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TRENDS AND DECOMPOSITION OF CROP OUTPUT GROWTH IN ETHIOPIA

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ABSTRACT

Ethiopia has achieved impressive agricultural growth over the past two decades and is seen as one of the fastest-growing economies in Africa. Most of the impressive growth was registered in the crop sub-sector. This study employed agricultural sample national-level survey data from 2004/05 to 2019/20 period corresponding to successive five-year development plan periods. Descriptive analysis using the crop cut data used to show crop productivity growth for crop categories. Growth accounting analysis was applied by computing Total Factor Productivity (TFP) change with four scenarios -using primary and intermediate longitudinal inputs data. Results showed total crop output grew by 2.6-fold with an average rate of 9.0% per annum. Crop output increases were mainly driven by strong yield growth and increases in labour use, chemical fertilizer, TFP, and area under improved seed. Together these factors accounted for 74% of the growth in total real crop output and 21% for cultivated land, rural roads, and return to scale (RTS) together. The key drivers were labour (26%), chemical fertilizer and TFP each accounting for 17%, improved seed (14%) and expansion in cultivated land (9%). Estimates of average annual TFP growth for the period 2004/05-2009/10 depicted the highest annual average growth (0.54-6.64%) but declined during GTP-I (0.58 to 5.3%) and more in GTP-II (-0.1%-3.4%). The results reflect a need for a strong investment push for expanding the use of inputs such as improved seed, fertilizer, pesticide and irrigation through intensive extension to curb the recent crop productivity decline.

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INTRODUCTION

Reports show that Ethiopia has achieved impressive economic growth over the past almost two decades and was referred to by some as the 'Great Run'- like the surges of the Asian Tigers - with the ambition of lifting the country to a middle-income status by 2025 (WB, 2015). Since the beginning of the 2000s, the country introduced the Agriculture and Rural Development Strategy (ARDS) (FDRE, 2001) and other series of poverty-focused development strategies and programs. The ARDS defined in more detail the agriculture-centred rural development vision for Ethiopia and emphasized labor-intensive rural development approaches. The strategy intended to contribute to the transformation of the productive rural sector from a primarily subsistence-oriented to a more market-oriented sector, contributing to overall economic growth and poverty reduction. However, policy debates on commercialization of the

dominantly smallholder agriculture have been recurring. The 2001/2 comprehensive program on poverty reduction called Sustainable Development and Poverty Reduction Program (SDPRP) articulated in line with the millennium development goals (MDGs) to achieve annual real GDP growth averaged 6.4% during 2002/03-2004/05 which was suppressed severely as a result of severe drought in 2002/03 and followed by strong positive performance (11.9% and 10.6% in 2003/04 and 2004/05 respectively) (MoFED, 2002).

Ethiopia's subsequent plans called Plan for Accelerated and Sustained Development to End Poverty (PASDEP) (MoFED, 2006) placed agriculture at the recentre of the country's growth strategy aspiring for an increasing and leading role of the private sector. The PASDEP medium-term plan during 2005/06-2009/10 achieved economic growth exceeding the 10%t average which was regarded as remarkable following a 7.5% growth in the SDPRP period (EEA, 2017). In succession, the First Growth and Transformation Plan (GTP I) (2010/11-14/15) and the Second (GTP II) (2015/16– 2019/20) guided the economic activity, with a focus to boost agricultural productivity, strengthen the industrial base and improve the participation and involvement of the private sector. The economy recorded a 6.1 % average growth rate in 2019/20 which was a lower growth rate than both the preceding year, 2018/19 (9%) and at the beginning of the study period, 2004/05 (11.4%). However, the agricultural sector showed a 4.3 % average growth rate in 2019/20 which was higher than the previous two consecutive years, but much lower than the growth in 2004/05 (13.5 %). The trend generally showed that the overall economic growth performance of the country has been historically mimicking the performance of the agricultural sector over most of the years in the study period (Figure 1). It also shows the recent declines in overall economic and agriculture sector growth performances. This relates to a declining trend in agriculture's contribution to GDP growth in recent years, which was 11.3 % in 2015/16, increasing to 24.6% in 2016/17, and then declining to 16.5% in 2017/18 and 14.6% in 2018/19 (PDC and NBE database). Better contribution (22.9%) was registered in 2019/20. The agriculture sector historically is the engine of the country's economy, but the decline also shows the sector is giving way to the expansion of the other economic sectors. This is evident from NBE (2021) report that the agriculture sector's share of GDP shrank by more than 25% during 2005 and 2020, while the service sector's share grew by 28% during the same period (NBE Annual Report, 2005-2020). This could have been dictated to a larger degree by the decline in crop productivity and the associated decline in agricultural contribution to the economy.

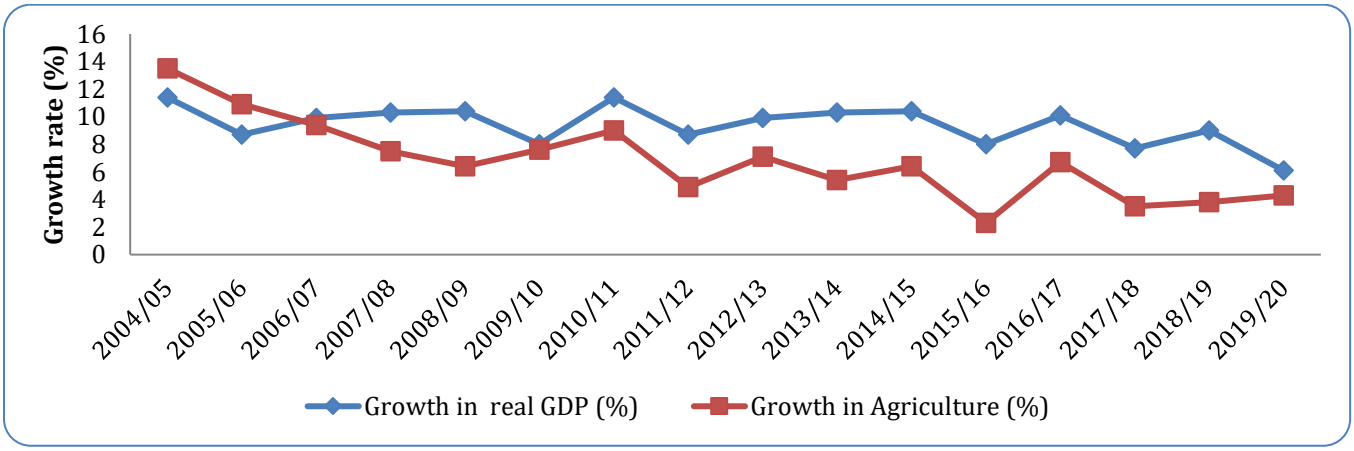

Figure 1. Growth in GDP and Agriculture.

(Source: PDC and NBE data various years)

Despite the successive impressive changes, shaping and buildup of the policy environments in favour of agricultural development in Ethiopia since the early 2000s, arguments persist if policies were pursued at ease simplified to favour enhanced productivity growth in agriculture at large across differing crop cultures and environments. Others consider as Ethiopia's agriculture is generally characterized by seasonality, geographic

dispersion, ecological diversity and risk as well as the uncertainty associated with it such that the socio-political landscape complexity also adds up to this complexity, and breakthrough might not be easily attained. Yet others further argue that given the predominant smallholder system with an average per capita farm land size of 0.2 hectares - 1.02 hectares per household with crop area holding size declining every year, this makes it doubtful if the acclaimed growth in agriculture has occurred.

Holding these arguments for a while, the continuing importance of agriculture in the national economy is reflected through the association between agricultural growth and the growth of the Ethiopian economy as a whole despite its declining contribution. This parallel between agricultural and GDP growth suggests that the factors which affect agricultural performance are well linked to the performance of the other sectors of the economy such as industry, service and export. Expanding agricultural production through technological changes and trade creates important demands for the outputs of other sectors, notably fertilizer, transportation, commercial services, and construction. At the same time, agricultural households are often the basic market for a wide range of consumer goods that loom large in the early stages of industrial development. The importance of trade for agricultural growth has been evident from the export share of agricultural output which was 76.4% in 2017 (CSA, 2018). Therefore, the export market can be another major factor determining agricultural growth in Ethiopia and affecting the overall economic growth as well (ESSP, 2004-2014).

