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Research article

Trend, instability and decomposition analysis of coffee production in Ethiopia (1993–2019)

Assefa Ayele [a,*], Mohammed Worku [b], Yadeta Bekele [a]

[a] Department of Agricultural Economics and Agribusiness Management, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box 307, Jimma, Ethiopia
[b] Department of Horticulture and Plant Sciences, College of Agriculture and Veterinary Medicine, Jimma University, P.O. Box 307, Jimma, Ethiopia

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ABSTRACT

Measuring the trends of growth and variability in agricultural production is important to understand how outputs change over time. Ethiopia is the largest producer of coffee in Africa and the fifth in the world. Despite the abundant opportunities and continuous efforts made to enhance its production, it is often said that the productivity of Ethiopian coffee remains far below its potential. Yet, empirical data on the status of coffee production over time in Ethiopia is scant. We, thus, analyzed the trend, instability, and decomposition of coffee production in Ethiopia for three periods, i.e., the entire period (1993–2019), the pre-Agricultural Growth Program period (1993–2010), and the Agricultural Growth Program period (2011–2019). In all three periods, harvested area and production showed an increasing trend while productivity showed a cyclical decreasing trend. The compound growth rates of harvested area (8.14%) and production (6.68%) in the 1993–2019 period were positive and significant at 1% level, whereas that of productivity (-0.45%) was not significant. Similarly, the compound growth rates of harvested area and production during pre-AGP (6.02 and 6.06%) and AGP (6.43 and 3.57%) were positive, but only significant during AGP, and that of productivity in both pre-AGP and AGP (0.19 and -1.6%) were not significant. Productivity was, however, more stable than harvested area and production during the entire and pre-AGP periods, while harvested area and production were more stable in AGP than in the other two periods. Besides, the harvested area effect on production differentials was substantial in all three periods, while productivity and productivity-harvested area interaction effects declined production during the entire and AGP periods. Overall, the results demonstrate that to enhance and sustain coffee production in Ethiopia, using improved varieties and agronomic practices can be a better option than expanding the cultivation area since land is scarce and fixed in supply.

1. Introduction

Achieving sustainable agricultural performance requires not only promoting agricultural growth but also reducing production instability. Agriculture, a key sector to ensure food security and maintain macroeconomic stability for many developing countries, including Ethiopia, is vulnerable to natural disasters, such as the occurrence of drought, erratic rainfall, and crop pests and diseases (Swain, 2014; FAO, 2021). This can result in production instability that in turn increases price instability and the vulnerability of low-income households to food insecurity, exposing them to market forces. This will in turn impact the food management and macroeconomic stability of a country (Chand and Raju, 2009; FAO, 2015).

Agricultural growth is crucial for the economic development of many developing countries. The policy for agricultural growth can be achieved through horizontal and vertical agricultural expansion, which respectively entails expanding the area of agricultural lands and introducing modern technologies that aid in increasing productivity (Pretty and Bharucha, 2014; El-Rasoul et al., 2020). However, producing more food on the existing land by using modern agricultural technologies is believed to be a better strategy than expanding the area of agricultural lands as it can lead to deforestation and land is a scarce resource with a fixed supply (Angelsen and Kaimowitz, 2001; Azadi et al., 2011; Laurance et al., 2014). Consequently, it is believed that advancing and using agricultural technology contributes to a more sustainable agriculture

* Corresponding author.
E-mail addresses: assefa.ayele50@gmail.com, ayele.assefa@ju.edu.et (A. Ayele).

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system that promotes continuous improvement of agricultural production.

