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Dahima SR

Ph.D. Scholar, Department of
Agricultural Economics, C. P
College of Agriculture, SDAU,
Sardarkrushinagar, Dantiwada,
Gujarat, India

Thakar KP

Professor and Head, Department
of Economics, C. P College of
Agriculture, SDAU,
Sardarkrushinagar, Dantiwada,
Gujarat, India

Soumya C

Assistant Professor, Department
of Agricultural Economics, C. P
College of Agriculture, SDAU,
Sardarkrushinagar, Dantiwada,
Gujarat, India

Corresponding Author:

Dahima SR

Ph.D. Scholar, Department of
Agricultural Economics, C. P
College of Agriculture, SDAU,
Sardarkrushinagar, Dantiwada,
Gujarat, India

Growth rate of area, production and productivity of various crops in differences regions of Gujarat

Dahima SR, Thakar KP and Soumya C

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Abstract

The present study takes into consideration area, production and productivity of major food grain and non-food grain crops of Gujarat State and thus 12 major crops were selected. The overall period of study between 1982-83 to 2017-18 (over 36 years) divided into period I (pre-WTO 1982-83 to 1994-95) and period II (post-WTO 1995-96 to 2017-18). An economic analysis was conducted to compare the compound growth rates of key crops including cereals, pulses, oilseeds and commercial crops across four regions within the state: North Gujarat, Saurashtra, Central Gujarat, and South Gujarat. The results revealed that, the Compound growth rate analysis has shown that in Gujarat State area, production and yield under rice crop were significantly increased during over all period by 1.57, 3.77 and 2.17 per cent per annum respectively.

In Gujarat state during overall period area under pearl millet crop declined significantly -2.92 per cent per annum, while productivity increased significantly 3.10 per cent per annum. Area, production and Productivity of Maize are significantly increasing at 1.21, 2.72 and 1.49 per cent per annum in Gujarat over last 36 years. Area, Production and Productivity in Gujarat shows positive growth in Wheat at 2.99, 4.29 and 1.25 per cent per annum respectively, its major staple cereal crop. The area, production and productivity of gram significantly increased in Gujarat at 2.57 per cent, 4.32 per cent and 1.70 per cent per annum and production and productivity of black gram increased significantly in Gujarat at 2.13 per cent, 1.55 per cent. In groundnut crop area decline during overall period -0.37 per cent per annum while production and productivity increased significantly in Gujarat at 3.55 per cent, 3.95 per cent per annum. In Gujarat state during overall period area, production and productivity of castor crop increased significantly at 4.07 per cent, 5.83 per cent and 1.69 per cent per annum. In case of cotton crop area, production and productivity increased significantly during overall period at 2.99, 7.01 and 4.92 per cent per annum in Gujarat state. While in sugarcane crop area, production and productivity increased significantly during overall period at 2.44, 6.80 and 4.24 per cent per annum in Gujarat state. At state level significant soybean area expansion is observed at 5.58 per cent per annum production rise at 7.85 per cent per annum and productivity rise at 2.15 per cent per annum.

Keywords: Growth rate, area, production, productivity

Introduction

Gujarat holds a crucial position in India's agricultural development and is recognized as one of the progressive states in the nation. However, a long-standing assertion suggests that Gujarat faces a deficit in its primary economic activity, namely agriculture. The agricultural productivity in Gujarat has historically faced challenges due to factors like soil quality, rainfall patterns, topography, and climate. These conditions have often led to lower crop yields compared to other Indian states. Since its establishment in 1960-61, efforts have been made to address these issues through increased investments. These investments have been directed towards enhancing agriculture, including providing better access to fertilizers, improving irrigation facilities, and promoting the development of high-yielding crop varieties.

The 1970s, on the other hand, present a more optimistic scenario with significant growth in production levels. Agricultural output in the state finally broke free from its stagnant state and experienced much-needed expansion.

However, it's worth noting that while average production levels might have risen during and after the seventies, this increase also introduced noticeable fluctuations in output, leading to instability in income and employment. Unfortunately, Gujarat's agricultural performance wasn't particularly impressive during this phase.

The growth and productivity of the agricultural sector are significantly influenced by the allocation of resources and the mix of inputs used. In advanced countries, these inputs mix and resource allocation have evolved over time and will continue to do so in the future. Technological advancements have led to an upward and rightward shift in the production function, enabling farmers to leverage yield-enhancing inputs. In India, agricultural development has been accelerating due to the adoption of modern production techniques, notably the use of chemical fertilizers, irrigation, and high-yielding seeds. These elements are crucial components of the new production technology. As farming transitions from traditional to modern methods, the demand for these advanced inputs is expected to increase. To effectively formulate strategies for boosting agricultural output through the adoption of these technologies, it is imperative to have empirical evidence showcasing their growing utilization and impact on agricultural development.

All these circumstances and actual evidences, the present research study entitled estimate growth rate and instability of area, production and yield of various crops in differences regions of Gujrat.

Methodology

Study Area: Present study entire Gujarat state was selected along with four regions (i.e., North Gujarat, Middle Gujarat, South Gujarat, Saurashtra regions) of state

Period of study: The time period was divided as under.

| | | |
|---------------|-------------|--------------------|
| Pre WTO | (Period I) | 1981-82 to 1994-95 |
| Post WTO | (Period II) | 1995-96 to 2017-18 |
| Entire period | (Overall) | 1981-82 to 2017-18 |

The overall period 1981-82 to 2017-18 was considered to understand the overall performance of agriculture over the long period of 36 years.

