TOTAL FACTOR PRODUCTIVITY, TECHNICAL CHANGE AND VALUE CHAIN OF COTTON (*Gossypium* Spp.) IN INDIA: A SPATIAL AND TEMPORAL ANALYSIS

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CERTIFICATE

This is to certify that the thesis entitled **"TOTAL FACTOR PRODUCTIVITY, TECHNICAL CHANGE AND VALUE CHAIN OF COTTON (*Gossypium* spp.) IN INDIA: A SPATIAL AND TEMPORAL ANALYSIS"** submitted in partial fulfillment of the requirement for the degree of **DOCTOR OF PHILOSOPHY** in **AGRICULTURAL ECONOMICS** to the University of Agricultural Sciences, Bangalore, is a record of bona-fide research work done by **Mr. MURALI, N., I.D. No. PALB 8004** during the period of his study in this University, under my guidance and supervision. This thesis has not previously formed the basis for award of any degree, diploma, associateship, fellowship or other similar titles.

Bengaluru
December, 2022

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Affectionately Dedicated to

My Parents Smt. Munilakshmamma and Shri Narayanaswamy

My Dear sisters Anitha and Ashwini

My Teachers

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TOTAL FACTOR PRODUCTIVITY, TECHNICAL CHANGE AND VALUE CHAIN OF COTTON (GOSSYPIUM SPP.) IN INDIA: A SPATIAL AND TEMPORAL ANALYSIS

MURALI, N.

ABSTRACT

Cotton, the king of fibers often quoted as white gold and which is one of the important commercial crop providing attractive income and employment to nearly one crore of the population of our country. Globally, India shares major area (37 %) under cotton cultivation (13.50 million hectares). India, is the only country in the world that grows not only the four cultivated species of cotton, but also their inter and intra specific hybrids on a commercial scale. The present study was taken-up in three distinct cotton producing agro-ecological zones *viz*., Northern zone (Punjab, Haryana and Rajasthan), Central zone (Gujarat, Maharashtra and Madhya Pradesh) and Southern zone (Andhra Pradesh, Telangana, Tamil Nadu and Karnataka) of India. In order to measure the effect of technological interventions on cotton production in different zones, Total Factor Productivity (TFP) analysis was employed to isolate its contributing factors. The changes in TFP indices over a short period indicated the significant role of technology in increasing resource use efficiency. The TFP for cotton across different zones of India had increased during the study period from 0.932 (2001-02) to 2.003 in (2017-18) which was attributable to significant contribution of technological and infrastructural factors. There was a positive change in total factor productivity across all the cotton producing zones of India due to pure technological changes i.e., introduction of *Bt* cotton. The study emphasizes on improvement in scale of operations and managerial practices in order to increase the productivity which would contribute the income of the farmers and employment opportunities across zones.

December, 2022

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ಭಾರತದ ಹತ್ತಿ (ಗಾಸ್ಸಿಪಿಯಮ್ ಪ್ರಭೇದ) ಬೆಳೆಯಲ್ಲಿ ಒಟ್ಟು ಪರಿಕರ ಉತ್ಪಾದಕತೆ, ತಾಂತ್ರಿಕ ಬದಲಾವಣೆ ಮತ್ತು ಮೌಲ್ಯ ಸರಪಳಿ: ಪ್ರಾದೇಶಿಕ ಮತ್ತು ಕಾಲಾಂತರಿಕ ವಿಶ್ಲೇಷಣೆ

ಮುರಳಿ, ಎನ್.

ಸಾರಾಂಶ

ನಾರಿನ ರಾಜ ಹತ್ತಿಯನ್ನು ಸಾಮಾನ್ಯವಾಗಿ ಬಿಳಿ ಚಿನ್ನ ಎಂದು ಕರೆಯಲಾಗುತ್ತದೆ ಮತ್ತು ಇದು ಪ್ರಮುಖ ವಾಣಿಜ್ಯ ಬೆಳೆಗಳಲ್ಲಿ ಒಂದಾಗಿದೆ. ಕಾರಣ, ಇದು ನಮ್ಮ ದೇಶದ ಹೆಚ್ಚಿನ ಜನಸಂಖ್ಯೆಗೆ ಲಾಭದಾಯಕ ಆದಾಯ ಮತ್ತು ಉದ್ಯೋಗವನ್ನು ಒದಗಿಸುತ್ತದೆ. ಜಾಗತಿಕವಾಗಿ, ಭಾರತವು 13.50 ಮಿಲಿಯನ್ ಹೆಕ್ಟೇರ್ ಪ್ರದೇಶದಲ್ಲಿ (ಶೇ. 37) ಹತ್ತಿಯನ್ನು ಬೆಳೆಯಲಾಗುತ್ತಿದೆ. ಹತ್ತಿಯ ನಾಲ್ಕು ಕೃಷಿ ಜಾತಿಗಳನ್ನು ಬೆಳೆಯುವ ವಿಶ್ವದ ಏಕೈಕ ದೇಶವೆಂದರೆ ಅದು ಭಾರತ! ಆದರೆ ಅವುಗಳ ಅಂತರ ಮತ್ತು ಅಂತರ್ ನಿರ್ದಿಷ್ಟ ಮಿಶ್ರತಳಿಗಳನ್ನು ವಾಣಿಜ್ಯ ಪ್ರಮಾಣದಲ್ಲಿ ಬೆಳೆಯಲಾಗುತ್ತಿದೆ. ಪ್ರಸ್ತುತ ಅಧ್ಯಯನವನ್ನು ಹತ್ತಿಯನ್ನು ಉತ್ಪಾದಿಸುವ ಮೂರು ವಿಭಿನ್ನ ಕೃಷಿ–ಪರಿಸರ ವಲಯಗಳಾದ ಉತ್ತರ ವಲಯ (ಪಂಜಾಬ್, ಹರಿಯಾಣ ಮತ್ತು ರಾಜಸ್ಥಾನ), ಮಧ್ಯ ವಲಯ (ಗುಜರಾತ್, ಮಹಾರಾಷ್ಟ್ರ ಮತ್ತು ಮಧ್ಯಪ್ರದೇಶ) ಮತ್ತು ದಕ್ಷಿಣ ವಲಯ (ಆಂಧ್ರಪ್ರದೇಶ, ತೆಲಂಗಾಣ, ತಮಿಳುನಾಡು ಮತ್ತು ಕರ್ನಾಟಕ) ಗಳಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಗಿದೆ. ಭಾರತದ ವಿವಿಧ ವಲಯಗಳಲ್ಲಿ ಹತ್ತಿ ಉತ್ಪಾದನೆಯ ಮೇಲೆ ತಾಂತ್ರಿಕ ಮಧ್ಯಸ್ಥಿಕೆಗಳನ್ನು ಮೌಲ್ಯಮಾಪನ ಮಾಡಲು, ಒಟ್ಟು ಪರಿಕರಗಳನ್ನು ಹೆಚ್ಚಿಸುವ ಬದಲು ತಂತ್ರಜ್ಞಾನದ ಕೊಡುಗೆಯನ್ನು ಅಂದಾಜಿಸಲು ಒಟ್ಟು ಪರಿಕರ ಉತ್ಪಾದಕತೆ (ಟಿ.ಎಫ್.ಪಿ.) ವಿಶ್ಲೇಷಣೆಯನ್ನು ಬಳಸಲಾಗಿದೆ. ಗಣನೀಯವಾಗಿ ದೀರ್ಘಾವಧಿಯಲ್ಲಿ ಟಿ.ಎಫ್.ಪಿ. ಸೂಚ್ಯಂಕಗಳಲ್ಲಿನ ಬದಲಾವಣೆಗಳು ಸಂಪನ್ಮೂಲ ಬಳಕೆಯ ದಕ್ಷತೆಯನ್ನು ಹೆಚ್ಚಿಸುವಲ್ಲಿ ತಂತ್ರಜ್ಞಾನದ ಪಾತ್ರವನ್ನು ಸೂಚಿಸುತ್ತವೆ. ಭಾರತದ ವಿವಿಧ ವಲಯಗಳಲ್ಲಿ ಹತ್ತಿಯ ಟಿ.ಎಫ್.ಪಿ. ಅಧ್ಯಯನದ ಅವಧಿಯಲ್ಲಿ ಅಂದರೆ 2001–02 ರಲ್ಲಿ 0.932 ರಿಂದ 2017–18 ರಲ್ಲಿ 2.003 ಕ್ಕೆ ಏರಿತು, ಇದು ಹತ್ತಿ ಉತ್ಪಾದನೆಯ ಬೆಳವಣಿಗೆಯಲ್ಲಿ ತಾಂತ್ರಿಕ ಮತ್ತು ಮೂಲಸೌಕರ್ಯ ಅಂಶಗಳ ಕೊಡುಗೆಯನ್ನು ಸೂಚಿಸುತ್ತದೆ. ಶುದ್ಧ ತಾಂತ್ರಿಕ ಬದಲಾವಣೆಗಳು ಅಂದರೆ ಬಿಟಿ ಹತ್ತಿಯ ಪರಿಚಯದಿಂದಾಗಿ ಭಾರತದ ಎಲ್ಲಾ ಹತ್ತಿ ಉತ್ಪಾದನಾ ವಲಯಗಳಲ್ಲಿ ಒಟ್ಟು ಅಂಶ ಉತ್ಪಾದಕತೆಯಲ್ಲಿ ಧನಾತ್ಮಕ ಬದಲಾವಣೆ ಕಂಡುಬಂದಿದೆ. ವಲಯಗಳಾದ್ಯಂತ ರೈತರ ಆದಾಯ ಮತ್ತು ಉದ್ಯೋಗಾವಕಾಶಗಳಿಗೆ ಕೊಡುಗೆ ನೀಡುವ ಉತ್ಪಾದಕತೆಯನ್ನು ಹೆಚ್ಚಿಸುವ ಸಲುವಾಗಿ ಕಾರ್ಯಾಚರಣೆಗಳ ಪ್ರಮಾಣದಲ್ಲಿ ಮತ್ತು ನಿರ್ವಹಣೆಯಲ್ಲಿ ಸುಧಾರಣೆ ತರುವುದಕ್ಕೆ ಅಧ್ಯಯನವು ಒತ್ತಿ ಹೇಳುತ್ತದೆ.

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ಕೃಷಿ ಅರ್ಥಶಾಸ್ತ್ರ ವಿಭಾಗ | **ಮುರ್ತುಜಾ ಖಾನ್**

ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯ, ಜಿಕೆವಿಕೆ, ಬೆಂಗಳೂರು | (ಪ್ರಮುಖ ಸಲಹೆಗಾರರು)

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ABBREVIATIONS USED IN THE THESIS

GVA	Gross Value Addition
USDA	United States Department of Agriculture
ha	hectare
USD	United States dollars
TFP	Total Factor Productivity
HYV	High Yielding Varieties
Km^2	Kilo Meter Square
LoS	Level of Significance
CAGR	Compounded Annual Growth Rate
TE	Triennium Ending
FL	Family Labour
GDP	Gross Domestic Product
Qtl	Quintal
Rs/q	Rupees per quintal
Rs/ha	Rupees per hectare
Bt	*Bacillus thuringiensis*
FCI	Food Corporation of India
NAFED	National Agricultural Cooperative Marketing Federation of India
FPO	Farmers Producer Organisation

INTRODUCTION

I INTRODUCTION

Agriculture is critical for any nation's economy and people's overall growth since it provides life's most fundamental necessities, such as food, clothing and shelter. Agriculture has thus remained a major source of livelihood for a large proportion of the population in India, as well as throughout the world, since time immemorial. Agriculture is important for boosting the overall economy as it provide raw materials to other sectors. Agriculture has been an evolutionary and on-going process from the beginning of cultivation to the present day, and it will continue to do so in the future. Agriculture in India provides not only food and raw materials, but also employment opportunities for a large portion of the population.

In rural India, agriculture is a vital source of income, besides agriculture and allied sector activities employ 54.60 per cent of the entire workforce and contribute for 17.80 per cent of the country's Gross Value Addition (GVA) in 2019-20 (at current prices) (Anonymous,2021a). Agriculture contributes for about 15 per cent to the total export revenue. Textiles, sugar, flour mills, jute, garments, and other industries rely on raw materials supplies from the agricultural sector.

India, world's second-largest producer of agricultural commodities, accounting for 7.39 per cent of global agricultural output (Anonymous, 2021b). India's agricultural contribution exceeds that of the world's average economy (6.40 %). There was nearly fourfold increase in food grain production, which saved the country from starvation during one of the country's most serious crises after independence, stands out the most. Given the importance of the agriculture sector, the Indian government has taken several steps to ensure its long-term development. Because of two factors, the current state of Indian agriculture warrants renewed attention. First, farmers' earnings continue to be negatively impacted by monsoon failures at the local level. Second, at the macro level, the rapidly changing international agricultural trade competitiveness, necessitates more efficiency in agriculture (Anonymous, 2021a). Agriculture's poor or stagnant growth is thought to be a drag on overall economic growth.

Fibre crops are a type of natural fibres as they are obtained naturally and directly from the different sources of plants and their products. In India, fibre crops are playing vital role in the economy of a country. Cotton, jute, kenaf, industrial hemp, sun hemp and flax are among the well-known fibre crops. Cotton is one of the most important fibre and cash crop of India and plays a dominant role in the industrial and agricultural economy of the country. It provides the basic raw material (cotton fibre) to cotton textile industry.

History and Importance of Cotton

Cotton was used as natural fibre in old world at least 7000 years ago. Cotton cultivation becomes more wide spread during the Indus valley civilization which covered parts of modern eastern Pakistan and North eastern India. Between 2000 and 1000 BC cotton became wide spread across most parts of India; for example, it has been found at the site of halloos in Karnataka dating from around 1000 BC. Cotton fabrics discovered in a cave near Toucan Mexico have been dated to around 5800 BC. Cotton (*Gossypium hirsutum*) belongs to the Malvaceae family and has an important four cultivable species, *viz, Gossypium arboreum, Gossypium barbadence, Gossypium hirsutum and herbaceous.* Cotton has different staples according to length of fibres such as short staple (20.00 mm & below), medium staple (20.5 mm to 27.00 mm), long staple (27.50 mm to 32.00 mm) and extra-long staple (32.5 mm and above).

Cotton, the king of fibres is often quoted as 'White Gold' because of its more commercial value. It is a primary raw material in the textile industries. Cotton, cotton yarn, cotton fabrics and garments have substantial demand in the global market. The cotton seed which remains after the cotton ginning is used to produce cotton seed oil, which, after refining, can be consumed by humans like any other vegetable oil. The cotton seed meal that is left generally is fed to ruminant livestock. Cotton seed hulls can be added to dairy cattle feed.

Cotton is the principal commercial crop in India, influencing the country's economy as it provides remunerative income and employment to most of the population of our country. Globally, India shares major area under cotton cultivation which is 13.50 million hectares (37 %) (Anonymous, 2021c). India is the earliest domesticated nation in the world and manufacturer of cotton fabrics. Cotton accounts for almost 44 per cent of the world's fibre and ten per cent of the entire world edible oil production. India is next to China's second-largest exporter and producer of cotton. India's production, however, is well below that of other cotton-growing countries. The USA and Africa are the top seed cotton exporters.

Presently, 80 million people in India depend on cotton cultivation, marketing, processing and exports for their livelihood (Anonymous, 2021c). India is the only country in the world that grows not only the four cultivated species of cotton but also their intra-and-inter-specific hybrids on a commercial scale. The textile industry, which consumes the cotton, as its principal raw material, contributes about 4 per cent to the GDP and is the major exchange earner for India. Hence, growth and development of cotton and cotton-based textile industry has a vital bearing on the overall development of the Indian economy**.**

Cotton cultivation

The cultivation practices, climatic and soil conditions for the crop are presented below under following headings.

Climate and soil requirement

Cotton, a semi-xerophyte crop grown in tropical and sub-tropical conditions. Minimum temperature of 15^0C is required for better germination at field conditions. The optimum temperature for vegetative growth is 21-27^0 C and it can tolerate temperature to the extent of 43^0C but temperature below 21^0C is detrimental to the crop. Warm days of cool nights with large diurnal variations during the period of fruiting are conducive to good boll and fibre development.

Cotton is grown on a variety of soils ranging from well drained deep alluvial soils in the North to black clayey soils of varying depth in Central region and in black and mixed black and red soils in South zone. Cotton is semi-tolerant to salinity and sensitive to water logging and thus prefers well drained soils.

Crop season

The sowing season of cotton varies considerably from region to region and is generally early (April-May) in Northern India and is delayed as we proceed to down South (monsoon based in Southern zone). Cotton is a *Kharif* crop in the major parts of the country *viz.* Punjab, Haryana, Rajasthan, Uttar Pradesh, Madhya Pradesh, Gujarat, Maharashtra and parts of Andhra Pradesh and Karnataka. In these areas, the irrigated crop is sown from March-May and the rain fed crop in June-July with the commencement of the monsoon. In Tamil Nadu, the major portion of the irrigated and rainfed crop is planted in September-October, whereas the sowing of the rain fed crop in the Southern districts is extended up to November. In parts of Karnataka and Andhra Pradesh, the desi cotton is usually sown in August-September. In addition, summer sowings in Tamil Nadu are done during February-March. The sowing of cotton in the rice fallows of Andhra Pradesh and Tamil Nadu extent from the second half of December to the middle of January.

World scenario of cotton

Cotton is one of the most important natural fibre and a cash crop plays a dominant role in the industrial and agricultural economy of many countries. Worldwide area under cotton cultivation for the year 2020-21 was 31.66 million hectares with production and productivity of 113.11 million bales (one bale is equal to 170 kg) and 778 kg per hectare, respectively. India emerged as the largest producer of Cotton in the world and occupies the first position in terms of its area and production. Among the major Cotton exporting countries in the world, India occupied third position with 5.50 million bales after the USA (16.25 million bales) and Brazil (10.70 million bales) (USDA, 2020-21).

Indian scenario of area and production of cotton

India produced about 371 lakh bales of cotton from an area of 129.57 lakh hectares with a productivity of 517.70 kg per hectare during the year 2020-21 (Anonymas,2021c).

In India, there are ten major cotton growing states which fall under three zones *viz.*, the Northern Zone (Punjab, Haryana and Rajasthan), the Central Zone (Maharashtra, Madhya Pradesh and Gujarat ; and the Southern Zone (Andhra Pradesh, Telangana, Karnataka and Tamil Nadu). Nearly 65 per cent of the cotton crop is cultivated under rainfed condition in the country. Nearly 2/3rd of the cotton production in India comes from the states of Maharashtra, Gujarat, Andhra Pradesh and Telangana collectively known as cotton Basket of India.

Table 01: Area, production and productivity of cotton in India in 2020-21

Zone	Area (lakh ha)	Production (lakh bales)	Yield (kg/ha)
North zone	19.10 (14.74)	64.00 (17.25)	555.63
Central zone	71.01 (54.80)	197.50 (53.23)	526.88
South zone	37.73 (29.12)	103.00 (27.76)	534.72
Others	1.68 (1.30)	6.50 (1.75)	453.55
India	**129.57**	**371.00**	**517.70**

Source: des.gov.in ,2021

Note: The figure in parentheses indicates the variables respective percent share to the India.

In terms of area and production of cotton, the Central zone of India shown on top, followed by the Southern and Northern zone of the country, where in terms of yield per hectare, the Northern zone outperformed than the others. (Table 01)

Exports and Imports of cotton

The India's trend in cotton trade are presented in the Table 02 revealed that the average export of Cotton was 73.98 lakh bales during the period from 2006-07 to 2020-21, whereas the imports during the same period stood at 13.98 lakh bales (Anonymous, 2021c). The average annual compound growth rate of exports were decreased and growth rates found significant (-1.46 %) whereas imports showed a positive and significant growth rate (11.40 %). The average value of exports is more than imports of cotton as usual.

Table 02: **Exports and Imports of cotton in India from 2006-07 to 2020-21**

Year	Exports		Imports	
	Quantity (lakh bales)	Value (Rs. in Cr.)	Quantity (lakh Bales)	Value (Rs. in Cr.)
2006-07	58.00	5267.08	5.53	752.29
2007-08	88.50	8365.98	6.38	978.54
2008-09	35.00	3837.13	10.00	1377.80
2009-10	83.00	10270.21	6.00	1195.64
2010-11	76.50	14483.31	2.38	1709.11
2011-12	129.57	23488.59	7.51	1059.20
2012-13	101.43	17462.87	14.59	2057.77
2013-14	116.96	23153.24	11.51	2746.16
2014-15	57.72	9499.87	14.39	2848.50
2015-16	69.07	11434.80	22.79	4230.00
2016-17	58.21	11676.00	30.94	7268.00
2017-18	67.59	13976.71	15.80	4224.84
2018-19	43.55	9502.72	35.37	8339.26
2019-20	47.04	8731.32	15.50	3588.38
2020-21	77.59	17753.83	11.oo	3482.72
AVERAGE	**73.98**	**12224.99**	**13.98**	**3026.82**
CAGR (%)	**-1.46*** **	**3.78*** **	**11.40*** **	**17.76*** **

Source: Cotton Corporation of India.

Note: ***, ** and * indicates one, five and ten percent level of significance.

The average exports of cotton by India was 73.98 lakh bales and imports were 13.98 lakh bales from 2006-07 to 2020-21. The cotton exports from India were decreasing (-1.46 %) and annual compound growth rate significant at five percent, whereas imports from India showed significant growth rate of 11.40 per cent per annum. Even though, the growth rate of exports decreasing during 2014-15 to 2020-21 in absolute terms have increased from 57.72 lakh bales to 77.59 lakh bales whereas imports have decreased from 22.79 lakh bales to 11.00 lakh bales, signaling the better terms of trade for cotton.

Bt cotton in India

Bacillus thuringiensis (*Bt*.) is a naturally-occurring soil bacterium that produces a protein which is toxic to Lepidopteran insect pests. *Bt*. cotton is an insect-protected variety of cotton which is most widely grown in various parts of the country.

Bt. cotton was first approved for field trials in the United States in 1993, and first approved for commercial use in the United States in 1995. In 2002, a joint venture between Monsanto and Mahyco introduced *Bt*. cotton in India.

Despite the challenges of misinformation, the technology has enjoyed the confidence of farmers, researchers and policymakers, due to the attributes of genetically engineered hybrid seeds and the results observed in the field in terms of pest control that lead to increased yield and farm remuneration. The extent of achievement can be drawn from the fact that about 11.7 million hectares (93.60 %) of total 12.50 million hectares under cotton cultivation in 2019-20 was planted with *Bt*. cotton seeds (Anonymas,2021a).

There is no doubt that *Bt*. cotton has not only benefitted the farmers, but also the textile industry and oil industry are boosted our economy. According to the Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, over the last decade, cotton yield in the country increased by more than 300 per cent; pesticide consumption reduced by 50 per cent; acreage increased by 150 per cent and production increased by 400 per cent. This technological advancement enabled over 7 million farmers earn an additional farm income of USD 16.69 billion. While yield increase was not a claim for the *Bt*. technology, excellent control of bollworms led to reduced stress on the crops that resulted in higher yields. Before *Bt*. cotton was used, the total income per hectare was Rs.7,558 in the rain-fed area. However, it went up to Rs.16,000 in rainfed areas and even up to Rs.25,000 in irrigated areas within a decade.

The benefits of *Bt*. cotton have spread beyond the farming community. Since 2002, *Bt*. cotton technology has boosted the fortunes of the Indian cotton seed industry by giving technology access to small and medium-sized seed companies. This has enabled companies to invest in innovation, improve their cotton seed germplasm and adopt various mechanization options in the field. Numerous stakeholders across the cotton value chain seed industry, ginners, spindlers, weavers, dyers and apparel manufacturers of textile industry have benefitted from the technology. Not surprisingly, over the last decade, cotton seed industry (consisting of more than 90 per cent share for Indian seed companies) has grown eight times from Rs. 0.45 billion in 2002 to Rs. 40 billion in 2018, the Indian textile industry which today employs over 0.04 billion workers continues with large-scale investments.

Total factor productivity change

Measuring productivity is essential in order to account for economic growth. In simple terms, productivity is defined as the ratio of output to input (Coelli *et al*., 1998). The partial productivity measures like labour productivity and land productivity are of limited use in the presence of multiple outputs and multiple inputs as they do not indicate the overall productivity when considered in isolation. When the productivity concept is extended beyond single output and single input case, an alternative approach for aggregating output and inputs is used. Total Factor Productivity **(**TFP) is ratio of aggregate output index to aggregate input index (Kannan, 2011). TFP, also called multi-factor productivity, is a variable which accounts for effects in total output not caused by traditionally measured inputs of labour and capital. Thus, TFP can be taken as a measure of an economy's long-term technological change or technological dynamism. TFP growth indicates technical progress, which represents shifts in the production function over time. In the Indian context, technical progress measures the impact of shift in production technology on account of irrigation, High-Yielding Varieties (HYVs), modern agricultural equipment, fertilisers, pesticides, etc. It also captures the effect of improved labour quality, better management practice, and intensive use of resources which lead to increased cropping intensity, change in cropping pattern in favour of high value-added crops, etc. Although, boosts in TFP growth can be due to good weather but the influence of short-term effects on TFP growth can be moderately reduced by studying a longer period of time. TFP growth becomes an important indicator for quantifying the sustainability of a growth process if longer period of time is considered.

India has become the global leading grower and the largest producer of cotton, with increasing growth rate in area, production and yield in the current decade. Hence, it necessitates a study to analyse the factors responsible for such changes. The Total Factor Productivity approach is considered as suitable tool to examine the growth in agricultural productivity and to separate out the effect of inputs and other factors like technology, infrastructure etc., on productivity growth.

Total Factor Productivity of cotton

In order to measure the technological interventions on cotton production in India, TFP analysis is an attempt to measure the amount of increase in the total output, which is not accounted for by increase in total inputs. There is a large residual, measured by total factor productivity, which is the contribution of improvement of technology, infrastructural developments, human capital improvement and policy interventions. Total factor productivity relates output to all inputs simultaneously. The changes in total factor productivity indices over a substantially long period of time indicate the role of technology in increasing resource use efficiency.

Value addition in cotton

Cotton is an important fibre crop in the world. Being a prime supplier of raw material for the textile industry, it plays a vital role in the Indian economy. Besides sustaining the country's textile industry, it also earns precious foreign exchange for the country from the export of raw cotton and finished goods. Although, cotton is primarily fibre crop, it is also used as a food and feed crop. Cotton seed being the world's second most oilseeds used for culinary purposes and the oil cake residue is a protein rich feed for ruminate livestock.

The processing of cotton is a business which is undertaken for the purpose of value addition to the product. The value addition to cotton takes place at three main stages of processing *viz.*, ginning, spinning and weaving. The end product in cotton processing is the cloth which will result at the weaving stage of cotton processing.

The cotton processing industry, in fact, is the largest labor-intensive economic activity next to agriculture and provides employment opportunity to Indian population either directly or indirectly. It is the largest organized and unorganized sector constitutes integral part of the urban and rural life of the country. India like other countries in the world preserves its ancient and time-honored traditions of ginning, spinning, weaving, dyeing and printing crafts.

