Original Research Article

Total factor productivity growth and changing cost structure of sugarcane in Gujarat

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ABSTRACT

Aims:
1. To estimate the growth of input, output indices and total factor productivity of sugarcane in Gujarat
2. To estimate the changing cost structure of sugarcane

Place and Duration of Study: Department of Agricultural Economics, Junagadh Agricultural University (between June 2018 and July 2020).

Methodology:.This paper has estimated the growth in total factor productivity of sugarcane cropusing Tornqvist Theil index and growth trends in cost structure of sugarcane crop in Gujarat.

Results: The results showed that the growth rate of TFP indices of sugarcane planted crop and ratoon crop were negative about -0.86 and -0.31 per cent per annum, respectively. Negative TFP growth resulted due to a relatively faster rate of total input growth than total output growth. in the total cost of cultivation of sugarcane, the cost share of human labour, irrigation and miscellaneous in Gujarat has shownan increasing trend. while, rental value of land showina g declining trend**.**

Conclusion: Study suggested that technological gains have not been experienced in this crop needs concentrated efforts to bridge extension gap and further research to evolve concrete strains, resistant to pest and diseases which reduce the real cost of production.

1. INTRODUCTION

Sugarcane (*Saccharum officinarum L.*) occupies very prominent position on the agricultural map of India. It provides employment to over a million people directly or indirectly besides contributing significantly to the national exchequer. The cultivation of sugarcane in India dates back to the *Vedic* period. Sugarcane is one of the most important commercial as well as industrial crop as the cane is supplied to sugar industries, where various products are produced from its juice. Sugar industry is such an industry located in rural areas which provides opportunities for the uplifting of rural masses. Today sugarcane is cultivated in 130 countries. India is the second largest producer of sugarcane after Brazil. Whereas, Gujarat accounts for about 3 per cent of India's production of sugarcane. The major sugarcane growing districts in Gujarat are Surat, Navsari, Bharuch, Tapi, Valsad, Gir Somnath and Vadodara, which together contributes to about 99.57 per cent and 99.64 per cent of total area and total production of sugarcane, respectively. Presently, in India nearly 60 lakh farmers have been cultivating sugarcane in the vast area of around 50 lakh ha and a large number of agricultural labours are involved in cane production activities. More than 5 lakh workers, mostly from rural areas, are engaged in sugar industry (Plaisier et al. 2017).

The government has allocated a significant proportion of its resources to agricultural research in the state. Total factor productivity (TFP) is measured as the rate of index of total output to index of total inputs and encompasses the

impact of technical change as well as change in the level of all inputs. Thus, TFP trends indicate whether production growth is taking place in a cost effective and sustainable manner or not. (Dhandhalya et. al, 2019). A number of factors such as research, extension, human capital, intensity of cultivation, balanced use of fertilizers, infrastructural facilities, health of natural resources, climate, etc influence the TFP. As an input to public investment decisions, it is useful to understand the relative importance of these yield-enhancing factors in determining productivity growth. (Chand et. al, 2012).Therefore, it is impressive to look at current research efforts and their accuracy in order to address emerging regional research needs. Therefore, the present study was undertaken to analyse the decadal shift in sugarcane area, production and productivity, change in cost structureand to estimate the growth of total factor productivity of sugarcanein Gujarat.

2. MATERIAL AND METHODS

The study covers Gujarat state, located on the Western cost part of India, which has one third of the coastline of the country and one of the major sugarcane growing state in India. This study is based on secondary data on input, output and prices of sugarcane crop collected from Department of Agricultural Economics, Junagadh Agricultural University, Junagadh and area, production and yield from other public sources. The analysis of TFP was carried out for the period from 1990-91 to 2018-19. This period is divided into four periods *i.e.* Period-I (1990-91 to 1999-00), Period-II (2000-2001 to 2009-10), Period-III (2010-11 to 2018-19) and overall Period-IV (1990-91 to 2018-19).