However, many researchers working on agricultural production growth and variability, which are important indicators of the performance of agricultural production, reported contradictory findings that resulted in a great debate among scholars. Sen (1967) first looked at a causal link between agricultural productivity growth and instability and hypothesized that variability in production rises as cultivation expands to marginal land and the use of purchased inputs rises. However, Rao (1975) argued that productivity-based growth results in greater production variability because productivity variability is far greater than area variability. Later, Narain (1977) also questioned whether seed-fertilizer technology increases production and production variability or not. Similarly, some recent studies (e.g., Chand and Raju, 2009; Ayalew and Sekar, 2016; Ikuemonisan et al., 2020; Sadiq et al., 2020) that examined the impacts of cultivation of additional marginal land and adoption of improved technologies on crop production variability showed less production variability due to adoption of modern technology and/or marginal land expansion, while others (e.g., Mahir and Abdelaziz, 2011; Hemant, 2015; Deb and Soumitra, 2015) reported the opposite.

Agriculture plays a key role in the Ethiopian economy, contributing to over 35.8% of the Gross Domestic Product (GDP), almost 90% of exports, about 72.7% of employment, and 70% of the country's raw material requirements for industries (FAO, 2019). In the 2018/19 marketing year, the country earned 2.3 billion USD from agricultural exports (USDA, 2020). However, the share of agriculture in the country's economic growth in recent years has steadily been declining as compared to those of other sectors. In the 2018/19 marketing year, for example, the share of agriculture in real GDP growth (3.8%) was lower as compared to 11 and 12.6% in the service and industrial sectors, respectively (NBE, 2019). The coffee industry in Ethiopia dominates the agriculture sector in its contribution to the national economy in general and exports in particular (Birhe, 2010). Coffee in Ethiopia accounts for 4–5% of GDP, 10% of total agriculture production, 40% of total exports, 10% of total government revenue, and 25–30% of total export earnings (Worku, 2019). Coffee exports of the country generated 811.7 million USD in the 2014/2015 marketing year (Tefera and Francom, 2016) and over 25% of the population of the country are directly or indirectly engaged in the production, processing, trading of coffee and deriving a significant part of their livelihoods from coffee (EBI, 2014; Feleke, 2018). Moreover, Ethiopia is the largest producer of coffee in Africa and the fifth in the world, next to Brazil, Vietnam, Colombia, and Indonesia, contributing to about 4.2% of the global coffee production (ICO, 2016), which is very low compared to the aforesaid countries.

Despite the abundant opportunities in the country for increasing coffee production and productivity, such as a suitable growing environment and an adequate labor force, the country's average coffee productivity (0.71 t/ha) is consistently lower than that of other coffee-producing countries, such as Brazil (0.78 t/ha), Vietnam (1.31 t/ha) and Colombia (0.76 t/ha) (FAOSTAT, 2020). This could be due to several factors, which include biotic factors (e.g., diseases and pests), climatic factors (e.g., recurrent drought and rainfall fluctuation), low soil fertility (Fekede and Gosa, 2015; Jima et al., 2017; Tadesse et al., 2020) and traditional coffee management (lack and slow adoption of improved coffee varieties and agronomic practices) (Jezeer et al., 2018; Amarasinghe et al., 2015). About 90% of the Ethiopian coffee is produced by smallholder farmers on less than 2 ha of land by using a traditional coffee management system (Worku, 2019).

To address the problem of this low productivity of coffee, the Ethiopian government has often included the coffee sector while implementing different agricultural reform programs to improve the agricultural productivity of the country. The Agricultural Growth Program (AGP) that began in 2011 with the overall goal of improving agricultural productivity and market access for key crops and livestock products, including coffee, is one of the reform programs. It is a multifaceted policy program that includes (1) strengthening the capacity of the farmers' organizations and service providers of the farmers, (2) strengthening processing and marketing of agricultural commodities through the engagement of the private sector, and (3) development and management of small-scale rural infrastructures that can increase productivity, value-chain efficiency, and market access of agro-products (Berhane et al., 2013). Under this AGP, various coffee improvement programs and projects (e.g., Coffee Improvement Program, AGP–Agribusiness and Market Development, TechnoServe Coffee Initiative, Ethiopian Coffee Development Program, and Agricultural Value Chains Project) have been implemented. Some of the major activities done by these programs and projects include the establishment of coffee nurseries and pulping stations, training and support of farmers in improved coffee management practices, expansion of cultivation, the establishment of coffee quality control systems and inspection centers, the establishment of coffee marketing and traceability systems, market promotions, and providing innovative grant support to farmers, and other stakeholders of the coffee sector (UNIDO, 2015). Coffee cultivated land has expanded by 97.4% in the AGP period (between 2010 and 2019) (CSA, 2019).