Crops covered

The state of Gujarat demonstrates a diverse crop pattern across its various regions, which is influenced by distinct agro-climatic conditions. As a result, the study focuses on key principal crops, in cereals viz., wheat, pearl millet, paddy, maize, in pulses viz., gram, green gram and black gram, in oilseeds viz., groundnut, castor, soybean and commercial (cash) crops viz., cotton and sugarcane were selected for the present study.

Selected crops based on highest triennium average area for the study (2015-16 to 2017-18)

| Cereals | Pulses | Oilseeds | Cash crops |
|--------------|------------|-----------|------------|
| Rice | Green gram | Groundnut | Sugarcane |
| Wheat | Black gram | Castor | Cotton |
| Pearl millet | Gram | Soybean | |
| Maize | | | |

Nature of data and their sources

The current study utilized secondary time series data to achieve its objectives. This data was acquired from various

secondary sources such as published records from state government, cooperative, and private institutions.

Analytical Techniques

Compound growth rates for estimation of growth in area, production and yield of crops

(The algebraic form function refers from book Mathematics and Statistics for Economics, G. S. Monga)

$$Y = ab^t$$

Where,

y = area, production and yield of selected crops

t = time variable in years

a = intercept

b = regression coefficient

he above equation can also be written as,

$$\text{Log } Y = \text{Log } a + t \text{ Log } b$$

$$r = [\text{antilog log } (b)-1] \times 100$$

Where,

r = compound growth rate

The t' test applied to test the significance of b

The compound growth rates were calculated using time series data on crop area, production, and yield for all regions, including Gujarat as a whole, spanning 36 years from 1981-82 to 2016-17. These rates were determined to analyze the annual percentage changes in the specified parameters. The following exponential growth functions were used.

Results and Discussion

Compound growth rate

The calculation of growth rates is a vital aspect of the agricultural domain, as it signifies progress over time. Proficiency in computing growth rates not only aids in monitoring advancements, but also in strategizing, target establishment, and foreseeing outcomes or formulating agricultural policies.

Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of North Gujarat

It can be observed from Table 4.1 that the area, production and yield of rice increased significantly up to 3.02, 8.39 and 5.21 per cent respectively during pre-WTO period but there was significant decline up to -4.34 per cent in area, during post-WTO period because the rice is water loving crop and the water level in north Gujarat has been decreased in this period. Production also decreased by -2.71 per cent significantly during post-WTO period. Interestingly, The compound growth rate of rice yield exhibited significant growth rates of 1.69% and 2.89% during the post-WTO period and the overall period, respectively. This growth can be primarily attributed to the notable difference between the rate of decline in production compared to that of the cultivated area. Contrastingly, for Pearl millet, both the cultivated area and production witnessed substantial declines of -1.37% and -1.31% respectively, during the pre-WTO period. However, during the post-WTO period and the overall period, the area under Pearl millet cultivation decreased by -

2.67% and -1.51% respectively. Remarkably, the production of Pearl millet increased significantly by 2.59% and 1.82% during the post-WTO period and overall period respectively. Yield showed significant increase during pre-WTO period as 0.06 per cent, post-WTO period 5.42 per cent and in overall period 3.42 per cent. Area, production and yield of maize increased up to 2.60, 7.40 and 4.67 per cent significantly during pre-WTO period respectively but there was significant decline in area up to -3.54, -0.85 per cent during post-WTO period as well as in overall period respectively. It might be due to the heavy infestation of the stem borer during this period and also the farmers might not get the sufficient price for crop produce as compared to other crop under cultivation. Production also decreased to -3.00 per cent significantly during post-WTO period. Yield showed increase up to 4.67, 0.55 and 0.10 per cent during pre-WTO period, post-WTO period and in overall period respectively. In case of wheat, area, production and yield increased up to 0.56, 1.57 and 1.00 per cent significantly during pre-WTO period, post-WTO period and in overall period respectively. As wheat requires comparatively less labours in its cultivation, the area of wheat has been increased during the post-WTO era. It might be also because of the introduction and implementation of the new technologies and machineries. During the post-WTO era, the consumption of wheat-based products has also been increased in market. Area and production of gram increased up to 0.46 and 0.13 per cent significantly during pre-WTO period but there was significant decline in yield by -0.32 per cent during this period. During post-WTO period and in overall period, area, production and yield of gram increased significantly because it requires less water for its cultivation. The government has also started giving higher MSP and the cost of cultivation is also very less. The infestation of pest and disease is low as compared to other crops. In case of black gram, area, production and yield increased up to 9.65, 13.93 and 3.90 per cent significantly during pre-WTO period respectively whereas area showed significant decline by -0.48 per cent and production and yield showed significant increase up to 0.26, 0.75 per cent during post-WTO period. Yield showed significant increase up to 1.37 per cent in overall period. Area and production of green gram increased up to 1.41 and 0.06 per cent significantly during pre-WTO period but there was significant decline in yield by -1.33 per cent during this period. During post-WTO period, area showed significant decrease as -0.77 per cent while production and yield of green gram increased up to 1.96 and 2.77 per cent significantly. In case of groundnut, area showed significant