In the present study also, the TornqvistTheil index was used for computing the total output index, total input index and total factor productivity index. The divisia indexhas two important attractive properties: It satisfies the timereversal and factor reversal test for index numbers andit is a discrete of the components, so that aggregate couldbe obtained by the aggregation of sub-aggregates.(Kumar et al., 2008).These indices were calculated as follows:

Total Output Index (TOI):

Total output indices were constructed using the Tornqvist Theil index approach as follows:

$$TOI_t / TOI_{t-1} = \pi_j (Q_{jt} / Q_{jt-1})^{(R_{jt} + R_{jt-1})^{1/2}}$$

Total Input Index (TII):

$$TII_t / TII_{t-1} = \pi_i (X_{it} / X_{it-1})^{(S_{it} + S_{it-1})^{1/2}}$$

where,

Q_{jt}	=	Output of jth crop in t^{th} year
Q_{jt-1}	=	Output of jth crop in $(t-1)^{th}$ year
R_{jt}	=	Output share of jth crop in total revenue in t^{th} year
R_{jt-1}	=	Output share of jth crop in total revenue in $(t-1)^{th}$ year
X_{it}	=	Quantity of ith input used in j^{th} crop in t^{th} year
X_{it-1}	=	Quantity of ith input used in j^{th} crop in $(t-1)^{th}$ year
S_{it}	=	Share of input 'i' in total input cost in t^{th} year
S_{it-1}	=	Share of input 'i' in total input cost in $(t-1)^{th}$ year

In the case of TFP for a single crop, revenue share refers to the share of main product and by-product in total revenue from the crop, while output includes main product and by-product. Thus, total output and input indices for sugarcane crop were prepared taking 1990-91 as the base year. The input data available only in value terms has been converted into quantity indices by dividing with its respective price indices. Input has been aggregated using their farm rental prices.

Total Factor Productivity Index (TFPI)

Total factor productivity index was computed as the ratio of total output index (TOI) to total input index (TII).

$$TFPI_t = (TOI_t / TII_t) \times 100$$

The estimation of input, output and TFP growth rates for any specified was done by fitting an exponential (or semi-log) trend equation to input, output and TFP indices, respectively.

3. RESULTS AND DISCUSSION

3.1 Decadal shift in area, production and productivity of sugarcane crop

The shift in sugarcane acreage, production and productivity in Gujarat was examined for the period from 1969-70 to 2018-19. It can be seen from the table 1 that the average area under cultivation of sugarcane crop largely increased from 0.42 lakh hectares in 1969-71 to 2.59 lakh hectares in 1999-01 (triennium average), then after it went on declining. The percentage change in area under sugarcane over last two decades was reported negative. While, the average production of sugarcane crop almost tripled from 2.51 lakh tonnes in 1969-71 to 7.46 lakh tonnes in 1979-81 (triennium average), then after it further increased up to 17.97 lakh tonnes in 1999-01. However, in 2016-18, it declined sharply to 11.78 lakh tonnes.

The percentage change in production of sugarcane over last two decades was reported negative. In case of sugarcane productivity, the average productivity of sugarcane crop increased from 59.68 tonnes per ha in 1969-71 to 75.88 tonnes per ha in 1979-81, then after it went on declining up to 2009-11. In 2016-18, average productivity of sugarcane crop slightly increased. Also the percentage change in productivity of sugarcane was reported negative in 1979-81 to 2009-11. However, it showed slight improvement in recent years 2016-18 (triennium average).

This indicates that area and production of sugarcane in Gujarat is constantly decreasing from last two decades, and yield is also stagnant or decreasing. This might be due to the fact that the labour and other input costs have increased largely in last decade. Hence, the income of farmers goes on decline, resulted in reduction of sugarcane areas, because the productivity did not increase to compensate the same.

Table 1: Decadal shift in sugarcane acreage, production and productivity in Gujarat

Period	Particulars	Absolute change over previous decade	Percentage change over previous decade
Area (00' ha)			
1969-71	421	-	-
1979-81	988	567	134.68
1989-91	1631	643	65.08
1999-01	2595	964	59.10
2009-11	1941	-654	-25.20
2016-18	1686	-255	-13.40
Production (00' tone)			
1969-71	2506	-	-
1979-81	7464	4959	197.90
1989-91	11571	4107	55.02
1999-01	17972	6401	55.32
2009-11	13272	-4700	-26.15
2016-18	11783	-1489	-11.22
Productivity (tone/ha)			
1969-71	59.69	-	-
1979-81	75.88	16.20	27.15
1989-91	70.95	-4.93	-6.50
1999-01	69.33	-1.62	-2.28
2009-11	68.38	-0.95	-1.37
2016-18	70.07	1.69	2.47

Source: DAG, GoG, 2020.

