard Error for the X variable shows 0.6009 value which is very small in comparison with the value of the X coefficient 4.406. Hence, the data shows a good fit.
- The P value again shows a very small value (0.0000). It is the same as the Significance F since this is a simple regression with only one independent variable. Since it is very small, it indicates that the null hypothesis can be rejected.
- The upper and lower boundaries of the confidence interval are depicted by the upper 95% and lower 95% respectively. The value of the coefficient is shown to be 4.406, but it can vary from 3.168 to 5.644. Since this range does not include 0, we have confidence that FHP is significantly correlated to production of sugarcane.

The following trend line has been obtained from the data for area under sugarcane cultivation and FHP of sugarcane in Pune district for the period 1991-92 to 2017-18.

Fig. 6.24: Trend line showing correlation between area under sugarcane cultivation and FRP of sugarcane in Pune district between 1991-92 and 2017-18.



Source: Table 6.16

The regression equation is given as:

Y = b*X + a

The above graph shows the equation as
Y = 4.4065 * X + 340.07

These are the same values obtained in the coefficients table.

This means that the value of the dependent variable "Y" which is the area under sugarcane cultivation can be calculated for every value of the independent variable "X" i.e., the FHP of sugarcane by multiplying it with the value of "b" which is the slope of the trend line (4.4065) and adding the value of "a" which is the Y intercept (340.07).

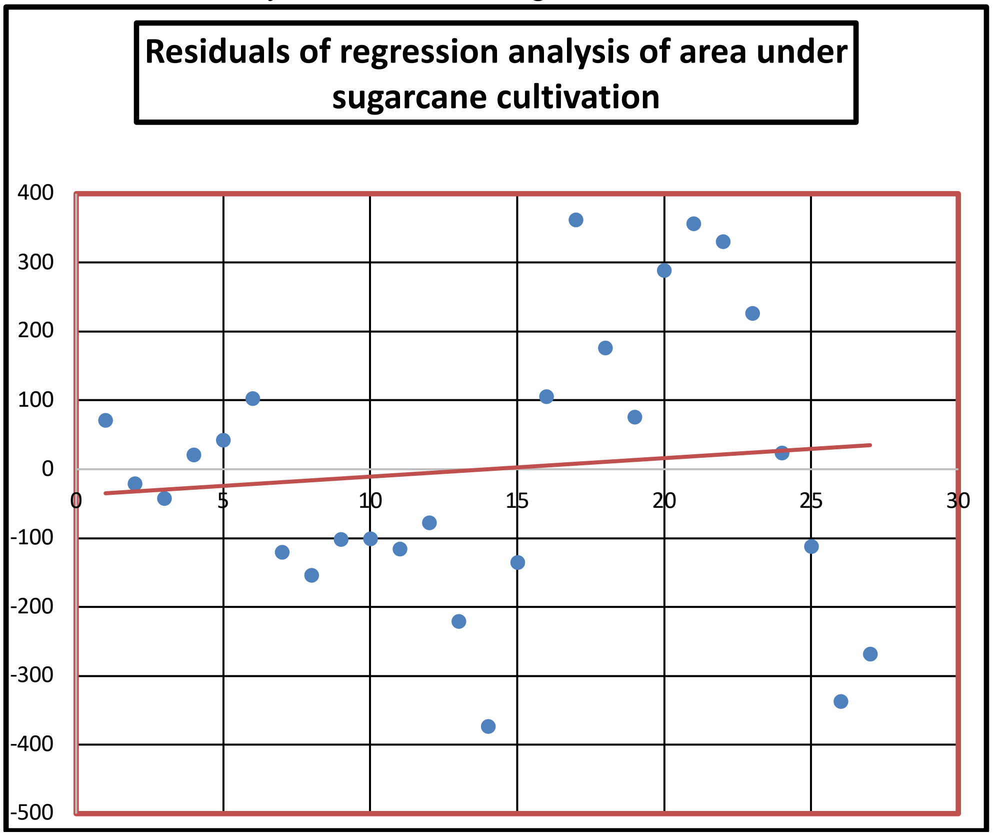
The following table shows the predicted values of the dependent variables and the variance between the predicted values and the actual values. These variances are called residuals.

Table 6.30: Residual output for regression analysis between area under sugarcane cultivation and its FRP

RESIDUAL OUTPUT		
Observation	*Predicted Y*	*Residuals*
1	449.1025	70.8975
2	462.6746	-20.6746
3	469.1610	-42.1610
4	505.4707	20.5293
5	519.8536	42.1464
6	534.2364	102.7636
7	545.0236	-120.0236
8	563.0022	-154.0022
9	577.3851	-101.3851
10	588.1722	-101.1722
11	602.5551	-115.5551
12	612.9897	-77.9897
13	617.1142	-221.1142
14	655.4333	-373.4333
15	673.0594	-135.0594
16	676.9019	105.0981
17	680.1803	361.8197
18	680.1803	175.8197
19	879.8837	76.1163
20	826.2300	288.7700
21	942.9146	356.0854
22	1046.6264	330.3736
23	1212.8050	226.1950
24	1254.6493	23.3507
25	1295.8943	-111.8943
26	1295.8943	-336.8943
27	1399.6061	-268.6061

Source: Table 6.16

Fig. 6.25: Scatter diagram showing the residuals and the corresponding trend line for regression analysis of area under sugarcane cultivation



Source: Table 6.30

The residuals in the graph above show a random pattern. A few of the readings lie above 0, while a few are negative. This random pattern is suitable for a linear trend line. (In case of U shaped or inverted U shaped patterns, a non-linear model will be the correct fit.)

From the above analysis it can concluded that the area under sugarcane cultivation is significantly related to the Fair and Remunerative Prices of sugarcane in Pune district. Thus, we can reject the null hypothesis Ho5 and accept the alternative hypothesis Ha5.

6.6.6 Simple Regression Analysis of production of sugarcane and FRP of sugarcane in Pune district.

The data for the analysis has been taken from Table 6.16, an extract of it has been presented below for ready reference. **A Confidence Interval of 95% has been assumed; i.e., alpha is 0.05.**

YEAR	Pune's final SMP/FRP (RS/QUINTAL) (Variable X)	PRODUCTION (00 MT) (Variable Y)
1991-92	24.74	31303.00
1992-93	27.82	26847.00
1993-94	29.30	25404.00
1994-95	37.54	35092.00
1995-96	40.80	32989.00
1996-97	44.06	35362.00
1997-98	46.51	40762.00
1998-99	50.59	39227.00
1999-00	53.86	47775.00
2000-01	56.30	45583.00
2001-02	59.57	41610.00
2002-03	61.94	46900.00
2003-04	62.87	27560.00
2004-05	71.57	23619.00
2005-06	75.57	50361.00
2006-07	76.44	68726.00
2007-08	77.18	101577.00
2008-09	77.18	83328.00
2009-10	122.50	91121.00
2010-11	110.33	110831.00
2011-12	136.81	131576.00
2012-13	160.34	138884.00
2013-14	198.06	169635.00
2014-15	207.55	138339.00
2015-16	216.91	122854.00
2016-17	216.91	90709.00
2017-18	240.45	132706.00

Table 6.31: Simple Regression Analysis between production of sugarcane and FRP of sugarcane in Pune district for the period 1991-92 to 2017-18.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.8683							
R Square	0.7540							
Adjusted R Square	0.7441							
Standard Error	22452.3892							
Observations	27.0000							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1.0000	38620246843.3175	38620246843.3175	76.6108	0.0000			
Residual	25.0000	12602744490.6825	504109779.6273					
Total	26.0000	51222991334.0000						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	16425.3773	7633.6648	2.1517	0.0413	703.5504	32147.2042	703.5504	32147.2042
X Variable 1	575.6039	65.7626	8.7528	0.0000	440.1634	711.0445	440.1634	711.0445

Source: Table 6.16

1. Regression statistics:

- Multiple R: shows the value of correlation coefficient as 0.86 thus showing a high correlation between production of sugarcane and FHP of sugarcane
- R Square: shows the coefficient of determination (percentage of variance in the dependent variable that is predictable from the independent variable), so a value of 0.75 shows that 75% of the values lie near the trend line (or that 75% of the Y values can be predicted) thus showing a good fit.
- Adjusted R Square does not apply since this is simple regression and not multiple variable analysis
- Standard Error: Lower values of S are better because it signifies that the distances between the data points and the fitted values are smaller. This is an **absolute value** and as such a value of 22452 being very small in comparison with the values of the Y variable, production of sugarcane, hence again shows a good fit.
- Observations**:** simply means the number of observations.

2. ANOVA Table:

- df: These are the degrees of freedom associated with the sources of variance. The total variance has N-1 degrees of freedom. In this study, it is 27-1 = 26. The model degrees of freedom corresponds to the number of predictors minus 1 (K-1). This would be 1-1 (since there is 1 independent variable in the model). But, the intercept is automatically included in the model (unless you explicitly omit the intercept). Including the intercept, there are 2 predictors, so the model has 2-1= 1 degrees of freedom. The Residual degrees of freedom is the DF total minus the DF model, 26-1 = 25.