The highly competitive prices of Indian cotton fibers in the global market coupled with the increasing export demand for cotton yarn and textile products will cause India's domestic cotton consumption to rise in Marketing Year (MY) 2021-22. Cotton imports have also been rising due to a strong demand from cotton mills to fulfill their export orders. (Table 02)

Since cotton is very important fibre and cash crop in India and there is a neck-to-neck competition between major cotton producing countries. Populated countries like India, there is a lot of demand for cotton products like, fabrics and clothes. Hence this study focused on finding out the total factor productivity change and technological change of cotton in different producing zones of India, value addition of cotton to frame policies to emerge with better research strategies to increase the production. In this background present study was undertaken with the following specific objectives:

1. To assess the growth performance of Cotton

2. To analyse Total Factor Productivity in Cotton across different zones of India

3. To assess the impact of technical change of Cotton in different zones of India

4. To analyse the value chain in Cotton.

Hypotheses

The following hypotheses were proposed in achieving the aforesaid objectives

1. The area, production and productivity of cotton is increasing over the years.
2. The technological and infrastructural factors favours the TFP growth across cotton producing zones.
3. The efficiency and technical change have influenced the TFP change across cotton producing zones.
4. Value addition in cotton through ginning and spinning is economically profitable.

Limitations of the study

In the present study, the secondary data were collected from the Directorate of Economics and Statistics, Government of India and Cost of Cultivation scheme. Due to non-availability of data on cost of cultivation of cotton the study period is restricted to period from 2000-01 to 2017-18. Primary data collected through personal interview method using a pre-tested schedule associated with some amount of recall bias might be associated with the collected data since the farmers do not have the written record of information about the different expenditure, inputs used and income generated. However, the efforts were made to avoid errors through cross checks. And all stages of cotton value addition are not carrying in the same individual industry. Therefore, careful and rigorous procedures have been adopted while carrying out the research.

Presentation of the study

The thesis is organized and presented in six chapters

Chapter I - It delineates the introduction, objectives of the study, hypotheses, scope and limitations of the present study.

Chapter II – It gives a brief review of previous studies in accordance with the objectives of the present study.

Chapter III - Focuses mainly on methodology covering description of the study area, sampling method employed for data collection, sources of data, methods of data collection and different analytical tools employed in data analysis including different terms and concepts used in the study.

Chapter IV – Includes presentation of results of the study in the form of tables and figures and also discussion of the outcomes of the study in the light of the plausible reasons.

Chapter V – This chapter provides summary, conclusion and also suggest policy recommendations based on the outcomes of the study.

Chapter VI – Lists the references of the referred literature (publications, journals, reports, books and websites, and so on) during the course of the present study.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

A review of past research studies helps in identifying gaps in conceptual and methodological issues and research output relevant to the present study proposed. This will enable us to collect relevant data, develop appropriate model for analysis and for meaningful interpretation. Keeping in view the objectives of the study, this chapter provides a brief review of the relevant studies under the following headings.

2.1 Growth rate analysis

2.2 Total Factor Productivity

2.3 Technical change

2.4 Value chain analysis

2.1 Growth rate analysis

Basavaraj *et al*. (2005) revealed that the area under *kharif* sorghum was declining by about 3 per cent per annum at the state level and also in the study districts during the period 1970-71 and 1997-98. The study also indicated that, there is decrease in kharif sorghum production in the Karnataka state due to contraction in its area during the study period. Whereas, the productivity of kharif sorghum for the state grew at a positive rate during the sub-periods 1970-71 to 1975-76 and 1991-92 to 1997-98.

Mohamed and Hag (2010) estimated growth rate of area and productivity of major crops grown in the Gezira scheme. Two different time periods *viz.*, before liberalization policy (1970-71 to 1991-92) and after liberalization policy (1992-93 to 2007-08) were taken into consideration. The results revealed that there was variations in growth rates of area and productivity for the crops during the two periods. The growth rate was positive and increasing during the two periods for sorghum, positive and decreasing for cotton and negative and decreasing for groundnut.

Saraswati *et al.* (2012) estimated the growth in area, production and productivity of different crops in Karnataka using compound growth rate. The results showed that there was a significant positive growth in area under pulses, vegetables and spices and fruits and nuts while cereals showed significant negative growth. The growth in area under oilseeds and commercial crops was negative but not significant. The production of cereals, pulses, vegetables and fruits showed a significant positive growth. The productivity of different crops recorded significant growth in case of cereals, pulses and fruits. Productivity of oilseeds recorded moderately positive growth. The productivity of commercial crops registered nonsignificant positive growth and for vegetables the growth in productivity was nonsignificant and negative.

Anjani and Rajni (2013) examined the growth and instability in Indian agricultural productivity at district and state level. The productivity of crop sector has shown tremendous variations across districts both for the country as a whole and within a state. The varying performance of crop sector has emphasized the need for evolving regionally differentiated strategies for ensuring sustainable and inclusive agricultural growth in a state and consequently in the country. The instability in productivity continues to persist and there are wide variations in instability across different districts. To mitigate the consequences of persisting instability, large-scale promotion of stabilization measures like insurance should be pursued vigorously. The analysis of district level data revealed the important role of modern inputs in enhancing the productivity of crop sector.

Maikasuwa and Ala (2013) estimated the trend (1993 to 2012) in area and productivity of sorghum in Sokoto state, Nigeria. The study revealed that the computed growth rate for area was negative (-0.015) and positive for productivity (0.035).

Mehta (2013) analysed the trend in instability in crop production in Gujarat for the 30 year period from 1980-81 to 2010-11 by following the method of 'first differences' or the moving period approach. The relation of instability with growth has also been examined. Instability in area under food grains was quite high during the decade of 1980s as the growth rates showed standard deviation of 4.5 per cent. For cereals, the trend in area instability was similar to that of food grains; it halved in the 1990's to 2.4 per cent, but again increased to 5.3 per cent in the 2000's decade. The study observed the decade of 2000 to be the period of high growth in the agricultural sector.

Paltasingh and Goyari (2013) analyzed the growth and instability in subsistence agriculture of Odisha. The analysis has shown a gloomy picture in the post reform era, as instability has augmented during this period, rendering the agricultural sector of Odisha as unsustainable. The various causes of low growth rate have been identified. The analysis of growth rate of production has shown that some crops like wheat, ragi and millet experienced decline in the pre-liberalization period, which exacerbated in the post-liberalization period. Other crops like bajra, jowar, gram, arhar, experienced a deceleration in post-reform period compared to pre reform period. The rice and maize were the two crops which maintained a positive growth trend in both the periods. Weather variability and price risk as prime source of instability have been analyzed and the study has shown that mainly weather variability played a pivotal role than price fluctuations in augmenting risk.

Saleem *et al.* (2014) analysed the growth and trend in area, production and yield (1981-2012) of major crops of Khyber Pakhtunkhwa, Pakistan. The results revealed that there was a decreasing trend in area and increasing trend in production and productivity under wheat and rice. The area, production and productivity of maize and sugarcane showed positive growth.

Satishkumar and Prakash (2014) assessed the trends in area, production and productivity of jowar in Vijayapura district of Karnataka during the period 1980-81 to 2010-11. The results indicated negative trend for area and production. Positive trend was noticed in productivity and the negative trend in production was because of decrease in the area over the years.

Swain (2014) identified sources of growth and instability in agricultural production in Western Odisha, India. The extent of instability in agricultural production and productivity in the region was found quite high on account of high level of rainfall variability and the low irrigation coverage. The instability index values were much higher in case of production and productivity of food grains and paddy. The average production and productivity of both food grains and paddy were much less during the second sub-period (1994–2009) compared to the first sub-period (1984–1993).

Ahmad *et al.* (2015) assessed trend in area, production and productivity of major cereals in Nigeria and India. The computed growth trend for cereals in India was negative (-0.07 %) and significant at one per cent for area, positive for production (0.84%) and productivity (0.94 %) which was significant at one per cent, whereas in Nigeria the computed growth rates were positive for area (1.05 %), production (1.24 %), and productivity (0.18 %), which were significant at one per cent in case of area and production and five per cent in case of productivity.

Pavithra *et al.* (2018) made a study on growth in area, production and productivity of food grains in Karnataka State. The growth in the area, production and productivity of food grains in Karnataka was estimated using the compound annual growth rate analysis. The necessary secondary data were collected for a period of 25 years from 1990- 91 to 2014-15. Growth rates showed a significant positive growth in case of both cereals and pulses. In case of cereals, the highest positive CAGR was observed in maize area and production. Paddy and sorghum were found to be non-significant for growth of area, production and productivity. Among the pulses, chickpea and pigeon pea exhibited a significant positive growth rate in case of area, production and productivity. Field bean showed significant positive growth in case of production and productivity. Horse gram, black gram and green gram were found to be non-significant.

Atla *et al.* (2021) conducted trend analysis on area, production and productivity of paddy in India by using exponential growth function during pre-WTO period (1970-71 to 1994-95), post-WTO period (1995-96 to 2017-18) and overall period (1970-71 to 2017-18). In India, the growth rates of area, production and productivity were positive and significant in Uttar Pradesh, West Bengal, Karnataka, Maharashtra, Punjab and Assam and the growth rate in area was negatively significant while, the production and productivity was positively significant in Andhra Pradesh and Tamil Nadu for entire period.

Above reviews indicated that, in majority of the crops, area and production had a negative growth whereas, productivity had a positive growth

2.2 Total Factor Productivity

Evenson *et al.* (1999) used Tornqvist- Theil TFP index to estimate total factor productivity for the period 1956-57 to 1987-88 in 271 districts covering 13 states. The study revealed that India has made significant gains in TFP. The high- yielding varieties of wheat and rice introduced in the late 1960s certainly contributed to these gains. Growth in TFP has contributed 1.1–1.3 per cent per year to crop production growth in India. Conventional inputs have contributed about 1.1 per cent per year since 1956. TFP and conventional inputs have thus contributed roughly 2.3 per cent per year to the growth of crop production.

Forstner and Isaksson (2002) computed Malmquist TFP index using Data Envelopment Analysis to estimate productivity change over two decades for 32 Least Developed Countries. They found an overall decline in total factor productivity (TFP), pointing to technology as a major problem area in the growth of these countries.

Coelli and Prasad (2003) estimated total factor productivity growth in agriculture using a Malmquist index analysis of 93 countries. The study showed measures of annual changes in technical efficiency, technical change and TFP change by different regions. Results revealed that, Asia as a region posted the highest TFP growth of 2.9 per cent (mainly due to efficiency change growth of 1.9 %) followed by North America (consisting of USA and Canada). The continent-level results shows that, the largest difference occurs for South and Central America, where the average TFP growth measure increases from 0.6 per cent to 1.5 per cent per annum. This is not a minor difference and emphasizes the key point that TFP indices depend crucially upon the prices that are used by the market prices or shadow prices.

Coelli *et al.* (2003) estimated TFP for Bangladesh agriculture for the period 1961-1992 using stochastic frontier approach and found a decline in TFP over the study period (mean TFP change = 0.9537).

Joshi *et al.* (2003) carried out a study on a comprehensive productivity analysis in the irrigated agro-ecosystem concentrated in the Indo- Gangetic Plains (IGP) for the rice and wheat crops. The TFP growth of rice and wheat in the IGP has been found quite impressive during the past three decades, 1970- 1999. The annual compound growth rate of TFP was 2.43 per cent for rice and 2.99 per cent for wheat during this period. The contribution of TFP to output growth was 56 per cent in rice and 70 per cent in wheat. This shows that technology played a key role in increasing the rice and wheat output in IGP.

Nin *et al.* (2003) estimate TFP growth for 20 countries during 1961-1994 using non parametric Malmquist TFP index with an alternative definition of technology-Sequential technology and found that the earlier results reverse and most of the developing countries experience productivity growth.

McKinsey and Evenson (2003) analysed the impact of crop genetic improvement on Indian agriculture and observed that the productivity impacts of state research, private research, extension, and market development were positive. Extension and market development would not have made large impacts in the absence of modern varieties. Extension was productive when the extension service had new technology to extend. Similarly, the improvement of markets was important as it facilitates adoption and diffusion of modern varieties. The role of each source of growth was complementary.

Rahman (2004) applied sequential Malmquist index approach to estimate TFP from 1964 to 1992 and finds TFP rising at the rate of 0.9 per cent per annum and this growth was primarily led by those regions which have experienced high levels of green revolution technology. Technical progress was found growing at 1.9 per cent per annum that offsets declining efficiency at one per cent per annum.

Ananth (2004) study on returns to investment on agricultural research in major field crops of Karnataka state, revealed that the agricultural research investment registered a growth rate of 14.7 per cent per annum during the period of 25 years. The crop wise analysis showed that the growth in research investment was highest for tur (15.10 %) followed by sunflower (10.45 %), groundnut (8.8 %) and ragi (7.5 %) in real term. The total factor productivity index showed increasing trend in case of rice, ragi, cotton and sugarcane. The decreasing trend noticed in case of tur and sunflower. The study also revealed that the returns on the agricultural research investment were highest in rice followed by sugarcane, ragi, cotton and jowar. The returns were negative in case of tur, groundnut and sunflower.

Aliva *et al* (2004) measured the changes in TFP for crop production, livestock production and aggregate agricultural production in India for two periods, 1961-1980 and 1981-2001 using FAO published data on crop land, pasture land, human labour, fertilizers, seeds, tractors and combine harvesters and animal stocks. Use of modern varieties, increase in the years of schooling of labour force, and enhances in dietary energy were reported as sources of TFP growth in the study. The contribution of TFP was maximum to modern varieties (64 %), followed by years of schooling (22 %) and nutritional security (14 %).

Kumar *et al.* (2004) estimated the total factor productivity for the inland and marine fisheries using Divisia-Tornqvist index. The estimates revealed that the TFP annual growth rate of 4 per cent for the aquaculture sector and 2 per cent for the marine sector.

Kumar *et al.* (2004) observed that the TFP growth of the crop sector in the Indo-Gangetic plains had risen at the rate of 1.2 per cent per annum during the period 1980-81 to 1996-97. The analysis has confirmed that contribution of TFP growth to output growth had started declining and was, in fact showing a tendency of further deterioration in the process.

Thirtle *et al.* (2004) estimated the total factor productivity growth in UK agriculture, from 1953-2000 by using Tornqvist-Theil index. The study revealed that prior to 1984 TFP grew at 1.68 per cent per annum and after that at only 0.26 per cent per annum. The study also revealed that the decline in TFP growth was mainly due to cuts in R&D, fewer patents, less growth in farm size and the demise of public extension.

Bhushan (2005) used Data Envelopment Analysis (DEA) to estimate Malmquist TFP index for major wheat producing states in India- Punjab, Haryana, Madhya Pradesh, Uttar Pradesh and Rajasthan. He found highest TFP growth in Punjab and Haryana which was attributed to technical progress in these two states. Rajasthan (with no efficiency change) and Uttar Pradesh (with improvement in efficiency and negative growth in technological progress) had positive TFP growth rate while Madhya Pradesh (no change in efficiency and negative growth of technical progress) reported to record negative TFP growth rate. As compared to 1980s, mean growth of TFP was found higher in 1990s and the primary source of TFP growth was technical progress and not efficiency improvements.

Kumar and Jha (2005) estimated TFP growth and return to research of rice in India. The results of TFP growth of rice across the states revealed that the high growth was observed in Uttar Pradesh and Punjab. The marginal internal rate of return varied from 32 per cent in Karnataka to 74 per cent in Uttar Pradesh.

Ranjitha and Mruthyunjaya (2005) analysed total factor productivity growth in Indian crops and the livestock sector for the period 1964-65 to 1991-92 and also attempted for the decomposition of TFP growth. The analysis revealed that the growth rate of TFP has been falling over the years in Indian crops and livestock sector during the study period and research factor contributed 48 per cent to TFP growth.

Rao (2005) computed TFP using Tornqvist-Theil index in the crop sector, food grain crops and non-food grain crops in Andhra Pradesh during 1980-81 to 1999-2000 period. The analysis revealed that the average annual total factor productivity index during post reform period has been found five per cent less than that during pre-reform period in the state in the crop sector as a whole. The contribution of total factor productivity to yield growth has been found healthy at 31 per cent in the pre reform period. An absolute decline (-37) has been noted during the post reform period in the crop sector.

Kumar and Mittal (2006) estimate crop-specific TFP growth across different states for paddy and wheat. They found TFP of paddy started showing deceleration in Haryana and Punjab but TFP of wheat was still growing in these two green revolution states. About 60 per cent of the area under coarse cereals was facing stagnated TFP. Similarly, the productivity gains which occurred for pulses and sugarcane during the early years of green revolution, have now exhausted their potential.

Thorat *et al.* (2006) have analysed total factor productivity in horticultural crops in Konkan region of Maharashtra. The comparative picture of TFP growth by sub period wise has revealed that the magnitude of TFP growth varied from 1.3 per cent per annum during the 1990s to 6.2 per cent per annum during the 1980s. During the entire period under study (1981-2000), TFP has been found growing at the rate of 5.4 per cent per annum. The researchers also noticed that the returns to horticultural research was high with a pay-off to the tune of 119 per cent IRR.

Arega (2009) analysed total factor productivity growth in African agriculture under contemporaneous and sequential technology frontiers over the period 1970–2004. The study further investigated the sources of agricultural productivity growth using a fixed-effects regression model and a second-degree polynomial distributed lag structure for agricultural research. The conventional estimates showed an average productivity growth rate of only 0.3 per cent per year over the period 1970–2004. In contrast to conventional measures, however, the improved measures under sequential technology show that agricultural productivity grew at a higher rate of 1.8 per cent per year. Technical progress, rather than efficiency change, was the principal source of productivity growth. Researcher concluded that Agricultural research has turned out to have positive and significant impacts on productivity. The estimated productivity elasticity with respect to agricultural research was 0.04 and suggests that doubling research investments would lead to a 4 per cent increase in total factor productivity. Consistent with the induced intensification hypothesis, population pressure has a positive and significant effect on agricultural productivity.

Bryce *et al.* (2009) analysed the productivity growth in Canadian Prairie primary agriculture from 1940 to 2004. Total factor productivity (TFP) was measured using Tornqvist-Theil indexing procedures for the Prairie Provinces. It was found that during the 1940 to 2004 period, productivity growth in prairie agriculture grew at a rate of 1.56 per cent a year. During this time, agricultural output increased at a rate of 2.43 per cent per annum thus increasing productivity accounted for 64 per cent of output growth. It was found that the productivity growth in crops (2.85 %) was considerably higher than productivity growth of livestock (1.56 %).

Elumalai (2011) assessed total factor productivity growth and its determinants in Karnataka agriculture. The analysis confirms that most crops have registered low productivity growth across periods. Interestingly, during 2000-01 to 2007-08 all crops have showed a positive growth in TFP. Further, the analysis of determinants of TFP indicates that the government expenditure on research, education and extension, canal irrigation, rainfall and balanced use of fertilizers were the important drivers of crop productivity in Karnataka. Hence it was necessary that both public and private investment should be enhanced in agricultural research and technology, and rural infrastructure for sustaining productivity growth in the long run.

Chand *et al.* (2011) estimated the total factor productivity and returns to public investment on research in India. The Divisia-Tornqvist index was used in this study for computing TFP indices for major crops, *viz.* cereals, pulses, edible oilseeds, sugarcane, cotton, and jute grown in different states of India. The estimates of TFP revealed considerable variations across crops in different states and at all-India level during the period 1975-2005. The public investment in research has been a significant source of TFP growth in rice, wheat, maize, sorghum, pearl millet, chickpea, redgram, groundnut, rapeseed and mustard and cotton. During the period 1975-2005, the overall internal rates of return (IRR) to public investment in agricultural research were highest for red gram (57 %), followed by sorghum and cotton (39 % each), wheat (38 %), chickpea (34 %), pearl millet (31 %), rice (29 %), maize (28 %), and the lowest was in groundnut (18 %).

Shilpa (2012) analysed the trends in total factor productivity in Indian agriculture using non-parametric Sequential Malmquist Index. The study using index of agricultural production as the measure of output, changes in TFP were estimated using non-parametric Sequential Malmquist TFP index. The change in TFP was decomposed into efficiency change and technical change and the results found that, productivity improvements were marked in very few states. The improvements in efficiency was observed low for most of the states and efficiency decline is observed in several states implying huge gains in production possible even with existing technology. In order to achieve higher productivity, it is essential to increase the efficiency level as well as achieve a more even spread of new technology.

Das Varun Kumar (2015) assessed the total factor productivity growth of jowar and bajra in India using different methods of TFP computation. In this study, total factor productivity growth of jowar and bajra has been estimated using three different methods, *viz.* Solow index, Tornqvist index and Malmqvist index method. The Solow index method and Tornqvist index method imposes certain theoretical restrictions while calculating the TFP growth. Therefore these restrictions can be addressed by using Malmqvist index method. Though jowar and bajra being rainfed crops, the rainfall has been considered as one of the inputs in the production of these coarse cereals in the Malmqvist index method. Hence it is argued that on a number of counts, the Malmqvist index method could be more preferable as it gives reliable estimates about total factor productivity

Suresh and Chandrakanth (2015) estimated the total factor productivity and returns to investment in ragi (finger millet) crop in Karnataka state. The total factor productivity indicates the contribution of non inputs to the growth of agricultural productivity. The result indicates that, the total factor productivity index of ragi grew at the rate of 4.75 per cent per annum. The average TFP index for 20 years was 1.87. Public research significantly contributed to TFP growth in ragi. The additional investment of one rupee in ragi research generated additional income of Rs. 26.84, indicating substantial rate of returns to investment on research in ragi in Karnataka. Hence the Government should allocate substantial funds to public research in ragi for productivity improvement of ragi crop providing food security to masses.

Above reviews indicated that, in majority of the crops, the TFP index was more than one indicating there was contribution of both conventional and non-conventional inputs to the output growth. Both public and private research contribution was more towards output growth.

2.3 Technical change

Bhushan (2005) used Data Envelopment Analysis to estimate Malmquist TFP index for major wheat producing states in India- Punjab, Haryana, Madhya Pradesh, Uttar Pradesh and Rajasthan. He found TFP growth rate to be highest in Punjab and Haryana which was attributed to technical progress in these two states. Rajasthan (with no efficiency change) and Uttar Pradesh (with improvement in efficiency and negative growth in technological progress) had positive TFP growth rate while Madhya Pradesh (no change in efficiency and negative growth of technical progress) was reported to record negative TFP growth rate. As compared to 1980s, mean growth of TFP was found to be higher in 1990s and the primary source of TFP growth was technical progress and not efficiency improvements.

Belloumi and Matoussi (2009) investigated the patterns of agricultural productivity growth in 16 Middle East and North Africa (MENA) countries during the period 1970 - 2000. They used a non-parametric, output-based Malmquist index to examine whether our estimates confirmed or invalidated the previous studies results indicating the decrease of agricultural productivity in developing countries. The average agricultural productivity growth increased at an annual rate of one per cent during the whole period. The estimates showed that the technical change was the main source for the increase in productivity growth.

Candemir *et al.* (2011) studied production efficiencies and total factor productivity changes of Hazelnut Agricultural Sales Cooperatives Unions (HASCUs) in Turkey over the period 2004-2008. To measure production efficiencies, Data Envelopment Analysis (DEA) Approach and Malmquist Productivity Indexes are used. In efficiency analysis, the data of 50 HASCUs is considered but only the data of 37 cooperative units is found appropriate for the DEA. The findings of our study showed that the average annual technical efficiency scores of HASCUs change between 0.841 and 0.938. It has also been observed that there are average annual 1.3 per cent improvements in technical efficiency, 3 per cent regress in technical change, and 1.7 per cent decreases in the total factor productivity of the HASCUs over the period 2004-2008.

The study on Decomposition of Technical Change and Productivity Growth in Indian Agriculture Using Non-Parametric Malmquist Index was conducted by Singh and Singh (2012). The study estimated the total factor productivity growth and technical progress of Indian Agriculture between the period 1971 to 2004, using Data Envelopment Analysis. It has been observed that the productivity growth of Indian agriculture is negative, thus confirms that the entire output growth is contributed by input growth. The decomposition of productivity growth into efficiency changes and technical progress reveals that the efficiency change is positively contributing towards the growth of productivity whereas, the negative growth of technology restricts the potential productivity growth in Indian agriculture. Further, it has also been observed that efficiency change is insignificant whereas, the technical change is of Hicks non-neutral type in Indian agriculture.

Chaudhary (2012) studied total factor productivity (TFP) in Indian agriculture at state-level using Index of Agricultural Production as the measure of output, changes in TFP are estimated using non-parametric Sequential Malmquist TFP index. It was found that productivity improvements are marked in very few states, and so is technical change. The improvements in efficiency are observed to be low for most of the states and efficiency decline is observed in several states implying huge gains in production possible even with existing technology. In order to achieve higher productivity, it is essential to increase efficiency levels as well as achieve a more even spread of new technology.

Suresh (2013) made a study on trends in the total factor productivity (TFP) growth of rice in India for the period 1980-81 to 2009-10 and has decomposed the TFP growth into its constituent components, *viz.* change in technical progress and technical efficiency. For overall period, the TFP change has been at a moderate rate of 0.2 per cent per year, with large interstate variations. The positive TFP growth has been associated with a mean technical progress of 0.3 per cent and a deterioration of the mean technical efficiency by -0.1 per cent per year. Across the states, Andhra Pradesh, Punjab, Tamil Nadu and Uttar Pradesh have exhibited positive TFP growths during the overall period. The revival of the mean TFP to the level of 1.8 per cent per year during period II has mainly been affected by the positive technical change during this period. However, a matter of concern is the decline in technical efficiency. It is also observed that over the years the less-progressive states with respect to TFP growth during the period-I have caught up with the progressive states, mainly propelled by high rate of technical progress. The study has identified that during period-II the share of current and capital inputs in total cost of cultivation has reduced and input intensification has slowed down. The results have revealed that the recent yield stagnation in rice is not due to technology fatigue, but could be due to the sluggish input intensification.

Kumar and Anwer (2015) analysed total factor productivity (TFP) growth and its components in production of rapeseed and mustard (R&M) in major states of India. The productivity growth has been estimated through Data Envelopment Analysis (DEA) based Malmquist Productivity Index (MPI) for the period 1994– 95 to 2011–12. Decomposition analysis of TFP change had revealed that output growth of rapeseed and mustard was driven by both technical change and technical efficiency change. This was further witnessed by the positive and significant growth of yield in increasing production of rapeseed and mustard. The analysis of input use had shown lower growth during study period. That the share of current and capital inputs in total cost of cultivation has shrunk and input use efficiency had slowed down significantly (except Rajasthan). The study has concluded that the recent growth trends in yield of rapeseed and mustard in the states studied could be due to inefficiency of input use rather than slowdown in technical change.