Despite these efforts, coffee productivity during the AGP period has been below expectations. This could be due to a lack of political leadership at all levels; poor monitoring, financial management, and procurement (including contracting of consultants) practices; planning and coordination; and, related to coordination, weak extension/research linkages (Kassa and Alemu, 2016; Debele et al., 2019; Gebremariam et al., 2021). For instance, the amount of coffee produced by smallholder farmers in the 2014/15 cropping years was only 60.8% of the first five-year average target of AGP (i.e., 690.6 thousand tonnes with a productivity of 0.75 t/ha) and the productivity was projected to reach 1.1 t/ha by 2019/20 (NPC, 2016). But, the AGP effects on the production and productivity of coffee have not been examined so far. Furthermore, empirical data on Ethiopian coffee production over the years is scant, although there is a long history of coffee production in Ethiopia and coffee is an important agricultural commodity for the country's national economy. However, analyzing the trends of growth and variability in agricultural production and the sources of its variability is important to formulate appropriate policies and strategies that can enhance sustainable agricultural production and develop a reliable future projection (Deb and Soumitra, 2015). Due to this, several studies (Pattnaik and Shah, 2015; Sharma et al., 2017; Jainuddin et al., 2019; El-Rasoul et al., 2020; Ikuemonisan et al., 2020) examined the trends in production growth and variability of various crops in various parts of the world. The present study is, hence, aimed at estimating the growth rate and instability in harvested area, production, and productivity of coffee, and examining the contributions of harvested area and productivity and their interaction to the growth of coffee production in Ethiopia in the entire (1993–2019), pre-AGP (1993–2010) and AGP (2011–2019) periods.

2. Data and methodology

2.1. Data sources and the way of using the data

This study used time series data of the harvested area, production, and productivity of Ethiopian coffee from 1993 to 2019 (27 years of data) obtained from the FAOSTAT database. During this period, various economic reform programs were implemented in Ethiopia to boost the overall economic growth and transform the agriculture of the country. Agricultural Development Program (AGP) is one of the agricultural reform programs that has been implemented since 2011 and focuses on the production and productivity improvement of that livestock and crops including coffee important for the development of the country's economy. To assess the effect of the AGP reform program on the growth and instability of coffee production and productivity, we divided the data of each studied variable (i.e., harvested area, production, and productivity) in the entire study (pooled) period (1993–2019) into two datasets: (1) a pre-Agricultural Development Program implementation period (pre-AGP) (1993–2010) and (2) Agricultural Development Program implementation period (AGP) (2011–2019). Then, we used the three datasets (i.e., data of the pre-AGP period (1993–2010), AGP period (2011–2019) and the entire period (1993–2019)) for statistical analysis. We also compared the production and productivity of Ethiopian coffee with those of the four top coffee-producing countries in the world (i.e. Brazil, Vietnam, Colombia, and Indonesia) in the entire period.

2.2. Analytical framework

2.2.1. Estimation of growth rates

Linear growth rate (LGR) and compound growth rate (CGR) are two distinct approaches for estimating the growth rate in production. According to Dandekar (1980), the LGR has inherent limitations to the comparison of growth rates between periods. Avoiding seasonal and cyclical fluctuations in LGR estimation is not compelling, and the metric does not account for compound effects in time series data. Thus, it seems more appropriate to use the CGR for analyzing the growth rate in harvested areas, production, and productivity of coffee between the two periods. Based on the following formula given by Rehman et al. (2011), the CGR function is estimated by fitting a semi-log trend equation as follows:

$$Y = ab^t e \tag{1}$$

The CGR was obtained by transforming Eq. (1) to logarithmic form as below:

$$lnY = lna + t(lnb) + e \tag{2}$$

where Y is the harvested area (ha)/production (t)/productivity (t/ha); t is the period in the year; a is the constant; b = (1 + r) is the slope coefficient that measures the instantaneous relative change in Y for a given absolute change in the value of an explanatory variable; r is growth rate; ln is the natural logarithm, and e is the error term.