Various empirical studies on crop output growth at national level were carried out in Ethiopia, including Alemayehu (2009), Alemayehu *et al.* (2013). These studies examined TFP trend change overtime. However, crop output growth better examined by employing multiple factor analysis in different scenarios. In this regard, a pioneering study by Nisrane (2015) applied the technique using data sets from 2004/05 to 2009/2010 in Ethiopia. This study accounted eight-factor of TFP growth change under four different possible scenarios using relatively longer longitudinal data sets from 2004/05 to 2019/20 periods. The time periods covered three successive five-year development plans of Ethiopia, which helps to evaluate the policy outcomes in terms of crop output growth over the periods.

The main objective of this analysis is to characterize the crop production and productivity growth and identify the drivers of this growth over the last fifteen years and the challenges facing keeping up its trend based on the main cropping season data that accounts for more than 95% of the country's crop output. A better understanding of agricultural growth is expected to help measure the success of the reforms that took place through successive growth and development plans> Results will give insight into growth performance and whether the transformational growth anticipated in the strategies and policies of the country has taken place. The analyses in this study will help explore factors that contributed to gaining the momentum of the registered crop output growth over the study period and cast more evidence for context-based policymaking and short and long-term intervention needs.

METHODOLOGY

Data types and sources

Data used for the analysis presented here are from the Agricultural Sample Survey of the Central Statistical Agency (CSA) of Ethiopia. In addition, various other data sources such as the National Bank of Ethiopia (NBE) time series and reporting data were used for the year from 2004/05 to 2018/19 which corresponds to three consecutive five-year development plan periods in Ethiopia: The Plan for Accelerated and Sustained Development to End Poverty (PASDEP) from 2004/05 to 2009/2010 and the First and Second Growth and Transformation Plan periods (GTP-I and GTP-II) corresponding to 2010/11-2014/15 and 2015/16 - 2020/21, respectively. Data was summarized yearly for the different selected analytical variables from CSA raw data and compared with its summarized data with necessary adjustment of the CSA data upon consultation with the corresponding data management units. Crop (cereals, pulses, oil crops, vegetables, root and tubers and fruits as a group and specific crop level) output data per holdings mainly for the major cropping season called Meher season, crop area, yield and productivity, data for prices, irrigation, extension, inputs, and investment was used.

The trend in Total Factor Productivity (TFP) growth

Growth accounting model specification

Detail time series data was used to compute growth accounting analysis and TFP from 2004/05 to

2018/2019 using data from reliable national sources. Primary and intermediate inputs (land, labour, capital, technology uses such as improved seed, chemical fertilizer, irrigation, pesticides) and agri-services and exogenous factors such as infrastructure proxied by rural roads were considered under four different scenarios detailed below. To decompose the change in output into factors over the period, the total agriculture production proximately explained using the aggregate crop production function in a given year and specified of the form:

$$Q = f(L_t, K_t, La_t; t) \quad (1)$$

$$Q = f(L_t, K_t, La_t, F_t, I_t, P_t, I_t, S_t; t) \quad (2)$$

Where Q is the real value of total crop output at a given period of time t (subscript), and K, L, La, and t, respectively represent the value of primary inputs; labor (L), capital (K), and land (La), intermediate inputs (fertilizer (F), improved seed (I), pesticides (P), and agriculture service input (S), irrigation inputs (I) applied to produce crop output Q during the same period. Where the value of t in both equation (1) and (2) stands for the cumulative effect of technical change. Based on Solow (1957), the above production function could be re-written by assuming the neutral technological change which means the marginal rates of substation of the production function is constant and explained as;

$$Q = A(t)f(L_t, K_t, lA_t; t) \quad (3)$$

$$Q = A(t)f(L_t, K_t, La_t, F_t, S_t, P_t, I_t, S_t; t) \quad (4)$$

Where the value of A(t) measures the cumulative changes in TFP that occurred over time. Differentiating equation 3 and 4 with respect to time and dividing the result by Q collecting like terms, respectively.

$$\frac{\dot{Z}}{Z} = \frac{\dot{Q}}{Q} - W_L\frac{\dot{L}}{L} - W_K\frac{\dot{K}}{K} - W_{LA}\frac{\dot{La}}{la} \quad (5)$$

$$\frac{\dot{Z}}{Z} = \frac{\dot{Q}}{Q} - W_L\frac{\dot{L}}{L} - W_K\frac{\dot{K}}{K} - W_{LA}\frac{\dot{La}}{la} - W_F\frac{\dot{\mathrm{S}}}{\mathrm{S}} - W_F\frac{\dot{\mathrm{P}}}{\mathrm{P}} \quad (6)$$

$$\frac{\dot{Z}}{Z} = \frac{\dot{Q}}{Q} - W_L\frac{\dot{L}}{L} - W_K\frac{\dot{K}}{K} - W_{LA}\frac{\dot{La}}{la} - W_F\frac{\dot{\mathrm{S}}}{\mathrm{S}} - W_F\frac{\dot{\mathrm{P}}}{\mathrm{P}} - W_I\frac{\dot{\mathrm{I}}}{\mathrm{I}} - W_S\frac{\dot{\mathrm{S}}}{\mathrm{S}} \quad (7)$$

Where $\frac{\dot{Z}}{Z}$ represent the rate of change in TFP. WL, WK, WLA, WF, WS, WP and WI are shares of capital, labor, land, fertilizer, improved seed, pesticide, irrigation and agriculture service inputs in total agriculture output, respectively.

The output shares of factor inputs for the year 2005/06, 2007/08, 2009/10 and 2013/14 of the Social Accounting Matrix (SAM) method developed by Kedissoe (2018-19) and most recent update price of input applied corresponding to each year. In addition, a similar type of analysis attempted in Ethiopia by Nisrane (2015).

The study estimated the growth accounting model analysis by excluding and including the factors separately under four scenarios (Table 3): First, the growth accounting model specification given in equation (5) estimated the change in TFP using the three primary inputs, was used as baseline or starting point of reference.

Second, the growth accounting model specification in equation (6) estimated the change in TFP using all primary and intermediate manufacturing inputs (chemical fertilizer, improved seed and pesticides). This specification helps to investigate the effects of changes in application rates of intermediate inputs effects on TFP changes. Third, the growth accounting model specification in equation (7) estimated the change in TFP using all inputs (primary inputs, intermediate manufacturing and service inputs, irrigation). This specification helps to investigate the effects of changes in application rates of both agriculture extension service and irrigation effects on TFP Changes. Fourth, the growth accounting model specification in equation (7) estimated the change in TFP using all inputs (primary inputs, intermediate manufacturing and service inputs, irrigation) and accounting both the RTS and exogenous factors (proxied by infrastructure). In this study, the current and lagged expansion in rural roads were used as proxies to account for the contribution of exogenous factor (proxied by the expansion of rural roads in km) in TFP.

$$\Delta TFP = \frac{\Delta Q}{Q} - \sum W_i\frac{\Delta P}{P} - \theta\Delta RTS - \beta\Delta\Phi \quad (8)$$

Where TFP stands for the change in TFP, Wi is the relative share of input i in crop output, $\Delta\Phi$stands for changes of exogenous factor, and β stands for the rate at which output changes per unit change in exogenous factor. ΔRTS and θestimates the changes in RTS which shows that the rate of output changes per unit change in RTS, respectively.

Synthesize

The Ethiopian economy showed unprecedented record of average annual growth of 10.9 per cent between 2004 - 2014 and a 9.3 per cent growth during 2013/14 - 2017/18 and declined to 6.5% in 2019/20 as estimated just before the outbreak of the Covid-19 Pandemic.

Agricultural GDP declined from 7.0% (during PASDEP and during the Growth and Transformation Period-I or GTPI) to 4.1 in GTPII (four years average). This growth changes very well correspond to cereals production growth of 10% and productivity growth by 7.2% per year for the last fifteen years. This is understandable since crop share of the agricultural GDP ranges between 65-70% during the same period (NBE, 2018). Cereals accounted for about 83% of the total crop output in 2018/19 with no relative change compared to its share in 2004/05. During this period the total crop area increased by 2.8 million hectares, but persistently declining from gain of 4.08 to mere 0.48% in fifteen years, but with average rate of 2.12% increase per annum. The land fragmentation continues but at slower rate, and yet will persist imposing more challenge to agricultural productivity growth in the future.