Praveena *et al.* (2015) assessed the performance and efficiency level of sugar mills in India. Data Envelopment Analysis (DEA) by using constant returns to scale method was applied on the input and output data for the period of 2009– 2014. The total factor productivity was calculated by using the Malmquist DEA. The study revealed that the average technical efficiency of sugar mills in India was 59.50 per cent. Based on the average technical efficiency change most of the mills were performing at the optimum level and some of the mills were underutilizing its labour input. The mills located in the southern regions were performing well when compared to the other counter parts of the region. TFP change could be increased or decreased based on the technical and technological change. The TFP values of some of the firms were more than unity indicating the productivity gain of the mills.

Das (2015) estimated the total factor productivity (TFP) growth of jowar and bajra using three different methods, *viz.* Solow index method, Tornqvist-Theil index method and the Malmquist index method. The first two methods imposed certain theoretical restrictions while calculating TFP growth. These restrictions were addressed by using the third method, *viz.*, the Malmquist index method. Jowar and bajra being rainfed crops, rainfall has been considered as one of the inputs in the production of these coarse cereals in the Malmquist index method. Hence, it was argued that on a number of counts, the contemporaneous Malmquist index method of TFP measurement could be more preferable as it gave reliable total factor productivity estimates.

Suresh and Reddy (2016) examined the consumption pattern of pulses in India and has estimated the TFP growth of major pulses (chickpea, pigeon pea, green gram and black gram) in the country. The study carried out for the period from 1994-95 to 2012-13, has used Malmquist productivity approach to estimate the TFP. The study revealed that pulses were the cheapest source of proteins among all foods and therefore, had a significant place in improving nutrition at individual level as well as country level. The case study on chickpea in Andhra Pradesh had shown that productivity improvement was directly related to the share of improved varieties adoption. The study had concluded that the development of affordable technologies suitable for marginal environments and emerging cropping patterns would help improve the productivity of pulses in India, thereby contributing to the under-consumption of protein.

Liu *et al.,* (2020) conducted study on sources of total-factor productivity and efficiency changes in China’s agriculture. The agricultural technical efficiency level fluctuated between 80 per cent and 91 per cent with a stable trend and a slight decline in later years, while TFP improved consistently over time, mainly driven by technological progress. Among the determinants, government investment in agricultural development projects significantly drives, TC and TE, while the experienced labor force significantly increases TE. The disaster rate significantly reduces TE but promotes TC and TFP. The literacy rate significantly improves TC and TFP. However, government expenditures in “agriculture, forestry and water” significantly reduce TE, TC, and TFP.

2.4. Value chain analysis

Doddamani and Kunnal (2007) have analysed the value addition to naturally-coloured cotton at different stages of processing in Uppinabetageri village of Dharwad district, in Karnataka. It has been found that during ginning one quintal of colour cotton yielded 35 kg lint, 64 kg seed and 1 kg of waste. This lint underwent spinning process and yielded 29.69 kg yarn and 5.31 kg waste. The yarn underwent the weaving process and yielded 28.96 kg cloth and 0.98 kg waste. The 29.96 kg cloth has been found equivalent to 106.28 metres of cloth. While preparing (cuttings) shirts, 1.28 m of waste material was obtained. Finally, 42 shirts were made from 105 m of cloth. The study has found that an additional value of Rs. 5,875 was generated through processing kapas into cotton garments (shirts). Its break-up at different levels of processing has been recorded as follows: ginning, Rs.327 (5.57 %); spinning, Rs.781 (13.30 %); weaving, Rs.1626 (27.68 %); and garments manufacturing, Rs. 3140 (53.45 %).

Shwetha (2008) has conducted a study on documentation and evaluation of indigenous method of papad preparation in Dharwad district of Karnataka. The production and cost analysis of rice nere happala was assessed in comparison with blackgram dhal papad.The returns per rupee spent on nere happala was Rs. 1.55 was higher than blackgram dhal papad Rs. 1.36. Where seven days of soaking affected the aroma and taste of bajra, maize and jowar nerehappala while ragi, rice and wheat nere happala were highly accepted by the consumers.

Lawal *et al.* (2010) examined the profitability to the farmers' households through value addition in the Cashew in Kogi state of Nigeria. The cashew tree is an economic crop in Nigeria grown in small plantations in almost every State because of the ease of cultivation and need for minimum attention. Study revealed that the profit per farmer adding value to apples and nuts stood at US$ 566.42 per tonne of cashew. The gross revenue, gross margins and net income per farmers adding value are higher ($ 566.42; $ 495.55 and $ 487.26) than those of farmers not adding value ($ 378.28; $ 313.83 and $ 306.49). There is a profit margin of US$188 between the two groups. There was a significant difference (P<0.05) between net income per farmer adding value (US$ 487.26) and not adding value (US$ 306.29). Also, the benefit-cost ratio of adding value was 1:2.30.

Sharma *et al.* (2010) have studied the extent of value addition in different agro-processing units in Himachal Pradesh where there are about 9,000 tiny and medium sizes of agro-processing units for processing of fruits, vegetables, cereals, pulses, oilseeds and a variety of ancillary agricultural commodities. These units have used the total input worth of 7, 97,182 in production of various value-added products, realizing the returns of 10, 84,921 resulting in the net value addition of 36 per cent over input cost. In the case of rice mill, 13 per cent value addition was made with rice milling. The value addition was quite high in bakeries (99 %), pulses (89 %), vegetables and fruit-based processing industries (133 %).

Kusuma *et al*. (2013) assessed the cost and return from the production and value addition of the Foxtail millet in the Bellary district of Karnataka. The per hectare total cost of cultivation of foxtail millet worked out to be Rs. 11607.21 and returns was Rs.17190 per hectare. Total cost involved in the preparation of Papad was Rs.7000, gross returns realized were Rs.11880 and net returns were Rs. 4880. In preparation of tambittu, gross returns were Rs. 14250 and net returns were Rs.5960 after deducting total cost of Rs.8290 from gross returns. Value added products of foxtail millet brought more returns to the farmers than the foxtail millet grains.

Mirjana *et al.* (2013) examined general tendencies in the fruit production and processing in Serbia. The analysis of production volume change was conducted in major semi-processed and finished fruit products during 2001-2010.The results revealed that in the period 2001-2010, the total production of volume of processed fruit products in Serbia was 193,329 tonnes ranging from 84,118 tonnes in 2001 to 284,463 tonnes in 2010. The highest production was recorded in fruit juices 155,012 tonnes and in frozen fruits 24,602 tonnes. These processed fruit products account for 92.91 per cent of the total analysed processed fruit products in Serbia. The production volumes of the other analysed processed fruit products ranged from 329 tonnes (dried fruits) to 5,032 tonnes (concentrated fruit juices).

Radhika *et al.* (2013) have analysed value addition in cotton in Hyderabad. The value addition to cotton takes place at three main stages of processing *viz.*, ginning, spinning and weaving. The results of analysis indicated that an additional value to the extent of Rs. 2297.54 was created in the course of processing cotton kapas in to yarn. The breakup of the same at different levels of processing i.e., at ginning was Rs. 339.54 (14.78 %) and spinning Rs. 1958 (85.22 %).

Michael and John (2014) made a comparative analysis of the profitability of pineapple-mango blend and pineapple fruit juice processing in Awutu-Senya-East district of Ghana. This study compares the profitability of blend (i.e. fruit juice made up of pineapple and mango blend) with that of pineapple juice alone. The empirical results revealed that Pineapple juice processing had a benefit cost ratio of 1.03, NPV of GHS. 11,728 and IRR of 23 per cent which is greater than the discount factor 21 per cent. The blend yielded benefit cost ratio of 1.36, NPV of 1, 76,831 and

IRR of 23 per cent. They concluded that it is more profitable to invest in the blend, because the net cash flow in the second year (GHS 58,146.00) for the blend is more than triple that of the pineapple juice only (GHS 17,826.00).

Thakur *et al.* (2016) examined the economics of three Ocimum species, namely *O. tenuiflorum, O. gratissimum and O. basilicum* grown under teak based silvi-medicinal (teak + *Ocimum spp.*) and sole cropping systems and has investigated the effect of value addition due to herb and oil production in Navasari university of Gujrath. The study has found that herbage production of *O. gratissimum* provided highest net returns of Rs. 38,018 per ha and benefit-cost ratio of 1.85 when grown under sole cropping and ` 25,418 per ha and benefit cost ratio of 1.24 when grown under silvi-medicinal system. The value addition due to essential oil production provided additional returns of Rs. 66,324, Rs. 12,141 and Rs. 69,908 in *O. tenuiflorum*, *O.gratissimum* and *O. basilicum* respectively under sole crop and generated additional returns of Rs.52,401, Rs.7,661 and Rs.53,721 in *O. tenuiflorum*, *O. gratissimum* and *O. basilicum* respectively under intercropping system. The essential oil production from *O. basilicum* accrued the highest net returns of Rs. 1,03,327/ha with benefit cost ratio of 2.56 compared to herb.

Thippanna *et al.* (2016) assessed the economics of processing and marketing of grapes in raisin and wine making in Vijayapura and Belagavi district of North Karnataka. The costs and returns in processing grapes into different value-added products like raisins and wine was estimated. The results revealed that the total cost incurred by the processors in processing of grapes into one quintal of raisin was Rs. 5835 and hundred lit of wine was Rs. 5856. The major item was rent of the rack (Rs. 120 per q) followed by packing material of Rs. 70 (28.63 %) in raisin production and packing material was the major item which accounted for Rs. 150 (71.51 %), followed by transportation of Rs. 20 in case of Wine production. The degree of value addition in the cases of grape raisin was found to be 56.22 per cent and 56.88 per cent in case of grape wine.

METHODOLOGY

III METHODOLOGY

A general description of the study area, the data base, the sampling techniques, tools and techniques used for analysis is presented in this chapter. For better understanding chapter is arranged in an appropriate sequence under following sub-heading.

3.1 General description of the study area.

3.2 Sampling procedure adopted.

3.3 Nature and sources of data.

3.4 Analytical tools and techniques employed.

3.1 General description of the study area

The geographical, demographic and socio-economic features of the study area are presented in this section.

In India, cotton is grown in three distinct agro-ecological zones as given by (CCI), *viz.*, Northern zone (Punjab, Haryana and Rajasthan), Central zone (Gujarat, Maharashtra and Madhya Pradesh) and Southern zone (Andhra Pradesh, Telangana, Tamil Nadu and Karnataka)

Northern Zone of India

Northern zone comprising the three states *viz*., Punjab, Haryana and Rajasthan.

Punjab

Punjab, the land of five rivers, is located at the northern zone of India. Punjab has a total area of 50,362 km^2, which is around 1.54 per cent of the total geographical area of the country. It is located between 29^0 30' N to 32^0 32' N latitude and 73^0 55' E to 76^0 50' E longitude. Punjab has earned the title of Granary of India or Food Basket of India. Sugarcane, pearl millet, maize, barley and many horticultural crops are the major crops grown in Punjab. Cotton and Rice are the major commercial crops grown in Punjab.

Haryana

Haryana is a landlocked state in northern zone of India. It is between 27°39' to 30°35' N latitude and between 74°28' and 77°36' E longitude. The total geographical area of the state is

44,212 km^2, which is 1.4 per cent of the geographical area of the country. Haryana is also one of the most economically developed regions in South Asia and its agricultural and manufacturing industry has experienced sustained growth since 1970s. The main crops of Haryana are wheat, rice, sugarcane, cotton, oilseeds, pulses, barley, maize.

Rajasthan

Rajasthan is the largest state by area in India and also called land of kings located in northern part of India. It covers 342,239 km^2 or 10.4 per cent of India's total geographical area. Rajasthan, lies between 23°30' and 30° 11' North latitude and 69° 29' and 78° 17' East longitude. A significant portion of the economy of Rajasthan is agrarian. Cotton, wheat, barley, maize, bajra and oil seeds are the major crops grown in Rajasthan.

Central Zone of India

Central Zone of India comprising of three states *viz*., Gujarat, Maharashtra and Madhya Pradesh.

Major Cotton Producing Zones in India

Fig 1. Cotton producing zones of India

Gujarat

It is situated between 20^0 1' and 24^0 7' north latitudes and 68^0 4' and 74^0 4' east longitudes. The state has an area of 1,96,024 km^2, the seventh largest state in terms of area in India. Agriculture is the main occupation of the rural people and major source of employment in state. Gujarat is the largest producer of major cash crop like cotton, groundnut, tobacco, cumin, sesamum, etc. in India. Other major crops produced are rice, wheat, jowar, bajra, maize, tur, and gram.

Maharashtra

Maharashtra with a total area of 307,713 km^2, is the third-largest state by area in terms of land area and constitutes 9.36 per cent of India's total geographical area. The State lies between 15°35' N to 22°02' N latitude and 72°36' E to 80°54' E longitude. Almost 82 per cent of the rural population depends on agriculture for livelihood. The main crops of Maharashtra are mangoes, grapes, bananas, oranges, wheat, paddy, jowar, bajra, and pulses and Cash crops include groundnut, cotton, sugarcane, turmeric, and tobacco.

Madhya Pradesh

Madhya Pradesh is situated in the central region of India and that's why it is called the Heartland State. Madhya Pradesh literally means "Central Province", and is located in the geographic heart of India, between latitude 21.2°N-26.87°N and longitude 74°59'-82°06' E. Madhya Pradesh with an area of 3,08,245 km^2, is the second largest state in India. Madhya Pradesh is an agrarian economy with 35 per cent share of GVA coming from primary sector, especially agriculture and allied sector Agriculture is the main source of livelihood of a large number of the people in the state. Cotton, soyabean, wheat, paddy, jowar, maize, gram, mustard, tuar are the main crops of the state.

Southern Zone of India

Southern Zone of India comprising of four states *viz*., Andhra Pradesh, Telangana, Tamil Nadu and Karnataka

Andhra Pradesh

Andhra Pradesh lies between 12°41' and 19.07°N latitude and 77° and 84°40'E longitude. It is the seventh-largest state by area covering an area of 162,975 km^2 and tenth-most populous state. Agriculture plays an important role in the livelihood of people as 70 per cent of the population in Andhra Pradesh live in rural areas and depend on agriculture and related livelihood opportunities. The important crops grown are paddy, maize, pulses, groundnut, cotton, chillies, tobacco and sugarcane.

Telangana

Telangana lies between 15°46'and 19°47′ N latitude and 77° 16′ and 81° 43'E longitude situated in southern part of India covering an area of 112,077 km^2. Agriculture contributes 16 per cent to the economy of Telangana. Telangana state has considered agriculture as its primary goal to improve farmer community wellness, educate on latest technical farming knowledge, train framers to boost the agricultural production and productivity. Crops that are grown in Telangana are paddy, maize/ corn, red gram, green gram, jowar, sesame, castor, cotton, groundnut, soyabean, black gram.

Tamil Nadu

Tamil Nadu covers an area of 130,058 km2 and is the eleventh largest state in India. Tamil Nadu lies between 8° 5' and 13° 35' N latitude and 76° 15' and 80° 20' E longitude. Tamil Nadu agriculture is the most overriding sector in the economy of the state around 70 per cent of the state's population are involved in agricultural activities as this is one of the major means of livelihood in Tamil Nadu. The major crops grown in the state are rice, jowar, maize, bajra, ragi and pulses. Some other highly cultivating commercial crops are tea, coffee, sugarcane, cotton and coconut.

Karnataka

The state Karnataka is located between 11.5º and 18º 27' latitude and 74º 5' and 78º 33' longitude. Karnataka is the 7th largest state with an area of 191,791 km^2 and accounts for 5.83 per cent of the total geographical area of the India (3.29 lakhs km^2). Karnataka is ranked 8th place in terms of population with population of 6,11,30,704. Paddy, maize, jowar, bajra, green gram, ground nut, sunflower and soybean are the major field crops along with many horticultural crops in Karnataka. Sugarcane and cotton are the major commercial crops popularly grown in Karnataka.

3.2 Sampling procedure adopted

Simple random sampling technique was employed in the selection of sample cotton industries. A total of 10 sample respondents were considered for the study which comprised of five ginning industries and five spinning industries. The data were collected through personal interview using pre-tested well-structured schedule.

3.3 Nature and sources of data

3.3.1 Primary data

The primary data pertaining to, income, input use and marketing practices of cotton value added products *i.e.*, from raw cotton to lint (ginning) and lint to yarn (Spinning) were collected from five ginners and five spinners in Karnataka.

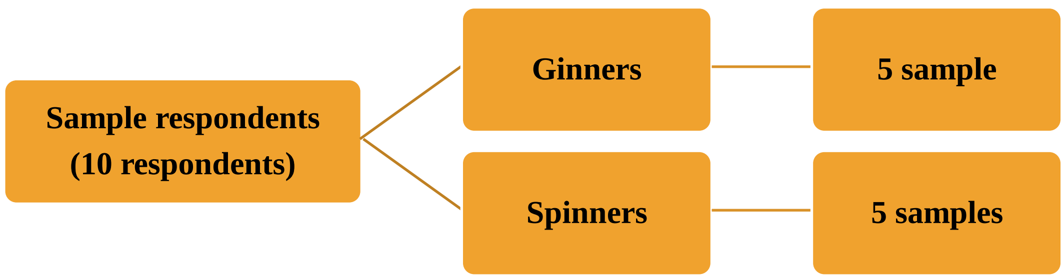

Fig. 2 Sampling design in the study area

The value addition on cotton occurs at three stages of processing *viz.*, ginning, spinning and weaving. Out of these three stages of processing, two stages *viz.*, ginning and spinning stages were considered for the present study. Conventional, functional and financial analytical tools were employed for estimating the costs and returns in cotton production, cost of processing, returns and value addition to cotton in each stage of processing.

3.3.2 Secondary data

The data pertains to area, production and productivity of cotton were collected from the Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare and Cotton Corporation of India Ltd. The time series data for the period from 1990-91 to 2020-21 were collected and categorized in to three periods *viz.*, Period I (1990 to 2000), Period II (2001-2010) and Period III (2011-2021) for cotton producing zones of India. Further the cost of cultivation data of cotton in different cotton producing zones of India collected and compiled from the cost of cultivation scheme of the Government of India from the year 2000 to 2018.

3.4 Analytical tools used

The analytical tools and techniques used for achieving the objectives of the study are presented below.

3.4.1 Descriptive statistics

3.4.2 Growth rate analysis

3.4.3 Production function analysis

3.4.4 Bai-Perron test

3.4.5 Cost and return analysis

3.4.6 Total factor productivity

3.4.7 Technical change

3.4.8 Amortized cost and Compounding

3.4.9 Cost of processing and returns

3.4.1 Descriptive statistics

The information on socio economic characters, input use, output, prices of cotton were analysed using the descriptive statistics. Important statistical measures like per centages, averages and appropriate tests were used for meaningful comparison and interpretation of the results which are presented in the form of comprehensive tables and graphs.

3.4.2 Growth rate analysis

In order to assess the trend in area, production and productivity of cotton crop in different zones of India the compound annual growth rate analysis was employed. Compound growth rates were computed using the exponential function of the form. Several functional forms were used to estimate the growth rates of the selected economic variables. Finally exponential growth model was selected for the analysis and the model is of the following form.

$$Y = a\ bt\ e^{Ut} \quad \text{………………………} (1)$$

Where,

$Y =$ Area (lakh ha.) / Production (lakh bales) / Productivity of cotton (kg/ha.),

$a =$ Intercept,

$b =$ Regression coefficient (*'a'* and *'b'* are the parameters to be estimated)

$U_t =$ Disturbance term in year *'t'*

The equation (1) was transformed into log linear form and written as;

$$\log Y = \log a + t \log b + U_t \quad \ldots\ldots\ldots\ldots (2)$$

Equation (2) was estimated by using Ordinary Least Squares (OLS) technique.

Compound growth rate (g) was then computed

$$g = (b - 1)\,100 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where,

g: Compound growth rate in per cent per annum

b: Antilog of log b

The standard error of the growth rate was estimated and tested for its significance with 't' statistic which is defined as,

$t = b_i / se\,(b_i)$

where,

b_i= Regression coefficient

se (b_i)=Standard error of the regression coefficient

3.4.3 Regression analysis

Here, relationship between inputs and output was estimated mathematically to give logical explanation i.e., production function. Production function is a relationship between crop output (output or dependent variable or regress and) and inputs (explanatory variables or regressors).

3.4.3.1 Cobb-Douglas production function

To explore the factors determining growth in area under cotton, the Cobb Douglas type of production function was fitted for the data (Beeraladinni *et al*., 2016**)**. The functional form of regression used was

$$Y = \beta_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} e^u \text{ .... } (4)$$

Where,

Y= cotton area (lakh ha.)

β_0 = Intercept

X_1 = MSP for cotton (Rs. /Qtl.)

X_2 = Rainfall (mm)

X_3 = lagged Yield of cotton (kg/ha)

(Lagged yield of cotton was taken due to increased MSP during previous year act as incentive for the farmers to take up crop in the coming years)

X_4 = Net irrigated area (thousand ha.)

β_1, β_2, β_3 and β_4 = Regression co-efficient for input

u = Random error term

The Cobb-Douglas production function was converted into log linear form and co-efficient were estimated using Ordinary Least Square (OLS) as given below.

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \text{..........} + \beta_4 \ln X_4 + u \ln e \text{............ } (5)$$

The regression co-efficient (β's) were tested using 't' test at chosen Level of Significance (LoS)

3.4.4 Bai-Perron test

To know the multiple breaks in area and production of cotton across different zones of India during 1990 to 2021 bai and perron test was used.

Both the statistics and economics literature contain a vast amount of work on the issues related to structural change, most of it specifically designed for the case of a single change. But most macroeconomic time series usually can contain more than one structural break. The econometrics literature has witnessed recently an upsurge of interest in extending procedure to various models with unknown break point. With respect to the problem of testing for structural change, recent contribution includes the treatment by Andrews (1993a, 1993b), Andrews *et al.* (1994, 1996) and Bai and Perron (1998,2003). In this section, the Bai and Perron (1998) method is considered in order to examine if there are any structural break in the series for both area and production with span from 1990 to 2021 time period. To that effect, Bai and Perron (1998) provided a comprehensive analysis of several issues in the context of multiple structural change models and develop some tests which preclude the presence of trending regressors. This test is helpful in the changes present and also it endogenously determines the points of break with no prior knowledge. The details of the methodology on structural break may be found in the article written by Bai and Perron (1998). We consider the following linear regression with m breaks (m+1 regime):

$$y_t = x_t \beta + z_t \delta_j + \mu_t \; t = T_{j-1}, \ldots T \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$(j = 1, \ldots, m+1, \; T_0 = 0 \text{ and } T_{m+1} = T)$$

Where, y_t is the observed dependent variable, x_t □□□^{p} and z_t □□□^{q} are vectors of covariates, β and δ_j are the corresponding vectors of coefficients with δ_i ¹ δ_{i+1} *(1 £ i £ m)* and μ_t is the error term at time t. The break dates $(T_1, \ldots, T_m)$ are explicitly regarded as unknown. It may be noted that this is a partial structural change model in so far as β doesn't shift and is effectively estimated over the entire sample. Then the purpose is to estimate the unknown regression coefficients and the break dates, that is to say ($\beta, \delta_1, \ldots \delta_{m+1}, T_1, \ldots, T_m$), when T observations on (y_t, x_t, z_t) are available. Note that this is a partial change model in the sense that β is not subject to shifts and is effectively estimated using the entire sample.

Bai and Perron (1998) built a method of estimation based on the least square principle. For an m-partition ($T_1, \ldots, T_m$), denoted {*Tj*}, the associated least square estimator of δ_i is obtained by minimizing the sum of squared residuals. Minimizing the sum of squared residuals ∑ $^{+1}$ $_{=1}$ ∑ $_{=}$ $_{=1}$ $[y_t - x_t \beta + z_t \delta_j]^2$

Under the constraint δ_i ¹ δ_{i+1} (*1 £ i £ m*). Let *δ* ({*Tj*}) be the resulting estimate. Substituting it in the objective function and denoting the resulting sum of squared.

residuals as $S_T (T_1, \ldots, T_m)$, the estimated break dates $(T_1, \ldots\ldots\ldots T_m)$ are such that

$$(T_1, \ldots Tm) = \text{argmin } (T_1 \ldots T_m) \; S_T (T_1, \ldots, T_m) \; \ldots\ldots\ldots\ldots \; (7)$$

Where argmin denotes algorithm minimum and the minimization is taken over all partitions $(T_1, \ldots, T_m)$ such as $T_i - T_{i-1}$ ³ *[εT]*. The term *[εT]* is interpreted as the minimal number of observations in each segment. Thus, the breakpoint estimators are global estimators are globaly minimizes of the objective function. Finally, the regression parameter estimates are obtained using the associate least-squares estimates at the estimated m-partition, $\{T_j\}$ *i, e.* d = d ($\{T_j\}$).

3.4.5 Cost and return analysis

Cost concepts

The cost and returns analysis were worked out using the methodology proposed by the Commission for Agricultural Costs and Prices (CACP). CACP is an advisory body that is attached to the Ministry of Agriculture and Farmers Welfare of India (New Delhi, India). In accordance with this methodology, there are cost concepts such as cost A_1, A_2, B_1, B_2, C_1 and C_2.

Cost A1 = Value of hired human labour (HL), value of hired bullock labour (BL), value of owned bullock labour, value of owned machine labour (ML), hired machinery charges, value of seed (both farms produced and purchased), value of pesticides, value of manure (owned and purchase), value of fertilizers, irrigation charges, depreciation on implements and farm building, land revenue, cesses and other taxes, and interest on working capital

Cost A_2 = Cost A_1+ Rent paid for leased-in land,

Cost B_1 = Cost A_1 + interest value of owned fixed capital assets (excluding land)

Cost B_2 = Cost B_1 + Rental value of owned land (net of land revenue) and rent paid for leased-in land

Cost C_1 = Cost B_1 + imputed value of family labour

Cost C_2 = Cost B_2 + Imputed value of family labour

Rates of Returns over Different Cost Concepts

Gross Income: [Yield of main product (in kg/hactare) x Its prices (Rs.)] + [Yield of by product (in kg/hactare) and Its prices (Rs.)]

Net Income: Gross Income – Cost C_2.

Returns per rupee of expenditure: Return per rupee of expenditure was calculated by dividing the gross income by cost C_2.

3.4.6 Total factor productivity index

Total Factor Productivity (TFP) measures the increase in total output which is not accounted for by increases in total conventional inputs. The TFP index is computed as the ratio of an index of aggregate output to an index of aggregate inputs. Growth in TFP is therefore the growth rate in total output less the growth rate in total inputs (Rose and Evenson,1995).

Selection of variables

Data on quantity and prices of following variables were collected for the estimation of total factor productivity and different efficiency measures.

a) Output series

The total value of output of a cotton was derived by summing up the values of main product and the by-product in rupees. This gross value of the output was then divided by area under the crop to get the price of main product.

b) Input series

For construction of input Index, data on the following inputs – human labour, animal labour, machine labour, seed, fertilizers (NPK), manures, irrigation of cotton in all zones of India has been taken.