decline as -2.23 per cent whereas production and yield increased up to 4.24 and 0.52 per cent significantly during pre-WTO period. Area, production and yield increased significantly during both post-WTO period and in overall period. Area, production and yield of castor increased significantly during pre-WTO period, post-WTO period and in overall period. In case of cotton, area and production declined up to -6.66 and -5.41 per cent significantly during pre-WTO period whereas yield showed significant increase by 4.41 per cent during the same period. Area, production and yield showed significant increase during post-WTO period and in overall period because of the introduction of BT-cotton due to which the infestation of boll worms has been reduced. Area and production of sugarcane decreased significantly -6.89 and -6.41 per cent during pre-WTO period but there was significant increase up to 1.32 per cent in yield during this period. During post-WTO period and in overall period, area, production and yield of sugarcane decreased significantly as this crop required higher amount of water for its cultivation but water availability has been reduced. In case of soybean, area, production and yield increased significantly up to 5.15, 5.01 and 7.29 per cent respectively during post-WTO period and in overall period. This result is similar to Goel and Agrawal (1979).

Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall Period (1982-83 to 2017-18) of Saurashtra

It can be observed from Table 4.2 that the area and production of rice were decline significantly up to -16.98 and -16.40 per cent during pre-WTO period but there was significantly increased up to 0.70 per cent in yield during pre-WTO period. However, area, production and yield decline -3.19, -5.11 and -9.69 per cent significantly during post-WTO period as well as -1.02, -10.03 and -7.36 per cent in overall period. This could be attributed mainly to the fact that the rate of decline in production is much lesser than that of area. In case of pearl millet, area declined by -1.02 per cent significantly during pre-WTO period but yield increase up to 1.76 per cent significantly during pre-WTO period Whereas area and production showed decline by -9.74 and -6.85 per cent during post-WTO period and -6.47 and -2.85 per cent in overall period but yield increased up to 3.20 and 3.87 per cent significantly during both post-WTO period and overall period respectively.

Table 1: Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of North Gujarat

| Crop | Pre-WTO (1982-83 to 1994-95) | | | Post-WTO (1995-96 to 2017-18) | | | Overall (1982-83 to 2017-18) | | |
|--------------|------------------------------|------------|---------|-------------------------------|------------|--------|------------------------------|------------|--------|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| Rice | 3.02** | 8.39** | 5.21** | -4.34** | -2.71** | 1.69** | -1.09 | 1.77* | 2.89** |
| Pearl millet | -1.37** | -1.31** | 0.06** | -2.67** | 2.59** | 5.42** | -1.54** | 1.82** | 3.42** |
| Maize | 2.60** | 7.40** | 4.67** | -3.54** | -3.00** | 0.55** | -0.85* | 1.23 | 2.10** |
| Wheat | 0.56** | 1.57** | 1.00** | 4.78** | 5.72** | 0.88** | 3.38** | 4.08** | 0.67** |
| Gram | 0.46** | 0.13** | -0.32** | 7.89** | 9.61* | 1.59** | 3.93** | 4.59** | 0.63* |
| Black gram | 9.65** | 13.93** | 3.90** | -0.48** | 0.26** | 0.75** | 0.59 | 1.98 | 1.37* |
| Green gram | 1.41** | 0.06** | -1.33** | -0.77** | 1.96** | 2.77** | 0.73 | 2.67 | 1.93 |
| Groundnut | -2.23** | 4.24** | 0.52** | 3.59** | 7.01** | 3.29** | 1.86** | 4.51** | 2.60** |
| Castor | 3.99** | 8.58** | 6.66** | 3.19** | 4.78** | 1.53** | 3.41** | 5.37** | 1.89** |
| Cotton | -6.66** | -5.41** | 4.41** | 3.20** | 8.72** | 5.34** | 1.90** | 6.12** | 4.14** |
| Sugarcane | -6.89** | -6.41** | 1.32** | -18.6** | -23.0** | -35.4 | -1.53** | -1.94** | -2.56 |
| Soybean | NA | NA | NA | 5.15** | 5.01** | 7.29** | 5.15** | 5.01** | 7.29** |

Note: *, ** represents level of significance at 5 and 1 per cent respectively (p value)

Production and yield of maize increased up to 7.54 and 2.72 per cent significantly during pre-WTO period but there was significant decline by -9.69 and -8.81 per cent in area and production during post-WTO period as well as -4.00 and -2.44 per cent in overall period that might be due to the farmers not getting the sufficient price for crop as compared to other crop under cultivation and due to the heavy infestation of the stem borer during this period, but Yield increase up to 0.98 and 1.62 per cent significantly during post-WTO period as well as in overall period respectively. In case of wheat, production and yield increased up to 2.02 and 1.36 per cent significantly during pre-WTO period however in post-WTO period area and production increased up to 4.91 and 6.40 per cent significantly but yield decline by 0.62 per cent significantly. Area, production and yield increased up to 2.57, 4.24 and 0.69 per cent significantly during overall period. Area, production and yield of gram decline by -1.26, -3.06 and -1.82 per cent significantly during pre-WTO period but there was significant increase up to 6.03, 10.06 and 3.80 per cent in yield during post-WTO period and 3.77, 6.47 and 2.59 per cent in overall period. The area of gram has been increased in post-WTO era as compared to pre-WTO era because it requires less water for its cultivation. It might be due the government has also started giving higher MSP and the cost of cultivation is also very less. The infestation of pest and disease is low as compared to other crops. In case of black gram, area and production increased up to 18.40 and 15.76 per cent significantly during pre-WTO period whereas yield showed significant decline by -2.23 per cent during pre-WTO period. In post WTO period area decline by -0.19 per cent significantly however production and yield increased up to 1.68 and 1.88 per cent significantly. Area, production and