Individual crop growth performance varied widely. Productivity increase for crops like maize, wheat, sorghum, soybean, chickpea and tef is remarkably high for the whole period. However, productivity progress in high value crops such as sesame, cotton, fruits and vegetables was not remarkable because these crops did not receive better input and crop management to boost productivity. Yield levels of indigenous crops like tef, sunflower, neug, linseed, coffee, sorghum, barley has remained small, although relative increase is high because of starting from already low yield levels. The differential productivity progress indicates lack of farming system based strategic interventions that extends beyond food security interests to indigenous and high value crops (both grain and horticulture). Therefore, not enough technological options were provided to bring the desired change in crop output growth.

Crop growth achievements in the PASDEP period was better than both GTP periods. Growth during GTPII is far less than previous plan-periods achievements and compared to the set targets and ranged only between 9 and 24% of the goal for cereals, pulses and oil crops. Technological interventions had big impact on crop output growth but the desired shift to diversify to high value crops and export commodities did not occur meaningfully. The GTPII plan period crop output decline is triggered mainly due to the El Niño caused droughts of 2015-2016 and its aftermath, and other factors such as political unrest and internal conflicts, reduced input use and the COVID-19 pandemic. The current crop productivity levels allowed farmers to sale out only 17-18% of their grain produced, which is low and strongly urges the need for change through better intervention strategies.

The main drivers of crop output growth over the 15 year of the study period have primarily been due to increased inputs such as labor and land, and technological inputs such as fertilizer, improved seeds, pesticide and irrigation in that order. The effect of improved seed and irrigation has been awkwardly low due to poor access to quality seed and too much dependance on rain. During this period total crop output grew on average by 7.56%. There was a significant growth in TFP with an average of 1.7% per annum but with a declining trend across the successive development plan's periods. The more pronounced decline in TFP in the last period and less contribution of irrigation and agri-services deserve greater attention.

The results clearly showed the potential of the Ethiopian agriculture to grow and produce surplus for export of grain and horticulture products if properly guided with sufficient investment to diversify and intensify input such as improved seed, fertilizer, irrigation, pesticide, extension and training and market access supports.

RESULTS

Crop output growth and productivity changes

The national crop cut data showed, in fifteen years (2004/05 - 2018/19), the total crop output has grown by 2.6-fold from 14 to 37 million MT (Table 1) and showed an average growth rate of 9.0% per annum. Crop output growth declined consecutively from the first phase (2004/05 to 2009/10) to the second (2010/11-2014/15) and to the third phase (2015/16-2019/20) or five-year plan period except during 2007-2009 where it had grown by 5, 7 and 12.5% for the three consecutive years followed by lowest records in the last five years (GTPII period). Cereals accounted for about 83% of the total crop output and grew by 10% (Table 1) and productivity by 7.3% per year (Table 2) for the same period while annual crop output growth for vegetables and fruit crop was about 7% each while root crops showed a higher increase from 1.34 million MT to 4.5 million MT, a 17.0% annual growth (Table 1). Despite strong domestic market and export needs for oilseeds, growth was slow about 4.3% per annum. Pulses production have shown strong growth (9.8% per year), a 2.4-fold increase during the period.

Table 1. Crop output (in million MT).

Crop	2005/06	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	% Growth /year
Grains	13.4	15.0	16.1	17.1	18.1	20.4	21.9	23.1	25.2	27.0	26.7	29.0	30.6	31.6	9.71
Cereals	11.6	12.9	13.7	14.5	15.5	17.8	18.8	19.7	21.6	23.6	23.1	25.4	26.8	27.8	9.92
Pulses	1.3	1.6	1.8	2.0	1.9	2.0	2.3	2.8	2.9	2.7	2.8	2.8	3.0	3.0	9.79
Oilseeds	0.5	0.5	0.6	0.7	0.6	0.6	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.8	4.30
Vegetables	0.5	0.4	0.5	0.6	0.6	0.7	0.8	0.9	0.7	0.6	0.7	0.8	0.7	0.9	6.97
Root crops	1.3	1.4	1.5	1.2	1.8	1.9	1.7	3.6	4.2	5.5	4.0	4.6	4.6	4.5	17.04
Fruit crops	0.4	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.7	0.7	0.8	0.8	0.8	6.71

Source: Authors' computation using CSA annual reports (CSA Volume I 2004-2018).

Yield levels of all cereals more than doubled (116% increase) from 1.2 t ha^{-1} in 2004/05 to 2.56 t ha^{-1} at the end of the period (Table 2). The increase for yield levels of the five important cereals barley, maize, tef, wheat and sorghum ranged from 40 to 80% during the period. Yield levels of pulses and oilseeds showed somewhat a steady linear increase (Figure 2). In horticultural crops except for root and tubers the trend did not change and yields of fruits and vegetables respectively were about 86 and 76% higher at the end of the period while root crops showed a 250% increase particularly due to high rise from 2012/13 to 2014/15 (Figure 2). However, root crops have been on decline since its peak growth year and at a faster rate. Yields of vegetables on the other hand stagnated for long period and declined further from 2011/12 onwards. Interestingly, the proportion of cereals to the total crop output estimated at 83% remained the same after 15 years (Figure 3). There was a 5.8% decline in its share from 2011/12 to 2012/13 and remained between 82-83% since then.

Table 2. Crop yields (t ha^{-1}) at the end of three planning periods (PASDEP, GTP-I and GTP-II) in Ethiopia.

		End of PASDEP	End of GTP-I	End of GTP-II*	% Growth
Crop	2004/05	2009/10	2014/15	2018/19	/Year**
Cereals	1.18	1.69	2.34	2.56	7.26
Barley	1.55	1.31	1.97	2.18	8.12
Maize	2.2	1.94	3.43	3.99	8.78
Tef	1.23	1.15	1.58	1.76	8.38
Wheat	1.83	1.73	2.54	2.76	9.56
Sorghum	1.84	1.74	2.28	2.73	7.09
Pulses	0.87	1.18	1.78	1.86	8.49
Oilseeds	0.54	0.78	0.95	1.05	8.48
Vegetable	5.72	5.36	5.95	4.65	-0.02
Root Crops	9.8	8.84	27.3	14.45	6.09
Fruits	4.69	7.33	7.07	6.22	-1.99

* GTP-II ends in the year 2019/20 which is not included in this data;

** % growth computed from 2005/06-2018/19

Source: Authors' computation using CSA annual reports (CSA Volume I 2004-2018).

The total crop area in Ethiopia increased by 2.8 million hectares during the period, which is a 31.8% increase at rate of 2.12% per annum. At the same time the number of holders increased from 10.4 to 16.0 million during the period, a 53% overall increase or a 3.6% per annum growth, which is faster than cultivated area rate of expansion showing the continued land fragmentation

imposing more challenge to production and productivity.

Crop output growth during 2004/05-2017/18 excluding the lower yields of 2015/16 caused by the El Niñ drought, averaged nearly 7% or higher in all crops except vegetables and fruits (Figure 4.). The overall performance show that crop output growth was almost similar in the first two five-year plan periods for almost all crop categories except in vegetables and root crops, but a considerable growth decline was observed in the third five-year period (2014/15-2018/19) for all crops except in vegetables (Figure 4). It appears that growth in total crop output was driven by large expansion in cultivated area for total grain crops and cereals (Figure 5 and 6). At the beginning of the study land area expansion amounted 4.08% of the total crop area. However, this continued to decline substantially and reached only 0.83% by the end of the study period (Figure 5).