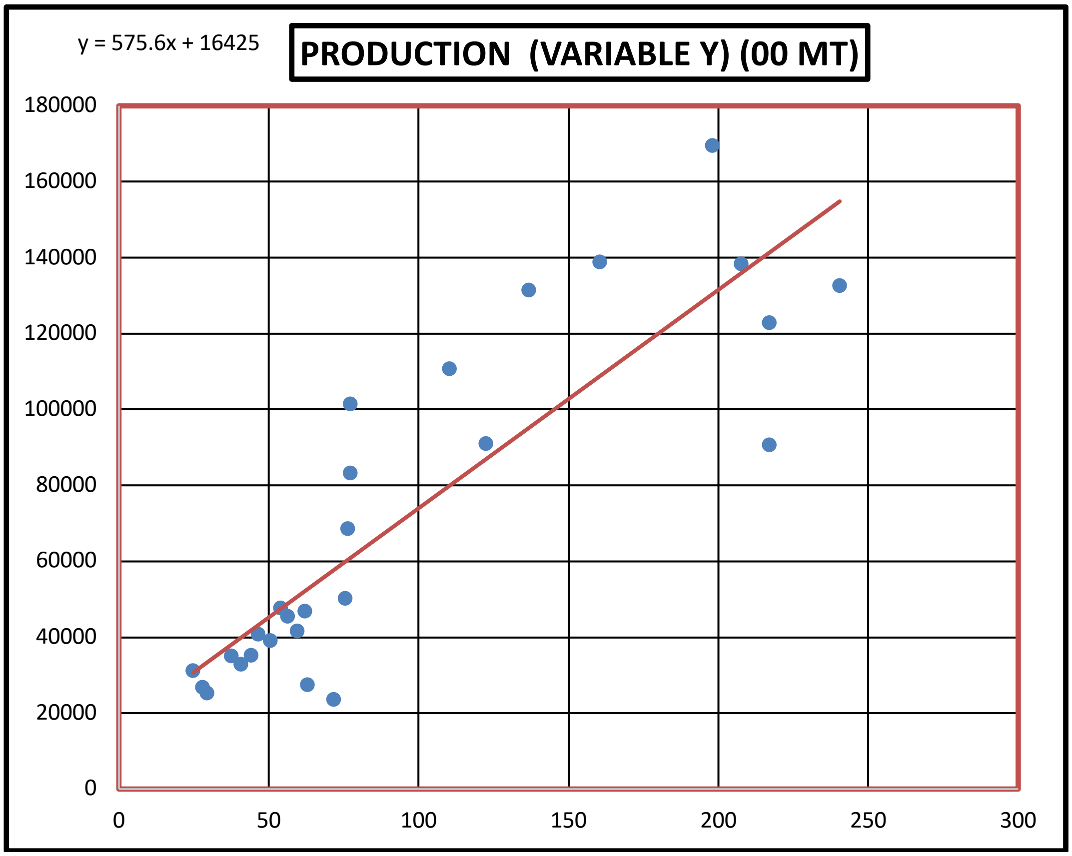
- **The important reading here is the Significance F. This value is equal to 0.0000. Since this reading is below the significance level of 0.05, it means that the null hypothesis can be rejected**.

3. Coefficients Table:

- The coefficient for the Intercept shows a value of 16425.37 which is the value of Y when X = 0.
- The coefficient for X variable is 575.60 which means that the value of Y changes by that amount for every unit increase in X.
- The Standard Error for the X variable shows 65.76 value which is very small in comparison with the value of the X coefficient 575.60. Hence, the data shows a good fit.
- The P value again shows a very small value (0.0000). It is the same as the Significance F since this is a simple regression with only one independent variable. Since it is very small, it indicates that the null hypothesis can be rejected.
- The upper and lower boundaries of the confidence interval are depicted by the upper 95% and lower 95% respectively. The value of the coefficient is shown to be 575.60, but it can vary from 440.16 to 711.04. Since this range does not include 0, we have confidence that FHP is significantly correlated to production of sugarcane.

The following trend line has been obtained from the data for production of sugarcane and FHP of sugarcane in Pune district for the period 1991-92 to 2017-18.

Fig. 6.26: Trend line showing correlation between sugarcane production and FRP of sugarcane in Pune district between 1991-92 and 2017-18.



Source: Table 6.16

The regression equation is given as:

Y = b*X + a

The above graph shows the equation as
Y = 575.6 * X + 16425

These are the same values obtained in the coefficients table.

This means that the value of the dependent variable “Y” which is the production of sugarcane can be calculated for every value of the independent variable “X” i.e., the FHP of sugarcane by multiplying it with the value of “b” which is the slope of the trend line (575.6) and adding the value of “a” which is the Y intercept (16425).

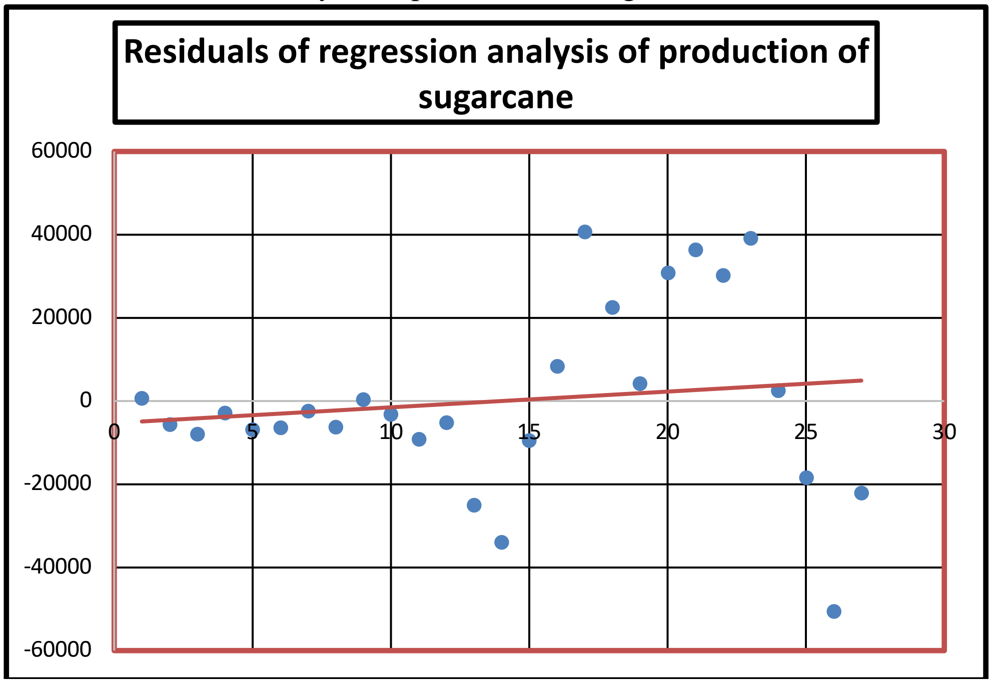
The following table shows the predicted values of the dependent variables and the variance between the predicted values and the actual values. These variances are called residuals.

Table 6.32: Residual output for regression analysis between production of sugarcane and its FRP

RESIDUAL OUTPUT		
Observation	***Predicted Y***	***Residuals***
1	30668.1213	634.8787
2	32440.9814	-5593.9814
3	33288.2704	-7884.2704
4	38031.2469	-2939.2469
5	39910.0181	-6921.0181
6	41788.7894	-6426.7894
7	43197.8679	-2435.8679
8	45546.3320	-6319.3320
9	47425.1032	349.8968
10	48834.1817	-3251.1817
11	50712.9529	-9102.9529
12	52075.9831	-5175.9831
13	52614.7484	-25054.7484
14	57620.2002	-34001.2002
15	59922.6160	-9561.6160
16	60424.5426	8301.4574
17	60852.7920	40724.2080
18	60852.7920	22475.2080
19	86939.1626	4181.8374
20	79930.6090	30900.3910
21	95172.6014	36403.3986
22	108720.0158	30163.9842
23	130427.1917	39207.8083
24	135893.1267	2445.8733
25	141280.7796	-18426.7796
26	141280.7796	-50571.7796
27	154828.1940	-22122.1940

Source: Table 6.16

Fig. 6.27: Scatter diagram showing the residuals and the corresponding trend line for regression analysis of production of sugarcane



Source: Table 6.32

The residuals in the graph above show a random pattern. A few of the readings lie above 0, while a few are negative. This random pattern is suitable for a linear trend line. (In case of U shaped or inverted U shaped patterns, a non-linear model will be the correct fit.)

From the above analysis it can concluded that the production of sugarcane is significantly related to the Fair and Remunerative Prices of sugarcane in Pune district. Thus, we can reject the null hypothesis Ho6 and accept the alternative hypothesis Ha6.

As can be seen from the Correlation Analysis, all the variables, Average Area, Average Production and Average Yield are highly correlated (0.8 to 0.9) to the Average FHP/FRP of the three crops (except yield of soybean). The Simple Regression Analysis has further substantiated the hypotheses that the cropping pattern with respect to the three crops is significantly influenced by the prices obtained for them by the farmers. As such, pricing is a very important tool which the government can use to bring about a change in the cropping pattern of Pune district. Considering the huge commercial potential of maize and soybean as well as the unsustainability of sugarcane cultivation, a shift in the cropping pattern in the district is the need of the hour. The next sections (trend analysis and optimization modelling) are an attempt to suggest a more sustainable and remunerative cropping pattern with respect to the three crops viz., maize, soybean and sugarcane in Pune district.

6.7 TREND ANALYSIS

In the next step, the trend analysis for the data was done with respect to the total area under cultivation of the three cash crops maize, soybean, and sugarcane. The following table presents the data for total area under cultivation of these three crops for the period 1991-92 to 2017-18.