yield increased up to 3.93, 6.06 and 2.04 per cent significantly during overall period. Area and production of green gram increased significantly up to 9.18 and 4.43 per cent respectively during pre-WTO period but there was significant decline by -4.35 per cent in yield during this period. During post-WTO period, area showed significant decrease by -0.09 per cent while production and yield of green gram increased significantly up to 1.40 and 1.50 per cent respectively. However, area and production increased significantly up to 1.09 and 3.21 per cent respectively during overall period. In case of groundnut, yield significantly increased up to 0.71 per cent. Area showed significantly decline by -1.47 per cent during post WTO and -0.53 per cent in overall period. However, production and yield increased up to 3.00 and 4.54 per cent significantly during post WTO and 3.92 and 4.48 per cent in overall period. Area, production and yield of castor increased significantly during pre-WTO period, post-WTO period and in overall period but the area of castor has been decreased in post WTO era as compared to pre-WTO era, that might be due to the farmers didn't get the fair price, higher incidence of wilt because of heavy rainfall. The crop duration is also very long viz. 8 months. In case of cotton, area, production and yield increased significantly during pre-WTO period, post-WTO period and in overall period. Area and production of sugarcane decreased by -6.23 and -5.56 per cent significantly during pre-WTO period but there was significant increase up to 5.41 per cent in yield during this period. During post-WTO period area showed significantly decline by -4.70 per cent but production and yield increased up to 4.75 and 9.92 per cent significantly. However, area decline by -4.79 per cent during overall period but yield increased up to 4.94 per cent

Table 2: Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of Saurashtra

| Crop | Pre-WTO (1982-83 to 1994-95) | | | Post-WTO (1995-96 to 2017-18) | | | Overall (1982-83 to 2017-18) | | |
|--------------|------------------------------|------------|---------|-------------------------------|------------|---------|------------------------------|------------|--------|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| Rice | -16.98** | -16.40** | 0.70** | -3.19** | -5.11** | -9.69 | -1.02** | -10.03** | -7.36 |
| Pearl millet | -1.02** | 0.72 | 1.76** | -9.74** | -6.85** | 3.20** | -6.47** | -2.85** | 3.87** |
| Maize | 4.69NS | 7.54** | 2.72** | -9.69** | -8.81** | 0.98** | -4.0** | -2.44 | 1.62** |
| Wheat | 0.64 | 2.02** | 1.36** | 4.91** | 6.40** | -0.62** | 2.57** | 4.24** | 0.69** |
| Gram | -1.26** | -3.06** | -1.82** | 6.03** | 10.06** | 3.80** | 3.77** | 6.47** | 2.59** |
| Black gram | 18.40** | 15.76* | -2.23** | -0.19** | 1.68** | 1.88** | 3.93** | 6.06** | 2.04** |
| Green gram | 9.18** | 4.43** | -4.35** | -0.09** | 1.40** | 1.50** | 1.09* | 3.21** | 2.10 |
| Groundnut | 0.28 | 1.68 | 0.71** | -1.47** | 3.00** | 4.54** | -0.53** | 3.92** | 4.48** |
| Castor | 28.91** | 35.34** | 1.40** | 3.44** | 3.81** | 0.36** | 9.38** | 12.26** | 2.63** |
| Cotton | 0.14** | 5.56** | 4.98** | 4.53** | 8.52** | 3.82** | 4.31** | 8.40** | 3.92** |
| Sugarcane | -6.23** | -5.56** | 5.41** | -4.70** | 4.75** | 9.92** | -4.79** | -0.98 | 4.94** |
| Soybean | NA | NA | NA | 3.87** | 2.91* | 5.50** | 3.87** | 2.91* | 5.50** |

Note: *, ** represents level of significance at 5 and 1 per cent respectively (p value)

Significantly during overall period. In case of soybean, area, production and yield increased significantly during post-WTO period and in overall period. This result is similar to Mander and Sharma (1995) [6].

Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of Central Gujarat

It can be observed from Table 4.3 that the area and production of rice increased significantly up to 2.02 and 4.74 per cent respectively during pre-WTO period but there was significant decline by -3.87 per cent in yield during pre -WTO period. However, Area, production and yield of rice crop were significantly increased up to 1.99, 5.98 and 3.91 per cent

respectively during post- WTO as well as 1.89, 4.79 and 2.85 per cent in overall period. In case of pearl millet, area, production and yield declined significantly by -0.66, -1.21 and -0.55 per cent respectively during pre-WTO period, whereas area showed decline as -1.96 per cent during both post-WTO period as well as -1.69 per cent in overall period but Production and yield increased significantly up to 0.63 and 2.64 during both post-WTO period respectively and 2.16 per cent in overall period. Area, production and yield of maize increased significantly up to 1.27, 1.64 and 0.35 per cent respectively during pre-WTO period, 1.72, 3.10 and 1.35 per cent in post-WTO period as well as 1.90, 3.27 and 1.34 per cent in overall period. In case of wheat, area, production and yield increased significantly during pre-WTO period, post-WTO period and in overall period. Area and production of