3.2 Changing cost structure of sugarcane crop

The cost structure of sugarcane crop has changed with the advent of new technology, machinery and management practices. The availability of inputs at affordable rates and their use determine crop productivity. Trends in cost structure of sugarcane represented in Table 2. It can be seen from table that the cost share of human labour in total cost of cultivation has showed increasing trend. Whereas, the percent cost share of bullock labour has increased between

1992-93 and 2002-03, then after it went on declining. The cost share of seed was remained between 11 to 12 per cent during the study period. The share of manures also remained around 5 per cent. The per cent cost share of fertilizers was 9.74 per cent in 1992-93, which was increased to 10.02 per cent in 2002-03 and in 2012-13, its share decreased to 6.6 per cent. Whereas, share of irrigation in total cost of sugarcane cultivation has increased from 10.59 per cent in 2002-03 to 12.59 per cent in 2018-19. Share of miscellaneous cost showed the similar trend as irrigation. The per cent cost share of rental value of land showed declining trend over time. Inputs like human labour and rental value of owned land have accounted for about 50 per cent of total cost of sugarcane cultivation in Gujarat. Kannan (2011) stated similar trends in cost structure of principal crops in Karnataka during 1982-83 to 2007-08 and stated similar results in cost share of seed, fertilizers and pesticides in total cost of cultivation of groundnut crop.

Table 2: Trends in cost structure of sugarcane crop in Gujarat   (in per cent)

Items	TE 1992-93	TE 2002-03	TE 2012-13	TE 2018-19
Human Labour	21.90	28.82	32.03	34.71
Bullock Labour	1.84	3.55	2.95	0.97
Seed	12.08	11.11	11.32	11.36
Manure	4.52	4.56	5.03	4.28
Fertilizers	9.74	10.02	6.62	8.49
Irrigation	11.47	10.59	11.96	12.59
Insecticides/pesticides	0.26	0.67	0.59	0.63
Miscellaneous	11.52	8.23	10.25	14.34
Depreciation	0.37	0.47	0.35	0.20
Rental value of land	26.30	21.98	18.90	12.43
Total cost	**100.00**	**100.00**	**100.00**	**100.00**

3.3 Growth in input, output and TFP indices of sugarcane

Measurement of productivity is an important and necessary step to understand in context of agricultural economics. There are various measures such as labour productivity, capital productivity, *etc*. Among them total factor productivity is a comprehensive measure of productivity and has gained acceptance as such among government officers, policy makers, productivity specialists and economists.

The annual compound growth rates of total output indices and total input indices decreased at the rate of -0.34 per cent and -0.77 per cent per annum, respectively (Table 3). Whereas, the growth rate of TFP indices increased slightly at the rate of 0.43 per cent per annum. This indicates the stagnant growth of TFP for sugarcane in Gujarat. The reason for stagnant growth of sugarcane TFP in last three decades in Gujarat, might be that the state has achieved the higher productivity growth in 1970s and 1980s, but that could not be sustained later on due to lack of proper agronomical practices and proper control of pests and diseases. Such type positive annual growth in TFP, it is not meaningful as it is associated with a negative input-output growth. Chand *et al.* (2011) also reported negative input growth (-2.09%), negative output growth (-1.26%) and positive TFP growth (0.85%) for maize crop in Uttar Pradesh during 1975-76 to 2005-06. Kannan (2011) also obtained similar slightly positive results regarding sugarcane TFP growth in Karnataka state and indicated that sugarcane production is input based with technology playing some role in it.

The decade wise results of input indices, output indices and TFP indices of sugarcane are also presented in Table 4. The annual compound growth rates of output indices were -1.10, 0.43 and -1.39 per cent, total input indices were -1.42, 0.19 and 0.41 per cent during 1990-91 to 1999-00, 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. Whereas, the annual growth rates of TFP indices were 0.32, 0.23 and -1.79 per cent during 1990-91 to 1999-00, 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively.

During 1990s though sugarcane output indices showed negative growth, but the input indices also noticed more negative growth as compared to output indices. Hence, the TFP growth remained slightly positive. This indicates that, there is an effect of technology on sugarcane productivity, but not up to the mark that bring more improvement in yield level, which results in higher growth of TFP. Besides, during 2000s, the input, output and TFP growth found positive, but stagnant (*i.e.* <0.5%). This indicated that the sugarcane output growth has been mainly input-based, which may not be sustained in future in the absence of input-saving varieties and technologies. In the current decade of 2010s, the sugarcane input use growth has surpassed the output growth, resulted in moderately negative growth in TFP (-1.79%). This is a sign of non-sustainability of sugarcane production in the Gujarat state. Many high yielding varieties of sugarcane *viz.,* Gujarat sugarcane-2 (CoN-95134) in 2000, Gujarat sugarcane-4 (CoN-03131) in 2005, Gujarat sugarcane-5 in 2007, Gujarat sugarcane-7 in 2011, released for farmers' cultivation could not able to augment the sugarcane yield in the state.