Table 6.33: Data showing total area under cultivation of the three cash crops, maize, soybean and sugarcane in Pune district for the period 1991-92 to 2017-18 (Area in 00 hectares)

YEAR	Maize area	Soybean area	Sugarcane area	Total Area
1991-92	76.00	5.00	520.00	601.00
1992-93	78.00	4.00	442.00	524.00
1993-94	43.00	5.00	427.00	475.00
1994-95	79.00	8.00	526.00	613.00
1995-96	87.00		562.00	649.00
1996-97	151.00	3.00	637.00	791.00
1997-98	125.04	15.00	425.00	565.04
1998-99	139.00	4.00	409.00	552.00
1999-00	150.00	6.00	476.00	632.00
2000-01	162.00	7.00	487.00	656.00
2001-02	153.00	4.00	487.00	644.00
2002-03	149.00	4.00	535.00	688.00
2003-04	104.00	6.00	396.00	506.00
2004-05	153.00	12.00	282.00	447.00
2005-06	165.00	18.00	538.00	721.00
2006-07	183.00	19.00	782.00	984.00
2007-08	166.00	30.00	1042.00	1238.00
2008-09	174.00	24.00	856.00	1054.00
2009-10	160.00	33.00	956.00	1149.00
2010-11	253.00	29.00	1115.00	1397.00
2011-12	272.00	39.00	1299.00	1610.00
2012-13	252.00	42.00	1377.00	1671.00
2013-14	319.00	69.00	1439.00	1827.00
2014-15	360.00	71.00	1278.00	1709.00
2015-16	372.00	161.00	1184.00	1717.00
2016-17	426.00	180.00	959.00	1565.00
2017-18	473.00	202.00	1131.00	1806.00

Source: Table 6.02, Table 6.08, and Table 6.16.

Based on the above data, as well as the data for 2018-19 where the total land under cultivation for the three crops was 156700 hectares, a forecast was made for the next 5 years using the TREND function in Excel. The results are as follows:

Table 6.34: Trend forecast for the next 5 years showing total area under cultivation of maize, soybean, and sugarcane.

YEAR	Total Area (00 hectares)
2019-20	1785.25
2020-21	1838.52
2021-22	1891.80
2022-23	1945.07
2023-24	1998.34

Source: Own analysis

The trend forecast shows that the combined area under the three crops will be 199834 ha in the year 2023-24 based on the data for the last 28 years.

6.8 OPTIMIZATION OF CROPPING PATTERN IN PUNE DISTRICT WITH RESPECT TO THREE CASH CROPS, VIZ., MAIZE, SOYBEAN AND SUGARCANE

As has been shown in the previous sections, the FHP/FRP of the cash crops, viz., maize, soybean, and sugarcane procured by the farmers plays a significant role in incentivizing them to undertake the cultivation of the said crops. However, sugarcane being economically and ecologically unsustainable needs to be replaced by the more sturdy and economically viable crops, maize and soybean. Accordingly, taking the statistics of area, production, and yield of the three crops for 2017-18, a possible reallocation of the area under the three crops has been done using the optimization model. The GRG non-linear method in Solver was used in Excel to work out the optimum cropping pattern. The crops chosen are maize, soybean and sugarcane since all three of them are cash crops and hence comparable on commercial terms. Table 6.35 shows the data for the year 2017-18 of area, production and yield of maize, soybean and sugarcane for Pune district.

Table 6.35: Area, Production and Yield of maize, soybean and sugarcane in Pune district in 2017-18.

Crops	Area (ha)	Production (Mt)	Yield (tons/ha)
Maize	47328	146600	3.10
Soybean	20231	40900	2.02
Sugarcane	113140	13270600	117.29
	180699		

Source: Table 6.02, Table 6.08, and Table 6.16

The optimization model was worked out and the results obtained are given in the table below.

Table 6.36: Optimum allocation of land towards maize, soybean and sugarcane cultivation

Crops	Area (in hectares)	Production (in Mt)	Yield (tons/ha)
Maize	96554.25	531048	5.50
Soybean	51640.32	146142	2.83
Sugarcane	51640.32	5164027	100.00
Total	199834.88		

Source: Own analysis

Table 6.36 shows the optimized data for which the following parameters were set:

1. The **objective** is set at 199834.70 ha (the sum of the areas for all the 3 crops combined). This is the value arrived at by the forecast in TREND analysis.

2. The **decision variables** are the **area and the production figures for all the three crops** because all these are required to be **changed.**

3. **Constraints have been set as follows:**

Area for maize >= Area for sugarcane

Area for soybean >= Area for sugarcane

Yield for maize = 5.5 tons/ha

Yield for soybean = 2.83/ha

Yield for sugarcane = 100 tons/ha

Reasons for setting these constraints:

a. Area under sugarcane needs to be reduced since it is a water guzzling crop and has to be replaced by other cash crops like maize and soybean which are both economically and environmentally sustainable.

b. Yield levels for maize and soybean have been set at 5.5 tons/ha and 2.83 tons/ha respectively since these are the world average yield levels for these crops. While the yield level of soybean is already very good in Pune at 2.02 tons/ha and requires only marginal improvement, the yield level of maize is lagging currently at 3.10 tons/ha. This will have to be improved by the promotion of rabi maize and single hybrids as also better irrigation.

c. Yield for sugarcane has been set at 100 tons/ha (which is lower than current yield levels in Pune district) since the world average yield for sugarcane is around 75 tons/ha, but can vary from 80-160 tons/ha. However, a lower level at 100 tons/ha is being assumed since even this level of yield requires very high levels of inputs in terms of fertilizers and irrigation.

The result of such an optimization is as follows:
1. Area under maize and soybean is doubled.
2. Area under sugarcane cultivation is halved.
3. Production of maize and soybean is increased nearly three times.
4. Production of sugarcane is reduced by a third.

The reallocation of land towards the cropping pattern of the three cash crops maize, soybean and sugarcane can be easily achieved by linking the market prices of sugar with the FRP which mills are mandated to pay to the cane growers. However, prices being sticky downwards, the government has already taken one step in this direction by keeping the FRP constant in the year 2019-20 as that of the last year, 2018-19 at Rs.285 per ton of sugarcane crushed. This is doubly justified since monocropping is anyway not an ecologically friendly practice. At the same time, higher MSPs for maize and soybean will incentivize the farmers to alternate the cultivation of sugarcane with these cash crops which will result in sustainable agricultural practice.

6.9 CONCLUSION

In this chapter an attempt has been made to propose a solution to the current cropping pattern. As has been shown in Chapter 1, agriculture in Pune is dependent mostly on rainfall. And a lion's share of the irrigation is allocated for sugarcane cultivation. While a large proportion of the horticultural crops are also being cultivated under irrigated conditions, sugarcane is the only crop which is being cultivated under 100 percent irrigated conditions. It has been shown in the previous sections that while the area, production, and FRP of sugarcane has been consistently increasing, the yield of sugarcane has stagnated for nearly two decades. Studies show that the cane growers are using greater amounts of fertilizers per hectare to achieve the same yield levels. But farmers are incentivized to go in for sugarcane cultivation due to government intervention. The sugar industry is in a severe crisis due to the existence of dual pricing. The prices of sugar have been deregulated following the Rangarajan Committee recommendations in 2013. As a result, sugar prices are market determined and have been falling or at least have not been increasing due to increased supply in the market. On the other hand, the mills are mandated to pay higher FRPs to the cane growers every year as mandated by the government. Due to the disconnect with market sugar prices, cane growers are incentivized to go in for cane cultivation. The result is that with increasing cost of production and higher FRPs to be paid by the mills to the cane growers, but lower sugar prices in the market, sugarcane mills are in the red and are frequently unable to pay the cane growers. The arrears to be paid by the mills builds up to such an extent that ultimately the government is frequently required to step in and bail out the industry. This happens due to the huge political patronage being enjoyed by the sugar industry. Thus, the sugar industry is neither economically viable nor environmentally sustainable. There is a dire need to reallocate irrigation from sugarcane towards other crops which are ecologically and economically sustainable. Hence, the author has worked out a solution using an optimization model. The possibility of replacing sugarcane with more remunerative and sturdy crops like maize and soybean has also been recommended in the PMKSY report.

REFERENCES

BOOKS

Debertin, L. D. (2012). *Agricultural Production Economics*. Second Edition, Amazon Createspace. ISBN-13 978-1469960647.

JOURNALS/REPORTS

Mechri, A. Lys, P. Cachia, F. (2017). Productivity and Efficiency Measurement in Agriculture. Food and Agriculture Organisation, United Nations.

WEBSITES

https://www.ers.usda.gov/data-products/international-agricultural-productivity/documentation-and-methods/#overview

DATA SOURCES

1. data.gov.in
2. krishi.maharashtra.gov.in
3. Maharashtra State Agricultural Marketing Board, Gultekdi
4. Sugar Commissionerate office, Shivajinagar
5. Economic and Political Weekly Time Series

CHAPTER 7
CONCLUSIONS

7.1 Introduction

7.1.1 Cropping Pattern of India

7.1.2 Cropping Pattern of Maharashtra

7.2 Findings

7.2.1 Pune's Irrigation Scenario

7.2.2 Pune's Cropping Pattern with reference to 13 major crops

7.2.3 Pune's Cropping Pattern with reference to selected cash crops Viz., Maize, Soybean and Sugarcane between 1991-92 And 2017-18.