3.4.7 Tornqvist- Theil TFP Index

The total factor productivity of cotton in different cotton producing zones of India was estimated using Tornqvist-Theil Index. The Tornqvist Index of TFP is the commonly used index for measuring TFP growth. It does not require the assumption of neutral technical change and allows for variable elasticity of substitution (Evenson *et al.*, 1999). The Tornqvist Index of TFP is given by

$$\ln (TFP_{t+1} / TFP_t) = \tfrac{1}{2} \sum (R_{jt+1} + R_{jt}) \ln (Q_{jt+1} / Q_{jt}) - \tfrac{1}{2} \sum (S_{it+1} + S_{it}) \ln (X_{it+1} / X_{it}) \quad \ldots\ldots (8)$$

Where,

R_{jt} is the share of output j in revenues,

Q_{jt} is output j,

S_{it} is the share of input i in total input cost, and

X_{it} is input *i*, in period *t*.

$$R_{jt} = (P_{jt} * Q_{jt}) / \sum (P_{jt} * Q_{jt})$$

Here, P_{jt} is the price of output of crop Q_j in period t

$$S_{it} = (w_{it} * x_{it}) / \sum_{i=1}^{N} (w_{it} * x_{it})$$

Where,

W_{it} is the price of input X_i in period t.

In this study, the output index, input index and TFP index are constructed separately for different cotton producing zones (Northern, Central and Southern) of India. To construct output index, the time series data (2000-01 to 2017-18) on main product, by product and prices were used, where as to construct input index, the time series data with regard to inputs like seeds, manure, chemical fertilizer, human labour, bullock labour, machine labour, plant protection chemicals and prices of inputs are used. Finally, the TFP index was computed by dividing output index by input index.

We have specified that the index is equal to 1.00 in a particular year i.e., here we considered 2000-01 as base year and TFP chain index constructed as it provides annual changes in productivity over a period of time (Coelli, *et. al., 2005*). The Chain- linking index takes into account the changes in relative values/costs throughout the period of study. This procedure has the advantage that no single period plays a dominant role in determining the share weights and biases are likely to be reduced (Kumar *et al.*, 2004). The TFP indices were computed using the software TFPIP version 1.0, which developed by Tim Coelli, Centre for Efficiency and Productivity Analysis, University of Queensland, Australia.

Data: Panel data on costs and returns of cotton for the years 2000-01 to 2017-18.

Source: Plot level summary data under cost of cultivation scheme, Directorate of Economics and Statistics (DES), Government of India.

3.4.7.1 Sources of TFP Growth

The TFP is influenced by research, extension, human capital, and intensity of cultivation, application of plant nutrients, infrastructural development and climatic factors. As an input to public investment decisions, it is useful to understand the relative importance of these productivity-enhancing factors in determining productivity growth (Chand *et al.*, 2011).

In order to assess the determinants of TFP, the TFP index was regressed against the following variables:

Irrigated area (ha);

Annual rainfall (mm);

NP Ratio (Nitrogen to Phosphorus);

Scale of finance (Rs.);

Road density (km per 1000 km);

Minimum support price (Rs. /q)

Regression analysis was performed with above variables for cotton: The model specified in log linear form as:

$$\ln(TFP) = a+b_1\ln X_1+b_2\ln X_2+b_3\ln X_3+b_4\ln X_4+b_5\ln X_5+e \quad \ldots\ldots\ldots (9)$$

a = intercept;

X_1 = Irrigated area (ha)

X_2 = Annual rainfall (mm)

X_3 = N to P ratio (Nitrogen to Phosphorus)

X_4 = scale of Finance (Rs.)

X_5 = Road density (km/1000 km)

X_6 = Minimum support price (Rs. /q)

$B_i \ldots b_6$ = Regression coefficient of i^{th} (i = 1 to 6)

e = error term

3.4.8 The Malmquist productivity index

To find out the technical change of cotton in different cotton producing zones of India from 2000-01 to 2017-18, employed Malmquist productivity index. The Malmquist TFP index was first introduced by Caves *et al.* (1982). They defined the TFP index using Malmquist input and output distance functions, and thus the resulting index came to be known as the Malmquist TFP index. The period 't' Malmquist productivity index is given by

$$M^t = \frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \qquad (9)$$

i.e., they define their productivity index as the ratio of two output distance functions taking technology at time using period t as the reference technology. Instead of using period t's as the reference technology it is possible construct output distance functions based on period (t+1)'s technology and thus another Malmquist productivity index can be laid down as:

$$M^{t+1} = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)} \qquad (10)$$

Fare *et al*. (1994) attempted to remove the arbitrariness in the choice of benchmark technology by specifying their Malmquist productivity change index as the geometric mean of the two – period indices, that is,

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\right)\left(\frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \qquad (11)$$

Using simple arithmetic manipulation, the equation 11 can be written as the product of two distinct components-technical change and efficiency change Fare *et al*. (1994).

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)}\left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right)\right]^{\frac{1}{2}} \qquad (12)$$

Where,

$$Efficiency\ change = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \qquad (13)$$

$$Technical\ change = \left[\left(\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})}\right)\left(\frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)}\right)\right] \qquad (14)$$

Hence the Malmquist productivity index is simply the product of the change in relative efficiency that occurred between periods t and t+1, and the change in technology that occurred between periods t and t+1.

The efficiency change can be further decomposed into pure efficiency change and scale efficiency change. A detailed account on the Malmquist productivity index can be had from Fare *et al*. (1994), Coelli *et al*. (2005), Bhushan (2005) and Chaudhary (2012).

The total factor productivity change is decomposed into technical efficiency change and technical change indices. If technical efficiency change index is greater than one, it means that there is an improvement in efficiency or catching-up effect the best practice frontier. On the other hand, if it is less than one it shows a deterioration in production performance of the decision-making unit. The technical efficiency change is also decomposed into pure efficiency and change and scale efficiency changes. The scale efficiency change index being greater one indicates the success of cooperative to produce in optimal scale, while pure efficiency change index greater one indicates that there is a learning process in the decision-making unit.

Fare *et al*. (1994) identified four important advantages of using Malmquist Productivity Index compared to other approaches. They include:

(1) The approach requires data on only quantity, and not prices. Information on prices are generally not available for every input and output for many countries.

(2) The linear programming-based approach doesn't assume an underlying production function, and therefore the stochastic properties associated with the error term.

(3) No prior assumption regarding the optimizing behavior of the decision-making inputs and

(4) Since the approach allows for both movement towards the frontier and shift in the frontier, it is possible to decompose the TFP into its components viz technical change and efficiency change.

3.4.9 Value Chain of cotton in India

Cotton, being a commercial crop of great economic importance, has a value chain since time immemorial. The cotton value chain consists of cotton producers, traders, ginners, spinners, weavers, knitters, fabric processors, garment and apparel manufacturers and consumers. In an effective cotton value chain, all the stake holders right from cotton producers to consumers are benefitted in terms of high productivity and quality of raw material and finished goods at every stage in the chain.

Fig.3 Cotton value addition stages in India

The value addition on cotton occurs at three stages of processing *viz.*, ginning, spinning and weaving. Out of these three stages of processing two stages *viz.*, ginning and spinning stages were considered for the present study. Conventional, functional and financial analytical tools were employed for estimating the costs and returns in cotton production, cost of processing, returns and value addition to cotton in each stage of processing. In the conventional cotton value chain, seed cotton is converted into lint, spun into yarn, woven into fabric and finally converted into garments and made-ups for end users and export.

3.4.10 Estimation of cost and returns in processing of cotton

To study the value addition in cotton, calculations about the economics of cotton processing were made on per quintal basis using averages and per centages.

Cost concepts involved in Ginning and Spinning Units

Ginning

Ginning is the process by which the cotton fibers are separated from the seeds is called ginning.

Spinning

The process of producing yarns from the extracted cotton fibres is called spinning. In this process: The strands of cotton fibres are twisted together to form yarn.

Kapas

Kapas is raw cotton or seed cotton

Variable cost: Those costs vary with the level of production are considered as a variable cost. The items included in this category are raw material taken (Cotton and lint), raw material procurement cost (includes raw material cost), transportation, loading & unloading of raw material, wastage, maintenance and repair cost, electricity cost, labour for processing and miscellaneous cost.

Raw material cost: The cost incurred on purchase of both raw cotton and lint were considered.

Raw material procurement cost: The expenditure made on transportation, loading & unloading of raw cotton and lint procured including raw material cost were taken during calculation.

Wastage: The cost incurred on wastage during transportation, loading, unloading and storage in both ginning and spinning units.

Maintenance and repair cost: The expenditure towards maintenance of infrastructure which are required for ginning and spinning were considered during the calculations.

Electricity cost: The cost paid towards usage of electricity to run the ginning and spinning units.

Labour cost: The actual expenditure incurred on hired human labour and machine labour were recorded during processing (Ginning and spinning) of cotton were taken.

Miscellaneous cost: The cost includes information gathering, computer and telephonic charges *etc.*, were considered.

Fixed cost: These are the cost which do not varies with the level of production. The different items of fixed costs considered in the study are explained below: The components under amortized cost includes, Amortised cost of Buildings, Amortised cost of Plant machineries, Amortised cost of tools and equipment's

Amortized cost: Amortization is an accounting technique that reduces cumulative establishment cost at a discount rate over the economic life of the building. Plant machineries and tools & equipment's. To arrive at amortized establishment cost, the following formula was used:

Amortized Cost of building = $(Compounded\ cost\ of\ building)\frac{(1+i)^{AL}*i}{(1+i)^{AL}-1}$

Where,

AL = average age or life of building

i is discount rate considered = 2 per cent

Amortized Cost of Plant machineries =

$$(Compounded\ cost\ of\ Plant\ machineries)\frac{(1+i)^{AL}*i}{(1+i)^{AL}-1}$$

Where,

AL = average age or life of Plant machineries

i is discount rate considered = 2 per cent

Amortized Cost of tools and equipment's =

$$(Compounded\ cost\ of\ tools\ and\ equipment's)\frac{(1+i)^{AL}*i}{(1+i)^{AL}-1}$$

Where,

AL = average age or life of tools and equipment's,

i is discount rate considered = 2 per cent.

Compounding cost

Traders invest on construction of building during different time periods, and the buildings have different vintages. In order to bring all historical costs / investments on buildings on par, investments made by different traders in different years, are compounded to the present (Say 2020) at the interest rate of two per cent.

$$Compounded\ cost\ of\ Building = (Historical\ investment\ on\ building)*(1+i)^{(2020-year\ of\ purchase)}$$

$$Compounded\ cost\ of\ Plant\ machineries = (Historical\ investment\ on\ Plant\ machineries)*(1+i)^{(2020-year\ of\ purchase)}$$

$$Compounded\ cost\ of\ tools\ and\ equipment's = (Historical\ investment\ on\ tools\ and\ equipment's) * (1+i)^{(2020-year\ of\ construction)}$$

Insurance: Risk premium is the cost paid by the farmer to overcome the risk from natural calamities. A part of premium cost is also considered in the cost concept.

Tax: The cost of 5 per cent of Goods and Service tax will be considered.

Imputed land rent: The prevailing land rent will be considered during the calculation.

Returns from processing of cotton (kapas) to lint: The different components like Returns from main product (lint), Returns from by-product (seed), Cotton trash, Gross returns, Value addition, Processing cost, Net value addition, Benefit-cost ratio were considered.

Gross return: Gross returns included returns from main product valued at the selling prices and by-products valued at the prevailing prices in the both ginning and spinning units.

BC Ratio: It is calculated by dividing gross return to total cost incurred.

Marketing cost: The cost of yarn (Ginning) and lint (Spinning) marketing includes Packing material, selling expenditure, goods and services tax GST (5 %) and miscellaneous cost.

RESULTS AND DISCUSSION

IV RESULTS AND DISCUSSIONS

The findings of the study in consonance with the objectives of the study are presented in this chapter under the following headings

4.1 Growth in area, production and productivity of cotton in different zones of India

4.2 Costs and returns in cotton cultivation in different zones of India

4.3 Total factor productivity of cotton in different zones of India

4.4 Sources of total factor productivity growth of cotton in different zones of India

4.5 Technical change in cotton in different zones of India

4.6 Value chain in cotton

4.1 Growth in area, production and productivity of cotton in India

The CAGR computed for three sub periods i.e., Period I (1990 to 2000), Period II (2001 to 2010) and Period III (2011 to 2021) are presented below.

4.1.1 The compound annual growth rate (CAGR) of area under cotton in different zones of India

The growth rates of area under cotton in different zones of India from 1990-2021 are presented in the Table 03. The analysis of CAGR revealed that the area under cotton expanded in the central zone during both time periods (1990-2000 and 2001-2010), with CAGRs of 2.04 and 2.84 per cent, respectively and during 2011-21 it was only 0.01 percent due to the wide spread infestations of sucking pest in the region. The CAGR of area during period I turned out to be 1.23. However, during period II (-1.12 per cent) with overall growth rate of -0.91 per cent in northern zone due to farmers were switching over to other crops due to resurgence of sucking pest and leaf curl disease.

Similarly, in southern zone, growth in area was 2.68 per cent during during 1990 to 2000, and only 1.83 percent 2001 to 2010 however, during 2011 to 2021 CAGR was 3.22 and was significant this might be attributed to attractive price support programmes initiated by government of India (Beeraladinni *et al*., 2016). At all India level CAGR found to be 2.71 per cent, 2.03 percent and 1.10 percent during three study periods with CAGR of 1.96 per cent in overall study period. The similar findings obtained by Saraswati *et al.* (2012) who reported that significant positive growth in area under pulses, vegetables and spices and fruits and nuts however cereals showed significant negative growth in Karnataka.

Table 03: The compound annual growth rate of area under cotton in different zones of India from 1990 to 2021

(%)

Zones/periods	**1990-2000**	**2001-2010**	**2011-2021**	**overall**
Northern zone	1.23	-1.12	0.19	-0.91
Central zone	2.04*	2.84***	0.01	2.24***
Southern zone	2.68**	1.83	3.22**	2.96***
India	**2.71*****	**2.03****	**1.10***	**1.96*****

Note: ***, ** and * indicates one, five and ten per cent level of significance.

Table: 04: Growth rates of production of Cotton in different zones of India from 1990 to 2021

(%)

Zones/ periods	**1990-2000**	**2001-2010**	**2011-2021**	**overall**
Northern zone	-4.63*	8.43***	1.34	1.66***
Central zone	6.61**	18.46***	-1.25*	7.17***
Southern zone	1.82	8.52***	1.15	5.95***
India	**2.30***	**13.61*****	**0.30**	**5.41*****

Note: ***, ** and * indicates one, five and ten per cent level of significance.

4.1.2 The annual compound growth rate (CAGR) of production of cotton in different zones of India

The Table 04 depicts the growth rates in cotton production in different zones of India over the study period. In northern zone the production of cotton decreased significantly with a CAGR of -4.63 per cent during 1990 to 2000. While trend increasing at significant CAGR of 8.43 per cent during 2001-2010. However, it declined during 2011-2021 production registered CAGR of 1.34 per cent. In central and southern zones of India was observed that the production of cotton increased with a CAGR of 6.61 per cent to 18.46 per cent and 1.82 to 8.52 per cent from 1990-2000 to 2001-2010, respectively. The cotton production in India increased significantly with a CAGR of 2.30 to 13.61 per cent and declined during 2011-21 with CAGR of 0.30 per cent which was insignificant. In total, cotton production has increased from period I to period II due to introduction of *Bt* cotton and declined in the period III due to infestation of pink boll worm pest.

Table 05: Growth rates of cotton productivity in different zones of India from 1990 to 2021

(%)

Zones/periods	**1990-2000**	**2001-2010**	**2011-2021**	**overall**
Northern zone	-5.40**	9.39***	-0.30	2.25***
Central zone	4.21*	14.65***	-0.79	5.12***
Southern zone	-0.41	5.77***	-1.41	4.08***
India	**-0.39**	**11.34*** **	**-13.15***	**1.58**

Note: ***, ** and * indicates one, five and ten percent level of significance.

4.1.3 The compound annual growth rate (CAGR) of productivity of cotton in different zones of India

Growth rate of cotton productivity in all zones of India were depicted in the Table 05. From the analysis, it was observed that in northern zone growth rate of productivity of cotton increased significantly at the rate of negative -5.40 to 9.39 per cent during 1990-2000. However, the declined during 2011 to 2021 for about negative 0.30 per cent although non-significant. The similar observations were made in the central and southern zones of India, in which cotton yield level was increased with a CAGR of 4.21 to 14.65 per cent and negative 0.41 to 5.77 per cent from 1990 to 2010 respectively. However, declined productivity in both the zones were noticed with negative CAGR at 0.79 and 1.41 per cent during the period 2011-21. CAGR of productivity of cotton in India increased significantly from -0.39 to 11.34 per cent from the period I to period II and declined during 2011-21 with a negative CAGR rate at 13.15 per cent. In total, cotton productivity has increased from period I to period II due to introduction of *Bt*-cotton which significantly increased the productivity of cotton by means of all the sources of growth even though the technology mission on cotton was introduced much earlier.

4.1.4 Factors determining the sources of growth in cotton area across different zones and India

In order to estimate the factors influencing the sources of growth in cotton area across cotton producing zones and India, the Cobb-Douglas production function was fitted using MSP (minimum support price), rainfall, lagged yield, net irrigated area as the independent variables and area under cotton as dependent variable.

From the Table 06 the results show that the minimum support price found to be significant factor only in the northern zone of India with the coefficient of 0.65 which was significant at five per cent of probability. This implied that one per cent increase in the MSP results into 0.65 per cent increase in the acreage under cotton in the region. However, this is not true in other zones mainly due to the lack of awareness among the farmers and operations of MSP Scheme is limited to northern zone.

The net irrigated area found to be significant factor in influencing the cotton acreage in central zone with one per cent increase in the net irrigated area it led to 0.34 per cent increase in the acreage of cotton. However, production coefficient for net irrigated area found to be negative in the southern zone indicating that as increase in the area under irrigation which motivates those farmers to shift for water intensive crops like rice and sugarcane from the cotton crops due to well established market for these crops in the region. It could be also observed that net irrigated area negatively contributing to the overall cotton acreage with -2.88 per cent of coefficient at five per cent level of probability.

The lagged cotton yield found to be significantly contributing to cotton acreage in India. The co efficient for lagged yield of cotton was found to be significant in the southern zone with coefficient of 0.55 at five per cent level implying that one per cent in increase in lagged yield which contributes of an about 0.55 per cent increase in the acreage of cotton crop.

The model chosen was found to be good fit to the data as variables considered in the model explained 89 percent variations in cotton acreage at country level as revealed by R^2 (0.89) whilst, 88 per cent in both central and southern cotton producing zones and 75 per cent in the case of northern zone of India.

4.1.5 Structural breaks in area and production of cotton

The structural breaks have been estimated through employing Bai-perron test for area and production of cotton across cotton producing zones and India during the period from 1990 to 2021 and the results are presented in Table 07. The results showed that the northern zone showed two break periods during 2002 and 2017a, with an average growth rate of cotton acreage found to be -0.66 per cent in 2002 and 9.86 per cent in 2017. This implies that the commercial release of *Bt* cotton in 2002 contributed significantly to the phenomenal increase in the area under cotton and led to increase in the cotton production, which led to 7.73 per cent growth in cotton during 2004. In case of Central zone of India 1995, 2006 and 2010 observed as break years for cotton area whereas, 2003 and 2004 showed break years for production of cotton. In southern zone 2010 and 2007 was observed break years for area and production of cotton.

Table 06: Factors affecting area under cotton in different zones of India

Particulars	North Zone		Central zone		Southern zone		India	
	Coefficients	t value	Coefficients	t value	Coefficients	t value	Coefficients	t value
Intercept	0.08 (0.13)	0.61	0.09 (0.07)	1.4	0.30*** (0.09)	3.23	0.28** (0.04)	7.21
MSP	0.65** (0.29)	2.24	-0.14 (0.12)	1.11	-0.27 (0.54)	0.51	0.12 (0.12)	1.00
Rainfall	1.25 (0.91)	1.37	0.26 (0.20)	1.3	1.38*** (0.33)	4.21	0.45*** (0.13)	3.37
Lagged yield	0.16 (0.16)	0.99	0.20 (0.06)	3.69	0.55*** (0.12)	4.62	0.15*** (0.06)	2.67
Net irrigated area	9.51 (8.02)	1.19	0.34*** (1.62)	0.21	-10.23* (5.03)	2.04	-2.88*** (1.73)	1.67
Adjusted R^2	0.75		0.88		0.88		0.89	
MSE	0.17		0.24		0.11		0.06	
F value	3.46		54.12		54.12		60.92	
Observations	31		31		31		31	

Note: ***, ** and * indicates one, five and ten per cent level of significance

Table 07: Structural breaks in area and production of cotton in India from 1990-91 to 2020-21

Zones	Area		Production	
	Break years	Growth rates	Break years	Growth rates
Northern zone	2002 2017	-0.66(1990-2002) 9.86(2002-2017) 7.22(2017-2021)	1997 2004	-2.16(1990-1997) 7.73(1997-2004) 0.87(2004-2021)
Central zone	1995 2006 2010	2.33(1990-1995) 1.23(1995-2006) 5.02(2006-2010) -0.13(2010-2021)	2003 2010	3.29(1990-2003) 13.65(2003-2010) -1.17(2010-2021)
Southern zone	2010	0.65(1990-2010) 2.88(2010-2021)	2007	1.32(1990-2007) 4.95(2007-2021)
India	1995 2010	2.96(1990-1995) 1.02(1995-2010) 0.89(2010-2021)	2004 2010	1.06(1990-2004) 8.71(2004-2010) 0.20(2010-2021)

4.2 Cost of cultivation

The cost of cultivation and cost of production for cotton in selected zones namely, northern zone, central zone and southern zone was estimated for selected five triennium periods starting from 2000-01 to 2015-16.

Table 08: The Dynamics of cost components of cotton in northern zone: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	17244.62	23852.54	27157.79	41747.92	56878.89	66766.99	9.66**
A_2	17619.56	24155.89	27579.78	42346.06	58604.00	68297.95	9.72**
B_1	24003.02	32852.61	36379.71	53497.44	73840.89	90688.99	9.27***
B_2	28718.51	41249.37	46525.17	72642.17	96683.24	111096.15	9.63**
C_1	27881.18	37511.24	41301.89	62115.42	85907.88	103497.13	9.26**
C_2	32596.68	45908.00	51447.35	81260.14	108750.22	123904.29	9.57***

Note: TE- Triennium Ending
Note: ***, ** and * indicates one, five and ten percent level of significance.

4.2.1 The Dynamics of cost components of cotton in Northern Zone

Table 08 shows that the cost of cultivation of various cost components for cotton crop in India's northern zone. Over the selected TE periods, the average cost components were increased. In absolute terms, the cost of A_1 increased from Rs.17244.62 (TE 2000-01) to Rs. 66766.99 (TE 2015-16), representing a 9.66 per cent significant growth. Similarly, C_1 jumped by 9.26 per cent from Rs. 24003.02 (TE 2000-01) to Rs. 103497.13 (TE 2015-16). The C_2 cost grew at the fastest rate of all the other costs considered in the computations, with a CAGR of 9.57 per cent. Other costs, such as A_2, B_1, and B_2, increased from TE 2000-01 to TE 2015-16 with a CAGR of 9.72 per cent, 9.27 per cent and 9.63 per cent, respectively may be due to escalation in input prices and non-judicious application of critical inputs over the years by the farmer in northern cotton belt.

4.2.2 Dynamics of input use pattern of cotton in Northern Zone of India

The input use pattern over selected TE period for cotton in Northern Zone showed varied patterns (Table 09), the seed rate (kg/ha) was 13.32 kg in 2000-01TE has been decreased to 4.06 kg during 2015-16 TE. This may be due development of new varieties, depth of sowing maintained and placed at uniform depth, covered and compacted. The application of fertilizer has increased from 73.39 to 151.89 kg during 2000-01 TE to 2015-16 TE this may be due to farmers are applying the fertilizers in non-judicious manner in order to obtain higher yield and also due to high input demanding varieties. The labour utilization gradually increased from 2000-01TE to 2009-10 TE with 592.81 to 711.31 hours but in selected TE periods during 2012-13 to 2015-16, it was decreased from 654.92 to 558.72 hours might be farmers are substituting the labour with machine for important operations like sowing, weeding and harvesting. Similarly animal labour over the selected periods gradually declines from 15.98 pair hours in TE 2000-01 to 2.68 pair hours in 2015-16 TE obviously due to the intervention of machinaries in the farm.

Table 09: Dynamics of input use pattern of cotton in northern zone TE 2000-01 to 2017-18

(per ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Seed (Kg.)	13.32	10.46	7.58	3.31	4.21	4.06	-9.30
Fertilizer (Kg. Nutrients)	73.39	100.58	119.22	164.73	150.42	151.89	5.07**
Manure (Qtl.)	1.27	4.67	3.83	4.79	5.32	5.38	6.90**
Human Labour (Man Hrs.)	592.81	716.21	732.30	711.31	654.92	558.72	-0.59
Machine (Hrs)	20.39	16.42	15.46	18.15	18.31	20.07	-12.40
Animal Labour (Pair Hrs.)	15.98	16.04	16.81	7.81	4.55	2.68	0.42***

Note: TE- Triennium Ending
Note: ***, ** and * indicates one, five and ten percent level of significance.

Table 10: Trend in different components of cost of production of cotton in northern zone: TE 2000-01 to 2017-18

(Rs/qtl)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	1927.97	1521.71	1571.65	2205.39	3264.29	4757.63	6.77**
A_2	1968.77	1540.41	1595.71	2236.56	3364.30	4858.48	6.82***
B_1	2675.68	2100.44	2108.14	2825.75	4249.26	6513.31	6.39**
B_2	3185.55	2634.35	2693.60	3840.72	5549.06	7848.05	6.73***
C_1	3110.64	2398.23	2393.63	3280.66	4938.14	7428.78	6.37
C_2	3620.51	2932.14	2979.08	4295.62	6237.94	8763.53	6.67**
A_2+FL	2403.73	1838.20	1881.20	2691.46	4053.18	5773.95	6.72**

Note: TE- Triennium Ending, FL- Family Labour

Note: ***, ** and * indicates one, five and ten percent level of significance.

4.2.3 Trend in different components of cost of production of cotton in Northern Zone

The different cost components of cost of production of cotton in Northern Zone of India are depicted in Table 10. The average paid out cost of A_1 of cotton during selected TE periods increased from Rs. 1927.97 to Rs. 4757.63 with significant growth of 6.77 per cent and cost of production (A_2) increased from Rs. 1968.77 to Rs. 4858.48 per quintal with CAGR of 6.82 per cent with one percent level of significance. The cost of production (B_1) was increased from Rs. 2675.68 per quintal to Rs. 6513.31 per quintal with CAGR of 6.39 per cent whereas, the cost of production (B_2) increased from Rs. 3185.55 per quintal to 7848.05 per quintal with CAGR of 6.37 per cent. The cost of production of C_1 was increased from Rs. 3110.64 per quintal to Rs.7428.78 Rs. per quintal with CAGR of 6.37 per cent whereas, cost of production of C_2 increased from 3620.51 to 8763.53 with CAGR of 6.67 per cent mainly because of escalating in the cost of inputs as depicted in the Table 10. Similarly, the cost of production of A_2+FL increased to tune of Rs. 5773.95 per quintal (TE 2015-16) from Rs. 2403.73 (TE 2000-01) due to increase in the input use and cost of inputs as evident from the Table 08 and Table 09.