gram increased significantly up to 5.71 and 3.39 per cent respectively during pre-WTO period but there was significant decline by -2.19 per cent in yield during this period. During post-WTO period and in overall period, area, production and yield of gram increased significantly. In case of black gram, area, production and yield increased significantly up to 6.52, 12.52 and 5.64 per cent respectively during pre-WTO period whereas area and production showed significant decline by -2.43 and -0.45 per cent and yield showed significant increase up to 2.03 per cent during post-WTO period. Area declines by -0.54 per cent during overall period but yield showed significant increase up to 3.09 per cent in overall period. Area, production and yield of green gram increased significantly during pre-WTO period as well as post-WTO period. However, there was significant decline by -0.07 per cent in area during overall period. In case of groundnut, area and production showed significant decline whereas yield

increased significantly during pre-WTO period, post-WTO period and in overall period. Area and production of castor were significantly increased during pre-WTO period but there was significant decline in yield during this period. However, Area, production and yield of castor increased up to 3.30, 5.33 and 1.16 per cent significantly during post-WTO period as well as 3.30, 5.36, and 2.00 per cent in overall period. In case of cotton, area, production and yield declined significantly by -3.46, -1.55 and -3.87 per cent respectively during pre-WTO period. However, area, production and yield showed significant increase during post-WTO period as well as in overall period because of the introduction of BT-cotton due to which the infestation of ball worms has been reduced. Production and yield of sugarcane increased significantly up to 8.22 and 0.67 per cent respectively during pre-WTO period as well as 14.1 and 9.85 per cent in post-WTO period.

Table 3: Compound Growth Rate of Area, Production and Yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and Overall Period (1982-83 to 2017-18) of Central Gujarat

| Crop | Pre-WTO (1982-83 to 1994-95) | | | Post-WTO (1995-96 to 2017-18) | | | Overall (1982-83 to 2017-18) | | |
|--------------|------------------------------|------------|---------|-------------------------------|------------|--------|------------------------------|------------|--------|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| Rice | 2.02** | 4.74** | -3.87** | 1.99** | 5.98** | 3.91** | 1.89** | 4.79** | 2.85** |
| Pearl millet | -0.66** | -1.21** | -0.55** | -1.96** | 0.63** | 2.64** | -1.69** | 0.43 | 2.16** |
| Maize | 1.27** | 1.64** | 0.35** | 1.72** | 3.10** | 1.35** | 1.90** | 3.27** | 1.34** |
| Wheat | 1.06** | 1.50** | 0.43** | 4.67** | 6.79** | 2.02** | 3.35** | 5.00** | 1.60** |
| Gram | 5.71** | 3.39** | -2.19** | 3.66** | 6.57** | 2.81** | 2.02** | 2.94** | 0.89** |
| Black gram | 6.52** | 12.52** | 5.64** | -2.43** | -0.45** | 2.03** | -0.54** | 1.66 | 3.09** |
| Green gram | 2.79* | 4.00** | 1.17** | 1.07** | 1.72* | 0.63** | -0.07 | 1.19 | 1.27 |
| Groundnut | -3.08** | -1.01** | 2.13** | -4.65** | -2.69** | 2.05** | -5.65** | -3.96** | 1.78** |
| Castor | 6.72** | 11.66** | -0.53** | 3.30** | 5.33** | 1.16** | 3.30** | 5.36** | 2.00** |
| Cotton | -3.46** | -1.55** | -3.87** | 0.48** | 5.87** | 1.47** | 0.45* | 4.35** | 3.88** |
| Sugarcane | 7.50 | 8.22** | 0.67** | 3.89 | 14.1** | 9.85** | 4.20** | 8.30** | 3.93** |
| Soybean | NA | NA | NA | -5.00** | -3.69** | 1.37* | -5.00** | -3.69** | 1.37* |

Note: *, ** represents level of significance at 5 and 1 per cent respectively (p value)

However, area, production and yield were significantly increased in overall period. In case of soybean, area and production showed significant decline during post – WTO period as well as overall period but yield increased significantly during post-WTO period and in overall period. This finding is similar to Singh and Chandra (2001).

Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of South Gujarat

It can be observed from Table 4.4 that the area of rice declines significantly by -16.98 per cent during pre-WTO period but production and yield showed significant increase up to 4.23 and 2.70 per cent respectively during this period. However, area, production and yield increased significantly during post-WTO period as well as in overall period. It might be because of the changes in pattern of rainfall in South Gujarat supporting its higher water holding capacity, introduction of dwarf varieties providing higher yield. In case of Pearl millet, production increased significantly up to 0.92 per cent but yield was decline by -0.59 per cent significantly during pre-WTO period. Whereas area and production decline significantly during both post-WTO period and in overall period, however yield increased significantly during both post-WTO period and in overall period. Area, production and yield of maize increased significantly during pre-WTO period, post-WTO period as well as in overall period. In case of wheat, area, production and yield were decline significantly by -1.93, -2.79 and -0.87 per cent respectively during pre-WTO period. However, Area, production and yield were increased significantly during post-WTO period as well as in