The TFP of sugarcane was also calculated by taking three yearly moving average of input, output and TFP indices. The results revealed almost same for calculation based on single year values or the three year moving average values in all periods (Table 3).

The contribution of TFP to output growth of sugarcane in Gujarat revealed nearly 54 per cent, only during 2000s. In 1990s and 2010s, the TFP growth are not meaningful, as the rate of decrease in input indices was higher than the rate of output indices.

Table 3: Annual growth rates in input use, output, TFP and real cost of production (RCP) for sugarcane crop in Gujarat: 1990-91 to 2018-19 (in per cent)

Period	Input growth	Output growth	TFP growth	RCP growth	Share of TFP in output growth	Yield growth (CGR)
Based on single year values						
1990-91 to 1999-00	-1.42	-1.10	0.32	1.96	-	-0.32
2000-01 to 2009-10	0.19	0.43	0.23	0.23	54.39	0.44
2010-11 to 2018-19	0.41	-1.39	-1.79	4.91	-	0.22
1990-91 to 2018-19	-0.77	-0.34	0.43	0.96	-	-0.09
Based on 3 years average values						
1990-91 to 1999-00	-1.55	-1.14	0.42	1.62	-	-0.36
2000-01 to 2009-10	0.19	0.58	0.38	0.14	66.35	0.43
2010-11 to 2018-19	0.22	-1.58	-1.80	5.23	-	0.49
1990-91 to 2018-19	-0.87	-0.36	0.51	0.81	-	-0.17

The Table 3 further revealed that the real cost of production of sugarcane increased at the rate of 1.96 per cent per annum in 1990s and was stagnant in 2000s. But, in 2010s, the RCP was increased at the higher rate of about 4.91 per cent per annum, as the TFP revealed negative growth indicating that technology has not contributed in production growth.

Also there are two types of planting techniques for sugarcane has been followed in Gujarat (i) planted crop and (ii) ratoon crop. But the separate data on both the planting systems have been available from 2000-01, onwards. Hence, the TFP of both these systems were also calculated separately and discussed in next further section.

3.4 Growth in input, output and TFP indices of sugarcane ratoon and planted crop

Ratooning is an ancient method of propagation in sugarcane in which subterranean buds on the stubble give rise to a new crop stand, which is usually referred to as the 'ratoon' crop as opposed to 'planted crop', which is raised from seeds or seedlings. The growth of output, input and the total factor productivity of sugarcane ratoon crop and sugarcane

planted crop were calculated for the period from 2000-01 to 2018-19 for which data are available. This period further divided into two sub-periods *viz.,* Period I (2000-01 to 2009-10) and Period II (2010-11 to 2018-19) and results are presented in Table 4.

The annual compound growth rates of total output indices and total input indices of sugarcane ratoon crop increased at the rate of 0.06 and 0.37 per cent, respectively. Whereas, the growth rate of TFP indices of sugarcane ratoon crop reported negative about -0.31 per cent per annum. Negative TFP growth resulted due to relatively faster rate of total input growth than total output growth.

The decade wise results of input indices, output indices and TFP of sugarcane ratoon crop are also presented in Table 3. The annual compound growth rates of total output indices of sugarcane ratoon crop were 1.21 cent and -1.19 per cent during the period 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. While, the annual compound growth rates of total input indices of sugarcane ratoon crop were 0.28 and 0.31 per cent during the period 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. The annual growth rates of TFP indices of sugarcane ratoon crop were 0.93 per cent and -1.50 per cent during the period 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. During 2000s, the sugarcane ratoon crop responded TFP growth of about 0.93 per cent per annum, though it's a low growth, but reveals slight improvement over the stagnant growth. However, in later period from 2010s, it turned into negative TFP growth of about -1.50 per cent per annum, indicating the non-sustainability of sugarcane ratoon crop production system.