Table 11: The dynamics of cost structure of cotton in northern zone: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Human Labour	8543.75 (26.21)	11360.32 (24.75)	13645.74 (26.52)	26073.12 (32.09)	35313.68 (32.47)	37069.13 (29.92)	11.31**
Animal labour	554.61 (1.70)	659.21 (1.44)	841.35 (1.64)	774.05 (0.95)	657.95 (0.61)	527.98 (0.43)	-0.91
Machine labour	3661.64 (11.23)	4675.74 (10.19)	5616.33 (10.92)	6793.30 (8.36)	9461.49 (8.70)	11021.45 (8.90)	7.84***
Seed cost	1549.39 (4.75)	3999.23 (8.71)	5569.86 (10.83)	12156.34 (14.96)	14838.06 (13.64)	14407.57 (11.63)	16.58**
Fertilizer cost	1884.24 (5.78)	2775.00 (6.04)	3334.18 (6.48)	5150.01 (6.34)	7372.92 (6.78)	7379.83 (5.96)	10.19**
Manure cost	42.48 (0.13)	252.37 (0.55)	294.34 (0.57)	543.95 (0.67)	1208.32 (1.11)	1634.74 (1.32)	24.66**
Other costs	16360.57 (50.19)	22186.14 (48.33)	22145.56 (43.05)	29769.39 (36.63)	39897.809 (36.69)	51863.60 (41.86)	8.34***
Total cost (C_2)	32596.67 (100)	45908.00 (100)	51447.35 (100)	81260.14 (100)	108750.21 (100)	123904.28 (100)	9.57**

TE- Triennium Ending
Note: The figure in parentheses indicates the respective input share to the C_2 cost
Note: ***, ** and * indicates one, five and ten percent level of significance.
Other costs: irrigation cost, insecticides, depreciation of implements and farm buildings, land revenue cess and other taxes, interest on working capital and miscellaneous expenses on other input.

4.2.4 The dynamics of cost structure of cotton in Northern Zone

The share of inputs cost to the total cost of cultivation (C_2) of cotton in northern zone of India was depicted in Table 11. The per cent share of inputs cost to C_2 varied in the selected periods and results revealed that the share of cost on human labour and seed was found 26.21 per cent and 4.75 per cent during TE 2000-01 and 29.92 percent and 11.63 per cent during TE 2015-16 respectively. Share of machine labour and animal labour were found declining over the study period. Machine labour was 11.23 and animal labour was 1.70 per cent in 2000-01 TE and declined to 8.90 and 0.43 per cent to C2 in TE 2015-16 respectively. The fertilizer cost and manure were 5.78 per cent and 0.13 per cent (TE 2000-01) increased to 5.96 per cent and 1.32 per cent (TE 2015-16) whereas, others costs were declined to 41.86 percent from 50.19 percent to the total cost over the study period.

Table 12: Productivity and Profitability level of cotton in Northern Zone: TE 2000-01 to 2017-18

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16
Yield level (qtls/ha)	9.29	15.89	17.24	18.87	17.65	15.16
Gross income (per ha)	18168.74	32838.84	38684.88	75040.74	83687.68	77999.68
Net income (per ha)	-14427.94	-13069.16	-12762.47	-6219.4	-25062.54	-45904.61
Returns per rupee of expenditure	0.56	0.72	0.75	0.92	0.77	0.63

Note: TE- Triennium Ending

4.2.5 Productivity and Profitability level of cotton in northern zone

The Productivity and Profitability level of cotton in northern zone of India is depicted in the Table 12. The results indicated that yield level of cotton improved over the selected TE periods. Productivity level of cotton increasing from 9.29 quintal per hectare from TE 2000-01 to 15.16 quintal per hectare in 2015-16 TE due to improved varieties and management skills of the farmers. The gross income also increased from Rs.18168.74 to 77999.68 for the selected TE periods whereas net income was found to be negative in all the periods when compared to cost C_2. The returns per rupee of expenditure of cotton varied during different years and was found to be the highest during TE 2009-10 (0.92) and the least during TE 2000-01 (0.56).

4.2.6 The Dynamics of cost components in central zone

The information on cost of cultivation of cotton in central zone of India tabulated in Table 13. The findings indicated that average cost components increased over the selected TE periods. For instance, A_1 and A_2 costs were Rs. 13190.09 per hectare and Rs. 13196.84 per hectare during TE 2000-01 increased to Rs. 72364.54 per hectare and Rs. 73137.06 hectare during TE 2015-16 with significant growth of 12.74 and 12.86 per cent. Similarly, B_1 and B_2 was increased from Rs. 16394.71and Rs. 18574.61 in TE 2000-01 to Rs. 95638.20 and 110042.36 in TE 2015-16 with a CAGR of 13.02 and 13.01 per cent. The costs like C_1 and C_2 also were increasing from Rs. 18070.13 and 20250.02 to Rs. 104355.12 and 118759.28 with a CAGR of 12.97 and 12.96 per cent for the selected study periods due to increasing in input prices over the years.

Table 13: The Dynamics of cost components in central zone: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	13190.09	21025.55	25564.17	39550.40	69922.51	72364.54	12.74**
A_2	13196.84	21053.86	25613.00	39730.88	71760.13	73137.06	12.86***
B_1	16394.71	26256.00	31981.15	49540.88	85367.29	95638.20	13.02**
B_2	18574.61	31482.80	38946.82	61708.85	98743.47	110042.36	13.01**
C_1	18070.13	29061.52	35461.55	55196.33	93929.38	104355.12	12.97**
C_2	20250.02	34288.31	42427.23	67364.30	107305.56	118759.28	12.96**

Note: TE- Triennium Ending
Note: ***, ** and * indicates one, five and ten percent level of significance.

Table 14: Dynamics of input use pattern in central zone of India: TE 2000-01 to 2017-18

(per ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Seed (Kg.)	4.70	3.79	2.56	1.62	1.87	1.79	-6.76
Fertilizer (Kg. Nutrients)	81.66	106.74	143.63	201.43	202.80	204.52	6.92**
Manure (Qtl.)	24.45	23.50	27.01	30.04	278.49	22.83	3.76***
Human Labour (Man Hrs.)	706.11	966.95	988.59	1043.66	942.99	918.03	1.30***
Machine (Hrs)	8.07	8.42	10.62	10.22	16.19	18.59	5.99**
Animal Labour (Pair Hrs.)	79.28	80.93	71.60	59.28	41.89	35.71	-5.72

Note: TE- Triennium Ending
Note: ***, ** and * indicates one, five and ten percent level of significance.

4.2.7 Dynamics of input use pattern in central zone of India

The details of input use pattern over selected TE period for cotton of central zone are depicted in the Table 14. Among different inputs, human labour was found to be higher in cotton cultivation. Use of human labour was increasing from 706.11 hours (TE 2000-01) to 918.03 hours (TE 2015-16) followed by fertilizer usage which increased to 204.52 kg per hectare during 2015-16 TE from 81.66 kg in 2000-01 TE with significant growth of 6.92 percent. This may be due to extensive application of fertilizers by the farmers in order to obtain desired yields. Use of manure increased to 278.49 quintal per hectare in TE 2012-13 from 24.45 quintal per hectare in TE 2000-01 but declined to 22.83 quintal per hectare during TE 2015-16. Use of animal labour hours and seed rate were declined from 79. 28 hours to 35.71 hours and 4.70 kgs to 1.79 kgs per hectare.

Table 15: Trend in different components of cost of production of cotton in central zone of India: TE 2000-01 to 2017-18 (Rs/qtl)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	2020.45	1501.00	1561.08	2225.19	3909.06	3988.64	6.46**
A_2	2021.41	1503.20	1564.02	2235.37	4004.12	4032.25	6.58***
B_1	2515.89	1872.72	1952.31	2789.11	4810.22	5266.58	6.73
B_2	2850.10	2249.53	2375.77	3468.18	5562.05	6060.14	6.71**
C_1	2772.03	2072.65	2164.57	3107.16	5299.02	5748.69	6.67***
C_2	3106.24	2449.46	2588.02	3786.23	6050.86	6542.26	6.66 **
A_2+FL	2277.55	1703.13	1776.27	2553.41	4492.92	4514.36	6.52***

Note: TE- Triennium Ending

Note: ***, ** and * indicates one, five and ten percent level of significance.

4.2.8 Trends in different components of cost of production of cotton in central zone

The different cost components of cost of production of cotton in central zone of India is depicted in Table 15. The average paid out cost of A_1 of cotton during selected TE periods increased from Rs. 2020.45 per quintal to Rs. 3988.64 per quintal with a significant growth of 6.46 per cent and cost of production (A_2) increased from Rs. 2021.41 to Rs. 4032.25 per quintal with CAGR of 6.58 per cent at one percent level of significance. The cost of production (B_1) was increased from Rs. 2515.89 per quintal to Rs. 5266.58 per quintal whereas, the cost of production (B_2) increased from Rs. 2850.10 to Rs. 6060.14 with CAGR of 6.71 per cent. The cost of production of C_1 was increased from Rs. 2772.03 to 5748.69 with significant growth of 6.67 per cent whereas, cost of production of C_2 increased from Rs.3106.24 to Rs. 6542.26 with CAGR of 6.66 per cent at five percent level of significance. Similarly, the cost of production of A_2+FL increased to tune of

Rs. 4514.36 per quintal from Rs. 2277.55 in selected periods with a significant growth of 6.52 per cent.

Table 16: The dynamics of cost structure in central zone: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Human Labour	5330.08 (26.32)	8632.43 (25.18)	11279.41 (26.59)	20053.88 (29.77)	29824.51 (27.79)	34873.15 (29.36)	14.05**
Animal labour	1792.00 (8.85)	2499.01 (7.29)	2698.06 (6.36)	3315.74 (4.92)	3205.11 (2.99)	3738.41 (3.15)	4.63
Machine labour	1291.83 (6.38)	1719.94 (5.02)	2046.05 (4.82)	2897.32 (4.30)	5772.63 (5.38)	7630.48 (6.43)	12.95**
Seed cost	1241.87 (6.13)	3054.20 (8.91)	3151.89 (7.43)	4044.64 (6.00)	4973.92 (4.64)	4807.19 (4.05)	8.62
Fertilizer cost	1489.36 (7.35)	1992.54 (5.81)	2776.35 (6.54)	4424.51 (6.57)	7421.08 (6.92)	7754.90 (6.53)	12.90**
Manure cost	852.15 (4.21)	888.65 (2.59)	1238.23 (2.92)	2191.05 (3.25)	3834.22 (3.57)	3904.22 (3.29)	12.96***
Other costs	8252.74 (40.75)	15501.55 (45.21)	19237.23 (45.34)	30437.16 (45.18)	52274.10 (48.72)	56050.92 (47.20)	12.60***
Total cost (C2)	20250.02 (100)	34288.31 (100)	42427.23 (100)	67364.30 (100)	107305.56 (100)	118759.28 (100)	12.96**

Note: The figure in parentheses indicates the respective input share to the C2 cost.

Note: TE- Triennium Ending

Note: ***, ** and * indicates one, five and ten percent level of significance.

Other costs: irrigation cost, insecticides, depreciation of implements and farm buildings, land revenue cess and other taxes, interest on working capital and miscellaneous expenses on other input.

4.2.9 The dynamics of cost structure in central zone

The share of inputs cost to the total cost of cultivation (C_2) of cotton in central zone of India was depicted in Table 16. The per cent share of inputs cost to C_2 varied in the selected periods and results revealed that the share of cost on human labour and machine labour were increased to 29.36 and 6.43 per cent (2015-16) from 2.32 and 6.38 per cent (TE 2000-01) with a significant growth rate of 14.05 and 12.95 per cent respectively. The animal labour was found 8.85 per cent during

TE 2000-01 and declined to 3.15 per cent during TE 2015-16. Seed cost and fertilizer cost were found declining over the study period. Seed cost was 6.13 per cent and fertilizer cost was 7.35 per cent (TE 2000-01) declined to 4.05 and 6.53 per cent to C_2 (TE 2015-16) respectively. The share of manure cost was declined to 3.29 per cent during TE 2015-16 from 4.21 percent during TE 2000-01 however other costs was increased from 40.75percent to 47.20 percent over the study period to the cost C_2.

Table 17: Productivity and Profitability level of cotton in central zone: TE 2000-01 to 2017-18

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16
Yield level (qtls/ha)	6.58	14.08	16.30	17.85	17.69	18.11
Gross income (per ha)	12880.58	30030.84	40779.41	71760.76	78042.18	84626.19
Net income (per ha)	-7369.44	-4257.47	-1647.82	4396.46	-29263.38	-34133.09
Returns per rupee of expenditure	0.64	0.88	0.96	1.07	0.73	0.71

Note: TE- Triennium Ending

4.2. Productivity and Profitability level of cotton in central zone

The Productivity and Profitability level of cotton in central zone of India tabulated in Table 17. The findings indicated that productivity level improved over selected TE periods. It was 6.58 quintal per hectare (TE 2000-01) and it increased to 18.11 quintal per hectare (TE 2015-16) due to improved varieties. The gross income showed positive trend over the different periods with Rs. 12880 per hectare in TE 2000-01 and Rs. 84626 per hectare in TE 2015-16. However, the net income was found to be negative in different periods except TE 2009-10 where it was Rs. 4396 per hectare. The returns per rupee of expenditure of cotton was varied during different years as found to be the highest during TE 2009-10 (1.07) and the least during TE 2000-01 (0.64).

4.2.11The Dynamics of cost components in southern zone

The information of cost of cultivation of cotton in southern zone of India was tabulated in Table 18. The findings indicated that average cost components increased over the selected TE periods. For instance, A_1 and A_2 costs were Rs.16895.05 and Rs.17124.51 during TE 2000-01 and increased to Rs. 76943.85 and Rs.77374.92 during TE 2015-16 with a significant growth of 11.12 and 11.09 per cent. Similarly, B_1 and B_2 costs were also increased from Rs. 16917.98 and 22598.00

to Rs. 76986.95 and Rs. 98484.17 respectively over the study period. The costs like C_1 and C_2 increased from Rs. 18930.18 and Rs. 24610.20 (TE 2000-01) to Rs. 87903.96 and Rs. 109401.18 per hectare (TE 2015-16) per hectare due to escalation of input prices and non-judicious application of critical inputs over the years by farmers in southern cotton belt.

Table 18: The Dynamics of cost components in southern zone of India: TE 2000-01 to 2017-18 (Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	16895.03	21921.92	29949.77	40450.29	63902.52	76943.85	11.12***
A_2	17124.51	21961.00	30090.44	40861.87	64104.03	77374.92	11.09***
B_1	16917.98	21925.83	29963.84	40491.45	63922.67	76986.95	11.12**
B_2	22598.00	28502.72	37909.81	55377.65	81043.61	98484.17	10.88
C_1	18930.18	24179.64	34136.46	45471.22	71969.98	87903.96	11.29**
C_2	24610.20	30756.53	42082.44	60357.42	89090.92	109401.18	11.03**

Note: TE- Triennium Ending
Note: ***, ** and * indicates one, five and ten percent level of significance.

Table 19: Dynamics of input use pattern in southern zone of India: TE 2000-01 to 2017-18 (per ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Seed (Kg.)	6.66	5.81	3.32	2.27	6.16	3.39	-4.42
Fertilizer (Kg. Nutrients)	109.04	141.73	191.09	202.59	200.10	229.92	4.68**
Manure (Qtl.)	13.32	17.36	16.07	9.84	16.54	12.19	-1.19***
Human Labour (Man Hrs.)	828.99	853.64	786.20	686.80	706.35	688.00	-1.59
Machine (Hrs)	10.56	11.51	14.15	16.81	20.37	16.53	4.28**
Animal Labour (Pair Hrs.)	97.62	62.99	59.67	40.52	41.68	30.83	-6.64

Note: TE- Triennium Ending
Note: ***, ** and * indicates one, five and ten percent level of significance.

4.2.12 Dynamics of input use pattern in southern zone

The details of input use pattern over selected TE period for cotton in southern zone of India are showed in the Table 19. Among different inputs, fertilizer use was found to be increasing over the years in the table. The fertilizer application was increasing from 109.04 kg per hectare during 2000-01 TE to 229.92 kg per hectare during TE 2015-16 with a significant growth of 4.68 percent. The seed rate was declined from 6.66 kg per hectare (TE 2000-01) to 3.39 kg per hectare (TE 2015-16). The application of manure also observed declining trend for the selected TE periods which was declined from 13.31 quintals per hectare to 12.19 quintal per hectare over the study periods. The human labour and animal labour were declined to 688.00 hours and 30.83 hours per hectare during TE 2015-16 from 828.99 hours and 97.62 hours per hectare respectively however, machine usage hours increased to 16.53 hours per hectare (TE2015-16) from 10.56 hours (TE 2000-01) per hectare with a significant growth of 4.28 per cent.

Table 20: Trend in different components of cost of production of cotton in southern zone of India: TE 2000-01 to 2017-18 (Rs/qtl)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	1605.06	1885.52	2553.77	2657.38	3847.74	4248.02	6.97*
A_2	1626.98	1888.96	2562.71	2683.52	3860.67	4271.60	6.94**
B_1	1607.25	1885.86	2554.67	2660.00	3849.03	4250.38	6.97***
B_2	2147.42	2449.00	3174.62	3637.01	4887.04	5428.42	6.73***
C_1	1798.26	2080.18	2915.63	2987.56	4334.29	4854.09	7.13**
C_2	2338.43	2643.32	3535.57	3964.57	5372.30	6032.13	6.88**
A_2+FL	1817.99	2083.28	2923.67	3011.09	4345.92	4875.30	7.11*

Note: TE- Triennium Ending,

***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

4.2.13 Trend in different components of cost of production of cotton in southern zone

The different cost components of cost of production of cotton in southern zone of India is presented in Table 20. The average real paid out cost of A_1 of cotton during selected TE periods increased from Rs. 1605.06 to Rs. 4248.02 with CAGR of 6.97 per cent and cost of production

(A_2) increased from Rs. 1626.98 to Rs. 4271.60 per quintal with CAGR of 6.94 per cent over the study period. The cost of production (B_1) was increased from Rs.1607.25 per quintal with CAGR of 6.45 per cent whereas, the cost of production (B_2) increased from Rs. 2147.42 to 5428.42 with CAGR of 6.74 per cent for the selected TE periods. The cost of production of C_1 was increased from Rs. 1798.26 to 4854.09 with CAGR of 6.66 per cent whereas, cost of production of C_2 increased from 2338.43 to 6032.13 with CAGR of 6.56 per cent. Similarly, the cost of production of A_2+FL increased to the tune of Rs. 4875.30 per quintal from Rs. 1817.99 in selected periods with a growth of 7.11 per cent.

Table 21: Dynamics of cost structure in southern zone of India: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Human Labour	4859.39 (19.75)	6181.99 (20.10)	10615.13 (25.22)	14037.00 (23.26)	22434.44 (25.18)	27451.43 (25.09)	12.95**
Animal labour	5470.80 (22.23)	7322.80 (23.81)	9998.42 (23.76)	12379.49 (20.51)	20456.18 (22.96)	23795.89 (21.75)	10.61***
Machine labour	511.67 (2.08)	817.87 (2.66)	1141.82 (2.71)	2163.19 (3.58)	3159.02 (3.55)	4533.53 (4.14)	16.23**
Seed cost	925.06 (3.76)	1210.47 (3.94)	1650.88 (3.92)	2901.87 (4.81)	3887.05 (4.36)	4024.41 (3.68)	11.74**
Fertilizer cost	2118.34 (8.61)	2887.85 (3.39)	3083.31 (7.33)	4973.97 (8.24)	8809.92 (9.89)	9596.73 (8.77)	11.36***
Manure cost	544.14 (2.21)	913.73 (2.97)	914.94 (2.17)	1004.49 (1.66)	1355.89 (1.52)	1502.35 (1.37)	6.45
Other costs	10180.80 (41.30)	11421.82 (37.14)	14677.93 (37.88)	22897.41 (37.94)	28988.41 (32.54)	38496.83 (35.19)	8.99***
Total cost (C_2)	24610.20 (100)	30756.53 (100)	42082.44 (100)	60357.42 (100)	89090.92 (100)	109401.18 (100)	11.03**

Note: The figure in parentheses indicates the respective input share to the C_2 cost.

TE- Triennium Ending

***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

Other costs: irrigation cost, insecticides, depreciation of implements and farm buildings, land revenue cess and other taxes, interest on working capital and miscellaneous expenses on other input.

4.2.14 The dynamics of cost structure in southern zone

The share of real inputs cost to the total cost of cultivation (C_2) of cotton in southern zone of India was depicted in Table 21. The per cent share of inputs cost to C_2 varied in the selected periods and results revealed that share of cost on human labour and machine labour increasing from 19.75 per cent and 2.08 percent during TE 2000-01 to 25.09 per cent and 4.14 per cent during TE 2015-16 with a significant growth rate of 12.95 and 16.23 percent respectively. Manure cost and other costs were declined to 1.37 and 35.19 per cent in TE 2015-16 from 2.21 and 41.30 per cent in TE 2000-01 with a growth rate of 6.45 and 8.99 per cent respectively. The seed cost and animal labour were found 3.76 per cent and 22.23 per cent (TE 2000-01) and declined to 3.68 percent and 21.75 per cent (TE 2015-16) with a growth rate of 11.74 and 10.61 per cent respectively. The share of fertilizer cost was found increasing from 8.61 per cent during TE 2000-01 to 8.77 per cent during TE 2015-16 with a significant growth of 11.36 percent.

Table 22: Productivity and profitability levels of cotton in southern zone of India: TE 2000-01 to 2017-18

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16
Yield level (qtls/ha)	10.53	11.69	12.30	15.38	16.58	18.15
Gross income (per ha)	20075.86	23604.70	39788.03	55925.19	67081.20	81190.36
Net income (per ha)	-4534.34	-7151.83	-2294.41	-4432.23	-22009.72	-28210.82
Returns per rupee of expenditure	0.82	0.77	0.95	0.93	0.75	0.74

Note: TE- Triennium Ending

4.2.15 Productivity and profitability level of cotton in southern zone

The productivity and profitability of cotton in southern zone of India tabulated in Table 22. The findings indicated that productivity level improved over selected TE periods. It was 10.53 quintal per hectare (TE 2000-01) and it increased to 18.15 quintal per hectare (TE 2015-16) due to improved varieties. The gross income indicated positive trend over the selected TE periods. The gross income had increased to Rs. 81190.36 from Rs. 20075.86 per hectare. However, the net returns were negative in all selected TE periods. The returns per rupee of expenditure of cotton varied during different TE periods and was found to be highest during TE 2006-07 (0.95) and the least during TE 2015-16 (0.74).

Table 23: The Dynamics of cost components of cotton in India: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	15781.64	22266.67	27557.24	39878.23	63567.97	72025.12	11.13**
A_2	15985.94	22385.11	27761.07	40264.01	64822.72	72936.64	11.17**
B_1	20041.36	28122.11	33929.65	48680.38	76778.49	90776.41	10.93**
B_2	24240.39	34850.45	42282.02	63471.81	94558.31	109545.92	10.94***
C_1	22563.29	31361.43	38121.39	55098.12	86337.28	101590.43	10.93***
C_2	26762.32	38089.77	46473.76	69889.54	104117.10	120359.94	10.94**

Note: TE- Triennium Ending

***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

4.2.16 The Dynamics of cost components of cotton in India

The information of cost of cultivation of cotton in India was tabulated in Table 23. The findings indicated that average real cost components increased over the selected TE periods. For instance, A_1 and A_2 costs were Rs.15781.64 and Rs. Rs. 79980.61per hectare during TE 2015-16 in absolute terms registering a significant growth of 11.13 and 11.17 per cent. Similarly, B_1 and B_2 was increased from Rs. 20041.3 and Rs. 24240.39 (TE 2000-01) to Rs. 90776.41 and Rs. 109545.92 (TE 2015-16) with a CAGR of 10.93 and 10.94 per cent. The costs like C_1 and C_2 also were increasing from Rs. 22563.29 and Rs. 26762.32 to Rs. 101590.43 and Rs.120359.94 with a significant growth of 10.93 and 10.94 per cent for the selected study periods

4.2.17 Dynamics of input use pattern of cotton in India

The details of input use pattern over selected TE period for cotton of India were showed in the Table 24. Among different inputs, human labour was found to be higher. Human labour was increasing from 709.75 hours in 2000-01 TE to 721.58 hours in TE 2015-16 followed by the fertilizer which increased to 195.44 kg per hectare during 2015-16 TE from 88.04 kg in 2000-01 TE. Machine labour hours increased to 18.40 hours during TE 2015-16 from 12.99 hours in 2000-01 TE. Manure application was increased to 100.12 quintals per hectare during 2012-13 from 13.01 quintal per hectare in 2000-01 further declined to 13.46 quintal in 2015-16 TE however, animal labour hours declined to 23.08 hours from 64.34 hours per hectare for the selected TE periods.

Table 24: Dynamics of input use pattern of cotton in India: TE 2000-01 to 2017-18

(ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Seed (Kg.)	8.22	6.69	4.49	2.39	4.08	3.08	-6.78
Fertilizer (Kg. Nutrients)	88.04	116.35	151.32	185.64	184.44	195.44	5.51***
Manure (Qtl.)	13.01	15.18	15.64	15.11	100.12	13.46	3.35***
Human Labour* (Man Hrs.)	709.75	845.60	835.70	797.81	768.09	721.58	-0.24
Machine (Hrs)	12.99	12.12	13.41	15.05	18.29	18.40	3.08
Animal Labour (Pair Hrs.)	64.34	53.32	49.36	35.84	29.37	23.08	-6.62

Note: TE- Triennium Ending

***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

Table 25: Trend in different components of cost of production of cotton in India (in real terms): TE 2000-01 to 2017-18 **(Rs/qtl)**

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
A_1	1792.69	1605.86	1796.50	2326.39	3664.10	4242.44	6.87**
A_2	1815.77	1614.47	1809.63	2348.74	3735.66	4295.81	6.91***
B_1	2275.85	2029.87	2212.82	2839.24	4428.69	5349.29	6.68***
B_2	2751.59	2517.72	2755.32	3703.68	5455.00	6435.56	6.69***
C_1	2562.40	2264.14	2486.00	3213.91	4981.36	5988.20	6.67**
C_2	3038.15	2751.99	3028.49	4078.35	6007.67	7074.46	6.68**
A_2+FL	2102.32	1848.73	2082.80	2723.40	4288.33	4934.72	6.87***

Note: TE- Triennium Ending
***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

4.2.18 Trend in different components of cost of production of cotton in India

The different cost components of cost of production of cotton in India is presented in Table 25. The average real paid out cost of A_1 of cotton during selected TE periods increased from Rs. 1792.69 to Rs. 4242.44 with a significant growth of 6.87 per cent and cost of production (A_2) increased from Rs. 1815.77to Rs. 4295.81 per quintal with CAGR of 6.91 per cent over the study period. The cost of production (B_1) was increased from Rs. 2275.85 (TE 2000-01) per quintal to Rs. 5349.29 with CAGR of 6.68 per cent at one per cent level of significance whereas, the cost of production (B_2) increased from Rs 2751.59 to Rs. 6435.56 per quintal with CAGR of 6.83 per cent for the selected TE periods. The cost of production of C_1 was increased from Rs. 2562.40 to Rs. 5988.20 with a significant growth of 6.68 per cent whereas, cost of production of C_2 increased from 3038.15 to 7074.46 with CAGR of 6.85 per cent.