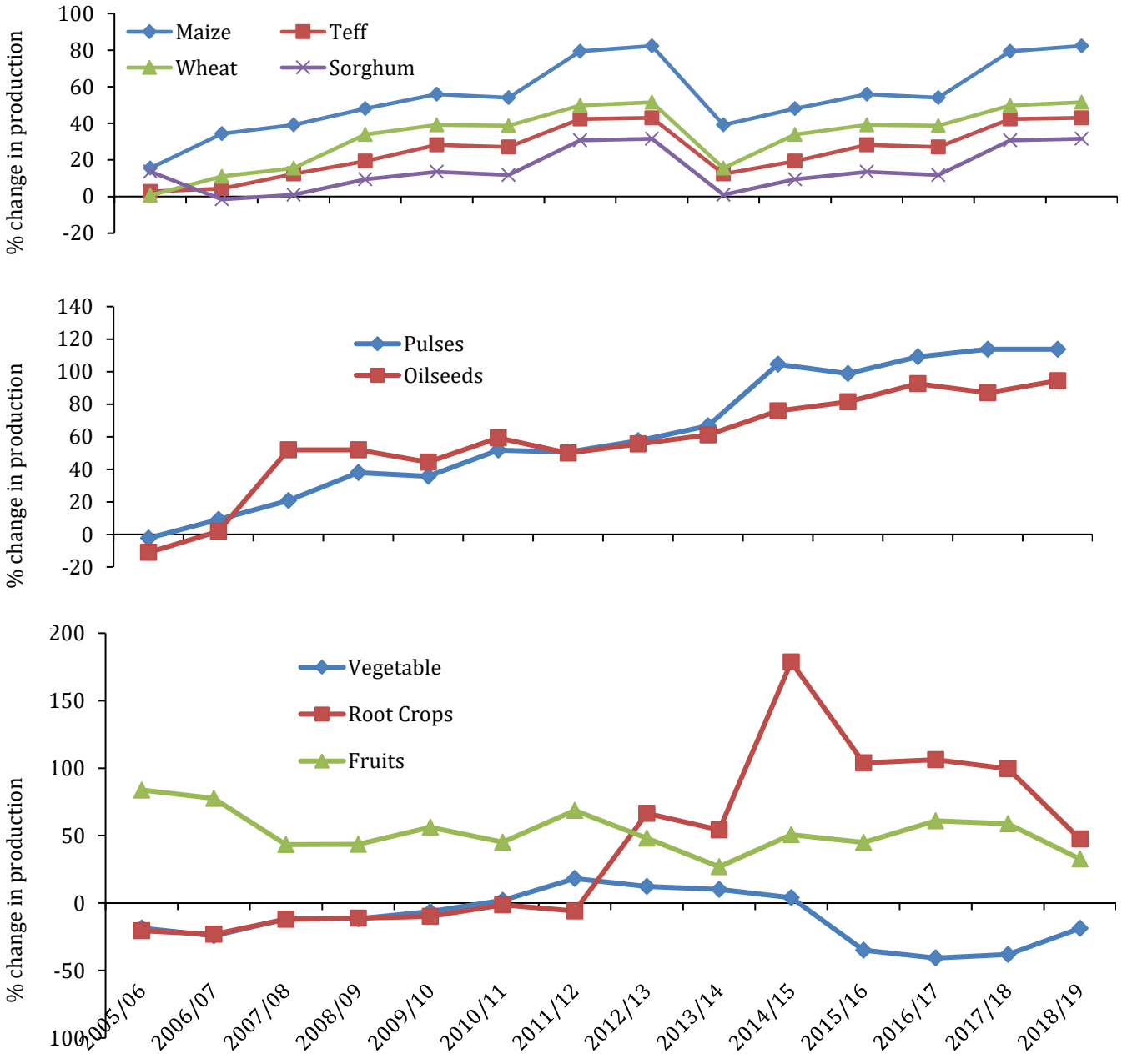

Figure 2. Percent increase in productivity (yield/area) for major cereals, pulses, oilseeds, and horticultural crops from 2004/05 to 2018/19 in Ethiopia.

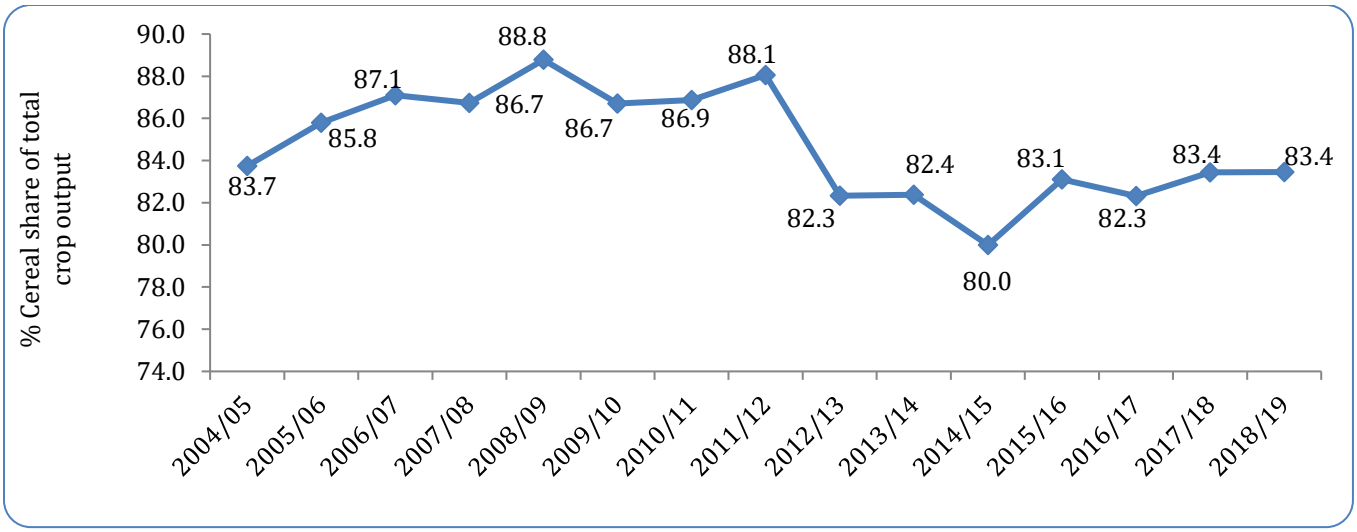

Figure 3. Trend in cereal share of total crop output in Ethiopia from 2004 to 2019.

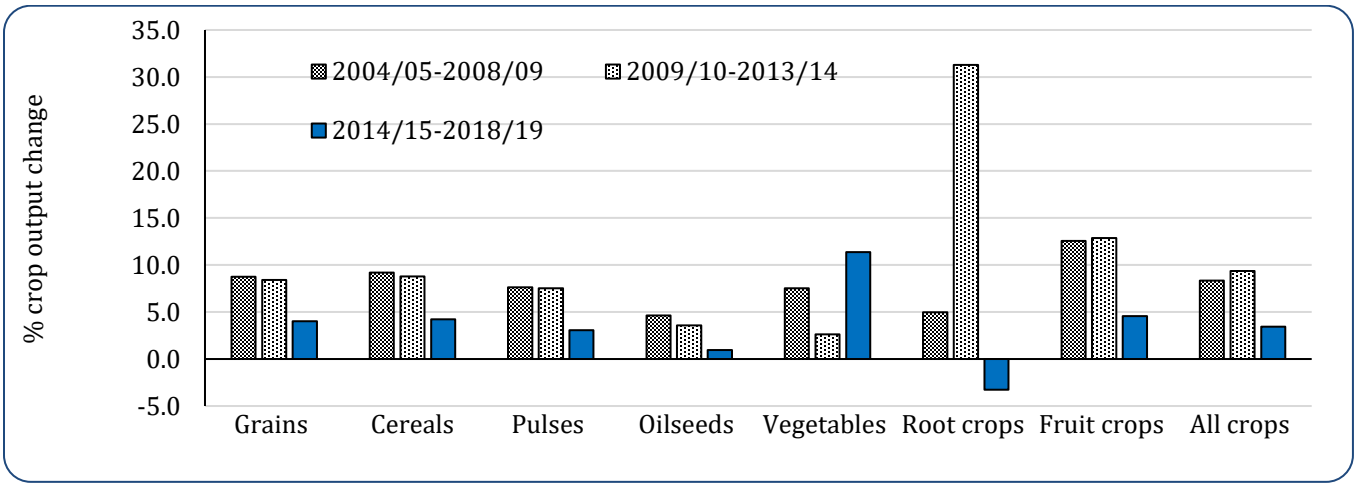

Figure 4. Crop output change as a measure of growth has declined in the 3rd period (2014/15-2018/19).