By multiplying the relative change in Y by 100, the percentage change or growth rate in Y for an absolute change in variable 't' will be obtained. The instantaneous rate of growth is also measured by the slope coefficient 'b'. Therefore, the CGR is then estimated using the following equation:

$$CGR = (antlog\ b - 1)*100 \tag{3}$$

The t-test at the 95% probability level was used to check whether there were statistically significant differences over the three studied periods (i.e., the entire, pre-AGP and AGP periods) in the harvested area, production, and productivity of coffee by setting a null hypothesis (H_0) (There is no trend in the growth rate in the harvested area, production, and productivity of coffee over studied times) and an alternative hypothesis (H_1) (There is a trend in the growth rate in the harvested area, production, and productivity of coffee).

2.2.2. Instability analysis

Agricultural instability in harvested area, production, and productivity can be measured by different methods. The three commonly used methods are coefficient of variation (CV), Cuddy -Della Valle Index (CDVI), and Coppock Instability Index (CII), each having their merits and demerits. Although these three methods overwhelmingly dominate the applications literature in measuring risk and instability of agricultural production, CV has been widely criticized because it overestimates instability, i.e., if CV is used to measure instability, a region with a constant rate of production growth will score a high level of instability. Several researchers (Bezabeh et al., 2014; Kumar et al., 2017; Bisht and Kumar, 2018; Baviskar et al., 2020) have applied the CDVI method to measure variability in time series data. Thus, the present study deployed CDVI to measure instability in coffee production in Ethiopia since it corrects the problem of CV, i.e., overestimation of the level of instability in time-series data by long-term trends. As against, CDVI attempts to de-trend the CV by using the coefficient of determination and showing the exact direction of the instability (Cuddy and Valle, 1978). A higher numerical value for the index represents greater instability and vice-versa. The CDVI is obtained from CV. According to Sandeep et al. (2016) and Ikuemonisan et al. (2020), CDVI to measure the variability in the time-series data can be calculated as:

$$CV = \frac{\text{standard deviation}}{\text{mean}} * 100 \tag{4}$$

According to Cuddy and Valle (1978), CDVI is estimated as follows:

$$CDVI = CV * \sqrt{1 - \overline{R}^2} \tag{5}$$

where, CV is the coefficient of variation in percent, and $\overline{R}^2$ is the coefficient of determination from a time-trend regression adjusted for its degrees of freedom.

2.2.3. Decomposition analysis

Any change in the production of a crop in physical terms depends fundamentally on the changes in the harvested area under the crop and its average productivity. A decomposition analysis model was used to measure the relative contribution of harvested area and productivity and the interaction of the two in total coffee production. As used by many researchers (e.g., Kakali and Basu, 2006; Dupare et al., 2014; Pattnaik and Shah, 2015; Verma et al., 2017; Sharma et al., 2017), the decomposition analysis in this study was performed by using the following equation:

$$\Delta P = Y_b \Delta A + A_b \Delta Y + \Delta A \Delta Y \tag{6}$$

where, ΔP = change in production = Pc-Pb; ΔY = Yc-Yb = change in productivity; ΔA = Ac-Ab = change in the area; Pb, Yb, and Ab are the production, productivity, and harvested area for the base year, respectively; and Pc, Yc, and Ac are the production, productivity and harvested area of coffee for the current year, respectively. The contributions of productivity, harvested area, and their interaction are estimated by applying the formula AbΔY/ΔP, YbΔA/ΔP, and ΔAΔY/ΔP, respectively.