4.2.19 The dynamics of cost structure of cotton in India

The share of real inputs cost to the total cost of cultivation (C_2) of cotton in India was depicted in Table 26. The per cent share of inputs cost to C_2 varied in the selected periods and results revealed that the share of cost on human labour and machine labour were increased from 27.39 per cent and 5.59 per cent (TE 2000-01) to 32.81per cent and 6.03 per cent (TE 2015-16) with the significant growth rates of 12.66 and 11.42 per cent however, animal labour was declined 11.58 per cent from 14.56 per cent with CAGR of 9.16 per cent for the selected study period. The share of seed cost to the cost C_2 was increased from 4.33 per cent to 5.00 per cent during 2000-01 to 2015-16. There was no much variation in the share of fertilizer and manure costs to the cost C_2 however other costs declined from 40.49 per cent to 36.45 per cent for the selected TE periods.

4.2.20 Productivity and Profitability level of cotton in India

The Table 27 depicted the results of Productivity and Profitability level of cotton growers in India. The findings indicated that productivity level improved over selected TE periods it was 8.82 quintal per hectare (TE 2000-01) increased to 17.74 quintal per hectare (TE 2015-16). Gross income was increased to Rs. 80726.74 during 2015-16 TE from Rs. 17030.82 during TE 2000-01 per hectare whereas net income was found to be negative in all selected TE periods. The returns per rupee of expenditure cotton was varied during different years as found to be highest during 2009-10 (0.91) and the least during 2000-01(0.64).

Table 26: The dynamics of cost structure of cotton in India: TE 2000-01 to 2017-18

(Rs/ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16	CAGR (%)
Human Labour	7330.33 (27.39)	10197.94 (26.77)	14194.38 (30.54)	22705.97 (32.49)	34459.41 (33.10)	39494.84 (32.81)	12.66**
Animal labour	3815.78 (14.26)	5130.64 (13.47)	6628.69 (14.26)	8052.61 (11.52)	12049.96 (11.57)	13943.14 (11.58)	9.16
Machine labour	1496.65 (5.59)	2021.30 (5.31)	2501.00 (5.38)	3531.76 (5.05)	5606.27 (5.38)	7259.47 (6.03)	11.42***
Seed cost	1133.82 (4.24)	2289.84 (6.01)	2804.38 (6.03)	4792.22 (6.86)	6074.51 (5.83)	6015.87 (5.00)	12.08***
Fertilizer cost	1656.69 (6.19)	2290.90 (6.01)	2760.25 (5.94)	4264.07 (6.10)	7225.45 (6.94)	7608.48 (6.32)	11.56
Manure cost	492.65 (1.84)	664.01 1.74)	796.26 (1.71)	1187.04 (1.70)	2022.72 (1.94)	2167.61 (1.80)	11.36
Other costs	10836.40 (40.49)	15495.14 (40.68)	16788.79 (36.13)	25355.87 (36.28)	36678.78 (35.23)	43870.54 (36.45)	9.71***
Total cost (C_2)	26762.32 (100)	38089.77 (100)	46473.76 (100)	69889.54 (100)	104117.10 (100)	120359.94 (100)	10.94**

Note: TE- Triennium Ending

Note: The figure in parentheses indicates the respective input share to the C2 cost.

***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

Other costs: irrigation cost, insecticides, depreciation of implements and farm buildings, land revenue cess and other taxes, interest on working capital and miscellaneous expenses on other input.

Table 27: Productivity and Profitability level of cotton in India: TE 2000-01 to 2017-18

(ha)

Particulars	TE 2000-01	TE 2003-04	TE 2006-07	TE 2009-10	TE 2012-13	TE 2015-16
Yield level (qtls/ha)	8.82	13.89	15.28	17.15	17.31	17.14
Gross income (per ha)	17030.82	28792.27	39635.02	63551.89	75822.95	80726.74
Net income (per ha)	-9731.5	-9297.5	-6838.74	-6337.65	-28294.15	-39633.2
Returns per rupee of expenditure	0.64	0.76	0.85	0.91	0.73	0.67

Note: TE- Triennium Ending

Across all the cotton producing zones, the cost of cultivation and cost of production increased during TE 2000-01 to TE 2017-18 due to increase in the input prices and application of manures and fertilizers also increased over the years due to non-judicious application in order to get the higher yields. Inputs like, human labour hours and animal labour hours usage was declined due to intervention of mechanization across all the cotton producing zones of India.

4.3 Total factor productivity of different cotton producing zones of India

Total factor productivity (TFP) measures the amount of agricultural output resulted from the combined set of inputs employed in production. Besides material inputs like seeds, fertilizers, manures etc., non-material inputs like dis-embodied technologies *viz.*, timely farm operations, availability of infrastructure facilities, suitable technological information, etc. would also influence production.

The productivity of resources is greatly dependent on magnitude of technological innovations adopted by the farmers, markets, road facilities, other infrastructure, etc. These largely influence timely access to inputs, market and thereby help realize higher income. The output, input and TFP indices are presented in the following section.

4.3.1 Total factor productivity (TFP) of cotton in north zone

The estimates of total factor productivity of cotton in northern zone of India were calculated by using Tornqvist-Theil index method and the results are presented in Table 28. It could be observed from the table that the TFP for cotton has increased over the years from 0.66 in 2001-02 to 1.54 in 2017-18. This indicated that technological and infrastructural factors together contributed for about more than 100 per cent increase in the cotton output growth. The highest TFP index was observed in 2016-17 (1.652) with the mean TFP score of 1. 237 during the study period which indicated positive TFP growth. This was mainly attributable to favorable MSP policy, irrigation infrastructure, modern technologies, new varieties and higher residuals as indicated by total factor productivity. The output growth also increased over the years from 0.583 in 2001-02 to 1.315 in 2017-18. The average output index was 1.315 indicating positive output growth. In the case of input index, relatively higher fluctuations observed over the years and the highest input index was observed during 2011-12 (1.227) and the lowest during 2015-16 (0.838). The average input index of cotton was 1.055 which indicates the positive input growth. These, even with positive growth in input index but output increased at a faster rate and thus resulted in higher TFP index growth.

Table 28: Total Factor Productivity of cotton in Northern zone of India (2000-01 to 2017-2018)

Year	Output index	Input index	TFP index
2000-01	1.000	1.000	1.000
2001-02	0.583	0.880	0.663
2002-03	0.750	0.935	0.802
2003-04	1.167	1.129	1.034
2004-05	1.500	1.179	1.273
2005-06	1.333	1.098	1.215
2006-07	1.333	1.134	1.176
2007-08	1.583	1.207	1.312
2008-09	1.417	1.147	1.235
2009-10	1.583	1.145	1.383
2010-11	1.500	1.050	1.429
2011-12	1.667	1.227	1.359
2012-13	1.583	1.148	1.379
2013-14	1.500	1.058	1.418
2014-15	1.333	0.947	1.407
2015-16	0.833	0.838	0.994
2016-17	1.583	0.959	1.652
2017-18	1.417	0.917	1.545
Mean	**1.315**	**1.055**	**1.237**

4.3.2 TFP of cotton in central zone

The results of total factor productivity, output index and input index of cotton in central zone of India obtained by employing Tornqvist-Theil index method are presented in Table 29. It could be observed from the results that the TFP for cotton has increased over the years from 1.150 in 2001-02 to 2.388 in 2017-18 with the mean TFP score of 1.846 which indicates that technological and infrastructural factors contributed about 84.60 per cent output growth over the years.

Table 29: Total Factor Productivity of cotton in Central zone of India (2000-01 to 2017- 2018)

Year	Output index	Input index	TFP index
2000-01	1.000	1.000	1.000
2001-02	1.417	1.232	1.150
2002-03	1.202	1.113	1.081
2003-04	2.096	1.417	1.479
2004-05	2.365	1.424	1.661
2005-06	3.289	1.676	1.963
2006-07	2.588	1.507	1.718
2007-08	3.126	1.515	2.063
2008-09	3.257	1.617	2.014
2009-10	3.162	1.586	1.994
2010-11	3.519	1.809	1.945
2011-12	3.140	1.537	2.044
2012-13	2.683	1.424	1.884
2013-14	3.762	1.774	2.121
2014-15	3.290	1.493	2.203
2015-16	3.120	1.428	2.184
2016-17	3.414	1.456	2.345
2017-18	3.433	1.438	2.388
Mean	**2.770**	**1.469**	**1.846**

The highest TFP index (2.388) was observed during the year 2017-18. There was increased growth in output index over the study period (1.417 to 3.433) due to the growth of input index as well as contribution of several variables like irrigation, road density and MSP and the input index also was increased from 1.232 in 2001-02 to 1.438 in 2017-18. The average output index was 2.770 indicating positive output growth. In the case of input index, the highest input index was observed during 2010-11(1.809) and the lowest during 2002-03 (1.113) with average input index for cotton of 1.469.

4.3.3 TFP of cotton in southern zone

The indices of total output, total input and total factor productivity were calculated for cotton in southern zone of India by employing Tornqvist-Theil index and the results were presented in the Table 30. From the analysis it was observed that the TFP for cotton has increased over the years from 1.169 in 2001-02 to 2.607 in 2017-18 with the mean TFP score of 1.661 which indicates that technological and infrastructural factors contributed about 66.10 per cent output growth over the years. The highest TFP index (2.607) was observed during the year 2017-18. There was not much variation in output growth over the year, whereas the input index has decreased from 0.903 in 2001-02 to 0.684 in 2017-18. The average output index was 1.377 indicating positive output growth. In the case of input index, the highest input index was observed during 2004-05 and the lowest during 2017-18 with average input index for cotton of 0.851. The findings are in line with Elumalai (2011) who examined that total factor productivity growth and its determinants in Karnataka agriculture indicated positive in TFP growth.

4.3.4 TFP of cotton in India

The estimates of total factor productivity of cotton in India calculated by using Tornqvist-Theil index method are presented in Table 31. It could be observed from the table that the TFP for cotton has increased over the years from 0.932 in 2001-02 to 2.003 in 2017-18. This indicates that technological and infrastructural factors contributed for about more than 100 per cent in the cotton output growth. The highest TFP index was observed in 2017-18 (2.003). The mean TFP score of 1. 491 which indicated positive TFP growth in India. The output growth also increased over the years from 0.931 in 2001-02 to 1.970 in 2017-18 due to the growth of input index and also positive impact of several variables such as, rainfall, road density and MSP. The average output index was 1.635 indicating positive output growth. In the case of input index, there was not much variation over the years. The mean input index score was 1.096. The findings are in line with Chand *et al.* (2011) the TFP estimates have considerable variations across crops in different states and at all-India level during the period 1975-2005.

4.4 Sources of TFP growth in cotton

The growth rate in TFP was analyzed to know the contributions of various factors to TFP growth such as irrigation, annual rainfall, N to P ratio, scale of finance, road density, MSP for cotton were considered. The analysis was carried out for all zones of cotton production.

Table 30: Total Factor Productivity of cotton in Southern zone of India (2000-01 to 2017- 2018)

Year	Output index	Input index	TFP index
2000-01	1.000	1.000	1.000
2001-02	1.055	0.903	1.169
2002-03	1.029	0.952	1.081
2003-04	1.186	0.946	1.254
2004-05	1.257	1.002	1.254
2005-06	0.984	0.890	1.105
2006-07	1.146	0.949	1.207
2007-08	0.845	0.813	1.040
2008-09	1.611	0.887	1.818
2009-10	1.644	0.793	2.075
2010-11	1.425	0.770	1.851
2011-12	1.436	0.741	1.938
2012-13	1.466	0.752	1.950
2013-14	1.572	0.763	2.059
2014-15	1.820	0.854	2.132
2015-16	1.638	0.813	2.015
2016-17	1.897	0.806	2.352
2017-18	1.783	0.684	2.607
Mean	**1.377**	**0.851**	**1.661**

Table 31: Total Factor Productivity of cotton in India (2000-01 to 2017- 2018)

Year	Input index	Output index	TFP index
2000-01	1.000	1.000	1.000
2001-02	0.999	0.931	0.932
2002-03	1.000	0.965	0.966
2003-04	1.149	1.355	1.179
2004-05	1.192	1.608	1.349
2005-06	1.189	1.600	1.345
2006-07	1.178	1.526	1.296
2007-08	1.144	1.625	1.420
2008-09	1.184	1.868	1.577
2009-10	1.138	1.944	1.709
2010-11	1.100	1.805	1.640
2011-12	1.123	1.886	1.679
2012-13	1.071	1.788	1.669
2013-14	1.119	1.977	1.768
2014-15	1.081	1.921	1.777
2015-16	1.015	1.596	1.572
2016-17	1.054	2.066	1.960
2017-18	0.984	1.970	2.003
Mean	**1.096**	**1.635**	**1.491**

4.4.1 Sources of TFP growth of cotton in north zone

Table 32 presents the contribution of various factors to the TFP growth in the northern zone of India. The results indicated that the coefficients for rainfall (0.768) was found significant, this indicated that rainfall enabled to realize higher productivity of cotton. The coefficient of irrigation (1.026), scale of finance (0.184) and MSP (0.266) were positive but non-significant and hence these variables were failed to exert any significant influence on the cotton productivity. The estimated R^2 value (0.35) indicated that 35 per cent of variation in TFP was explained by the factors included in the model.

Table 32: Estimated parameters of variables contributing to TFP of cotton in Northern Zone

Variables	Coefficients	Standard Error	t Stat
Intercept	-1.868	6.665	-0.280
Irrigated area (ha)	1.026	1.729	0.593
Annual rainfall (mm)	0.768***	0.078	9.846
N to P ratio	-0.994**	0.406	-2.444
Scale of finance (Rs.)	0.184	0.332	0.554
Road density (1000km)	-0.057	0.520	-0.109
MSP (Rs. /q)	0.266	0.571	0.465
Adjusted R^2	**0.35**		
Observations	18		

Note: ***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

4.4.2 Sources of TFP growth of cotton in central zone

Table 33 showing how considered factors would affect cotton's TFP growth in India's central zone. The findings showed that irrigation (0.856), road density (0.701), and MSP (0.744) had significant coefficients, indicating that these factors helped to boost cotton productivity. The scale of financing (0.190) and the coefficient of rainfall (0.600) were both positive but not statistically significant and had no discernible effect on the productivity of the cotton crop. According to the estimated R^2 value (0.82), the components in the model and its strong fit explained 82 per cent of the variation in TFP.

Table 33: Estimated parameters of variables contributing to TFP of cotton in central zone

Variables	Coefficients	Standard Error	t Stat
Intercept	-3.033	3.577	-0.848
Irrigated area (ha)	0.856**	0.123	6.950
Annual rainfall (mm)	0.600	0.981	0.612
N to P ratio	-0.473	0.350	-1.350
Scale of finance (Rs.)	0.190	0.090	2.110
Road density (1000km)	0.701***	0.203	3.463
MSP (Rs. /q)	0.744**	0.302	2.459
Adjusted R^2	**0.82**		
Observations	18		

Note: ***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

4.4.3 Sources of TFP growth of cotton in southern zone

Table 34 displays how various considered factors will impact TFP growth of cotton in the southern zone of India. According to the findings, irrigation (0.491), rainfall (0.332), and MSP (1.006) all had statistically significant coefficients, indicating that they were able to boost cotton productivity in the southern zone. The road density (0.022), scale of financing (0.002), and N/P ratio (1.026) all had positive but non-significant coefficients, indicating that they had no noticeable effect on cotton productivity. The components in the model and its strong fit explained 89 per cent of the variation in TFP, as indicated by the calculated R^2 value (0.89). The results are consonance with Elumalai (2011) who reported that the government expenditure on research, education and extension, canal irrigation, rainfall and balanced use of fertilizers were influential factors for crop productivity in Karnataka.

4.4.4 Sources of TFP growth of cotton in India

Table 35 shows various factors affecting cotton's TFP improvement in India. The results showed statistically significant coefficients for rainfall (1.320), road density (.933), and MSP (0.407), all of which were able to increase cotton productivity in India. The irrigation coefficient (0.019), which was positive but not statistically significant, showed that irrigation had no discernible impact on cotton productivity. The N/P ratio (-0.025) and scale of financing (-0.122) coefficients have a negative impact on cotton productivity in India. According to the calculated R2 value, the model's components and strong fit explained 92 per cent of the variation in TFP (0.92).

Table 34: Estimated parameters of variables contributing to TFP of cotton in Southern Zone

Variables	Coefficients	Standard Error	t Stat
Intercept	2.229	2.717	0.820
Irrigated area (ha)	0.491**	0.073	6.691
Annual rainfall (mm)	0.332**	0.098	3.388
N to P ratio	0.066	0.372	0.177
Scale of finance (Rs.)	0.002	0.178	0.010
Road density (1000km)	0.022	0.264	0.083
MSP (Rs. /q)	1.006***	0.179	5.622
Adjusted R^2	**0.89**		
Observations	18		

Note: ***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

Table 35: Estimated parameters of variables contributing to TFP of cotton in India

Variables	Coefficients	Standard Error	t Stat
Intercept	-5.484	1.924	-2.850
Irrigated area (ha)	0.019	0.127	0.151
Annual rainfall (mm)	1.320**	0.572	2.307
N to P ratio	-0.025	0.355	-0.070
Scale of finance (Rs.)	-0.122	0.190	-0.646
Road density (1000km)	0.933***	0.168	5.551
MSP (Rs. /q)	0.407**	0.159	2.565
Adjusted R^2	**0.92**		
Observations	18		

Note: ***, ** and * indicates significant at one per cent, five per cent and ten per cent probability level, respectively.

4.5 Technical change of cotton in different zones of India

To find out the Total Factor Productivity Change and its components in cotton production across different zones of India Malmquist Productivity Index was used. An attempt was made in this section to decompose the productivity growth of cotton in the present study into various efficiency measures using the Malmquist productivity indices. The technique used allowed to decompose the productivity growth into two mutually exclusive and exhaustive components namely, efficiency change (effch) or shifts in technology over time and technical change (tech). The effch index can further be decomposed into pure efficiency change (pech) and scale efficiency change (sech).

4.5.1 Malmquist productivity index for Northern Zone

To understand the dynamics in scale of production, Malmquist total factor productivity was worked out. The results for northern zone of India are presented in Table 36. From the analysis, 2000 to 2002 period observed a reduction in the productivity of inputs combination in cotton production as revealed by the reduction in productivity index to an extent of 0.41, but 2002-03 had positive productivity with the average total factor productivity change of 32.0 per cent. This significant change was due to pure change in adoption of technology to an extent of 32.0 per cent as indicated by the technological change factor (Table 28). This result is appropriate as the introduction and adoption of new innovation in the form of new variety of cotton that could withstand pest and diseases was released in the same period accompanied with effective extension education on the management and utilization of the new innovation.

The highest productivity of cotton was recorded in 2016-17 production season to the extent of 70.7 per cent. This was due to less incidence of whitefly and disease infestation coupled with the required rainfall pattern during the monsoon season (Anonymous, 2018). However, the precedent years 2014-15 and 2015-16 observed negative productivity growth to an extent of 22.2 per cent and 49.5 respectively. The sharp decline in productivity during these years was due to decline in area under cotton and pest attacks backed by failure of government inputs subsidy especially in urea and potash-based fertilizers in some states of the northern zone of India (Table 36). In general, over the 18 years period under study, there was a positive change in average total factor productivity of 12.0 percent. This was due to pure changes of technological effects. In summary, the results revealed that all farmers operated at the most productive scale size as the scale and efficiency change was constant throughout the period and thus, any reduction in productivity can be firmly ascribed to technological failure in the production due to pests and diseases infestation affecting their yield level adversely.

Table 36: Malmquist productivity index of cotton in Northern Zone from 2000-01 to 2017-18

Year	effch	techch	pech	sech	tfpch
2001-02	1.000	0.586	1.000	1.000	0.586
2002-03	1.000	1.320	1.000	1.000	1.320
2003-04	1.000	1.120	1.000	1.000	1.120
2004-05	1.000	0.910	1.000	1.000	0.910
2005-06	1.000	0.870	1.000	1.000	0.870
2006-07	1.000	1.009	1.000	1.000	1.009
2007-08	1.000	1.488	1.000	1.000	1.488
2008-09	1.000	0.752	1.000	1.000	0.752
2009-10	1.000	1.426	1.000	1.000	1.426
2010-11	1.000	1.077	1.000	1.000	1.077
2011-12	1.000	0.858	1.000	1.000	0.858
2012-13	1.000	1.053	1.000	1.000	1.053
2013-14	1.000	1.039	1.000	1.000	1.039
2014-15	1.000	0.778	1.000	1.000	0.778
2015-16	1.000	0.505	1.000	1.000	0.505
2016-17	1.000	2.707	1.000	1.000	2.707
2017-18	1.000	1.508	1.000	1.000	1.508
Mean	**1.000**	**1.120**	**1.000**	**1.000**	**1.120**

Note: effch- Efficiency change, techch-Technical change, pech- Pure efficiency change, sech- Scale efficiency change and tfpch- Total factor productivity change.

4.5.2 Malmquist productivity index in Central Zone

Malmquist indices of productivity growth of cotton in Central Zone of India were calculated to study and decomposes the productivity growth into various efficiency measures and results have been presented in Table 37. From the analysis, the year 2000 to 2002 observed as the years of increasing in the productivity of inputs combination in cotton production as revealed by the increased in productivity index to an extent of 25.10 per cent due to technological and scale management (farm management), but 2002-03 had negative productivity with the average total factor productivity change of 10.80 per cent due to sap sucking pests (Anonymous, 2003) but in 2003-04 had highest productivity with average total factor productivity change of 61.10 per cent. This significant change was due to pure change in adoption of technology to an extent of 61.10 per cent as indicated by the technological change factor. This result is appropriate as the introduction and adoption of new innovation in the form of 4.35 new variety of cotton (*Bt* cotton) that could withstand pest and diseases was released in the same period accompanied with effective extension education on the management and utilization of the new innovation. The lowest productivity of cotton in Central Zone of India was noticed in 2011-12 production season to the extent of 26.30 per cent. This was due to damage of cotton crop resulting from the unseasonal rains and extreme cold temperature in some states of Central and Southern Zones of India (Anonymous, 2011). In general, over the 18 years period under study, there was a positive change in average total factor productivity of 8.00 per cent. This was due to pure changes of technological effects. In summary, the results revealed that all farmers operated at the most productive scale size as the scale and efficiency change was constant throughout the period and thus, any reduction in productivity can be firmly ascribed to technological failure in the production due to pests and diseases infestation affecting their yield level adversely.

Table 37: Malmquist productivity index of cotton in Central Zone from 2000-01 to 2017-18.

Year	effch	techch	pech	sech	tfpch
2001-02	1.011	1.237	1.000	1.011	1.251
2002-03	1.000	0.892	1.000	1.000	0.892
2003-04	1.000	1.611	1.000	1.000	1.611
2004-05	1.000	1.158	1.000	1.000	1.158
2005-06	1.000	1.193	1.000	1.000	1.193
2006-07	1.000	0.850	1.000	1.000	0.850
2007-08	1.000	1.226	1.000	1.000	1.226
2008-09	1.000	1.277	1.000	1.000	1.277
2009-10	1.000	0.970	1.000	1.000	0.970
2010-11	1.000	1.047	1.000	1.000	1.047
2011-12	1.000	0.737	1.000	1.000	0.737
2012-13	1.000	0.877	1.000	1.000	0.877
2013-14	1.000	1.153	1.000	1.000	1.153
2014-15	1.000	0.946	1.000	1.000	0.946
2015-16	1.000	0.992	1.000	1.000	0.992
2016-17	1.000	1.133	1.000	1.000	1.133
2017-18	1.000	1.019	1.000	1.000	1.019
Mean	**1.000**	**1.080**	**1.000**	**1.000**	**1.080**

Note: effch- Efficiency change, techch-Technical change, pech- Pure efficiency change, sech- Scale efficiency change and tfpch- Total factor productivity change.

Table 4.36: Malmquist productivity index of cotton in Southern Zone from 2000-01 to 2017-18

Year	effch	Techch	pech	sech	tfpch
2001-02	1.000	1.164	1.000	1.000	1.164
2002-03	1.000	0.902	1.000	1.000	0.902
2003-04	1.000	1.326	1.000	1.000	1.326
2004-05	1.000	1.155	1.000	1.000	1.155
2005-06	0.939	0.996	1.000	0.939	0.936
2006-07	0.884	0.909	1.000	0.884	0.803
2007-08	1.013	1.240	1.000	1.013	1.256
2008-09	1.190	1.275	1.000	1.190	1.517
2009-10	1.000	1.161	1.000	1.000	1.161
2010-11	1.000	1.525	1.000	1.000	1.525
2011-12	1.000	0.624	1.000	1.000	0.624
2012-13	1.000	1.044	1.000	1.000	1.044
2013-14	1.000	1.335	1.000	1.000	1.335
2014-15	1.000	0.626	1.000	1.000	0.626
2015-16	1.000	0.912	1.000	1.000	0.912
2016-17	1.000	1.323	1.000	1.000	1.323
2017-18	1.000	2.203	1.000	1.000	2.203
Mean	**1.000**	**1.160**	**1.000**	**1.000**	**1.170**

Note: effch- Efficiency change, techch-Technical change, pech- Pure efficiency change, sech-Scale efficiency change and tfpch- Total factor productivity change.

4.5.3 Malmquist productivity index in Southern Zone

To understand the dynamics of scale of production, Malmquist total factor productivity was worked out for Southern Zone of India and the results are presented in Table 38. According to the analysis, the productivity of cotton production increased from 2000 to 2002, as indicated by the productivity index, which rose by 16.40 per cent as a result of technological change. However, in the following year, 2002–2003, there was a decrease in productivity, with an average total factor productivity change of 9.80 per cent as a result of rain deficiency in some states of the Southern Zone of India, which hampered the growth and flowering of the cotton crop. This significant change was due to pure change in adoption of technology to an extent of 32.60 per cent as indicated by the technological change factor (Table 38). The result was appropriate as the introduction of new variety of cotton and utilization of innovation. The highest productivity of cotton noticed in the year 2017-18 to the extent of 20.30 per cent mainly due to increase in area under cotton

(Anonymous, 2019 a). Whereas, lowest productivity was observed in 2011-12 to the extent of 37.40 per cent due to the unseasonal rains. Over the study period there was a positive change in average total factor productivity of 17.00 per cent. This was due to pure changes of technological effects.