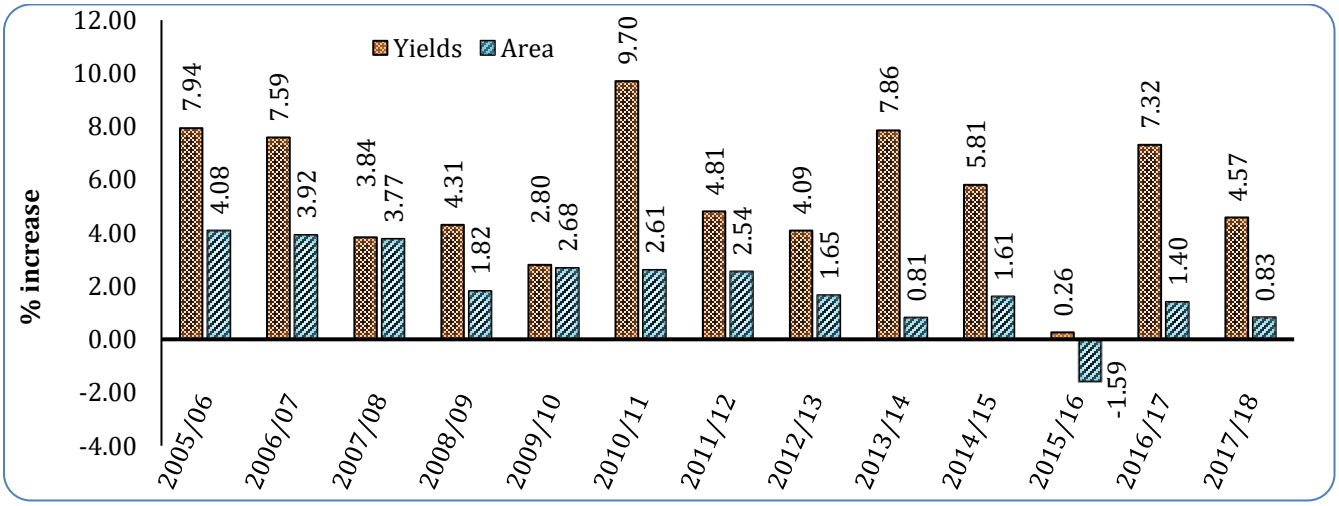

Figure 5. Growth in area cultivated and yield of grains
Source: Computation using CSA annual reports (CSA Volume I, 2004-2017).

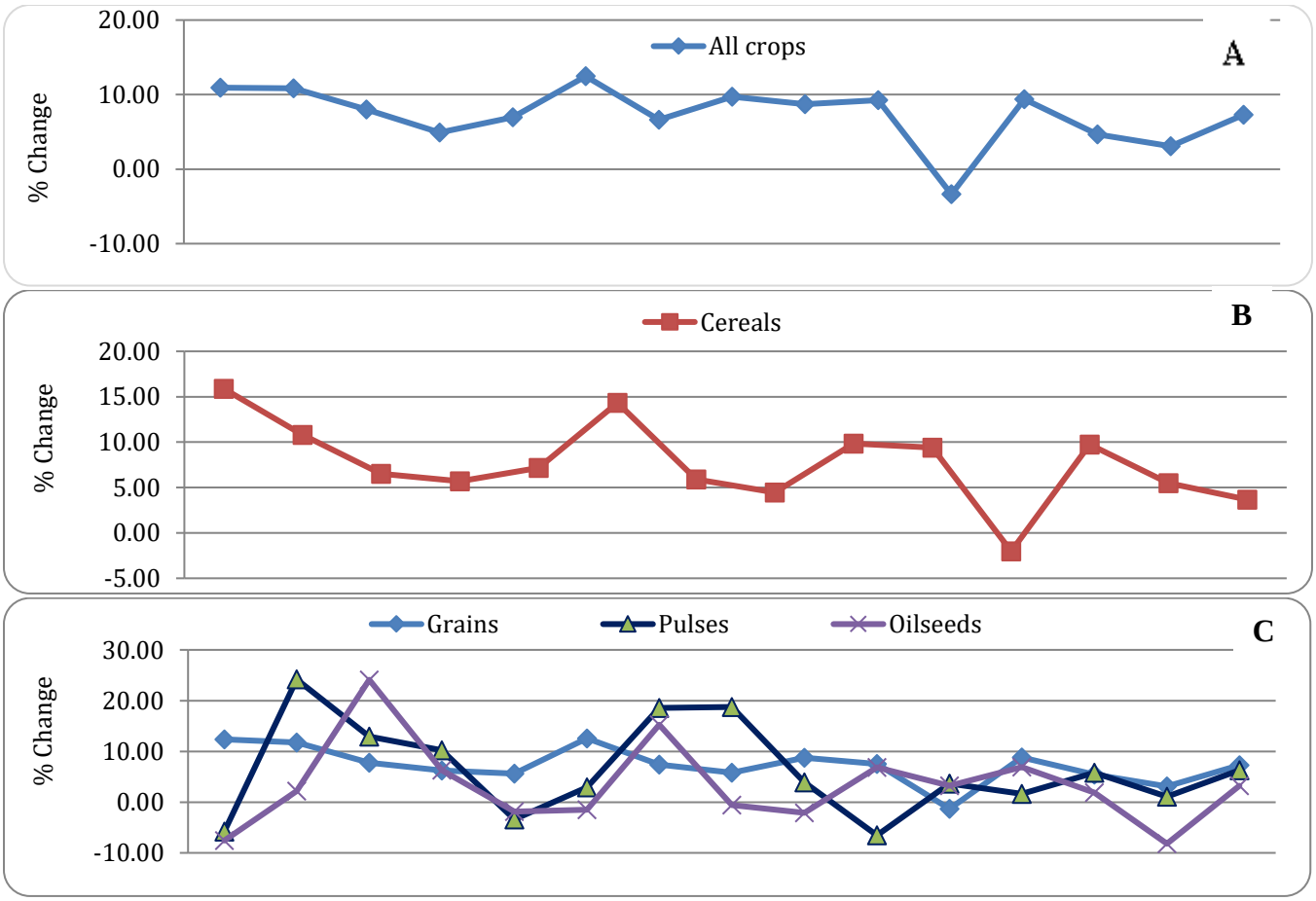

Figure 6. Percentage change in yield: for all crops (A), cereals (B), and grains, pulses and oilseed (C).

Percent increase in crop yield did not follow the declining trend of land expansion. The grain and cereal crop categories accounted for 97 and 77% of the total crop area of the country and grew at average annual rates of 2.2 and 2.5%, respectively. Land under pulses and oilseeds accounted for 6.2 and 2.9% of total crop area only. While pulses area grew by 20%, area for oil crops declined by 9.2% mainly due to area sown to linseed declining by about 67%. Area sown to horticultural crops accounted for a negligible share of total crop area. Crop production across the regional states in Ethiopia for the during the consecutive GTP plan-periods shows regions like Afar, Somali, Gambela and Harar had always been less stable in maintaining production levels with big fluctuations from year to year. The four other regions, Amhara, Oromiya, SNNPR and Tigray displayed rather more stable grain production during the period. However, grain production declined in Tigrai, Afar, Amhara and Dire Dawa as opposed to the Somali region from 2004/05 to 2009/10. The huge depression in yield (shown by line graph in Figure 7, bottom) is caused by to El-Nino and all regions except Afar which contains most of the irrigated production.

Crop output Growth Decomposition Analysis

Trend in Total Factor Productivity (TFP) growth

Results in Table 3 show that, out of the 7.6% average annual growth in real crop output from 2004/5 to 2018/19, increased use of all inputs contributed about 5.7%. Out of this, chemical fertilizer contributed 2.07%, labor and improved seed were next important at 1.74 and 1.14%, respectively. While the remaining inputs such as land, capital, pesticides, irrigation, and agriculture service together contributed 0.76%. Considering the 1st scenario, the annual Total Factor Productivity (TFP) growth rate averaged 5.23% during the 2004/05–2018/19 period. While in the 2nd and 3rd scenarios, annual TFP growth rates averaged 1.95 and 1.85% from 2004/05–2018/19. Estimates of average annual TFP growth in the crop sector in three different

development plan periods corresponding to the PASDEP, GTP-I and GTP-II show that the PASDEP period between 2004/05-2009/10 depicted the highest annual average growth of TFP (0.54-6.64%) but declined in GTP-I (0.58 to 5.3%) and more in GTP-II (-0.1%-3.4%) considering scenario I, II and III (Table 3).