3. Results and discussion

3.1. Trends of harvested area, production and productivity

As revealed in Figure 1, harvested area and production of coffee during 1993–2019 show a steeply increasing trend while coffee productivity shows a decreasing trend. There was the highest and the lowest productivity (0.52 t/ha, 0.92 t/ha) in 2000 and 2012, respectively. The corresponding coffee production in these years was 0.28 and 0.23 million tonnes, respectively. The decline of coffee productivity in 2012 coincided with the prevalence of coffee diseases (e.g., coffee berry disease, coffee wilt disease, and root rot disease) (The Economist, 2012) and erratic rainfall at the beginning of the rainy season (Davis et al., 2012) in major coffee-growing areas of the country. During the pre-AGP period (1993–2010), the harvested area and production of coffee exhibited two different trends; i.e., from 1993-2000 and 2006–2010 an increasing trend, and 2001–2005 a decreasing trend. Coffee productivity in the pre-AGP period exhibited a cyclical trend and it peaked in 2000. During the AGP period (2011–2019), except coffee production in 2012, both harvested area and production of coffee continually increased, but the productivity of coffee showed a decreasing cyclical trend with the lowest and the highest productivity in 2012 and 2014, respectively (Figure 1). The increase in coffee production during the AGP period, while there was a decline in coffee productivity, could be due to the expansion of coffee cultivation areas, which was one of the targets of the AGP program. For example, the average production and harvested area of coffee in the pre-AGP period were 0.23 million tonnes and 0.31 million hectares, respectively, but increased to 0.43 million tonnes and 0.64 million

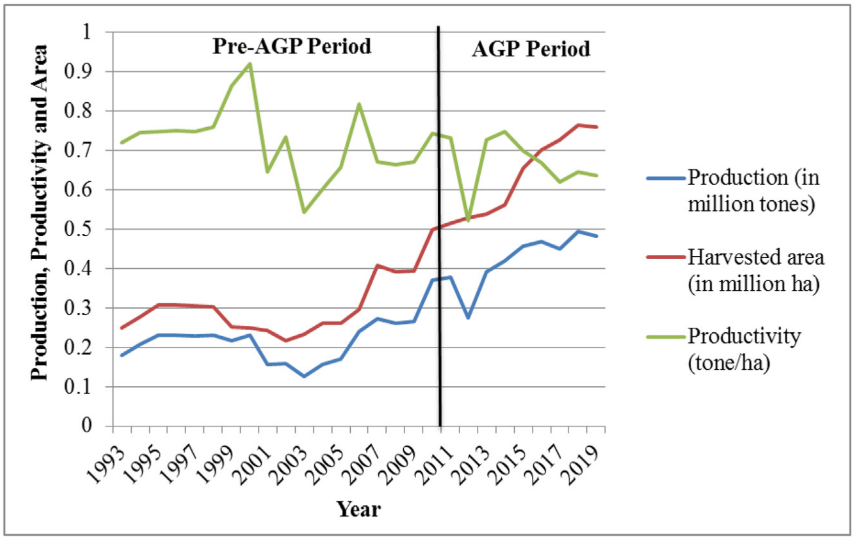

Figure 1. Trends in harvested area, production and productivity of coffee in Ethiopia for periods of 1993–2019; pre-AGP and AGP; authors' computation from FAOSTAT (2020).

Table 1. Compound growth rates (%) of harvested area, production, and productivity of Ethiopian coffee for the three study periods.

Study period	Harvested area (ha)	Production (t)	Productivity (t/ha)
Pre-AGP period (1993–2010)	6.02	6.43	0.19
AGP period (2011–2019)	6.06***	3.57**	-1.60
Entire period (1993–2019)	8.14***	6.68***	-0.45

and * indicate significant at 5% and 1% level, respectively.

hectares in the AGP period, whereas the average productivity decreased from 0.72 to 0.67 t/ha (FAOSTAT, 2020). Table 1 also confirms that there was a positive significant change in production and harvested area during the AGP period, but a negative insignificant change in productivity.