7.3 Conclusions

7.4 Suggestions

7.1 INTRODUCTION

According to the Malthusian theory, population growth should have outstripped growth in food grain production. But that has not in fact happened, primarily due to increase in productivity of land. Yet, the burgeoning world population combined with the problems arising from climate change and water scarcity are increasingly straining the agricultural sector. India is not exception to this scenario. While extensive cultivation was widely prevalent in India before the Green Revolution, this practice could not be continued indefinitely for obvious reasons. The introduction of hybrid variety seeds along with improved availability of fertilizers and irrigation enabled the productivity of land to increase tremendously and from a food deficient country India transformed into a self- sufficient country in the production of food grains. Though all crop varieties did not equally gain from the Green Revolution, in the 70s and 80s, cash crops like sugarcane and cotton found favor with farmers largely due to the increased availability of irrigation in Maharashtra. However, post liberalization, the agricultural sector witnessed stagnation in production and productivity across all crop categories, primarily due to fall in public investment in the sector. Taking cognizance of the deteriorating plight of farmers, the Government of India adopted a robust agricultural policy in 2005 which led to a dramatic recovery in the productivity of crops, notably pulses, oilseeds, and horticultural crops. Though the trajectory of growth for the agricultural sector has not been a smooth climb, the levels of agricultural production have seen steady growth over the decades since Independence. Moreover, the cropping pattern has also undergone changes across regions over time. The changes in the cropping pattern in India can be studied over the various time periods beginning with the pre-green revolution period, the period of green revolution, the post green revolution period, the post liberalization period and finally the period of recovery post 2005.

7.1.1 CROPPING PATTERN OF INDIA

Prior to the green revolution, Indian agriculture was characterized by production of coarse cereals and a few pulses. Both the yield and the value of these crops was low and as such subsistence farming was the norm. The Green Revolution introduced during 1966-67 changed the landscape of Indian agriculture hugely. The use of hybrid varieties of seeds and better agricultural inputs like chemical fertilizers and greater availability of irrigation substantially improved yield levels for wheat and rice. Due to procurement of these food grains by the government at the mandated prices, more and more land got allocated to the cultivation of wheat and rice. The impact of green revolution was also felt across other crop categories like oilseeds, fibre crops, horticultural crops, and sugarcane. However, between 1962-65 to 1982-83, the change in the cropping pattern was not substantial since food grains continued to dominate the gross cropped area in the country. The essential difference was that within the food grains sector, the share of coarse cereals dropped significantly in favour of rice and wheat. In the period between 1980-83 and 1990-93, there was a decline of over 4 million hectares in the gross cropped area under food grains. At the same time, the area under oilseeds increased by over 8 million hectares. Such a shift in favour of oilseeds was however to be found only in Central India and South India. The north-western region of the country continued to favour cultivation of rice, wheat and some remaining crops. The above said shift from food grains to high value crops continued in the post-liberalization period, albeit at a slower rate. While production and productivity of almost all crops stagnated during this period, a shift in the cropping pattern from coarse cereals and some pulses in favour of oilseeds, sugarcane and cotton continued. This shift was not very large however, as compared to the shift to other high value crops like fibre crops, spices, plantation crops and horticultural crops. As mentioned earlier, Central India however continued to favour oilseeds and cotton, while north western region continued to favour rice and other food grains. Thus, it can be said that economic reforms did not succeed in bringing about crop diversification in Central India and north western region of India. The robust agricultural policy adopted by the Government of India post 2005 saw a revival of the sector which then witnessed a growth rate of 3.75% p.a. between 2004-05 and 2012-13. Apart from the various schemes and reforms introduced in the agricultural sector, the government also focused on reducing regional disparities, providing food security to all and thus promoting inclusiveness overall. Thus, in spite of 2009-10 being a drought year, the agricultural sector showed remarkable resilience and stability not seen before. Improved irrigation facilities, adoption of drought proof technology as well as adoption of appropriate cropping pattern (factoring in the impact of climate change) has resulted in bumper harvests year after year. Between 2003-05 and 2011-13, overall food grain production consisting mainly of rice, wheat and maize increased by over 50 million tons. It should be noted that the star performer among food grains was maize which witnessed a doubling of production levels between 1995 and 2011. The boost given to production of pulses and oilseeds through various schemes showed successful results with the production of pulses registering a 25 per cent growth in just one year 2010-11 while oilseeds production also increased to 30.4 million tons, registering a growth of 5.6 million tons between 2011-13. To put things in perspective, the comparable figures for growth in oilseeds production was a measly 1.6 million tons for the period 1995-97. The "miracle crop" in the oilseed segment has been soybean which registered a doubling of production growth in those 8 years. Cash crops including cotton and sugarcane also showed good growth rates in production during this period. The production of sugarcane which had stagnated at around 300 million tons in 1999-2000 saw a sharp recovery post 2006-07 and reached a peak of 350 million tons in 2012-13. This of course created huge surplus of supply of sugar in the country.

7.1.2 CROPPING PATTERN OF MAHARASHTRA

Keeping in line with the trends at the macro level, the agricultural sector in Maharashtra also witnessed key changes in the cropping pattern over the decades since Independence. The period before the Green Revolution showed an expansion in the area under cereals and pulses. However, the low yield levels of these crops offset the increase in production due to increase in area. The period of Green Revolution between mid 1960s and up to 1980 showed a significant rise in the production of food grains (5% p.a.) due to increased productivity brought about by improved inputs. This is significant considering that area under food grains cultivation expanded by hardly 1%. This period also saw a decline in the area under groundnut cultivation. This trend was slightly reversed in the post green revolution period. Between 1980-81 and 1989-90, the production and productivity of all crops, notably pulses and oilseeds, witnessed an increase in production due to increase in productivity. The exceptions to this trend were wheat, sugarcane and rice where production actually fell due to reduction in area (for wheat and sugarcane) and due to reduction in productivity (for rice). Further, in the post liberalization era, up to 2005, production and productivity fell across all crop categories. This was particularly seen with respect to cereals where reduction in area led to a fall in production, especially for coarse cereals like jowar and bajra. The reduction in area under jowar was primarily the reason for a decline in the area under cereals by over 15% between 1965 and 2005. However, maize in spite of being a coarse cereal was a huge gainer with area, production and productivity increasing steadily over this period. There has been a modest increase in the area under pulses (of around 3 percent) for the same period. The biggest gainer has been the oilseeds category, primarily due to expansion in area soybean since 1990s in a very big way. Even cash crops like cotton and sugarcane which were favoured by farmers since the time of green revolution saw a contraction in are by 0.4 m ha and 1 per cent of the GCA respectively.

7.2 FINDINGS

This study has been conducted in three respects:

1. Pune's cropping pattern with respect to irrigation
2. Pune's cropping pattern with reference to 13 major crops between 2000-01 to 2016-17.
3. Pune's cropping pattern with reference to selected cash crops, viz., maize, soybean and sugarcane between 1991-92 and 2017-18.

7.2.1 PUNE'S IRRIGATION SCENARIO

Pune's agricultural sector is mostly dependent on rainfall and as such the rabi crop is the dominant season vis a vis kharif, summer and annual crops. An analysis of the Gross Cropped Area across crop categories reveals that coarse cereals occupy a prominent position (almost 52%), while cereals occupy only one eighth of the area (12.54%) in the district. Pulses and oil seeds together occupy below 15% of the total area under cultivation while area under cotton is negligible. Apart from coarse cereals, the other prominent crops are sugarcane and horticultural crops, each occupying around 10% of the total cultivated area. The shift towards horticultural crops is comparatively recent and is finding favor with farmers due to the increasing demand for fruits and vegetables and hence rising prices in the urban centers with increasing income levels. Being geographically situated in the scarcity zone, a little over 35% of the land under cultivation is irrigated. A lion's share of this irrigation (around 30%) is allocated towards the cultivation of sugarcane. While sugarcane is cultivated under 100% irrigation conditions, a high proportion of horticultural crops also receives irrigation. It was also found that the production of rainfed crops was more than that of irrigated crops. However, the productivity as well as the cost of cultivation was higher for the irrigated crops than the rainfed crops.

7.2.2 PUNE'S CROPPING PATTERN WITH REFERENCE TO 13 MAJOR CROPS

Traditionally, jowar and bajra were cultivated in Pune as food crops. The concept of cultivating cash crops gained tract due to the green revolution much like in the rest of the country. Thus, the coarse cereals have been increasingly replaced by more high value crops namely, rice, wheat, and sugarcane. While the post liberalization period saw a stagnation in the agricultural sector in Pune too in keeping with the macro trends, post the policy reforms introduced to give a boost to the farm sector, the production and productivity across crop categories saw remarkable improvement. To ascertain the changes in the cropping pattern of Pune district over the last two decades the area, production, and productivity of 13 major crops was analyzed for the three periods, 2000-01, 2007-08 and 2016-17.

Cereals:

Area under rice has declined marginally while that under wheat has increased. However, area under jowar and bajra have declined significantly. It was also seen that while the production of rice and jowar increased considerably over the two periods and the productivity of rice and wheat have increased to a certain extent but the productivity of jowar and bajra have declined. **The star performer is maize with area remaining almost the same between 2000-01 and 2007-08 but increasing 2.5 times between 2007-08 and 2016-17 from 16600 ha to 42600 hectares. Production increased three times between first and second period (15100 tonnes to 45200 tonnes) and jumped almost 3 times from 45200 to 129500 tonnes between 2007-08 and 2016-17. Again, yield of maize increased three times in the second period vis a vis the first period but only improved marginally in the third period from 2722 to 3040 kg/ha.**

Pulses:

Area under moong and gram has increased significantly, while area under tur and udid have declined considerably. Moong and gram have also shown improvement in production, but while the productivity of gram has increased, the productivity of moong has declined. For tur and udid, while production declined for both the pulses, the yield for tur has increased dramatically, while the yield for udid has fallen drastically.