In case of sugarcane planted crop, the annual compound growth rates of total output indices decreased at the rate of -0.14 per cent and annual compound rates of total input indices increased at the rate of 0.73 per cent. Whereas, the growth rate of TFP indices of sugarcane planted crop was negative about -0.86 per cent per annum. Negative TFP growth resulted due to a relatively faster rate of total input growth than total output growth.

The decade wise results of input indices, output indices and TFP of sugarcane planted crop are also presented in Table 4.The annual compound growth rates of total output indices of sugarcane planted crop were 0.43 per cent and -0.92 per cent during the period 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. While, the annual compound growth rates of total input indices of sugarcane planted crop were 0.12 and 0.15 per cent during the period 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. The annual growth rate of TFP indices of sugarcane planted crop were 0.31 per cent and -1.07 per cent during the period 2000-01 to 2009-10 and 2010-11 to 2018-19, respectively. This also revealed the stagnant growth of sugarcane planted crop in the Gujarat state indicating the new varieties developed and released for cultivation did not reached to the farmers' field. The case may be that farmers did not like it worthwhile to plant the new seeds or not followed the proper agronomical and pests and disease management practices, resulted in low yields. Rohini et al. (2018) also reported stagnant growth of TFP for fennel and garlic crops in Gujarat.

The Table 4 further revealed the contribution of TFP to output growth of sugarcane ratoon and planted crop in Gujarat revealed nearly 77 and 72 per cent during 2000s, respectively. Besides, due to low TFP growth the real cost of production was increase nearly 3 per cent per annum in both the systems of planting indicates non-sustainability of sugarcane in Gujarat.

Table 4: Annual growth rates in input use, output, TFP and real cost of production

(RCP) for sugarcane ratoon and planted crop in Gujarat: 1990-91 to 2018-19

(in per cent)

Period	Input growth	Output growth	TFP growth	RCP growth	Share of TFP in output growth
Sugarcane ratoon crop					
2000-01 to 2009-10	0.28	1.21	0.93	-0.41	77.01
2010-11 to 2018-19	0.31	-1.19	-1.50	4.37	-
1990-91 to 2018-19	0.37	0.06	-0.31	2.71	-
Sugarcane planted crop					

2000-01 to 2009-10	0.12	0.43	0.31	0.53	72.37
2010-11 to 2018-19	0.15	-0.92	-1.07	4.22	-
1990-91 to 2018-19	0.73	-0.14	-0.86	3.02	-

4. CONCLUSION

The study has used farm-level data collected from Department of Agricultural Economics, Junagadh Agricultural University, Junagadh and analyzed using Tornqvist Theil index for constructing aggregate output and aggregate input of the crop. The cost share of human labour in total cost of cultivation of sugarcane in Gujarat has showed increasing trend. It's share was increased from 21.90 per cent in 1992-93 to 34.71 per cent in 2018-19. Besides, the share of irrigation and miscellaneous have also shown increasing trend, whereas, the share of rental value of land in total cost has been noticed decreasing.

The investigation revealed that, the growth of total input and total output indices of sugarcane in Gujarat decreased at the rate of -0.77 and -0.34 per cent per annum during 1990-91 to 2018-19, respectively. Whereas, TFP indices increased slightly at the rate of 0.43 per cent per annum. But, such type of positive growth is not meaningful as it is associated with negative input-output growth. In case of decade-wise results, only during 2000s, the input, output and TFP indices growth were found positive, but it was stagnant (*i. e.* < 0.5%) indicating mainly input-based output growth, might not sustained in future, in absence of input saving varieties and technologies. Also, the sugarcane ratoon and planted crop system by and large revealed similar results regarding TFP growth rates.

This is a sign of non-sustainability of sugarcane production in the Gujarat state. Many high yielding varieties of sugarcane *viz.,* Gujarat sugarcane-2 (CoN-95134) in 2000, Gujarat sugarcane-4 (CoN-03131) in 2005, Gujarat sugarcane-5 in 2007, Gujarat sugarcane-7 in 2011, released for farmers' cultivation could not able to augment the sugarcane yield in the state. This implies that the research and extension efforts should be the priority to enhance productivity gains in sugarcane production in the state. This can be achieved by the efficient use of inputs along with development of new varieties and transfer of technology to farmers. However, the trends in cost structure of sugarcane crop in Gujarat indicates inputs like human labour and rental value of owned land have accounted for about 50 per cent of total cost of sugarcane cultivation in Gujarat in which human labour showing the increasing trend and rental value of owned land showing the declining trend over time.

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