3.2. Growth rates of harvested area, production and productivity

The growth rate results of harvested area, production, and productivity of coffee estimated using the CGR in the three periods (i.e., pre-AGP period (1993–2010), AGP period (2011–2019) and entire period (1993–2019) are presented in Table 1. The growth rate of the harvested area during the pre-AGP and AGP periods were 6.02 and 6.06%, respectively, and only statistically significant for the AGP period at 1% level. The growth rates of coffee production during the pre-AGP and AGP periods were 6.43 and 3.57%, respectively, and the growth rate of coffee production for the AGP period was statistically significant at 5%. The growth rates of productivity in the pre-AGP and AGP periods were 0.19 and-1.6%, respectively, and they were not statistically significant. The growth rates of harvested area (8.14%) and production (6.68%) of coffee for the whole study period (1993–2019) were positive and statistically significant at 1% level. In contrast, the growth rate of productivity (-0.45%) in this period was not significant (Table 1). Moreover, coffee productivity reduction during the AGP period (i.e., 2011–2019) is unexpected. This is because various coffee productivity-boosting interventions (e.g., establishing coffee nurseries and pulping stations, training and assisting farmers in improving coffee management practices, and innovative grant support) have been implemented in this period (UNIDO, 2015).

The analysis of production and productivity of the top five world coffee-producing countries between 1993 and 2019 (Table 2) shows that the production of all countries increased, but that of Ethiopian coffee (0.30 million tons) was much lower compared to that of the Brazilian and Vietnamese coffees (1.73 and 1.55 million tons). Moreover, the productivity of Ethiopian coffee was reduced by 0.08 t/ha while that of Brazilian, Vietnamese, Colombian, and Indonesian coffees was increased by 1.08, 1.05, 0.22, and 0.07 t/ha, respectively. The productivity of Ethiopian coffee in 2019 (0.64 t/ha) was also much lower than that of Vietnamese (2.71 t/ha), Brazilian (1.65 t/ha), and Colombian (1.04 t/ha) coffees. There was, however, not much difference between the productivity of Ethiopian coffee and those of other top coffee-producing countries (except Vietnam) in 1993. The CGR value of Ethiopian coffee productivity (-0.45%) is also negative as opposed to those of the top four coffee-producing countries, although the CGR value of Ethiopian coffee production (6.68%) is the highest next to Vietnam (54.87%) (Table 2). In general, these results show poor performance of Ethiopian coffee within the studied period as compared to that of the four top world coffee-producing countries; i.e., Brazil, Vietnam, Colombia, and Indonesia.

This low performance of Ethiopian coffee compared to that of the other top coffee producing countries could be due to several factors, but the lack of improved coffee production practices (e.g., improved

Table 2. Coffee production and productivity of the five major coffee-producing countries in the world.

Country	Production (t)			Productivity (t/ha)			CGR (%)	
	1993 (A)	2019 (B)	(B)- (A)	1993 (A)	2019 (B)	(B)- (A)	Production	productivity
Brazil	1278759	3009402	1730643	0.57	1.65	1.08	5.34	7.65
Vietnam	136100	1683971	1547871	1.66	2.71	1.05	54.87	2.46
Indonesia	438868	760963	322095	0.54	0.61	0.07	2.86	0.45
Colombia	818220	885120	66900	0.82	1.04	0.22	0.31	1.03
Ethiopia	180000	482561	302561	0.72	0.64	-0.08	6.68	-0.45

varieties, pruning, weeding, pesticides, and fertilizers) and adequate extension services, as well as infestations of diseases, are often mentioned in literature as the major ones. As per the World Bank report (2021), for example, nearly 80% of Ethiopia's one million hectares of coffee trees are under productive because coffee trees are not trimmed frequently enough. Even if several efforts such as AGP have been made so far, availability and adoption of improved coffee production practices and extension services are also still low in Ethiopia compared to in other coffee-producing countries (Fekede and Gosa, 2015; Kuma et al., 2017; Minten et al., 2019; Tadesse et al., 2020). As a result, more than 90% of Ethiopian coffee is still grown by smallholder farmers on less than two hectares of land by using a traditional coffee management system and rain-fed agriculture as opposed to the other top coffee producers like Brazil, Vietnam, and Colombia (GAIN, 2019; World Bank, 2021). For example, between 1995 and 2017, coffee productivity in Brazil and Vietnam increased by 30 and 100%, respectively, due to the utilization of advanced mechanization, selective crop breeding techniques, and irrigation technology (Sachs et al., 2019). Furthermore, a significant yield loss (up to 57%) due to infection by coffee diseases was reported in Ethiopia (Cerda et al., 2017).