4.5.4 Malmquist productivity index in all cotton producing zones

Malmquist indices of productivity growth of all cotton producing zones of India were calculated to study and decomposes the productivity growth into various efficiency measures and results have been presented in Table 39. According to the analysis, cotton productivity was decreased from 2000 to 2002 by 5.20 per cent, but it was increased from 2003 to 2004 with an average total factor productivity change of 33.70 per cent. This substantial transformation resulted from a simple shift due to technology adoption. This outcome is appropriate given that *Bt* cotton, a new type of cotton that could survive pests and diseases, was launched during the same time period and was accompanied by efficient extension education on the use and management of the new invention. The highest productivity of cotton observed in 2016-17 to an extent of 59.50 per cent due to the introduction of cotton improvement programmes like advancement of research on cotton under Technology Mission on Cotton (TMC) and introduction of transgenic cotton verities by ICAR (MoA, GOI 2019) whereas, lowest productivity recorded in 2011-12 to the extent of 6.70 per cent due to the unseasonal rains and cold temperature in the central and southern parts of the country. Over the study period there was a positive change in average total factor productivity of 9.00 per cent in all cotton producing zones of country was due to pure changes of technological effects. The findings are in line with Kumar and Anwer (2015) assess the TFP change for rapeseed and mustard from technical change and technical efficiency change.

4.5.5 Malmquist index of each zone

The productivity growth of cotton in different cotton producing zones were estimated and decomposed using the Malmquist approach and the results are presented in Table 40. From 2000-01 to 2017-18. From the analysis, the average performance of cotton in different zones over the period of time had improved as was evident from Table 40 when the mean productivity change was 6.8 per cent. The entire improvement in the productivity was due to improvement in the technological change or innovation. The highest improvement in the productivity was observed in southern zone of India to the extent of 11.00 per cent due to increased area under cotton and also well mechanized practices from 2000-01 to 2017-18 (Anonymous, 2019 b). In central zone the productivity change was increased to the extent of 6.00 per cent because farmers adopted advanced level of technologies as well as agronomic practices which increased the yield more and in Northern

Table 39: Malmquist productivity index of cotton in all zones from 2000-01 to 2017-18.

Year	effch	techch	pech	sech	tfpch
2001-02	1.004	0.945	1.000	1.004	0.948
2002-03	1.000	1.020	1.000	1.000	1.020
2003-04	1.000	1.337	1.000	1.000	1.337
2004-05	1.000	1.068	1.000	1.000	1.068
2005-06	0.979	1.011	1.000	0.979	0.990
2006-07	0.960	0.920	1.000	0.960	0.883
2007-08	1.004	1.313	1.000	1.004	1.318
2008-09	1.060	1.070	1.000	1.060	1.134
2009-10	1.000	1.171	1.000	1.000	1.171
2010-11	1.000	1.198	1.000	1.000	1.198
2011-12	1.000	0.733	1.000	1.000	0.733
2012-13	1.000	0.988	1.000	1.000	0.988
2013-14	1.000	1.170	1.000	1.000	1.170
2014-15	1.000	0.772	1.000	1.000	0.772
2015-16	1.000	0.770	1.000	1.000	0.770
2016-17	1.000	1.595	1.000	1.000	1.595
2017-18	1.000	1.501	1.000	1.000	1.501
Mean	**1.000**	**1.090**	**1.000**	**1.000**	**1.090**

Note: effch- Efficiency change, techch-Technical change, pech- Pure efficiency change, sech-Scale efficiency change and tfpch- Total factor productivity change.

Table 40: Malmquist productivity index of cotton for each zone from 2000-01 to 2017-18

Particulars	effch	techch	pech	sech	tfpch
Northern zone	1.000	1.035	1.000	1.000	1.035
Central zone	1.001	1.060	1.000	1.001	1.060
Southern zone	1.000	1.110	1.000	1.000	1.110
Mean	**1.000**	**1.068**	**1.000**	**1.000**	**1.068**

Note: effch- Efficiency change, techch-Technical change, pech- Pure efficiency change, sech-Scale efficiency change and tfpch- Total factor productivity change.

one the productivity change was 3.5 per cent. This was due to less incidence of whitefly and disease infestation coupled with the required rainfall pattern during the monsoon season (CCI, 2018). In general, the productivity change was increased in different zones of India mainly due to the development programmes like, Technology mission on cotton (TMC) and subsidiary programmes introduced by CCI (Cotton Corporation of India), introduction of *Bt* cotton, minimum support price (MSP) by government of India and also advanced mechanization practices.

4.6 Value chain of cotton in India

To work out the value addition in cotton, calculations about the economics of cotton processing were estimated on per quintal basis using averages and per centages.

4.6.1 Ginning units

Table 41: Cost of processing of kapas (raw cotton) to lint (ginning process)

Particulars	Rs/quintal	per centage
Variable cost		
Raw material taken (Cotton)	11289.00	71.28
Raw material procurement cost (includes raw material cost)	11504.00	72.64
1. Transportation	50.00	0.32
2. Loading & unloading of raw material	50.00	0.32
3. Wastage	116.00	0.73
Maintenance and repair cost	768.00	4.85
Electricity cost	1563.00	9.87
Labour for processing	1340.00	8.46
Miscellaneous cost	1.00	0.01
Total variable cost	**15392.00**	**97.19**
Fixed cost		
Amortised cost of Buildings	49.00	0.31
Amortised cost of Plant machineries	68.00	0.43
Amortised cost of tools and equipment's	114.00	0.72
Insurance	49.00	0.31
Taxes	8.00	0.05
Imputed land rent	158.00	1.00
Total fixed cost	**446.00**	**2.81**
Total cost	**15838.00**	**100**

4.6.1.1 Cost of processing of kapas to lint (Ginning)

The cost of ginning process *i.e.*, processing of kapas to lint per quintal is presented in Table 41. On an average, the total cost incurred in the processing of kapas to lint worked out to Rs.15838 per quintal of kapas. It is worth noting that the total variable cost (Rs. 15392 per quintal) formed a substantial component (97.19 per cent) of the total cost of processing of kapas to lint. The total fixed cost being Rs.446 per quintal, accounted for only 2.81 per cent of the total cost of processing. Considering variable cost, cost of raw material procurement cost (includes raw material cost) comprises about 72.64 per cent (Rs.11504) of total cost of processing. In the total fixed cost, imputed land rent (` Rs.158) were found to be the major component (1.00 per cent).

Table 42: Returns from processing of cotton (kapas) to lint (for one quintal of kapas ginned)

Sl. No.	Particulars	Amount (Rs)/qtl
1	Returns from main product (lint)	15505.00
2	Returns from by-product (seed)	4025.00
3	Cotton trash	300.00
	Gross returns	19830.00
1	Raw material cost (kapas)	11503.00
2	Value addition	8325.00
3	Processing cost	4001.00
4	Net value addition	4325.00
5	**Benefit-cost ratio**	**1.25**

4.6.1.2 Returns from processing of cotton

Details of returns from processing of raw cotton to the lint per one quintal of cotton were presented in the Table 42. From the figures it was noticed that the value of the raw material (kapas) was Rs. 11505 per quintal. Gross returns obtained from ginning of one quintal of cotton (kapas) was Rs. 19829 of which the returns from the main product (lint) was Rs. 15505 per quintal and that returns from byproducts i.e., seed was Rs. 4025 per quintal of kapas and value of the cotton trash (cotton waste) was obtained during kapas to lint processing was Rs.300 per quintal from the Table 42. The value addition to the product in the process was Rs. 8325. The net value added as a result of processing of kapas to lint was Rs. 4325 of kapas process. The cost incurred in the processing of kapas to lint was Rs. 4001per quintal. The benefit cost ratio worked out to be 1.25 in kapas processing.

Table 43: Cost of marketing of lint

Sl. No.	Particulars	Rs. / Quintal	per centage
1	Packing material	35.00	4.16
2	Selling expenditure	14.00	1.66
3	GST @ 5 %	775.00	92.15
4	Miscellaneous cost	17.00	2.02
	Total	**841.00**	**100**

4.6.1.3 Cost of marketing of lint

Table 43 depicts different costs involved in the marketing of lint per quintal to the further value addition. The total cost involved in marketing of lint per quintal was Rs.840 Among all the marketing costs of ginned cotton, the maximum cost was incurred on Goods and Services Tax (GST) Rs. 775 (92.15 %) per quintal. As GST was very important tax which was implemented by the government of India in 2017 and the GST for cotton products from raw cotton to yarn production was 5 per cent. Packing material was also important in case of lint marketing, it constituted the 4.16 per cent (Rs. 35.00). Miscellaneous cost involved in marketing of lint was Rs. 17.00 (2.02 %) followed by selling expenditure Rs. 14 (1.66 per cent) from the Table 43.

4.6.2 Spinning units

4.6.2.1 Cost of processing of lint to yarn (Spinning)

The cost of spinning process i.e., conversion of lint to yarn per quintal is provided in Table 44. The average overall cost for turning lint into yarn is shown in Table 44 and it was Rs. 36324 per quintal, of which the total variable cost was Rs. 32685 (89.98 %) and the total fixed cost was Rs. 3639 (10.02 %). The cost of procuring raw materials (including the cost of raw materials) made up the majority of the variable cost i.e., 86.20 per cent, at Rs. 31310 per quintal. The amortised cost of tools and equipment, which made up the majority (5.79 %) of the overall fixed cost, was Rs. 2102 per quintal.

Table 44: Cost of processing of lint to yarn (spinning process)

Particulars	Rs. /Quintal	per centage
Variable cost		
Raw material taken (Lint)	31250.00	86.03
Raw material procurement cost (including raw material cost)	31310.00	86.20
1. Transportation	15.00	0.04
2. Loading & unloading of raw material	15.00	0.04
Maintenance and repair cost	1038.00	2.86
Electricity cost	197.00	0.54
Labour for processing	110.00	0.30
Total variable cost	**32685.00**	**89.98**
Fixed cost		
Amortised cost of Buildings	124.00	0.34
Amortised cost of Plant machineries	218.00	0.60
Amortised cost of tools and equipment's	2102.00	5.79
Insurance	82.00	0.23
Taxes (GST @ 5 % for lint)	775.00	2.13
Imputed land rent	338.00	0.93
Total fixed cost	**3639.00**	**10.02**
Total cost	**36324.00**	**100**

Table 45: Returns in processing of lint to yarn (For one quintal of lint spinned)

Sl. no.	Particulars	Rs. / Quintal
1	Returns from main product(yarn)	51558.00
2	Cotton wastage generated	1315.00
	Gross returns	52873.00
1	Raw material cost (lint)	31250.00
2	Value addition	21623
3	Processing cost	20308.00
4	Net value addition	1315.00
5	**Benefit-cost ratio**	**1.45**

4.6.2.2 Returns from processing of lint to yarn

Returns from processing of lint to yarn production was depicted in table 45. From the analysis it was noticed that, the gross returns obtained from the processing (spinning) of one quintal of lint was Rs. 528723 which comprised of mainly returns from yarn (Rs.51558), wastage (Rs.1315) per quintal of lint. The raw material cost and processing cost of lint as Rs.31250 and 20308 per quintal. The value addition in the process was Rs.21623 per quintal (Table 45). The net value added as a result of processing of lint to yarn was 1315 per quintal of lint processed. The cost involved in the processing of lint to yarn was Rs.20308 per quintal. The benefit cost ratio worked out to be 1.45 in lint processing. The findings of Doddamani and Kunnal (2007) who reported that during ginning one quintal of colour cotton yielded 35 kg lint, 64 kg seed and 1 kg of waste. The additional value of Rs. 5,875 was generated through processing kapas into cotton garments (shirts).

Table 46: Cost of marketing of yarn

Sl. No.	Particulars	Rs. / Quintal	Per centage
1	Packing material	65.00	2.42
2	Selling expenditure	20.00	0.75
3	GST @ 5 %	2578.00	96.12
4	Miscellaneous cost	19.00	0.71
	Total	**2682**	**100**

4.6.2.3 Cost of marketing of yarn

The information of various costs involved in the marketing of yarn per quintal which subjected in to further processing were presented in the Table 46. From the analysis the results indicated that total cost incurred on marketing of one quintal of yarn was Rs. 2682 Among all the costs incurred in marketing of spinned cotton, the maximum cost was incurred on GST at 5 per cent Rs. 2778 per quintal (96.12 %). Packing material was also important in all value addition stages of cotton which constitutes 1.04 per cent (Rs.65) per quintal. The selling expenditure during marketing of yarn was Rs.20 (0.75 %) followed by miscellaneous cost was Rs. 19 (0.71 %) of the total cost of marketing of one quintal of yarn (Table 46).

SUMMARY

V SUMMARY AND CONCLUSION

A gist of research along with major findings is presented in this chapter. Policy recommendations are suggested for planners and administrators based on the results of the present study.

5.1 Introduction

Agriculture is critical for any nation's and people's overall growth since it provides some of life's most fundamental necessities, such as food, clothing, and shelter. Agriculture has thus remained a major source of livelihood for a large proportion of the population in India, as well as throughout the world, since time immemorial. In rural India, agriculture is a vital source of income. Agriculture is extremely important to India's economy. Agriculture and allied sector activities employ 54.6 per cent of the entire workforce and contribute for 17.8 per cent of the country's Gross Value Added (GVA) in 2019-20 (at current prices) (Anonymous 2021a). Agriculture contributes for about 15 per cent of total export revenue. Textiles, sugar, flour mills, jute, garments, and other industries rely on raw supplies from the agricultural sector. In this context cotton crop plays an important role in agricultural economy.

Cotton, the king of fibers is often quoted as 'White Gold' because of its higher commercial values. It is a primary raw material in the textile industries. Cotton, cotton yarn, cotton fabrics and garments have substantial demand in the global market. The cotton seed which remains after the cotton ginning is used to produce cotton seed oil, which, after refining, can be consumed by humans like any other vegetable oil. The cotton seed meal that is left generally is fed to ruminant livestock. Cotton is the principal commercial crop in India, influencing the country's economy as it provides remunerative income and employment to most of the people. India has the highest share globally, about 13.5 million hectares (37%) (Anonymous, 2021c) in terms of area under cultivation. India is the earliest domesticate nation in the world and manufacturer of cotton fabrics. Cotton accounts for almost 44 per cent of the world's fibre and 10 per cent of the entire world edible oil production. India next to China's second-largest exporter and producer of cotton (Anonymous, 2021c).

Since cotton is very important fibre and cash crop in India and there is a neck-to-neck competition between top cotton producing countries like China, USA, Brazil *etc.* Populated countries like in India there are a lot of demand for cotton products for different purposes. Hence this study focused on finding out the total factor productivity and technological change of cotton in different zones of India and also focused on the value addition of cotton in India in order to frame policies to emerge with more and better research strategies to increase the production. In this direction, present study was taken on cotton crop with the following specific objectives:

1. To assess the growth performance of cotton

2. To carryout comparative analysis of total factor productivity of cotton in different zones of India

3. To assess the technical change of cotton in different zones of India

4. To analyse the value chain in cotton

5.2 Methodology

The present study was taken-up in cotton producing three distinct agro-ecological zones (Cotton corporation of India), *viz.,* Northern zone (Punjab, Haryana and Rajasthan), Central zone (Gujarat, Maharashtra and Madhya Pradesh) and Southern zone (Andhra Pradesh, Telangana, Tamil Nadu and Karnataka) of India. The primary data pertaining to socio-economic characters, income, input use and marketing practices of cotton value added products *i.e.,* from raw cotton to lint (ginning) and lint to yarn (Spinning) were collected from each five ginners and five spinners. The value addition on cotton occurs at three stages of processing *viz.,* ginning, spinning and weaving. Out of these three stages of processing two stages *viz.,* ginning and spinning stages were considered for the present study. Conventional, functional and financial analytical tools were employed for estimating the costs and returns in cotton production, cost of processing, returns and value addition to cotton in each stage of processing.

The data pertains to area, production and productivity of cotton were collected from Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare and Cotton Corporation of India Ltd. The time series data for the period from 1990-91 to 2020-21 were collected and categorized in to three periods *viz.,* period I (1990 to 2000), period II (2001-2010) and period III (2011-2021) for cotton producing zones of India. Further the cost of cultivation data of cotton in different cotton producing zones of India were collected and compiled from the cost of cultivation scheme of the Government of India from the year 2000 to 2018. The different analytical tools like Descriptive statistics, Growth rate analysis, Production function analysis, Bai-Perron test, Cost and return analysis, Total factor productivity, technical change, and *etc.,* were used in the analysis.

5.3 Major findings of the study

- The growth of area under cotton in central and southern zones were increasing at the CAGR of 2.24 and 2.96 per cent respectively, however in Northern zone, the CAGR was decreasing (-0.94 %) for the selected study period.
- Cotton production has increased from period I (1990-2000) to period II (2000-2010) due to introduction of *Bt* cotton and declined in the period III (2010-2021) due to infestation of pink boll worm pest in all the zones.
- Cotton productivity has increased from period I to period II due to introduction of *Bt*-cotton had significantly increased all the sources of growth even though the technology mission on cotton was introduced much earlier.
- The variables like, minimum support price in northern zone, net irrigated area in central zones were influenced significantly however, rainfall and lagged yield were contributed significantly in southern zone of India.
- The multiple breaks were observed in area and production of cotton in different zones of India from 1990 to 2021.
- The cost of cultivation and cost of production of cotton were increasing in all the zones of India from the 2000 to 2018.
- The inputs like, fertilizer and manure application in cotton crop were increasing significantly in northern zone of India over the study period.
- The per cent share of inputs cost to C_2 varied in the selected periods and results revealed that all costs had declining trend over selected time period in northern zone of India.
- The yield level of cotton increasing from 9.29 quintal per hectare to 15.16 quintal per hectare in northern zone was mainly due to intervention of improved varieties and management skills of the farmers over the study period.
- The returns per rupee of expenditure in northern zone varied during different years and was found to be the highest during TE 2009-10 (0.92) and the least during TE 2000-01 (0.56).

- The inputs like, human labour, machine labour and application of fertilizers were increasing in the central zone of India over the study period.
- The variable like human labour share was increasing among different inputs in the central zone of India.
- The returns per rupee of expenditure in central zone varied during different years and was found to be the highest during TE 2009-10 (1.07) and the least during TE 2000-01 (0.64).
- The application of fertilizer and usage of machine labour were increasing significantly in southern zone of India.
- The per cent share of inputs cost to C_2 varied in the selected periods and results revealed that all costs had increasing trend over selected time period except the manure cost and other costs in the southern zone of India.
- In southern zone the returns per rupee of expenditure of cotton varied during different TE periods and was found to be highest during TE 2006-07 (0.95) and the least during TE 2015-16 (0.74).
- In India, the returns per rupee of expenditure of cotton varied during different years and was found to be highest during 2009-10 (0.91) and the least during 2000-01(0.64).
- The TFP for cotton in northern zone of India has increased over the years from 0.663 in 2001-02 to 1.545 in 2017-18 indicates that technological and infrastructural factors contributed for about more than 100 per cent in the cotton output growth and the average TFP growth was 1.237.
- In central zone of India, the TFP for cotton has increased over the years from 1.150 in 2001-02 to 2.388 in 2017-18 with the mean TFP score of 1.846 which indicates that technological and infrastructural factors contributed about 84.60 per cent output growth over the years.
- The TFP for cotton in southern zone of India has increased over the years from 1.169 in 2001-02 to 2.607 in 2017-18 with the mean TFP score of 1.661 which indicates that technological and infrastructural factors contributed about 66.10 per cent output growth over the years.

- In India, the TFP for cotton has increased over the years from 0.932 in 2001-02 to 2.003 in 2017-18 indicates that technological and infrastructural factors contributed in the cotton output growth. The highest TFP index was observed in 2017-18 (2.003). The mean TFP score of 1.491 which indicated positive TFP growth in India.
- The coefficients for rainfall (0.768) and significant indicated that rainfall enabled to increase the productivity of cotton in the northern zone of India over the study period.
- The factors like, irrigation (0.856), road density (0.701), and MSP (0.744) had significant coefficients, indicating that these factors helped to boost cotton productivity in central zone of India.
- The coefficients for irrigation (0.491), rainfall (0.332), and MSP (1.006) all had statistically significant, indicating that they were able to boost cotton productivity in the southern zone of India for the selected study period.
- The coefficients for rainfall (1.320), road density (.933), and MSP (0.407), all of which were positive and significant, indicating that these variables were contributed to increase the cotton productivity in India over the selected years.
- Over the study period (2000-2018), there was a positive change in total factor productivity of 12.00 per cent in northern zone of India. This was due to pure changes technological effects like, introduction of *Bt* cotton.
- For the cotton, in northern zone of India the highest improvement in the performance was observed in the year 2016-17 where the tfpch was 70.70 per cent and the entire improvement was due techch. This implied that there was significant improvement in the "innovation" in this year.
- The highest improvement in the performance of cotton in central zone of India was observed in the year 2003-04 where the tfpch was 61.10 per cent and the entire improvement was due to techch. This implied that there was significant improvement in the "innovation" in this year *i.e.*, introduction of *Bt* cotton.
- For southern zone of India, the highest productivity of cotton noticed in the year 2017-18 to the extent of 20.30 per cent indicating the entire improvement was due to techch. This was mainly due to increase in area under cotton.

- In all cotton producing zones (northern, central and southern) the highest productivity of cotton observed in 2016-17 to an extent of 59.50 per cent over the study period indicating the entire development due to techch. This was due to the introduction of cotton improvement programmes in India.

- The total cost incurred in the processing of kapas to lint (ginning) was Rs. 15838 per quintal of kapas. The total variable cost constitutes 97.19 per cent whereas, total fixed cost accounted 2.81 per cent to the total cost of processing. Considering variable cost, cost of raw material procurement cost (includes raw material cost) comprises about 72.64 per cent and in the total fixed cost, imputed land rent were found to be the major component (1.00 per cent).

- Gross returns obtained from ginning of one quintal of cotton (kapas) were, Rs.19830 The benefit cost ratio worked out to be 1.25 in kapas processing.

- The total cost involved in marketing of lint per quintal was Rs. 841 Among all the marketing costs of ginned cotton, the maximum cost was incurred on Goods and Services Tax (GST) Rs. 775 (92.15 %) per quintal. Packing material was also important in case of lint marketing, it constituted the 4.16 per cent (Rs. 35).

- The average overall cost for turning lint into yarn (spinning), was Rs. 36324 per quintal, of which the total variable cost was Rs. 32685 (89.98 %) and the total fixed cost was Rs. 3639 (10.02%).

- The gross returns obtained from the processing (spinning) of one quintal of lint were Rs. 52873. The benefit cost ratio worked out to be 1.45 in lint processing.

- The total cost incurred on marketing of one quintal of yarn was Rs. 2682. Among all the costs incurred in marketing of spinned cotton, the maximum cost was incurred on GST at 5 per cent Rs. 2778 per quintal (96.12 %).

Policy implications:

1. The technological intervention is the prerequisite in order to achieve the productivity level particularly in northern cotton producing zones.

2. The effective implementation of MSP based procurement system for cotton in all cotton producing zones is needed as procurement is not uniform in all the zones.

3. The efficient utilisation of water resources through irrigation schedules and water productivity enables for positive TFP growth across the cotton producing zones.

4. Developing hand loom sector in the cotton producing zones would generate employment and income around all the years.

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APPENDICES

Annexure I: The compound annual growth rate of area, production and productivity of cotton in Northern Zone of India from 1990 to 2021

Year	Area (lakh ha)	Production (lakh bales)	Productivity (kg/ha)
1990-91	16.50	39.80	1207.00
1991-92	16.40	45.50	1360.00
1992-93	17.00	47.40	1383.00
1993-94	16.60	34.80	1060.00
1994-95	16.50	40.30	1224.00
1995-96	20.00	45.70	1155.00
1996-97	20.50	48.00	1188.00
1997-98	20.10	29.30	750.00
1998-99	17.90	23.40	665.00
1999-2000	16.00	32.40	1035.00
2000-01	15.40	33.90	1122.00
2001-02	17.50	23.10	655.00
2002-03	13.50	23.70	862.00
2003-04	13.20	35.90	1361.00
2004-05	15.70	49.30	1562.00
2005-06	16.10	47.70	1485.00
2006-07	14.90	52.40	1695.00
2007-08	14.60	51.00	1723.00
2008-09	12.80	48.70	1839.00
2009-10	14.60	48.40	1658.00
2010-11	13.60	47.50	1736.00
2011-12	16.70	62.90	1884.00
2012-13	15.40	59.00	1929.00
2013-14	13.80	55.60	2037.00
2014-15	15.60	54.30	1784.00
2015-16	14.00	29.60	1111.00
2016-17	13.30	44.70	1730.00
2017-18	6.70	48.00	1717.00
2018-19	16.10	59.00	1889.30
2019-20	17.30	67.80	2035.00
2020-21	18.50	66.00	1666.90
CAGR	**-0.91**	**1.66*** **	**2.25*** **

Annexure II: The compound annual growth rate of area, production and productivity of cotton in Central Zone of India from 1990 to 2021

Year	Area (lakh ha)	Production (lakh bales)	Productivity (kg/ha)
1990-91	42.59	36.00	472.00
1991-92	44.19	25.82	324.00
1992-93	40.99	41.50	546.00
1993-94	40.94	46.68	571.00
1994-95	44.42	51.15	597.00
1995-96	49.89	54.22	560.00
1996-97	50.89	62.25	616.00
1997-98	51.73	54.42	619.00
1998-99	53.55	69.52	686.00
1999-2000	42.874	41.81	514.00
2000-01	51.899	32.05	305.00
2001-02	53.961	47.87	436.00
2002-03	49.941	46.71	452.00
2003-04	49.671	77.46	800.00
2004-05	53.224	82.90	782.00
2005-06	54.017	86.30	812.00
2006-07	61.359	142.34	1098.00
2007-08	62.474	161.56	1187.00
2008-09	61.244	126.22	997.00
2009-10	64.595	137.28	1030.00
2010-11	72.25	209.00	1561.00
2011-12	77.93	212.00	1468.00
2012-13	72.51	187.05	1532.00
2013-14	72.25	207.14	1615.00
2014-15	75.1	192.50	1472.00
2015-16	74.92	187.00	1434.00
2016-17	67.81	212.45	1669.00
2017-18	75.78	179.01	1355.00
2018-19	74.92	187.00	1528.00
2019-20	77.96	169.02	1233.00
2020-21	71.01	197.50	1580.64
CAGR	**2.24*****	**7.17*****	**5.12*****

Annexure III: The compound annual growth rate of area, production and productivity of cotton in Southern Zone of India from 1990 to 2021