Oilseeds:

Among the oilseeds, while safflower production declined gradually and has been completely stopped, groundnut area and production has also gone down considerably with yield stagnating. **The star performer among oilseeds is soybean with area increasing from a negligible 700 hectares in 2000-01 to nearly 18000 hectares in 2016-17. Production of soybean increased from 600 tonnes to 5200 tonnes and finally to 38300 tonnes over the three periods while productivity doubled from 857 to 1733 kg/ha in the second period over the first period and then to 2131 kg/ha in the third period.**

Most importantly, **sugarcane area and production doubled between 2000-01 and 2007-08. It remained at the same level for the third period, 2016-17, but yield levels have remained the same for all the three periods thus showing stagnation.**

7.2.3 PUNE'S CROPPING PATTERN WITH REFERENCE TO SELECTED CASH CROPS VIZ., MAIZE, SOYBEAN AND SUGARCANE BETWEEN 1991-92 AND 2017-18.

Maize

1. The comparison of prices at the macro and district levels (MSP recommended by CACP and FHP at Pune) showed that there was not much divergence between the two.
2. Average Area, Average Production, and Average FHP of maize showed huge increases between TE 1993-94 and TE2005-06 and also between TE 2005-06 and TE2017-18; the growth in the second period was higher than in the first period. However, yield of maize showed little increase in the first period and actually declined in the second period.
3. All the three variables, Average Area, Average Production and Average Yield showed a very high correlation to the Average FHP of maize.
4. The results of simple regression analysis showed that the null hypotheses Ho1 and Ho2 can be rejected and alternative hypotheses Ha1 and Ha2 can be accepted.
5. The residual output showed a linear correlation between Area and FHP as also between Production and FHP for maize.

Soybean

1. Overall, the FHP of soybean in Pune has been higher than the MSP recommended by CACP but it has fallen in the last 2 years of the study period.
2. Average Area, Average Production, and Average FHP (to some extent) of soybean showed incremental changes between TE1993-94 and TE2005-06 but showed exponential growth between TE 2005-06 and TE2017-18. However, yield of soybean showed little increase in the first period and actually declined in the second period.
3. While the Average Area and Average Production showed high correlation to FHP of soybean, Average Yield of soybean is not highly correlated to the FHP of soybean.
4. The results of simple regression analysis showed that the null hypotheses Ho3 and Ho4 can be rejected and alternative hypotheses Ha3 and Ha4 can be accepted.
5. The residual output showed a linear correlation between Area and FHP as also between Production and FHP for soybean.

Sugarcane

1. While the trends in the SMP/FRP of sugarcane at the all-India and district levels are the same, the rates paid by the sugarcane mills in Pune have generally been slightly lower than that recommended by CACP, and the gap is increasing in recent times due to the levy of Harvest and Transportation charges by the mills in Pune.

2. Area under sugarcane had been fluctuating in the first period and actually declined between TE1993-94 and TE2005-06, but after TE2008-09 it expanded greatly, increasing almost 3 times. Production of sugarcane showed incremental changes between TE 1993-94 and TE2005-06 but showed exponential growth between TE2005-06 and TE2017-18. SMP/FRP had been increasing gradually in the first period, but has seen massive increase in the second period. However, yield of sugarcane has shown little improvement in the first period while actually declining in the second period.

3. All the three variables, Average Area, Average Production, and Average Yield are highly correlated to the SMP/FRP of sugarcane.

4. The results of simple regression analysis showed that the null hypotheses Ho5 and Ho6 can be rejected and alternative hypotheses Ha5 and Ha6 can be accepted.

5. The residual output showed a linear correlation between Area and FRP as also between Production and FRP for sugarcane.

7.3 CONCLUSIONS

1. In the case of all the three crops the FHP/FRP obtained in Pune was in keeping with the trends at the all India level; i.e. the MSP recommended by CACP.

2. The trends showed that in the case of all the three crops, **area and production had been increasing gradually (fluctuating in the case of sugarcane) in the first period of the study, between TE1993-94 and TE2005-06, but showed massive increase in the second period of the study, between TE 2008-09 and 2017-18.**

3. The **FHP/FRP of all the three crops showed incremental increase in the first period (greater increase in the case of maize), and huge increases in the second period**. **Thus, prices obtained by farmers for their produce influences cropping pattern in a big way.**

4. The yield levels of all the three crops increased marginally in the first period and fell

in the second period.

5. The variables Average Area, Average Production and Average Yield are highly correlated **to the Average FHP/FRP for all the three crops (except Average Yield of soybean).**

6. The Simple Regression Analysis led to the following conclusions:

1. The **first Null hypothesis** that there is no significant relationship between the area under maize and FHP of maize is **rejected**. The **first Alternative hypothesis** that there is a significant relationship between the area under maize and the FHP of maize is **accepted**.
2. The **second Null hypothesis** that there is no significant relationship between the production of maize and FHP of maize is **rejected**. The **second Alternative hypothesis** that there is a significant relationship between the production of maize and the FHP of maize is **accepted**.
3. The **third Null hypothesis** that there is no significant relationship between the area under soybean and FHP of soybean is **rejected**. The **third Alternative hypothesis** that there is a significant relationship between the area under soybean and the FHP of soybean is **accepted**.
4. The **fourth Null hypothesis** that there is no significant relationship between the production of soybean and FHP of soybean is **rejected**. The **fourth Alternative hypothesis** that there is a significant relationship between the production of soybean and the FHP of soybean is **accepted.**
5. The **fifth Null hypothesis** that there is no significant relationship between the area under sugarcane and FRP of sugarcane is **rejected**. The **fifth Alternative hypothesis** that there is a significant relationship between the area under sugarcane and the FRP of sugarcane is **accepted.**
6. The **sixth Null hypothesis** that there is no significant relationship between the production of sugarcane and FRP of sugarcane is **rejected**. The **sixth Alternative hypothesis** that there is a significant relationship between the production of sugarcane and the FRP of sugarcane is **accepted**.

7.4 SUGGESTIONS

Using the TREND function in EXCEL, a forecast was made regarding the total area under cultivation of the three crops over the next five years. The figure thus obtained was then used to run an optimization model which provided an alternative cropping pattern to the current one and which will be economically viable and environmentally sustainable.

Crops	Area (in hectares)	Production (in Mt)	Yield (tons/ha)
Maize	96554.25	531048	5.50
Soybean	51640.32	146142	2.83
Sugarcane	51640.32	5164027	100.00
Total	199834.88		

The table has been reproduced here for reference. Since the area under cultivation is under stress due to fast urbanization, improving yield levels becomes crucial not just to maintain same levels of production but to augment production for meeting increasing demands of an ever-growing population. While the yield levels of soybean are good at the current level (2.02 tons/ha) and need moderate improvements, the yield level of sugarcane in Pune is already way above the world average of 75 tons/ha at 117 tons/ha. Hence, allowing for a reduction in the sugarcane yields and aiming for massive improvement in maize yield (from 3.10 ton/ha to 5.5 tons/ha), this model aims at reallocating land under cultivation from sugarcane towards maize and soybean. Thus, area under maize and soybean are doubled from the levels existing in 2017-18 while that under sugarcane is halved. Further, the production of maize and soybean are increased three times from the levels existing in 2017-18 while that of sugarcane is reduced by a third. Given the glut of sugarcane production in the market, such a reduction will do well to set right the imbalance between sugar prices and sugarcane prices. **Invaluable irrigation will also be made available to the water starved crops maize and soybean which will massively upgrade their yield levels.** It has already been mentioned in chapter 1 that studies in US have shown maize yields to increase by 30%. Again, though area under soybean cultivation has been increasing exponentially and soybean yields are also reasonably good in Pune, irrigation coverage for soybean has steadily been declining. This definitely needs to be set right.

Other studies have shown the efficacy of alternating sugarcane cropping with maize:
"On the basis of returns per rupee of investment among all the cropping systems for the system as a whole, CS-I (Sugarcane +Maize) found to be the most profitable (1.62) under irrigated condition followed by CS-III (1.39), CS-II (1.35) and CSIV (1.20), which is the least profitable

cropping systems in the study area. Therefore, it is advisable to follow the CS-I which comprises of Sugarcane +Maize" (Shinde et al, 2009, pp 823).

1. Thus, **reallocating land under sugarcane** which is neither economically viable nor environmentally sustainable towards more sturdy crops like maize and soybean which have become very important cash crops as well as are suited for the semi-arid climatic condition of Pune is highly recommended. The government is already mulling banning sugarcane cultivation in drought prone areas in Maharashtra.
2. The reduction in land under sugarcane cultivation would make excess irrigation available and the government must ensure a more equitable distribution towards other important crops like rice, jowar, wheat, pulses and groundnuts. This would enhance the productivity of these crops manifold and thus increase the income levels of small and marginal farmers greatly.
3. It is seen that higher MSPs are encouraging the farmers to go in sugarcane cultivation. As has been brought out in the data analysis, unlike sugarcane, the FHP of soybean has a high, but not very high correlation with the area and production of soybean. As such, the government should guarantee farmers of assured procurement of soybean at MSPs which are remunerative to the farmers. Moreover, the MSP should be calculated as recommended by Swaminathan Commission to include the imputed costs of land and other fixed assets.
3. The government has fixed MSP of sugar so that mills are able to obtain minimum prices (which will at least cover their cost of production) which they can pay to the cane growers. Instead of this, the **sugarcane prices should be linked with sugar prices** (allowing sugarcane prices to fall when there is a glut of sugar production) and thus discourage the farmers to go in for sugarcane cultivation. **Deregulation of the sugarcane industry** and making it competitive is required to be done on a war footing.
4. At the same time **agricultural extension, credit, insurance, improving seed quality and variety etc.,** have to go hand in hand.