overall period probably due to the introduction and implementation of the new technologies and machineries. The consumption of wheat- based products has also been increased in market. Area, production and yield of gram decline significantly by -2.28, -3.40 and -1.14 per cent respectively during pre-WTO period. However, area, production and yield of gram crop were increased significantly up to 6.94, 10.00 and 2.91 per cent respectively during post-WTO period and 3.63, 5.39 and 1.70 per cent in overall period might be due to the introduction of new resistant varieties incorporated with seed treatment which helps in preventing various diseases and pests and increased the yield. Area, production and yield of black gram decline significantly by -1.35, -2.10 and -0.75 per cent respectively during pre-WTO period but area and yield were increased significantly up to 0.13 and 2.27 per cent respectively during post-WTO period. However, in overall period production and yield were increased significantly up to 1.24 and 1.39 per cent respectively. Area, production and yield of green gram decline significantly by -0.49, -3.63 and -3.16 per cent respectively during pre-WTO period. During post-WTO period, area and yield showed significantly increased up to 7.99 and 1.20 per cent however in overall period area and production increased up to 3.60 and 4.19 per cent significantly. In case of groundnut, area showed significant decline by -0.10 per cent whereas production and yield increased up to 3.47 and 3.58 per cent significantly during pre-WTO period. Area and production decline significantly by -4.45 and -2.37 per cent respectively during post-WTO period but yield increased up to 2.17 per cent significantly during this period.

Table 4: Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of South Gujarat

| Crop | Pre-WTO (1982-83 to 1994-95) | | | Post-WTO (1995-96 to 2017-18) | | | Overall (1982-83 to 2017-18) | | |
|--------------|------------------------------|------------|---------|-------------------------------|------------|---------|------------------------------|------------|--------|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| Rice | -16.98** | 4.23** | 2.7** | 1.92** | 3.58** | 1.62** | 1.47** | 2.98** | 1.47** |
| Pearl millet | 1.52 | 0.92** | -0.59** | -7.58** | -3.91** | 3.97** | -6.36** | -3.23** | 3.35** |
| Maize | 1.52** | 4.31** | 2.74** | 2.66* | 3.77** | 1.08** | 4.49** | 6.44** | 1.86** |
| Wheat | -1.93** | -2.79** | -0.87** | 3.32** | 6.02** | 2.61** | 0.49 | 2.40** | 1.90** |
| Gram | -2.28** | -3.40** | -1.14** | 6.94* | 10.0* | 2.91** | 3.63** | 5.39** | 1.70** |
| Black gram | -1.35** | -2.10** | -0.75** | 0.13** | 2.41NS | 2.27* | -0.14 | 1.24** | 1.39** |
| Green gram | -0.49** | -3.63** | -3.16** | 7.99* | 9.29NS | 1.20** | 3.60** | 4.19** | 0.56 |
| Groundnut | -0.10** | 3.47** | 3.58** | -4.45** | -2.37** | 2.17** | -2.63** | -0.29 | 2.40** |
| Castor | 0.96** | 6.21NS | 5.55** | 8.28NS | 8.13* | -0.79** | 3.65** | 5.40** | 1.68** |
| Cotton | -3.17** | -1.02** | 9.66** | 0.73** | 4.24** | 2.31** | 2.42** | 5.14** | 2.65** |
| Sugarcane | 7.55** | 8.07** | 0.47** | -0.31** | 11.04** | 11.41** | 3.70** | 7.85** | 3.99** |
| Soybean | NA | NA | NA | 9.80 | 8.15 | 7.79 | 9.80 | 8.15 | 7.79 |

Note: *, ** represents level of significance at 5 and 1 per cent respectively (p value)

However, in overall period Area decline significantly by -2.63 per cent but yield increased up to 2.40 per cent significantly. Area and yield of castor increased significantly up to 0.96 and 5.55 per cent respectively during pre-WTO period, however in post-WTO period production increased up to 8.13 per cent significantly but yield was decline by -0.79 per cent significantly, while Area, production and yield increased significantly during overall period. In case of cotton area and production decline significantly by -3.17 and -1.02 per cent but yield showed significant increase up to 9.66 per cent during pre-WTO period. However, area, production and yield increased significantly during post-WTO period as well as in overall period. Area, production and yield of sugarcane increased significantly during pre-WTO period. During post-WTO period area showed decline by -0.31 per cent significantly, but production and yield increased significantly up to 11.01 and 11.41 per cent main reason for reduced area of sugarcane is farmers are moving towards horticultural crop. However, in overall period area, production and yield of sugarcane increased significantly. This result is similar to Saraswati *et al.* (2012) ^[7].

Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of Gujarat State

It can be observed from Table 4.5 that the area, production and yield of rice increased significantly up to 1.81, 4.43 and 2.57 per cent respectively during pre-WTO period, 1.67, 4.47 and 2.74 per cent in post-WTO period as well as 1.57, 3.77

and 2.17 per cent in overall period. In case of Pearl millet, area declined by -1.15 per cent significantly during pre-WTO period whereas yield showed increased up to 0.69 per cent significantly during this period. However, in post-WTO period area and production decline significantly by -4.25 and -0.53 per cent respectively but yield showed increased up to 3.88 per cent significantly. Area, production and yield of maize increased significantly during pre-WTO, post-WTO period as well as in overall period. In case of wheat, area, production and yield increased significantly during pre-WTO period, post-WTO period and in overall period exclude area in pre-WTO period. Area of gram increased up to 1.55 per cent significantly during pre-WTO period but there was significant decline by -0.30 and -1.83 per cent in production and yield during this period. During post-WTO period and in overall period, area, production and yield of gram increased significantly. In case of black gram, area, production and yield increased significantly up to 6.55, 8.85 and 2.15 per cent respectively during pre-WTO period whereas area showed significant decline by -0.72 per cent and production and yield showed significant increase up to 0.70 and 1.44 per cent respectively during post-WTO period. Production and Yield showed significant increase up to 2.13 and 1.55 per cent respectively in overall period. Area and production of green gram increased significantly up to 2.21 and 0.23 per cent respectively during pre-WTO period but there was significant decline by -1.91 per cent in yield during this period. During post-WTO period, area showed significant decrease by -0.10 per cent while production and yield of green gram increased significantly up to 2.25 and 2.36 per cent.