Year	Area (lakh ha)	Production (lakh bales)	Productivity (kg/ha)
1990-91	14.90	22.09	776.00
1991-92	15.57	25.23	822.00
1992-93	17.02	24.66	764.00
1993-94	15.28	25.48	861.00
1994-95	17.36	26.88	800.00
1995-96	19.94	27.98	693.00
1996-97	19.35	31.4	774.00
1997-98	16.33	23.99	761.00
1998-99	21.37	29.05	779.00
1999-2000	17.63	25.99	792.00
2000-01	17.434	28.345	857.00
2001-02	19.043	28.155	754.00
2002-03	12.716	15.001	561.00
2003-04	12.515	22.773	739.00
2004-05	18.284	30.728	796.00
2005-06	15.865	28.753	833.00
2006-07	14.483	30.119	1031.00
2007-08	16.363	44.697	1195.00
2008-09	19.225	46.227	1073.00
2009-10	20.281	43.202	1065.00
2010-11	25.46	110.851	1957.00
2011-12	25.66	65.50	1895.00
2012-13	30.13	91.05	2189.00
2013-14	32.03	92.39	1842.00
2014-15	35.96	96.38	2038.00
2015-16	32.23	79.18	1805.00
2016-17	25.33	63.77	1746.00
2017-18	32.73	95.71	2001.00
2018-19	33.10	77.50	1789.33
2019-20	37.71	120.89	2098.00
2020-21	37.73	103.00	1485.31
CAGR	**4.08*****	**5.95*****	**2.96*****

Annexure IV: The compound annual growth rate of area, production and productivity of cotton in India from 1990 to 2021

Year	Area (lakh ha)	Production (lakh bales)	Productivity (kg/ha)
1990-91	74.40	98.42	225.00
1991-92	76.61	97.06	215.00
1992-93	75.42	114.03	257.00
1993-94	73.21	107.41	249.00
1994-95	78.71	118.88	257.00
1995-96	90.35	128.61	242.00
1996-97	91.21	142.31	265.00
1997-98	88.68	108.51	208.00
1998-99	93.42	122.87	224.00
1999-2000	87.10	115.30	225.00
2000-01	85.34	95.20	190.00
2001-02	91.32	99.97	186.00
2002-03	76.70	86.24	191.00
2003-04	75.98	137.29	307.00
2004-05	87.87	164.29	318.00
2005-06	86.77	184.99	362.00
2006-07	91.45	226.32	421.00
2007-08	94.14	258.84	467.00
2008-09	94.07	222.76	403.00
2009-10	101.32	240.22	403.00
2010-11	112.35	330.00	499.00
2011-12	121.78	352.00	491.00
2012-13	119.77	342.20	486.00
2013-14	119.60	359.02	510.00
2014-15	128.19	348.05	462.00
2015-16	122.92	300.05	415.00
2016-17	108.26	325.08	512 .00
2017-18	125.86	328.05	443.00
2018-19	126.14	330.00	444.74
2019-20	134.77	360.65	455.00
2020-21	129.57	371.00	26.10
CAGR	**1.96*****	**5.41*****	**1.58**

Annexure IV: Cost of Cultivation of Cotton per hectare in India from 2000-01 to 2017-18

Year	Human labour (rs.)	Animal labour rs.	Machine (rs.)	Seed Value (Rs.)	Fertiliser (Rs.)	Manure (Rs.)	Insecticides (Rs.)	Irrigation Machine (Rs.)	Miscellaneous Cost (Rs.)	Land Revenue (Rs.)	Rent Paid for Leased in Land (Rs.)	Imputed Rent (Rs.)
2000-01	5823.00	348.18	1262.95	479.57	818.08	12.84	2356.14	362.31	1.44	1.41	448.73	5364.88
2001-02	5573.48	390.49	1978.05	551.96	856.07	15.43	4371.91	365.24	1.72	1.31	303.95	3355.00
2002-03	5691.02	370.56	1641.19	517.86	838.17	14.21	3422.36	363.86	1.59	1.36	372.15	4301.78
2003-04	7093.58	453.77	1958.34	658.28	967.72	30.49	4291.37	749.83	1.00	1.03	287.78	7460.59
2004-05	7927.17	426.28	1872.85	1474.33	1181.13	102.62	3017.70	1066.83	1.99	0.98	519.87	7956.48
2005-06	7699.90	438.37	2403.12	1866.62	1551.15	119.26	1909.66	887.97	12.57	1.18	102.40	8863.17
2006-07	7594.60	438.89	2088.98	1369.49	1249.73	86.88	3003.33	907.17	5.49	1.07	300.11	8132.72
2007-08	10905.03	709.95	2914.89	2327.38	1690.11	103.76	2137.21	1043.62	8.91	1.00	620.02	11483.24
2008-09	8791.85	533.85	2484.57	1872.99	1505.73	103.70	2331.26	948.60	9.07	1.08	345.84	9554.45
2009-10	15443.13	572.85	2997.05	3459.37	2047.04	77.92	1751.07	1619.65	8.71	0.77	656.65	15703.58
2010-11	14995.62	475.83	2808.73	3814.71	2226.10	63.58	2541.31	1423.25	1.83	0.70	297.67	18669.16
2011-12	21707.48	499.42	3251.94	4882.26	2593.53	402.45	3905.32	1518.53	129.42	2.03	840.11	21267.01
2012-13	23071.94	464.33	3877.68	4970.34	3247.25	450.70	3205.89	1604.00	20.83	2.32	1387.01	21439.65
2013-14	23730.61	437.22	4415.59	4962.58	3616.81	442.16	3420.00	1771.90	11.46	1.52	1433.86	22419.55
2014-15	23824.82	414.35	4322.05	4905.14	2966.50	315.46	3472.06	2134.02	117.81	1.91	2354.45	19492.50
2015-16	21608.65	529.65	4315.70	5115.97	3123.46	616.06	4601.69	1862.25	44.23	118.88	1002.76	11781.61
2016-17	26452.56	338.09	4695.24	4672.86	3250.94	735.66	3705.21	1914.42	34.08	2.34	1942.27	24809.81
2017-18	26077.05	188.21	5684.32	4618.74	3465.38	283.02	3645.66	2433.30	6.56	1.97	1647.84	20037.17

Annexure V: Schedule used for data collection

VALUE CHAIN ANALYSIS OF COTTON

Department of Agriculture Economics

University of Agricultural Sciences, Bengaluru 560065

Interview Schedule for Cotton Processing Industry

Schedule No.: ____________________________ Date of Interview: ____________________________

Name of the Investigator : ______________________________

1. Name of the Industry:
2. Year of establishment:
3. Registered / un registered (Tick the appropriate)
4. Type of ownership ____________________________ (Single, Partnership, Joint Stock and Cooperative)
5. Initial investment of the company (Rs)____
6. Production capacity of the plant ____________________________________(tonnes/annum)
7. Actual production..(tonnes/annum)

8. Assets and Costs incurred (other than production) in the industry

Sl. No.	Particulars	Year of establishment/ Purchase	Size or Quantity (in Number)	Value (Rs.)
1	Land			
2	Building			
3	Plant Machinery			
4	Tools and Equipments			

5	Computer and Peripherals			
6	Furniture and Fixtures			
7	Vehicles			
8	Salary , wages and other amenities to employees			
9	Administration charges (If any)			
10	Loan Type | Interest (%)			
11	License fee			
12	Others (Specify)			

Note: Administration charges include Electricity (office) charges, stationeries,

9. Procurement:

a. Procurement details of cotton (Season):

Sources of Purchase	Sourcing Area	Frequency of purchase	Procurement Quantity (in Quintal)	Commission (Rs.)	Price (Rs/ Qtl)	Transportation Cost (Rs.)	Handling Charges (Rs.)
Contract Farming							
Direct Purchase							
APMC							
Any Other sources (Specify)							

b. Procurement quantity of Cotton (last 12 months):

Month	Procurement Quantity (in tonnes)	Month	Procurement Quantity (in tonnes)
August		February	
September		March	
October		April	
November		May	
December		June	
January		July	

10. Processing:

a. List out the products produced from the industry:

Sl. No	Products Name	Started Year of manufacturing product	Quantity Produced (Last year)	Stages involved in Processing
1	Lint			
2	Yarn			
3	Cloth			
4	Garment			
5	Cottonseed oil			

b. Variable costs:

b1. Product Name: ____________________ Manufacturing slot/date: ____________________

Lead Time (Processing Time) ______________(hrs) Machinery used ___________________

Sl. No.	Particulars	Quantity	Unit cost (Rs)	Total Cost (Rs)
1	Raw material taken (Cotton)			
2.	Raw material procurement cost			
	1. Transportation			
	2. Loading & unloading of raw material			
	3. Wastage			
	4. Cost incurred while preparation of raw material for processing			
	5. Others (Specify)			

3.	Other ingredients cost	Name			
	1. Ingrdnt I:				
	2. Ingrdnt II:				
	3. Ingrdnt III:				
	4. Ingrdnt IV:				
4	Electricity cost :				
5					
6.	Labor for processing				
7	Miscellaneous cost				
8	Total variable cost				
9	Average yield of end product				

b2. Product Name: __________________ Manufacturing slot/date: ____________________

Lead Time (Processing Time) _______________(hrs) Machinery used _________________

Sl. No.	Particulars		Quantity	Unit cost (Rs)	Total Cost (Rs)
1	Raw material taken (Cotton)				
2.	Raw material procurement cost				
	6. Transportation				
	7. Loading & unloading of raw material				
	8. Wastage				
	9. Cost incurred while preparation of raw material for processing				
	10. Others (Specify)				
3.	Other ingredients cost	Name			
	5. Ingrdnt I:				
	6. Ingrdnt II:				
	7. Ingrdnt III:				
	8. Ingrdnt IV:				
4	Electricity cost :				
5					
6.	Labor for processing				
7	Miscellaneous cost				
8	Total variable cost				
9	Average yield of end product				

11. Marketing:

a. Marketing details of Cotton and its products

Sl. No.	Product Name	Method of sale*	Quantity sold (kgs)	Price of the product/ unit quantity	Commission on sale/ Discounts	Share in total sales (%)
1						
2						
3						
4						
5						
6						
7						

Method of sale* - Indenting -1, Produce and distribute -2:

b. Marketing costs:

Products	Package Size	Cost of Package Material (Rs)	Labeling Cost (Rs)	Labour Cost	Selling Price (MRP)	Basic Price (Rs)	Commission sale per unit (Rs)
1.							
2.							
3.							

4.							
Storage cost							
Cost of Loading & Unloading (Rs)							
Distribution cost (Rs)							
Cost of sales promotion (Rs)							

c. Production & selling details of Cotton processed products for last 12 months:

Month	Product 1		Product 2		Product 3	
	Quantity produced	Quantity sold	Quantity produced	Quantity sold	Quantity produced	Quantity sold
August						
September						
October						
November						
December						
January						
February						
March						
April						
May						
June						
July						

d. Channels of Marketing: (Tick the related channel/s)

1. Farmers- APMC-Processing Industry- Distributors-Wholesalers-Retailers-consumers
2. Farmers-APMC-Processing Industry-Super marketers (Organized retailers)-Consumers
3. Farmers-Processing Industry (Contract Farming)-Own outlets- Consumers
4. Farmers-Processing Industry (Contract Farming)-Distributors-Wholesalers-Retailers - Consumers
5. Farmers-Processing Industry (Contract Farming)-Exporters
6. Any others (Specify)

e. Production & selling details of Cotton processed products for last 12 months:

Month	Product 1		Product 2		Product 3	
	Quantity produced	Quantity sold	Quantity produced	Quantity sold	Quantity produced	Quantity sold
August						
September						
October						

November						
December						
January						
February						
March						
April						
May						
June						
July						

f. Marketing activities of processed Cotton products

1. How do you obtain the price information of Cottont and its products from market?

____

2. Do you access the information technology to know the price, market arrivals? Yes or No _____

2.a. If yes pls mention the source ____

3. How do you fix the price for the processed Cotton products / pricing strategies followed by the industry?

____
____

4. Details regarding sales promotion activities involved by the industry:

- Advertisement ____________________________________
- Trade promotion/Trade Discounts ___________________________________
  (for eg Buy one get one free, one rupee off)
- Participation in exhibition and sales fare __________________

5. Customer service provided:

- Free delivery to retail outlets _____________________
- Immediate response for customer complaints reg. products _______________
- Free packaging to retail outlets ______________________________

6. In which aspects do you differ (better or worse) from your competitor?

____
____

12. Constraints at various stages of Cotton value chain:

Constraints	Yes(√) / No (×)	Suggestions
High variation in yield at farmers level		
Non-availability of quality cotton		
High price fluctuations		
High Commission charges		
Involving Immoral Activities by the CAs		
Under utilization of plant		
Frequent power failure		
High cost of repairs and maintenance charges of plant and machineries		
Lack of skilled labour/staff		
High cost of raw material , ingredient and labour		
More physical loss/wastage of produce		
Storage problem		
Lack of Research and Development		
Failing in assessing demand at market		
More competitors		
No proper marketing channel		
Transportation and distribution issues		
Others (Pls Specify)		
1.		

13. How do you like to improve your business if you get finance from bank?

Sl. No	Facilities need to be improved	Required credit (in Rs.)

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Determinants of Production Performance of Cotton in Different Zones of India

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ABSTRACT

Cotton farming plays a significant role in providing direct livelihood to 11 million farmers. The cotton crop mainly confined to northern, central and southern zones with about 90 per cent of the area comes under three zones. This study aims at sources of growth and factors affecting the cotton area and production using, time series data took from 1990 to 2021 for cotton producing zones of India. Furthermore, periods have been classified into period I (1990 to 2000), period II (2001 to 2010) and period III (2011 to 2021). There was a significant increase in growth in area from 2.68 to 3.22 per cent from period I to period III in southern zone and same findings has been observed in rest of the zones. In order to estimate sources of growth cobb-douglas production function and bai-perron test were employed. The results clearly indicate that the MSP; net irrigated area and lagged yield are significantly affecting the cotton acreage across zones and India. The bai and perron test clearly shows that there was abrupt increase in area and production of cotton after commercial release of BT cotton across the zones and India. Therefore, improvement in the procurement network of cotton under MSP and effective implementation of decentralized procurement policy could benefit the larger section of the farmers particularly in cotton producing zones. The productivity of the cotton could be improved by developing biotic and abiotic resistance variety helps in expansion of the cotton area.

Keywords : Cotton, MSP, Cobb douglas function, Bai and perron test

COTTON is one of the significant fibre and cash crop of India and play vital role in the cotton industrial and agricultural economy of the country which provides employment to about 11 million farmers and indirectly about 40-50 million people are employed in various stages of processing and trade of cotton and its derivatives (Ramesh *et al*., 2020). Cotton is considered as 'White gold' being cultivated since immemorial and major producer, consumer and exporter of cotton in the world. (Dupdal and Patil, 2017). In India, cotton is cultivated in 12.90 million hectares constituting of 41 per cent of the world area (Cotton Corporation of India, 2021). Further, during 2019-20 the cotton area reached new record of 13.40 million ha with 361 lakh bales production (170 kgs per bale).

Cotton occupies an enviable place among the commercial crops of our country. It grown in the country under diverse agro-climatic conditions (Prabhu et al., 2017). It is unique among agricultural crops, because it is the main natural fiber crop, which provides edible oil and seed by-products for livestock feed.

In India, there are ten major cotton growing states and classified into three cotton producing zones, *viz*., northern zone, central zone and southern zone. The Northern zone comprising of Punjab, Haryana and Rajasthan occupied an area of 18.45 lakh hectares with a production of 66 lakh bales (170 kg each). The Central zone comprising of Madhya Pradesh, Gujarat and Maharashtra occupied 71.01 lakh ha producing 197.50 lakh bales of cotton. The Southern zone comprising of Karnataka, Andhra Pradesh, Telangana and Tamil Nadu occupied 37.73 lakh ha producing 103 lakh bales of cotton (Ministry of Agriculture and Farmers Welfare). Besides these ten states, cotton cultivation in the country has gained momentum in Odisha and in non-traditional states of Uttar Pradesh, West Bengal and Tripura.

In recent period the area, production and productivity of cotton increased substantial mainly due to the inception of Technology Mission on Cotton (TMC) during 2000 followed byintroduction of Bt-cotton in 2002, modernization of market yards along with increased number of ginning mills, operation of

Minimum Support Price (MSP) programme by Government of India through Cotton Corporation of India (CCI) significantly increased the sources of growth in cotton in India and also across the cotton producing zones in the country. The contribution of each of these factors towards the sources of growth is a researchable issue needs to be addressed by researchers, institutions and policy makers for enhancing growth and development of cotton and in turn the trade at large. In view of these developments, a study on dimensions of growth and development of cotton is under taken with an aim to know the factors determining growth of cotton in India as well as across the different cotton producing zones.

MATERIAL AND METHODS

The study is based on secondary data compailed from official websites of various departments. The data pertains to area, production and productivity of cotton were collected from Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare and Cotton Corporation of India Ltd. The time series data for the period from 1990-91 to 2020-21 were collected and categorised in to three periods *viz.*, period I (1990 to 2000), period II (2001-2010) and period III (2011-2021) for cotton producing zones of India.

For computing compound growth rate of area, production and productivity of cotton for cotton producing zones in India the exponential function of the following form was used (Divya *et al*., 2013).

$$Y = a\, b^{t} e^{U_t} \qquad (1)$$

Where,

Y = Area / production / productivity

a = Intercept

b = Regression coefficient (*'a'* and *'b'* are the parameters to be estimated)

U_t = Disturbance term in year *'t'*

The equation (1) was transformed into log linear form and written as;

$$\log Y = \log a + t \log b + U_t \qquad (2)$$

Equation (2) was estimated by using Ordinary Least Squares (OLS) technique.

Compound growth rate (g) was then computed

$$g = (b - 1)\, 100 \qquad (3)$$

Where,

g: Compound growth rate in per cent per annum

b: Antilog of log b

The standard error of the growth rate was estimated and tested for its significance with 't' statistic.

To explore the factors determining growth in area under cotton, Cobb Douglas production function was fitted for the data (Beeraladinni *et al*,. 2016**)**. The below variables were selected based on previous literature and experts guidance in the field. The functional form of regression analysis is expressed as

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} e^{u}$$

Where, Y = cotton area (lakh ha.)

β_0 = Intercept

X_1 = MSP for cotton (Rs./Qtl.)

X_2 = Rainfall (mm)

X_3 = Lagged yield of cotton (kg/ha)

(Lagged yield of cotton was taken due to increased MSP which resulted in sustained increase in production over the years, which act as incentive for the farmers to take up crop in the coming years).

X_4 = Net irrigated area (thousand ha.)

β_1, β_2, β_3 and β_4 = Regression co-efficient u = Random error term

The Cobb-Douglas production function was converted into log linear form and co-efficient were estimated using Ordinary Least Square (OLS) as given below.

$$\ln Y = \ln \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \ldots\ldots\ldots\ldots + \beta_4 \ln X_4 + u \ln e$$

The regression co-efficient (β's) were tested using 't' test at chosen Level of Significance (LoS) and also examine the structural breaks in the area and production of the cotton for the same period by using Bai and Perron (1998, 2003) for estimating multiple structural breaks in the linear model.

Results and Discussion

Growth in Area, Production and Productivity of Cotton in India

The CAGR computed for three sub periods *i.e.*, Period I (1990 to 2000), Period II (2001 to 2010) and Period III (2011 to 2021) presented below.

In the central zone the area under cotton has been increased in the both periods (1990 - 2000 and 2001 - 2010) with CAGR of 2.04 and 2.84 per cent, respectively. However, the area has been declined to 0.01 per cent during 2011-21 due to the wide spread infestations of sucking pest in the region. The CAGR of area has declined in north zone from 1.23 to 0.10 per cent from 1990 to 2021 with overall negative growth rate of 0.91 per cent because of farmers switching over to other crops due to resurgence of sucking pest and leaf curl disease. Similarly, in southern zone area has been declined from 2.68 to 1.83 per cent during 1990 to 2010, however, increased during 2011-2021 with CAGR of 3.22 per cent at five per cent level of significance because of price support programmes initiated by government of India (Beeraladinni *et al*,. 2016). In India, the CAGR declined from 2.71 to 1.10 per cent from 1990 to 2021 with over all CAGR of 1.96 per cent.

Table 1

The CAGR of production of cotton in different producing zones of India (Lakh ha.)

Zones/ periods	1990-2000	2001-2010	2011-2021	overall
Northern zone	1.23	-1.12	0.19	-0.91
Central zone	2.04 *	2.84 ***	0.01	2.24 ***
Southern zone	2.68 **	1.83	3.22 **	2.96 ***
India	2.71 ***	2.03 **	1.10 *	1.96 ***

Note : ***, ** & * indicates 1, 5 and 10 % level of significance

In northern zone the production of cotton increased significantly with a CAGR of -4.63 to 8.43 per cent during 1990 to 2010 - 11, however declined during 2011-2021 for about the 1.34 per cent although non-significant. The similar observation is made in the central and southern zone cotton production increased with a CAGR of 6.61 to 18.46 per cent and 1.82 to 8.52 per cent from 1990 to 2010, respectively. The cotton production in India increased significantly with a CAGR of 2.30 to 13.61 per cent and declined during 2011-21 with CAGR of 0.30 per cent although non-significant. In sum, cotton production has increased from period I to period II due to introduction of *Bt* cotton and declined in the period III due to infestation of pink boll worm pest.

Table 2

CAGR of production of cotton in different producing zones of India (Lakh bales)

Zones/ periods	1990-2000	2001-2010	2011-2021	overall
Northern zone	-4.63 *	8.43 ***	1.34	1.66 ***
Central zone	6.61 **	18.46 ***	-1.25 *	7.17 ***
Southern zone	1.82	8.52 ***	1.15	5.95 ***
India	2.30 *	13.61 ***	0.30	5.41 ***

Note : ***, ** & * indicates 1, 5 and 10 % level of significance

Table 3

CAGR of cotton productivity in different producing zones of India (Kg/ha.)

Zones/ periods	1990-2000	2001-2010	2011-2021	overall
Northern zone	-5.40 **	9.39 ***	-0.30	2.25 ***
Central zone	4.21 *	14.65 ***	-0.79	5.12 ***
Southern zone	-0.41	5.77 ***	-1.41	4.08 ***
India	-0.39	11.34 ***	-13.15 *	1.58

Note: ***, ** & * indicates 1, 5 and 10 % level of significance

In north zone CAGR of productivity of cotton increased significantly with a CAGR of negative 5.40 to 9.39 during 1990 to 2010, respectively (Table 3). however, declined during 2011 to 2021 for about negative 0.30 per cent although non-significant. The similar observation is made in the central and southern zone cotton production increased with a CAGR of 4.21 to 14.65 per cent and negative 0.41 to 5.77 per cent from 1990 to 2010, respectively. However, declined productivity in both the zones to negative 0.79 and 1.41 per cent during the 2011-21. CAGR of productivity of cotton in India increased significantly from 0.39 to 11.34 per cent and declined during 2011-21 with a CAGR of negative 13.15 per cent. In sum, cotton productivity has increased from period I to period II due to introduction of *Bt*-cotton had significantly increased all the sources of growth even though the technology mission on cotton was introduced much earlier.

Factors Determining Sources of Cotton Growth Across Zones and India

In order to estimate the factors influencing the sources of growth in cotton across cotton producing zones and India for this, the Cob Douglas production function is fitted with MSP (minimum support price), rainfall, lagged yield, net irrigated areas are the independent variables and dependent variable is area under cotton.

The findings of the results show that the minimum support price found to be significant only in the northern zone of India with the coefficient of 0.65 at 5 per cent LoS. Implies that one percent in increase in the MSP results into 0.65 per cent increase in the acreage of cotton in the region. However, this is not true in other zones mainly due to the lack of awareness among the farmers and operation of the MSP is limited to confined area.

The net irrigated area found to be a significant factor in influencing the cotton acreage. However it has contributing positive and negative in some region for instance, in central cotton producing zone the parameter positive influencing in acreage implies that one per cent increase in the net irrigated area led to 0.34 per cent increase in the acreage of cotton. However, it found to be negative in the southern zone indicating that as increase in the area under irrigation which motivates those farmers to go for water intensive crops (rice and sugarcane) from the cotton crops due to well established market in the region. It was also observed that negatively contributing to the overall cotton acreage with 2.88 per cent of coefficient at five per cent LoS.

The previous year obtained yield contributes significantly to cotton acreage in India. The lagged yield of cotton found to be significant with coefficient of 0.55 at five per cent LoS implying that one per cent in increase in lagged yield which contributes of an about 0.55 per cent increase in the acreage of cotton crop.

The variables considered in the model explains the total variations of the cotton acreage to the extent of 0.89 per cent in India, while it is 0.88 per cent in central and Southern cotton producing zones and 0.75 per cent in the northern zones.

Structural Breaks in Area and Production of Cotton

The multiple structural breaks have been estimated through employing Bai-perron test for area and production of cotton across cotton producing zones

TABLE 4

Regression estimates of factors determining area under cotton in India

Particulars	North zone		Central zone		Southern zone		India	
	Coefficients	t value	Coefficients	t value	Coefficients	t value	Coefficients	t value
Intercept	0.08 (0.13)	0.61	0.09 (0.07)	1.4	0.30*** (0.09)	3.23	0.28 (0.04)	7.21
MSP	0.65** (0.29)	2.24	-0.14 (0.12)	1.11	-0.27 (0.54)	0.51	0.12 (0.12)	1.00
Rainfall	-1.35 (0.91)	1.47	0.26 (0.20)	1.3	1.38*** (0.33)	4.21	0.45 (0.13)	3.37
Lagged yield	0.16 (0.16)	0.99	0.20 (0.06)	3.69	0.55*** (0.12)	4.62	0.15*** (0.06)	2.67
Net irrigated area	9.51 (8.02)	1.19	0.34*** (1.62)	0.21	-10.23* (5.03)	2.04	-2.88*** (1.73)	1.67
Adjusted R^2		0.25		0.88		0.88		0.89
MSE		0.17		0.24		0.11		0.06
F value		3.46		54.12		54.12		60.92
Observations		31		31		31		31

Note: ***, ** & * indicates 1 , 5 and 10 per cent level of significance and India. The findings indicated that in northern zone we have two periods (2002 and 2017) and average growth rate found to be -0.66 per cent in 2002 and 9.86 per cent in 2017 of cotton acreage implies that due to commercial release of *Bt*-cotton in 2002 contributed phenomenal increase in the area under cotton as results of this increase in the cotton production with 7.73 per cent growth in the cotton during 2004.

In the selected zones the cotton acreage and production increased after the *Bt*-cotton release which could be observed from the multiple breaks for instance central zone 2006 and 2017 are the break period in the area and 2003 and 2007 in the production. Similarly in southern zone 2010 for area and 2007 for the cotton production. This is true for overall India with regard to area and production of cotton.

Cotton is one of the significant fibre and cash crop of India and vital role in the cotton industrial and agricultural economy of the country which provides employment to about 11 million farmers and indirectly about 40 - 50 million people are employed in various stages of processing and trade of cotton and its derivatives. The tremendous increase in the area and production of cotton after the commercial release of *Bt*-cotton in 2002 which could be observed in all the zones later on due to wide infestation of sucking pests the area has been declined. The MSP; net irrigated area and lagged yield are significantly affecting the cotton acreage across zones and India. However, as the expansion of irrigated area has detrimental effect on the cotton area. The concerned departments may recommend the suitable crop planning in the respective zones. The operation of MSP is limited to specific area and crops and improvement in the procurement network of cotton and effective implementation of decentralized procurement policy could benefit the larger section of the farmers particularly in cotton producing zones. The productivity of the cotton is important yardstick for cotton crop growth and to meet the demand in this regard productivity of cotton could be improved and developing biotic and a biotic resistance varieties.

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