The study has thus fulfilled its objectives in the following ways:

i. **To review the cropping pattern in Pune district**: This has been done by analysing the cropping pattern in the district with reference to irrigation scenario using data for 2015 and also analysing the trends in area, production, and yield of thirteen major crops in the district between 2000-01 and 2016-17.

ii. **To analyse the area, production, and yield of selected cash crops in the period between 1991-92 and 2017-18 in Pune district**: For this, the relevant data for the three selected cash crops, namely maize, soybean, and sugarcane was analysed for the said period.

iii. **To analyse the trends in prices of selected cash crops in the study period**: This has been done by analysing the trends of the MSP/FRP at the macro level and comparing it with the trends in the actual FHP/FRP obtained by farmers in Pune district for the selected cash crops.

iv. **To study the impact of prices obtained by farmers for their produce on the cropping pattern with reference to the selected cash crops**: The trends showed that in the case of all the three crops, area and production had been increasing gradually (fluctuating in the case of sugarcane) in the first period of the study, between TE 1993-94 and TE 2005-06, but showed massive increase in the second period of the study, between TE 2008-09 and TE 2017-18. The FHP/FRP of all the three crops showed incremental increase in the first period (greater increase in the case of maize), and huge increases in the second period. Thus, prices obtained by farmers for their produce influences cropping pattern in a big way.

v. **To suggest policy measures for changing the cropping patterns with a view to achieving commercial viability and sustainability in agriculture in Pune district**: The Optimization model has been used to suggest the proportion of area that can be reallocated among the three crops so as to maximize yield and sustainability. Other policy measures such as decontrolling sugar industry, increased investment in seed variety, ensuring irrigation on a more equitable basis, implementation of MSP as recommended by Swaminathan Commission etc., have to be used to promote maize and soybean and discourage sugarcane cultivation.

It must be noted that a diversified cropping pattern has proved to be highly remunerative in Nashik district. Both Pune and Nashik are similar in terms of geographical area; but in terms of district GVA, per capita GVA, share of district GVA in the state GVA, and total irrigated area, Pune is far ahead of Nashik. Yet, the value of agricultural income generated by Nashik is twice that of Pune. An overview of the cropping pattern in Nashik revealed that the district has nearly 8 times the area under maize and 4 times the area under soybean as Pune. Also, giving importance to food security, the district has twice the area under rice as Pune. Even though a sizable area in Nashik is under cotton cultivation (42,500 ha), this water guzzling cash crop is cultivated as a kharif crop under rainfed conditions. Thus, whatever limited irrigation facility is available in Nashik is being utilized in such an optimum manner as to generate double the agricultural income level of Pune. Further research however needs to confirm these findings. Further research could also focus on studying the profitability of various crop categories being cultivated under irrigated conditions, (primarily horticultural crops in recent times) and bring to light an optimum allocation of irrigation to various crop categories.

REFERENCES

Shinde, N. Patil, B. L. Murthy, C. and Desai, N. R. M. (2009). Profitability analysis of sugarcane based inter cropping systems in Belgaum district of Karnataka. *Karnataka J. Agric. Sci., 22 (4) : (820-823) 2009*.

District Socio Economic Review (Nashik, 2019). Directorate of Economics and Statistics, Planning Department, Government of Maharashtra, India.

BIBLIOGRAPHY

BOOKS

Debertin, L. D. (2012). *Agricultural Production Economics*. Second Edition, Amazon Createspace. ISBN-13 978-1469960647.

Ercolani, M. G., & Wei, Z. (2010). *An empirical analysis of the Lewis-Ranis-Fei theory of dualistic economic development for China*. Department of Economics, University of Birmingham.

Expert Consultation. (2000). *Crop Diversification in the Asia Pacific Region.* Food and Agriculture Organization of the United Nations. Thailand.

Kalamkar, S. S. (2011). Agricultural Growth and Productivity in Maharashtra, Trends and Determinants. Allied Publishers, New Delhi.

Lele, U. Agarwal, M. Goswami, S. (2018). *Patterns of Structural Transformation and Agricultural Productivity Growth (With Special Focus on Brazil, China, Indonesia and India).*

Mellor, W. J. (2017). *Agricultural Development and Economic Transformation*: *Promoting Growth with Poverty Reduction*. Palgrave Studies in Agricultural Economics and Food Policy. ISBN 978-3-319-65258-0. A Palgrave Macmillan imprint published by Springer International Publishing, Switzerland. https://doi.org/10.1007/978-3-319-65259.7.

Mitra, K. A. (1996). *Agricultural Output Cost Pricing Analysis: Issues in the context of economic liberalization in India*. Gokhale Institute of Politics and Economics, Pune.

Rana, S.S. and Rana M.C. (2011). *Cropping System.* Department of Agronomy, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur.

JOURNAL ARTICLES/PAPERS

Abnave, V. B. and Babu, M.D. (2017). *State Intervention: A Gift or Threat to India's Sugarcane Sector?* Working Paper 385. ISBN 978-81-7791-241-8. The Institute for Social and Economic Change, Bangalore. Accessed on 25/09/2018

Acharya, S. P. Basavaraja, H. Kunnal, L. B. Mahajanashetti, S. B. and Bhat, A. R. S. (2012). Growth in area, production and productivity of major crops in Karnataka. *Karnataka J. Agric. Sci.,25 (4) : (431-436).*

Alston J. M. and P. G. Pardey (2017), Transforming Traditional Agriculture Redux, Working Paper Series No 260, African Development Bank, Abidjan, Côte d'Ivoire.

Ayalew, B. Sekar, I. (2015). Profitability of Coarse Cereals Production in India. International Letters of Natural Sciences. Vol 39. pp 10-19. SciPress Switzerland. Online: 2015-05-12.

Bhalla, G. S., & Singh, G. (1997). *Recent Developments in Indian Agriculture: A State Level Analysis.* Economic and Political Weekly, 32(13), A2–A18. Accessed on 25/09/2018.

Bhalla, G. S., & Singh, G. (2009). *Economic liberalisation and Indian agriculture: a State wise analysis.* Economic and Political Weekly, xliv(52), 34–44. Accessed on 25/09/2018.

Chand, R. (2003). Minimum Support Price in Agriculture: Changing Requirements. *Economic and Political Weekly July 19, 2003* pp: 3027-3028.

Chand, R. (2014). *From Slowdown to Fast Track: Indian Agriculture since 1995.* Working Paper 01/2014. National Centre for Agricultural Economic and Policy Research. Retrieved from http://www.ncap.res.in/upload_files/Slowdown_final for printing.pdf. Accessed on 25/09/2018.

Chand, R. and Parappurathu, S. (2012). Temporal and Spatial Variations in Agricultural Growth and Its Determinants. *Economic & Political Weekly Supplement*. June 30, 2012 Vol XLVII Nos 26 & 27. pp 55-64.

Dandekar, A. Bhattacharya, S. (2017). Lives in Debt: Narratives of Agrarian Distress and Farmer Suicides. *Economic and Political Weekly*. Vol XXI, No 21, pp 77-84.

Dantwala, M. L.. (1986). Prices and Cropping Pattern. *Economic and Political Weekly*, April 19, 1986. pp 694-695.

Das, P. (2006). *Cropping pattern (agricultural and horticultural) in different zones, their average yields in comparison to national Average/Critical Gaps/Reasons identified*. Indian Council of Agricultural Research, New Delhi, pp 33–47. Retrieved from https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwil66Pfjd3dAhUHKY8KHXaSCDcQFjAAegQICRAC&url=http%3A%2F%2Fwww.insightsonindia.com%2Fwp-content%2Fuploads%2F2013%2F08%2Fcrop-pattern-in-india.pdf&usg=AOvVaw2AlZPA8D4QdUPw0VGMRZoI. Accessed on 25/09/2018

Dev, Mahendra. (2012). Small Farmers in India: Challenges and Opportunities. Indira Gandhi Institute of Development Research, Mumbai. WP-2012-14. Retrieved from: https://www.researchgate.net/publication/241757590.
Accessed on 23/09/2018.

Fan, S. (2012). Can we free the world of hunger and Malthus's shadow forever? *The Crawford Fund for International Agricultural Research*, Australia. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwjOrZ703ufeAhVBto8KHUaZDDMQFjABegQIBRAC&url=https%3A%2F%2Fageconsearch.umn.edu%2Fbitstream%2F152407%2F2%2FFan2012.pdf&usg=AOvVaw3Dz6tYYeVifnEEF9xfbbRv

Gouel, C. (2012). Agricultural price instability: a survey of competing explanations and remedies. *Journal of Economic Surveys*, Wiley, 2012, 26 (1), pp.129-156. 10.1111/j.1467-6419.2010.00634.x. hal-01001218.

Jha, D. and Maji, C.C. (1971). Cobweb Phenomenon and Fluctuations in Sugarcane Acreage in North Bihar. *Indian Journal of Agricultural Economics*. Vol XXVI, No. 4. Oct-Dec 1971.. pp 415: pp 421. ISSN:0019-5014. Indian Society of Agricultural Economics, Bombay.

K., M. L. , R., W. , N., W. , P., B. , & S., S. (2016). Maize Utilization in India: An Overview. *American Journal of Food and Nutrition*, *4*(6), 169-176. Retrieved from: http://pubs.sciepub.com/ajfn/4/6/5

Kajale, J. S. and Bodkhe, N. (2016) Soybean Sector in Maharashtra: Bring Hope, Not Distress. *Agricultural Situation in India*. Directorate of Economics and Statistics.

Kothari, C. R. (2004). *Research Methodology, Methods and Techniques*. New Age International Publishers. New Delhi.

Kshirsagar, K. G. (2008). *Impact of Organic Farming on Economics of Sugarcane Cultivation in Maharashtra.* Gokhale Institute of Politics and Economics, Pune. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiD9rnboujeAhXHeisKHe1zB54QFjAAegQICxAC&url=http%3A%2F%2Fwww.indiaenvironmentportal.org.in%2Ffiles%2Fw15kgk.pdf&usg=AOvVaw1QzlOv197bb7FkvPaU-VrQ

Kumar, P. and Mittal, S. (2006). Agricultural Productivity Trends in India: Sustainability Issues. *Agricultural Economics Research Review*. Vol. 19 (Conference No.) 2006 pp 71-88.