Table 5: Compound growth rate of area, production and yield in pre-WTO (1982-83 to 1994-95), post-WTO (1995-96 to 2017-18) and overall period (1982-83 to 2017-18) of Gujarat State

| Crop | Pre-WTO (1982-83 to 1994-95) | | | Post-WTO (1995-96 to 2017-18) | | | Overall (1982-83 to 2017-18) | | |
|--------------|------------------------------|------------|----------|-------------------------------|------------|---------|------------------------------|------------|--------|
| | Area | Production | Yield | Area | Production | Yield | Area | Production | Yield |
| Rice | 1.81** | 4.43** | 2.57** | 1.67** | 4.47** | 2.74** | 1.57** | 3.77** | 2.17** |
| Pearl millet | -1.15** | -0.46 | 0.69** | -4.25** | -0.53** | 3.88** | -2.92** | 0.084 | 3.10** |
| Maize | 1.85** | 3.51** | 1.63** | 0.37** | 1.40** | 1.02** | 1.21** | 2.72** | 1.49** |
| Wheat | 0.57 | 1.47** | 0.89** | 4.74** | 6.26** | 1.44** | 2.99** | 4.29** | 1.25** |
| Gram | 1.55** | -0.30** | -1.83** | 5.03** | 8.48** | 3.27** | 2.57** | 4.32** | 1.70** |
| Black gram | 6.55** | 8.85** | 2.15** | -0.72** | 0.70** | 1.44** | 0.56 | 2.13** | 1.55** |
| Green gram | 2.21** | 0.23** | -1.91** | -0.10** | 2.25** | 2.36** | 0.77 | 2.45 | 1.66 |
| Groundnut | -0.007 | 1.75 | 1.76** | -0.52** | 3.24** | 3.78** | -0.37* | 3.55** | 3.95** |
| Castor | 5.61** | 10.42** | -5.77** | 4.01** | 4.66** | 1.98** | 4.07** | 5.83** | 1.69** |
| Cotton | -2.08** | 1.84** | -12.33** | 3.39** | 7.87** | -0.82** | 2.99** | 7.01** | 4.92** |
| Sugarcane | 3.94** | 4.93** | 0.95** | 0.06** | 10.67** | 10.60** | 2.44** | 6.80** | 4.24** |
| Soybean | NA | NA | NA | 5.58** | 7.85** | 2.15* | 5.58** | 7.85** | 2.15* |

Note: *, ** represents level of significance at 5 and 1 per cent respectively (p value)

In case of groundnut, yield increased up to 1.76 per cent significantly during pre-WTO period, however area decline by -0.007 per cent significantly while production and yield were increased significantly during post-WTO period and in overall period. Area and production of castor increased significantly up to 5.61 and 10.42 per cent respectively during pre-WTO period but yield decline by -5.77 per cent significantly during this period. However, area, production and yield increased significantly during post-WTO period and in overall period. In case of cotton, area and yield declined significantly by -2.08 and -12.33 per cent during pre-WTO period whereas production showed significant increase up to 1.84 per cent during the same period. Area and production showed significant increase during post-WTO period because of the introduction of BT-cotton due to which the infestation of boll worms has been reduced but there was significant decline by -0.82 per cent in yield in this period. However, area, production and yield increased significantly during overall period. Area, production and yield of sugarcane increased significantly during pre-WTO, post-WTO period and in overall period. In case of soybean, area, production and yield increased significantly during post-WTO period and in overall period. This finding is similar to Jalikatti and Poddar (2019)^[8].

Summary and Conclusion

Growth rate of major crops in Gujarat

In North Gujarat region during pre- WTO period among major crops compound growth rate of area was observed highly significant in black gram (9.65%) followed by castor (3.99%) while lowest in gram (0.46%). In the North Gujarat region, the compound growth rate of production exhibited notable variations across different crops during various periods. Castor showed the highest significant growth rate in production (8.58%) during the pre-WTO period, followed closely by rice (8.39%), whereas green gram had the lowest growth rate (0.13%). A similar trend was observed in terms of yield growth, with castor leading (6.66%) followed by rice (5.21%), while pearl millet had the lowest growth rate (0.06%).

During the post-WTO period, gram displayed a highly significant growth rate in cultivated area (7.89%), trailed by soybean (5.15%), while castor had the lowest growth rate (3.19%). In terms of production growth, gram stood out with a significant growth rate (9.61%), closely followed by cotton (8.72%), whereas black gram had the lowest growth rate (0.26%). For yield growth, soybean showed a highly significant rate (7.29%), followed by pearl millet (5.42%), and maize had the lowest rate (0.55%). Looking at the overall period in the North Gujarat region, soybean had the highest compound growth rate in cultivated area (5.15%), succeeded by gram (3.93%), whereas black gram had the lowest growth rate (0.93%). Cotton exhibited a highly significant growth rate in production (6.12%), followed by castor (5.37%), with maize having the lowest growth rate (1.23%). In terms of yield growth, soybean led with a highly significant rate (7.29%), followed by cotton (4.14%), and gram had the lowest rate (0.63%).