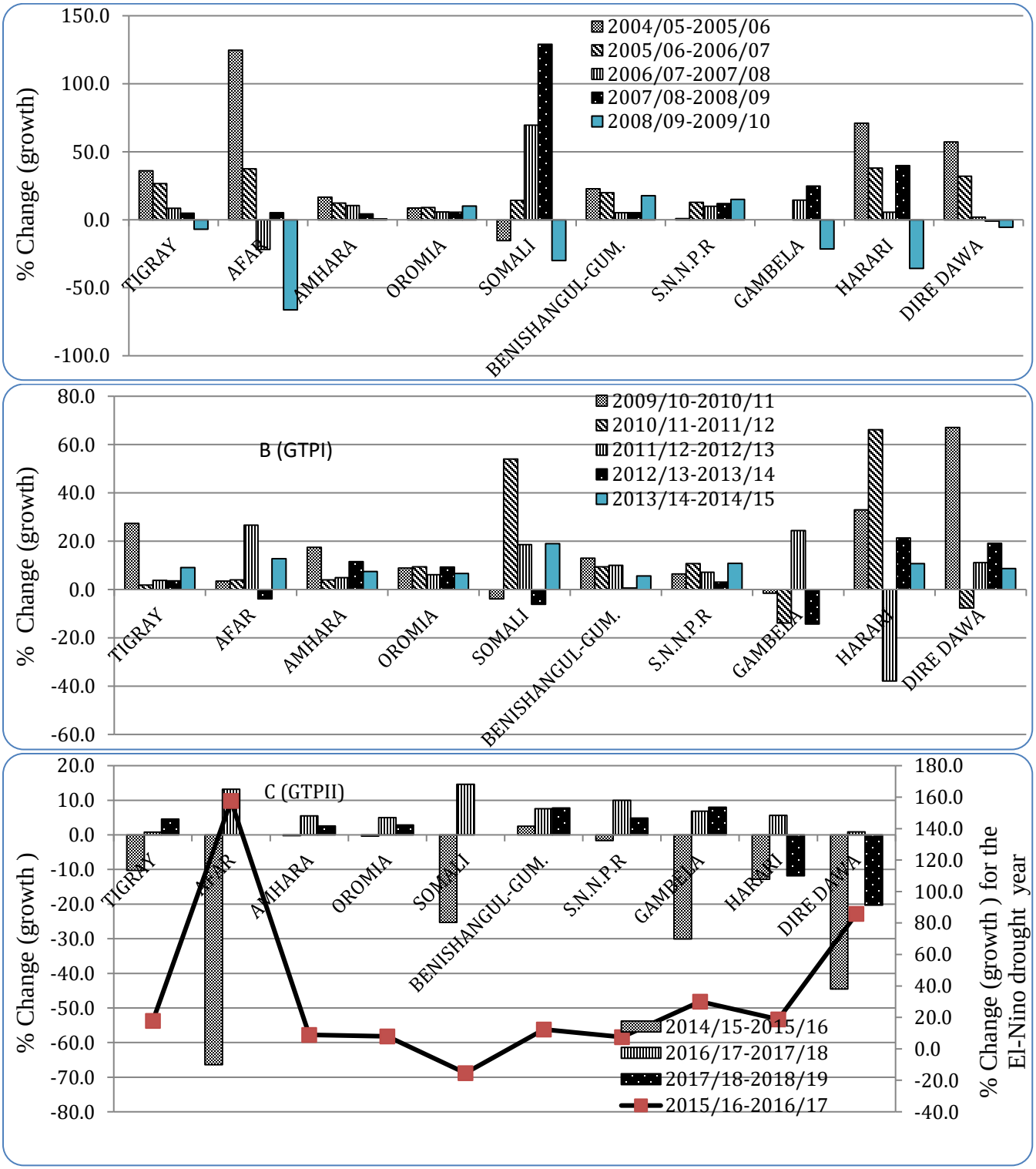

Figure 7. Estimate of major crops production changes in three periods: 2004/05-2009/10 (A), 2010/11-2013/14 (B) and 2015/15-2017/18 (C) (under the smallholder production by region (*Meher* season).

Table 3. Contribution of inputs, exogenous factors and TFP changes for growth using various year factor shares of SAM.

Source of growth	2005/06	2006/07	2007/08	2008/09	2009/10	**Average** (PASDEP)	2010/11	2011/12	2012/13	2013/14	2014/15	**Average** (GTPI)	2015/16	2016/17	2017/18	2018/19	**Average** (GTPII)	**Overall Average**
$\Delta Q/Q$	0.1515	0.1085	0.0799	0.0647	0.0874	**0.0984**	0.1032	0.0499	0.0819	0.0965	0.0418	**0.0747**	0.0344	0.0819	0.0471	0.0300	**0.0484**	**0.0756**
Labor	0.0079	0.0399	-0.1047	0.1970	-0.0223	**0.0236**	0.0218	0.0430	0.0317	-0.0067	-0.0144	**0.0151**	0.0359	0.0701	-0.0482	-0.0074	**0.0126**	**0.0174**
Capital	0.0002	0.0004	0.0006	0.0002	0.0002	**0.0003**	0.0003	-0.0001	0.0002	0.0001	0.0002	**0.0001**	0.0001	0.0002	0.0001	0.0001	**0.0001**	**0.0002**
Land	0.0079	0.0086	0.0093	0.0060	0.0090	**0.0082**	0.0087	0.0074	0.0056	0.0040	0.0052	**0.0062**	-0.0014	0.0042	0.0030	0.0024	**0.0021**	**0.0057**
Fertilizer	0.0163	0.0014	0.0048	-0.0028	0.0002	**0.0040**	0.0087	0.0003	0.0072	0.0556	0.0452	**0.0234**	-0.0001	0.0960	0.0209	0.0360	**0.0382**	**0.0207**
Improved seed	0.0314	-0.0133	0.0026	0.0067	0.0032	**0.0061**	0.0223	0.0114	-0.0114	0.0792	0.0071	**0.0217**	-0.0232	0.0152	0.0414	-0.0136	**0.0050**	**0.0114**
Pesticides	0.0013	0.0006	0.0005	0.0000	-0.0012	**0.0002**	0.0030	0.0001	0.0013	0.0000	0.0009	**0.0011**	0.0004	0.0002	0.0005	0.0000	**0.0003**	**0.0005**
Agri. Service	0.0005	-0.0004	-0.0002	0.0002	0.0001	**0.0000**	0.0008	0.0005	0.0001	0.0004	0.0001	**0.0004**	0.0000	0.0000	0.0001	0.0003	**0.0001**	**0.0002**
Irrigation	0.0052	-0.0021	0.0084	-0.0021	-0.0015	**0.0016**	0.0045	-0.0023	-0.0021	0.0024	0.0019	**0.0009**	0.0003	0.0020	-0.0018	0.0007	**0.0003**	**0.0010**
$\sum_f W_f \frac{\Delta X_f}{X_f}$	0.0707	0.0351	-0.0787	0.2052	-0.0123	**0.0440**	0.0701	0.0603	0.0326	0.135	0.0462	**0.0688**	0.012	0.1879	0.016	0.0185	**0.0586**	**0.0571**
Rural roads	-0.0145	0.0046	0.0030	0.0030	0.0021	**-.0004**	0.0059	0.0011	0.0014	0.0013	-0.0037	**0.0012**	0.0013	0.0023	0.0033	-0.0059	**0.0003**	**0.0004**
ΔTFP																		
ΔTFP_1	0.1354	0.0596	0.1747	-0.1385	0.1006	**0.0664**	0.0724	-0.0004	0.0444	0.0990	0.0507	**0.0532**	-0.0002	0.0074	0.0922	0.0348	**0.0336**	**0.0523**
ΔTFP_2	0.086	0.0713	0.167	-0.1426	0.0982	**0.0560**	0.0376	-0.0127	0.0472	-0.0361	-0.0025	**0.0067**	0.0227	-0.104	0.0293	0.0122	**-0.0100**	**0.0195**
ΔTFP_3	0.0808	0.0734	0.1586	-0.1405	0.0997	**0.0544**	0.0331	-0.0104	0.0493	-0.0385	-0.0044	**0.0058**	0.0224	-0.106	0.0311	0.0115	**-0.0103**	**0.0185**
ΔTFP_4	-0.0360	0.0790	-0.0567	0.0100	0.0235	**0.0040**	-0.0245	0.0080	0.0074	-0.0283	0.0704	**0.0066**	0.0083	0.0746	0.0238	0.0788	**0.0464**	**0.0170**

Source: Own computations using CSA (Volumes I, II, and III 2004/5-2018/19) and National Bank of Ethiopia various reports

Note: ΔTFP_1 Estimated change in TFP as per scenario-I –considering only primary inputs

ΔTFP_2 Estimated change in TFP as per scenario-II considering the primary inputs and intermediate inputs.