Kumar, S. and Gupta, S. (2015). "Crop diversification in India: Emerging trends, determinants and policy implications". *International Journal of Current Research, 7, (6), 17188-17195.*

Lalvani, M. (2008). Sugar Co-operatives in Maharashtra: A Political Economy Perspective. *The Journal of Development Studies*. 44. 1474-1505. 10.1080/00220380802265108.

Lundahl, M. (1987) 'Efficient but Poor', — Schultz' Theory of Traditional Agriculture, Scandinavian Economic History Review, 35:1, 108-129, DOI:10.1080/03585522.1987.10408083 https://doi.org/10.1080/03585522.1987.10408083

Mandal, R and Bezbaruah, M.P. (2013). Diversification of Cropping Pattern: Its Determinants and Role in Flood Affected Agriculture of Assam Plains. *Ind. Jn. of Agri. Econ. Vol.68, No.2, April-June 2013.* Pp 169-181.

Mason, O. J. (2012). Performing Regression Analysis Using Microsoft Excel. *International Journal of Arts and Commerce*. Vol 1. No. 5.

Mohan, G. (2017). Determinants of Cropping Pattern Changes in Andhra Pradesh, India. *Asian Journal of Agricultural Extension, Economics &Sociology*. 20(3): 1-15, 2017; Article no. AJAEES.36892. ISSN: 2320-7027.

Mruthyunjaya and Praduman Kumar. (1989). Crop Economics and Cropping Pattern Changes. *Economic and Political Weekly, Dec 23-30, pp A159-A166.* https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwinhM3_z9XdAhVEU30KHSwcD5kQFjABegQICRAB&url=https%3A%2F%2Fwww.epw.in%2Fjournal%2F1989%2F51-52%2Freview-agriculture-uncategorised%2Fcrop-economics-and-cropping-pattern-changes.html&usg=AOvVaw1tg8NOmpBgNIEY5tsXlf8l

Narayanamoorthy. (2013). Profitability in Crops Cultivation in India: Some Evidence from Cost of Cultivation Survey Data. *Indian Journal of Agricultural Economics*. Vol.68, No.1, Jan.-March 2013.

Nayak, D.K. (2016). Changing Cropping Pattern, Agricultural Diversification and Productivity in Odisha – A District-wise Study *Agricultural Economics Research*

Review. Vol. 29 (No.1) January-June 2016 pp 93-104 DOI: 10.5958/0974-0279.2016.00022.7

Orlov, L.M. (1996). Multiple Linear Regression Analysis using Microsoft Excel. Handout published by Chemistry Department, Oregon State University.

Pretty, J. (2008). Agricultural sustainability: concepts, principles and evidence. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *363*(1491), 447–465. http://doi.org/10.1098/rstb.2007.2163.

Ray, S. K. (2017). "Economics of Change in Cropping Pattern in Relation to Credit: A Micro Level Study in West Bengal". *Ind. Jn. of Agri. Econ. Vol.62, No,2 April-June 2007.* pp 216-231.

Saha, J. (2013). "Crop Diversification in Indian Agriculture with Special Reference to Emerging Crops". *Transactions* | *Vol. 35, No. 1, 2013* | pp 139-147.

Shinde, M. V. (2016). *Recent Trends in Agricultural Diversification*. VOLUME-III, ISSUE-VII ISSN (Online): 2350-0476 ISSN (Print): 2394-207X IMPACT FACTOR: 4.205 INTERNATIONAL JOURNAL OF MULTIFACETED AND MULTILINGUAL STUDIES. Retrieved from eprints.icrisat.ac.in/14407/1/IJMMS_3_7_1-8_2016.pdf Accessed on 21/09/2018.

Shinde, N. Patil, B. L. Murthy, C. and Desai, N. R. M. (2009). Profitability analysis of sugarcane based inter cropping systems in Belgaum district of Karnataka. *Karnataka J. Agric. Sci., 22 (4) : (820-823) 2009.*

Singh, H. S. (1962). *Changes in Cropping Pattern: Economic Criteria.* The Economic Weekly. Vol. 14, Issue No. 24, pp. 951-954. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&cad=rja&uact=8&ved=2ahUKEwjLnLqal6neAhXCbSsKHQttB0oQFjABegQIBxAC&url=https%3A%2F%2Fwww.epw.in%2Fsystem%2Ffiles%2Fpdf%2F1962_14%2F24%2Fchanges_in_cropping_patterneconomic_criteria.pdf&usg=AOvVaw2R0AGXaXXmpmcgyDvNZ6ah

Xie, H. and Wang, B. (2017). An Empirical Analysis of the Impact of Agricultural Product Price Fluctuations on China's Grain Yield. *Sustainability*, 2017, 9, 906. www.mdpi.com/journal/sustainability. Doi:10.3390/su9060906.

REPORTS

Annual Report 2017-18. Department of Agriculture, Cooperation and Farmers' Welfare. Extracted from agricoop.nic.in (Documents/Reports and Publications). Accessed on 23/09/2018.

Bhadwal, S., Ghosh S., Joshi, P.K., Mahtta, R. and Barkved, L. (2014). "*Assessment of potential impacts on dryland ecosystems of Jalna District, Maharashtra, India*". Final report on WP2.1: Extreme Risks, Vulnerabilities and Community-based Adaptation in India (EVA): A Pilot Study, CIENS-TERI, TERI Press, New Delhi, India

Bisaliah, S. (1986). *Soyabean Development in India*. CGPRT Centre. Retrieved from:https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwjCwsGsq-feAhXEOY8KHdQwA0IQFjAAegQIChAC&url=http%3A%2F%2Feprints.icrisat.ac.in%2F12155%2F1%2FRP-04796.pdf&usg=AOvVaw17gvnCsE6wSFPD24avaVoX

Comprehensive District Agricultural Plan: 2012-13 to 2016-17. (2012) Department of Agriculture, Government of Maharashtra. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiJ9JmO0tPeAhXFO48KHThhDfIQFjAAegQICBAC&url=http%3A%2F%2Fkrishi.maharashtra.gov.in%2FSite%2FUpload%2FPdf%2Fpune_cdap.pdf&usg=AOvVaw2krcvsuhWc3XUk9-Cf8WB0

Deshpande, T. (2014). *State of Agriculture in India*. PRS Legislative Research, (113), 1–29. Extracted from https://www.google.com/search?client=safari&rls=en&q=www.prsindia.org/uploa

ds/media/Analytical%2520Report/State%2520of%2520Agriculture%2520in%2520+India.pdf&ie=UTF-8&oe=UTF-8. Accessed on 23/09/2018

District Socio Economic Reviews (Pune, Mumbai, Thane, Nashik). Directorate of Economics and Statistics, Planning Department, Government of Maharashtra, India.

Economic Survey of Maharashtra 2017-18, 2019-20. Department of Economics and Statistics, Planning Department. Government of Maharashtra. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiVoez6ltHeAhXPXCsKHSk5BaYQFjAAegQICBAC&url=https%3A%2F%2Fmahades.maharashtra.gov.in%2Ffiles%2Fpublication%2FESM_17_18_eng.pdf&usg=AOvVaw3kMJ16TsOYNHQze3rLdfg1

Evaluation of the PPPIAD Project on SOYBEAN.(2014). FICCI. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=8&ved=2ahUKEwjf_MjW6OfeAhUlSo8KHa1WCvQQFjAHegQICBAB&url=http%3A%2F%2Fficci.in%2Fstudy-page.asp%3Fspid%3D20539%26sectorid%3D1&usg=AOvVaw1Z8YJJPgcJ5vSaLfG505ot

Evaluation Report On Efficacy of Minimum Support Prices (MSP) on Farmers (DMEO Report No.231). (Jan 2016). NITI Aayog.

India Grain and Feed Annual. (2016). GAIN Report Number: IN6033. Retrieved from:https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual_New%20Delhi_India_2-26-2016.pdf.

India Sugar Annual. (2018). GAIN Report Number: IN8047. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwiihtba-efeAhVJO48KHZe6BpAQFjAAegQICxAC&url=https%3A%2F%2Fgain.fas.usda.gov%2FRecent%2520GAIN%2520Publications%2FSugar%2520Annual_New%2520Delhi_India_4-19-2018.pdf&usg=AOvVaw0OZAXNzf9qI57y9m86rZqj

Jha, B. Kumar, N. and Mohanty, B. (2009). "*Pattern of Agricultural Diversification in India*". Institute of Economic Growth, University of Delhi Enclave.

Kalamkar, S.S. (2007). "*Agricultural Development and Sources of Output Growth in Maharashtra State*," Working Papers id:860, eSocialSciences.

Kannan, E. (May 2011). "*Determinants of Stagnation in Productivity of Important Crops (Consolidated Report)*". Agricultural Development and Rural Transformation Centre. Institute for Social and Economic Change, Bangalore. Research Report XI/ADRTC/127.

Kannan, E. and Sundaram, S. (2011). "*Analysis of Trends in India's Agricultural Growth*". Institute for Social and Economic Change. Working Paper 276.

Kumar, R., K. Srinivas and N. Sivaramane (2013), Assessment of the maize situation, outlook and investment opportunities in India. Country Report – Regional Assessment Asia (MAIZE-CRP), National Academy of Agricultural Research Management, Hyderabad, India.