In Saurashtra region during pre-WTO period among major crops compound growth rate of area was observed highly significant in castor (28.91%) followed by black gram (18.40%) while lowest in cotton (0.14%). The compound growth rate of production was observed highly significant in castor (35.34%) followed by black gram (15.76%) while lowest in pearl millet (0.72%). The compound growth rate of

yield was observed highly significant in sugarcane (5.41%) followed by cotton (4.98%) while lowest in rice (0.70%). In Saurashtra region during post-WTO period among major crops compound growth rate of area was observed highly significant in gram (6.03%) followed by wheat (4.91%) while lowest in castor (3.44%). The compound growth rate of production was observed highly significant in gram (10.06%) followed by cotton (8.52%) while lowest in green gram (1.40%). The compound growth rate of yield was observed highly significant in sugarcane (9.92%) followed by soybean (5.50%) while lowest in castor (0.36%). In Saurashtra region during overall period among major crops compound growth rate of area was observed highly significant in castor (9.38%) followed by cotton (4.31%) while lowest in green gram (1.09%). The compound growth rate of production was observed highly significant in castor (12.26%) followed by cotton (8.40%) while lowest in soybean (2.91%). The compound growth rate of yield was observed highly significant in soybean (5.50%) followed by sugarcane (4.94%) while lowest in wheat (0.69%).

In the central Gujarat region during the pre-WTO period, significant growth rates were observed for crop areas, with castor showing the highest (6.72%), followed by black gram (6.52%), while wheat had the lowest growth rate (1.06%). The growth rate of production was notably high for black gram (12.52%) and castor (11.66%), with wheat having the lowest (1.50%). Regarding yield growth rates, black gram led (5.64%), followed by groundnut (2.13%), whereas maize had the lowest (0.35%). In the post-WTO period, notable growth rates in crop area were seen for wheat (4.67%) and gram (3.66%), whereas cotton had the lowest (0.48%). Sugarcane and wheat exhibited significant growth rates in production (14.1% and 6.79% respectively), while pearl millet had the lowest (0.63%). Yield growth rates were highly significant for sugarcane (9.85%) and rice (3.91%), with green gram having the lowest (0.63%). During the overall period, sugarcane and wheat had noteworthy growth rates in crop area (4.20% and 3.35% respectively), while cotton had the lowest (0.45%). Sugarcane led in production growth (8.30%), followed by castor (5.36%), with pearl millet having the lowest (0.43%). For yield growth rates, sugarcane (3.93%) and cotton (3.88%) were significant, whereas gram had the lowest (0.89%).

In south Gujarat region during pre-WTO period among major crops compound growth rate of area was observed highly significant in sugarcane (7.55%) followed by maize (1.52%) while lowest in castor (0.96%). The compound growth rate of production was observed highly significant in sugarcane (8.07%) followed by maize (4.31%) while lowest in pearl millet (0.92%). The compound growth rate of yield was observed highly significant in cotton (9.66%) followed by castor (5.55%) while lowest in sugarcane (0.47%). In south Gujarat region during post- WTO period among major crops compound growth rate of area was observed highly significant in soybean (9.80%) followed by green gram (7.99%) while lowest in black gram (0.13%). The compound growth rate of production was observed highly significant in sugarcane (11.04%) followed by gram (10.0%) while lowest in rice (3.58%). The compound growth rate of yield was observed highly significant in sugarcane (11.41%) followed by soybean (7.79%) while lowest in maize (1.08%). In south Gujarat region during overall period among major crops compound growth rate of area was observed highly significant in maize (4.49%) followed by castor (3.65%) while lowest in wheat (0.49%). The compound growth rate of production was observed highly significant in sugarcane (7.85%) followed by

maize (6.44%) while lowest in black gram (1.24%). The compound growth rate of yield was observed highly significant in sugarcane (3.99%) followed by pearl millet (3.35%) while lowest in green gram (0.56%).

In the pre-WTO era in Gujarat state, among the major crops, there was a notably significant compound growth rate of area for black gram (6.55%), followed by castor (5.61%), while wheat had the lowest rate (0.57%). In terms of production, castor demonstrated a highly significant growth rate (10.42%), succeeded by black gram (8.85%), with green gram having the lowest rate (0.23%). As for yield, rice exhibited a highly significant growth rate (2.57%), trailed by black gram (2.15%), while pearl millet had the lowest rate (0.69%). Transitioning to the post-WTO period, in Gujarat state, among the major crops, soybean showed a highly significant compound growth rate of area (5.58%), followed by gram (5.03%), while sugarcane had the lowest rate (0.06%). In terms of production, sugarcane displayed a highly significant growth rate (10.67%), followed by gram (8.48%), while black gram had the lowest rate (0.70%). As for yield, sugarcane demonstrated a highly significant growth rate (10.60%), followed by pearl millet (3.88%), while maize had the lowest rate (1.02%).

Looking at the overall period in Gujarat state, among the major crops, soybean exhibited a highly significant compound growth rate of area (5.58%), followed by castor (4.07%), while black gram had the lowest rate (0.56%). In terms of production, soybean showcased a highly significant growth rate (7.85%), followed by sugarcane (6.80%), while pearl millet had the lowest rate (0.084%). As for yield, cotton displayed a highly significant growth rate (4.92%), followed by sugarcane (4.24%), while green gram had the lowest rate (1.66%).

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