ΔTFP_3 Estimated change in TFP as per scenario-III considering primary inputs, intermediate, irrigation and agriculture service inputs.

ΔTFP_4 Estimated change in TFP as per scenario-IV considering primary inputs, intermediate, irrigation and agriculture service inputs, accounting the role of RTS & exogenous factors (Infrastructure)

The growth decomposition of the change in TFP using the 4th scenario indicates the average contribution of factors shares expressed as a percentage of real crop output growth average from 2004/05 to 2018/19 (Figure 8). Growth in the amount of labor applied to real crop output growth accounted for 26% of the average real crop output. Similarly, the growth in the amount of chemical fertilizer applied to real crop output growth and the annual increment in TFP contributed equally 17% of the growth in real crop output. The area expansion covered by improved seed accounted for 14% while overall expansion in cultivated land accounted for about 9% in real crop output growth. Further, the growth in real crop output originated equally 6% from the expansion of rural roads and return to scale (RTS). However, the growth in agriculture extension services, an area covered by pesticide and irrigated land contributed equally 1 % to the real crop output growth from 204/05 to 2018/19.

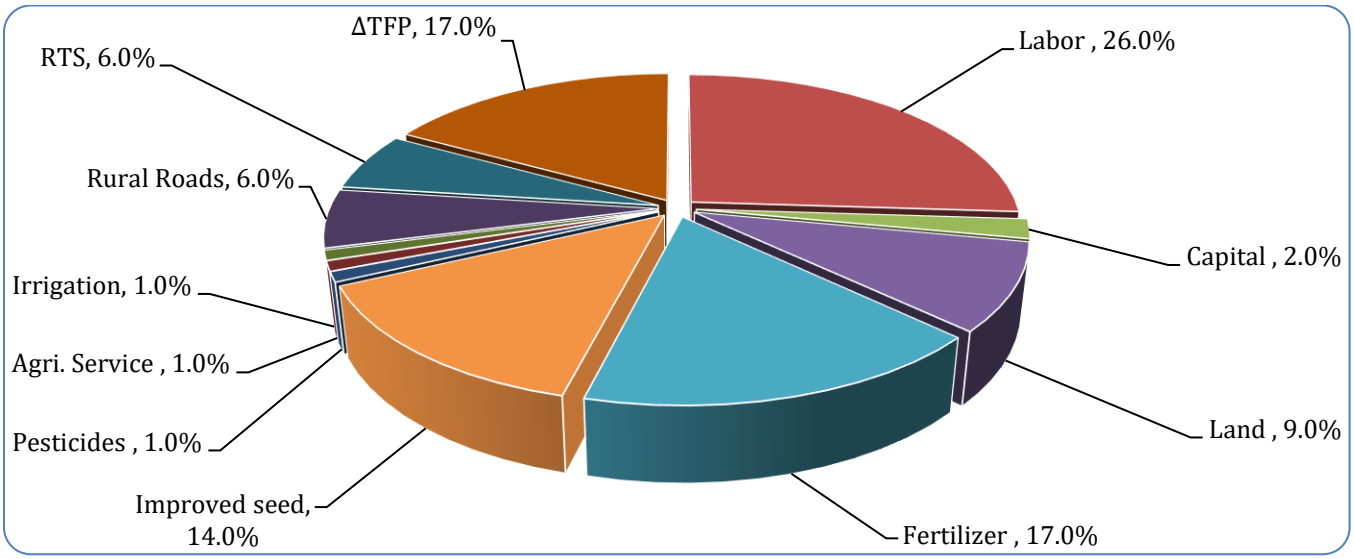

Figure 8. Average contributions of factors and TFP to crop output growth (2004/05 – 2018/19).

DISCUSSION

Crop output growth and productivity changes

Crop cut data showed a 2.6-fold total crop output growth with an average growth rate of 9.0% across the three plan periods in Ethiopia: The Plan for Accelerated and Sustained Development to End Poverty (PASDEP) , Growth and Transformation Plan (GTP-I) and GTP-II. However, the growth was not sustainable and declined during GTP-II period (2015/16-2019/20), the lowest growth in fifteen years. Yield depression began due to the 2015/16 El Niño droughts and did not recover previous growth since then (USAID, 2021). Cereals share of total crop output remained the same, about 83% after fifteen years but registered relatively high average productivity growth, 7.2% per year. The results reveal the long-persisted cereal dominated agricultural production system in Ethiopia which remained less diversified yet, particularly in areas where cereals have been intensively cultivated for centuries in the highland agroecology had the highest land expansion to produce the same crop. Despite anticipation by the overarching plans to bring about changes by engaging farmers to diversify towards high value, nutrient and vitamin rich crops, this had hardly taken place with the exception of limited expansion of horticultural crops in pocket middle-altitude areas and the rift-valley lake region that are closer to major cities and towns and few similar agroecology.

The overall performance show that crop output growth was almost similar in the first two five-year plan periods for almost all crop categories except in vegetables and root crops, but a considerable growth decline in the third five-year period (2014/15-2018/19) except in vegetables and root and tuber crops. Except in vegetables there was a decline in output change in all crop categories, root crops being the most severely affected. While a decline in crop area expansion is one of the serious input issues, more factors seem to involve

such as the El Niño drought impact of the 2015/16 resulting shrinking crop area. Farmers' ability to use more input and improved technologies was threatened severely due to the extensive El-Nino drought and production did not recover quickly in most crops. Consequently, non-stalk and stalk cereals, pulses, coffee and fruits failed to attain their corresponding production targets, while oilseeds, fruits and root crops were found less affected (data for fruits and root crops not shown). A slight change in intervention approaches including relative decline in inputs including quality seed, fertilizer, credit, extension and best practices due to transition period political crisis and change in the political governance since 2017/18 are expected to have contributed to the dynamics.

It is interesting to note that while crop growth (% increase in crop output) was not consistent and this was alternated between years and ranged between 0.26 - 9.7%, the lowest being during the El Niñ drought, area expansion had consistently declined throughout the period from gain of 4.08% at the beginning (2005/06) to mere 0.48% at the end of the period. On the other hand, the rise and fall of cereal area corresponds to a reversal rise and fall of pulses and oilseeds production areas mostly due to crop rotation exercises. This alternating pattern is an important issue of sustainability such as related to soil fertility, nutrition and income security strategies for millions of farmers.

Crop area in Ethiopia increased at rate of 2.12% per annum while number of holders increased at 3.6% per annum, and this continued exacerbating the land fragmentation issue imposing more challenge to production and productivity growth now and in the future. It appears that growth in total crop output was driven also by large expansion in cultivated area for total grain crops and cereals. Nevertheless, the change in crop output observed does not correspond to the decline in crop area which signifies other factors such as improved productivity are stimulating crop output growth in Ethiopia. About 25% of rural household cultivating land less than 0.9 ha, which is not enough land to produce adequate food for an average household. About 50% have less than 1.52 ha. A continued heavy dependency on small farm households with declining farm size and scattered plots cannot sustain production to meet the fast-rising demand for more food. Such a small plot size may not be enough land to produce adequate food for an average household unless supported with improved technologies to ensure higher productivity levels. Poor use of technology and low productivity is prevalent that needs to change through better management and efficient labor use to maximize crop output and raise productivity.

The yield increment during the GTPII period can be compared against the government plan for accelerated development in the same period. The plan for crop development categorized into three: food, industrial, and export crops with clear end line targets (productivity and production targets -data not shown). This was articulated as Goals 1 - 4 in the five-year plan with corresponding productivity increases in four areas: For non-stalk cereals a 47.1% increase from 2.1 - 3.1 t ha^{-1}; pulses a 53.5% increase from 1.72 – 2.64 t ha-1 and oil crops a 41.6% increase from 0.9 – 1.27 t ha^{-1} by the year 2020. However, due to decline in productivity during this phase, the achievements were only 15.2% for stalk cereals and each 9.0 per cent for non-stalk cereals and pulses. Oil crops had the highest (23.7 per cent) increase and coffee had rather a 12 per cent decline in productivity. The increase in volume of production also followed similar pattern. The shift to high value crops and export commodities has been much slower than anticipated in the GTP plans. However, considering that smallholder farmers sold out only 17-18% of their total grain production to market every year (data not shown) indicates that the surplus production is not yet achieved and raising productivity is a much-needed achievement to bring a meaningful impact in the livelihood of farmers and sustainably overcome food security challenges. It is also a basis for meaningful structural change in the economy from subsistent to one producing enough food, feed, export and industrial input.