Lundahl, M. (1987) 'Efficient but Poor', — Schultz' Theory of Traditional Agriculture, Scandinavian Economic History Review, 35:1, 108-129, DOI:10.1080/03585522.1987.10408083 https://doi.org/10.1080/03585522.1987.10408083

Maize in India. (2014). India Maize Summit – 2014. FICCI, KPMG, NCDEX. Retrieved from:http://ficci.in/spdocument/20386/India-Maize-2014_v2.pdf.

Maize Vision 2022. Agricultural Division, The Federation of Indian Chambers of Commerce and Industry (FICCI). March 2018.

Mechri, A. Lys, P. Cachia, F. (2017). Productivity and Efficiency Measurement in Agriculture. Food and Agriculture Organisation, United Nations.

OECD-FAO Agricultural Outlook 2018-2027, OECD Publishing, Paris/Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.1787/agr_outlook-2018-en

Pramanik, S. Dhumale, A.B. Duche, V.D. Khan, P.E. and Deb, U. (2015). "*Rapid Changes In Cropping Pattern in Akola Villages: Extent, Determinants and Policy Implications"*. International Crops Research Institute for the Semi-Arid Tropics, (ICRISAT) India.

Price Policy for Kharif Crops: The Marketing Season 2017-18. Commission for Agricultural Costs and Prices. Department of Agriculture, Cooperation and Farmers Welfare. New Delhi, March 2017.

Price Policy for Sugarcane: the 2012-13 Sugar season. Commission for Agricultural Costs and Prices. Ministry of Agriculture, Government of India. Retrieved from: https://cacp.dacnet.nic.in

Price Policy for Sugarcane: the 2014-15 Sugar season. Commission for Agricultural Costs and Prices. Ministry of Agriculture, Government of India.Retrieved from: https://cacp.dacnet.nic.in

Price Policy for Sugarcane. 2017-18 Sugar Season. Commission for Agricultural Costs and Prices. Department of Agriculture, Cooperation and Farmers Welfare. New Delhi, March 2017.

Pune District Marketing Strategy Supplement (MSS). (2016). Maharashtra Agricultural Competitiveness Project. Retrieved from: https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwib5e-tlejeAhWMr48KHQfBCNgQFjAAegQICRAC&url=http%3A%2F%2Fmacp.gov.in%2Fsites%2Fdefault%2Ffiles%2Fuser_doc%2FPune%2520MSS_0.pdf&usg=AOvVaw2AfgvxeQ0F0Q_MGywTBOBh

Sawant, S.D. Kulkarni, B.N. Achutan, C.V. and Satyasai, K.J.S. (1999). "*Agricultural Development in Maharashtra: Problems and Prospects*". Occasional Paper – 7. NABARD, Mumbai.

Sharma, B. Gulati, A. Mohan, G. Manchanda, S. Ray, I and Amarasinghe, U. (2018). "*Water Productivity Mapping of Major Indian Crops*". NABARD and ICRIER. Mumbai and Delhi.

Status Paper On Coarse Cereals, Directorate Of Millets Development, Jaipur, Department Of Agriculture And Cooperation, Ministry Of Agriculture, Government Of India, March 2014.

Status Paper on Sugarcane. DIRECTORATE OF SUGARCANE DEVELOPMENT, GOVT. OF INDIA, Ministry of Agriculture, January 2013.

Vishandass, A. and Lukka, B. (2013). "*Pricing, Costs, Returns and Productivity in Indian Crop Sector during 2000s"*. Commission for Agricultural Costs and Prices. Discussion Paper No. 7.

THESES

Joshi, V. J. (2015). "*An analytical study of changing cropping pattern in Maharashtra for the period of 1991 to 2012*". Tilak Maharashtra Vidyapeeth. http://hdl.handle.net/10603/106318

Kalaskar, P. (2006). "*Economic appraisal of agricultural development of Yavatmal district in Maharashtra*". Mahatma Phule Krishi Vidyapeeth http://krishikosh.egranth.ac.in/handle/1/96801

Kamble, C. P. (2016). "*A study of economic efficiency of farmers in agriculture in Pune district_2001 to 2010*". Savitribai Phule Pune University. http://hdl.handle.net/10603/175043

Najan, R. E. (2015). "*Changes in cropping pattern in South East part of Ahmed Nagar district from the period 1970-2010*". Savitribai Phule Pune University. http://hdl.handle.net/10603/77999

Patil, S. G. (2012). "*Spatio temporal analysis of agricultural land use pattern in Pune district*". Tilak Maharashtra Vidyapeeth. http://hdl.handle.net/10603/5666.

Tupe, B.K. (2014). "*Landuse and cropping pattern changes: a case study of Akole tahsil in Ahmednagar district*". Savitribai Phule Pune University. http://hdl.handle.net/10603/99860

WEBSITES

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwiAt9fG9NDdAhUPfSsKHb9WCE4QFjAAegQIABAC&url=http%3A%2F%2Feagri.org%2Feagri50%2FAGRO101%2Flec15.pdf&usg=AOvVaw0AmimCVag8ppaNT-M3OTKb.
(Cropping pattern and cropping system - Intensive cropping- Sustainable agriculture – IFS)
Accessed on 23/09/2018.

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=13&cad=rja&uact=8&ved=2ahUKEwjM3qr8wN_dAhXKvI8KHbmuBN4QFjAMegQICxAB&url=https%3A%2F%2Fwww.nal.usda.gov%2Fafsic%2Fsustainable-agriculture-definitions-and-terms&usg=AOvVaw2rqHvypbd2Drkdl4z8Gbqi
(United States Department of Agriculture)
Accessed on 29/09/2018.

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiCsozK1vnpAhUTfisKHQ9mCMEQFjADegQIAxAB&url=https%3A%2F%2Fdmi.gov.in%2FComProfiles.aspx&usg=AOvVaw3c7e3XI3nOw9Rh155LStYx
(Department of marketing and inspection)

https://dfpd.gov.in/gen_policy.htm
(General Policy, Department Of Food And Public Distribution, Government of India, 2018.)

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjyt-6v3ZfqAhX8xDgGHdx8BjAQFjAAegQIBBAB&url=https%3A%2F%2Fwww.businessinsider.in%2Findia-could-soon-become-the-worlds-largest-sugar-producer-but-heres-why-thats-a-problem%2Farticleshow%2F65657844.cms&usg=AOvVaw1TCkYIOeqo5cVBZGv3H00P
(Business insider)

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjWxLKL3pfqAhWbyTgGHRDyB54QFjAAegQIBhAB&url=https%3A%2F%2Fwww.business-standard.com%2Farticle%2Feconomy-policy%2Fcan-maharashtra-s-sugar-mills-bounce-back-115050701096_1.html&usg=AOvVaw0YkakpgOom-OqMNsCzyDL1
(Business-standard)

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwju-ZqLh5bqAhV3zTgGHdaRDeoQFjABegQIAxAB&url=https%3A%2F%2Fwww.sugarnews.in%2Fcrushed-by-the-cane-lobby%2F&usg=AOvVaw04A7MBi6-gspQyP4xen-fL
(The Hindu)

Directorate of Economics and Statistics. Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India. http://eands.dacnet.nic.in/LUS_2012-13/lus_2012-13.xls.

http://economictimes.indiatimes.com/news/economy/agriculture/government-allows-duty-free-import-of-maize-up-to-five-lakh-tonnes/articleshow/50465727.cms. 06 Jan 2016.

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=13&cad=rja&uact=8&ved=2ahUKEwjsloWytefeAhUaeisKHbqJBt8QFjAMegQICBAB&url=https%3A%2F%2Fwww.reuters.com%2Farticle%2Fus-brazil-soy-usa%2Fbrazil-to-pass-u-s-as-worlds-largest-soy-producer-in-2018-idUSKBN1IC2IW&usg=AOvVaw2PnytOWOlHmHJPxNEW1qI4. 12 May 2018

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=14&cad=rja&uact=8&ved=2ahUKEwjctK7o7efeAhXLtI8KHQZ_Dd8QFjANegQIChAB&url=https%3A%2F%2Fwww.investopedia.com%2Farticles%2Finvesting%2F101615%2F5-countries-produce-most-sugar.asp&usg=AOvVaw3LJi0R5NMDHubWA6vR-yO. 15 Nov 2018

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=15&ved=2ahUKEwjJ3sPA9uneAhWJq48KHRQMBIkQFjAOegQIDBAB&url=https%3A%2F%2Fwww.businessinsider.in%2Findia-could-soon-become-the-worlds-largest-sugar-producer-but-heres-why-thats-a-problem%2Farticleshow%2F65657844.cms&usg=AOvVaw1TCkYIOeqo5cVBZGv3H00P. 03 Sep 2018

https://www.google.co.in/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=2ahUKEwik7srB9-neAhXEMI8KHaxXC38QFjAAegQIChAB&url=https%3A%2F%2Feconomictimes.indiatimes.com%2Fnews%2Feconomy%2Fagriculture%2Findia-to-consider-sugar-export-subsidy-proposal-next-week%2Farticleshow%2F65868276.cms&usg=AOvVaw3bIab2vso-KDsgWi70wRER19 Sep 2018 www.krishi.maharashtra.gov.in

www.pmksy.gov.in

www.mapsofindia.com

www.macp.gov.in

www.krishi.maharashtra.gov.in

www.data.gov.in

https://www.ers.usda.gov/data-products/international-agricultural-productivity/documentation-and-methods/#overview

SOURCES OF DATA

1. data.gov.in
2. krishi.maharashtra.gov.in
3. Maharashtra State Agricultural Marketing Board, Gultekdi
4. Sugar Commissionerate office, Shivajinagar
5. Economic and Political Weekly Time Series