Productivity gaps between research results (experimental plots yield) and those obtained by farmers still very high but not for all cereals as technical efficiency values for some major crops were remarkably high, close to 90% (Debebe *et al.,* 2022). Therefore, it is to be noted that production growth, productivity and land expansion are declining at the same time when demand for food, feed and industrial raw material is soaring. The current state of crop productivity urges for quicker interventions with package of improved technology options to compensate for area decline and reducing holding size of farmers and support be made to improve technical capacity of growers through stronger extension presence and market linkage.

Although government commitment in spending and foreign investment in Agriculture in Ethiopia seemed to have paid off during the period for near threefold increase in annual agricultural value-added (USAID, 2021) generating high agriculture growth rates and significant welfare improvements, still a deep concern exists about how to improve the slow change in nutritional indicators and the high level of stunting reported (Giptan *et al*., 2022). This is especially true in rural areas which shows the need to expedite intensifying production and diversifying to nutrient, vitamin and protein rich agricultural products.

Generally, the period 2014/15-2019/20 has been a challenging one for Ethiopian agriculture where production has slowed down including total merchandise agricultural exports, where the later showed a 6% contraction owing to lower earnings from export of coffee, oilseeds, fruit and vegetables among other products (PSI, 2021). Especially, data for GTP II period (2016-2019) marked by a decline in the achievement of planned export targets. This was due to a recent decline in cereal, oil seed and some horticultural crops output as discussed earlier including displacement due to internal war and, Covid-19 effect, desert locust damage and other challenges facing the country. In every other year, either revenue or quantity drops or rises which relates also to the rise and fall of pulses and oilseeds production areas against a corresponding opposite change in cereal acreage. However, the results present a cheerful picture of the agricultural growth performance of the country over the last fifteen years which however is being seriously challenged and demands strategic investment and intervention to reverse some of the negative courses.

Trend in Total Factor Productivity (TFP) growth

A significant higher result in 1st scenarios showed that the importance of primary inputs (i.e. land, labor and capital) in the TFP changes during the studied years. TFP analysis revealed a 7.6% average annual growth in real crop output in fifteen years, and increased use of all inputs contributed the highest, about 5.7%. However, the similarity of TFP changes in the 2nd and 3rd scenarios owing to the relatively small role of irrigation and agriculture services over the intermediate inputs during the period. Moreover, the analysis in the last scenarios shows that an average annual growth change in TFP of 1.7% indicating increments of annual TFP growth changes from 2004/05 to 2018/19. Contribution of chemical fertilizer (2.07%) was followed by labor (1.74 %) and improved seed (1.14 %). The results reflect a considerable investment in raising input such as improved seed and fertilizer through intensive extension has occurred during and after the PASDEP period. However, the annual average TFP growth was leading in GTP-I (0.66%) followed by GTP-II (0.46%) and PASDEP (0.4%) using scenario IV. In general, the performance in terms of the contribution of TFP to output growth was very good in the crop sector, nevertheless the decline in annual TFP crop growth rate over the last periods depicts a clear signal for quick policy adjustment to maintain and further boost in crop output growth. The results of the growth accounting analyses not only show the importance of labor and land in the output growth recorded during the period, but also indicate the growing importance of technologies as modern inputs and agricultural extension services. Relative to the contribution of labor and land, modern inputs contribute more to crop growth showing the increasing importance of pushing up productivity for these factors than the limited land for example which kept declining its contribution throughout the period. The contribution of technological factors has increased over time. This is also the case for the area covered by extension packages. The contribution of the set of inputs was progressive and higher during GTP-I period relative to the PASDEP or the GTP-II while the reverse held true particularly for land and labor, which did not improve over 15 years. In general, input wise, the results were more revealing showing that intermediate inputs such as fertilizer and improved seed had relatively higher growth in input and raised TFP indices during the period 2009/10-2013/14. The performance in terms of the contribution of TFP to output growth was very good in the crop sector with the recent decline giving a clear signal for quick policy adjustment to maintain and further boost crop output growth.

The result further shows that crop output increases were mainly driven by strong yield growth and increases in labor use, chemical fertilizer, TFP, area under improved seed together form the major crop growth drivers that accounted for 74% of the growth in total real crop output and 21% accounted for cultivated land, rural road, and RTS together. These results are different from earlier reports (Nisrane, 2015; WB, 2015). Real crop output growth achieved through increase in labor

force deployed to agriculture, area covered by modern agricultural technologies (the use of chemical fertilizer and improved seed) and increment in TFP. In other words, cultivated land expansion contribution to real crop output was low. Furthermore, change in capital, extension service, area coved by pesticides, and irrigated cover accounted only the remaining 5.0% of the growth in output during 2004/05 to 2018/19. Average total factor productivity growth obtained was 1.7% per year which is lower than earlier reports of growth of 3.4 per cent during 2004-2014 (WB, 2015).

CONCLUSION

The Ethiopian economy showed unprecedented record of average annual growth of 10.9 per cent between 2004 - 2014 and a 9.3% growth during 2013/14 - 2017/18 and declined to 6.5% in 2019/20 as estimated just before the outbreak of the Covid-19 Pandemic. Agricultural GDP declined from 7.0% (during PASDEP and during the Growth and Transformation Period-I or GTPI) to 4.1 in GTPII (four years average). This growth changes very well correspond to cereals production growth of 10% and productivity by 7.2% per year for the last fifteen years. This is understandable since crop share of the agricultural GDP ranges between 65-70% during the same period (NBE, 2018). Cereals accounted for about 83% of the total crop output in 2018/19 with no relative change compared to its share in 2004/05. During this period the total crop area increased by 2.8 million hectares, but persistently declining from gain of 4.08 to mere 0.48 % in fifteen years, but with average rate of 2.12 % increase per annum. The land fragmentation continues but at slower rate but will persist imposing more challenge to agricultural productivity growth in the future.

Individual crop growth performance varied widely. Productivity increase for crops like maize, wheat, sorghum, soybean, chickpea and tef is remarkably high for the whole period. However, productivity progress in high value crops such as sesame, cotton, fruits and vegetables was not remarkable because these crops did not receive better input and crop management to boost productivity. Yield levels of indigenous crops like tef, sunflower, neug, linseed, coffee, sorghum, barley has remained small, although relative increase is high because of starting from already low yield levels. The differential productivity progress indicates lack of farming system based strategic interventions that extends beyond food security interests to indigenous and high value crops (both grain and horticulture). Therefore, not enough technological options were provided to bring the desired change in crop output growth. Crop growth achievements in the PASDEP period was better than both GTP periods. Growth during GTPII is far less than previous plan-periods achievements and compared to the set targets and ranged only between 9 and 24 % of the goal set for cereals, pulses and oil crops. Technological interventions had big impact on crop output growth but the desired shift to diversify to high value crops and export commodities did not occur meaningfully. The GTPII plan period crop output decline is triggered mainly due to the El Niño caused droughts of 2015-2016 and its aftermath, and other factors such as political unrest and internal conflicts, reduced input use and the COVID-19 pandemic. The current crop productivity levels allowed farmers to sale out only 17-18% of their grain produced, which is low and strongly urges the need for change through better intervention strategies. The main drivers of crop output growth over the 15 years study period have primarily been due to increased inputs such as labor and land, and technological inputs such as fertilizer, improved seeds, pesticide and irrigation in that order. The effect of improved seed and irrigation has been awkwardly low due to poor access to quality seed and too much dependance on rain. During this period total crop output grew on average by 7.56%. There was a significant growth in TFP with an average of 1.7 % per annum but with a declining trend across the successive development plan's periods. The more pronounced decline in TFP in the last period and less contribution of irrigation and agri-services deserve greater attention.

The results clearly showed the potential of the Ethiopian agriculture to grow and produce surplus for export of grain and horticulture products if properly guided with sufficient investment to diversify and intensify input such as improved seed, fertilizer, irrigation pesticide, extension and training and market access supports

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