On the other hand, the coffee productivity difference we have observed between these coffee-producing countries could also partly be due to the difference between the countries in the coffee types they are cultivating. For example, Ethiopia and Colombia cultivate only Arabica coffee, while Vietnam cultivates only Robusta coffee, and Brazil and Indonesia cultivate mainly Arabica and Robusta, respectively. Robusta is naturally more productive and disease resistant than Arabica, but it has less consumer preference and market price than Arabica (Worku, 2019). Thus, this finding will help coffee farmers in Ethiopia to compare their productivity performance to other countries. Evidence that their productivity is significantly lower than that of their counterparts in Brazil, Vietnam, Colombia, and Indonesia will undoubtedly encourage them to adopt global best management practices for optimal coffee production.

3.3. Instability of harvested area, production and productivity

The instability index for the harvested area, production, and productivity of Ethiopian coffee in the three study periods, i.e., the pre-AGP period (1993–2010), the AGP period (2011–2019) and the entire period (1993–2019), is presented in Table 3. The CDVI values of harvested area (20.65%), production (24.54%), and productivity (12.27%) of coffee were higher for the pre-AGP period than for the AGP period (4.60, 9.61 and 10.73%, respectively). This implies that the harvested area, production, and productivity of coffee in the pre-AGP period were more volatile and uncertain compared to the AGP period. Furthermore, the CDVI value of coffee production over the entire study period (1993–2019) (22.35%) shows that coffee production is relatively more uncertain than harvested area (20.42%) and coffee productivity (11.54%) over the same study period. These results generally show the existence of fluctuations in the harvested area, production, and productivity of Ethiopian coffee over the cropping years and different levels of fluctuation based on study period (pre-AGP, AGP, and entire period) and studied variables (harvested area, production, and productivity). There was also more fluctuation of the three studied variables in pre-AGP and the entire study periods compared to the AGP period, and of harvested area and production in pre-AGP and the entire study periods compared to productivity in the AGP period.

Table 3. Instability index for the harvested area, production, and productivity of Ethiopian coffee for the three study periods.

Study period	Instability index	Harvested area (ha)	Production (t)	Productivity (t/ha)
Pre-AGP period (1993–2010)	CV	24.50	25.93	12.51
	CDVI	20.65	24.54	12.27
AGP period (2011–2019)	CV	14.45	15.82	10.04
	CDVI	4.60	9.61	10.73
Entire period (1993–2019)	CV	43.70	40.15	12.40
	CDVI	20.42	22.35	11.54

3.4. Decomposition of production variability in coffee

The relative contributions of harvested area, productivity, and their interaction effects on the total coffee production variability of coffee production growth are presented in Table 4. The result reveals that an increase in coffee production during the pre-AGP period (1993–2010) was mainly due to harvested area, with a contribution of 93.93%. However, the contribution of productivity (3.04%) and the interaction effect between harvested area and productivity (3.03%) for coffee production growth was very small. Only the harvested area effect had a positive contribution to coffee production growth in the AGP period (2011–2019) and the entire study period (1993–2019), and it was the highest of all the remaining effects in all three study periods. It respectively contributed to about 167.62 and 121.01%, while the productivity effect and interaction effect between harvested area and productivity respectively were -45.99 and -21.63% for the AGP period and -6.93 and -14.09% for the entire study period (1993–2019) (Table 4).

4. Conclusion and policy options

The study analyzed the trend, instability, and decomposition of coffee production in Ethiopia for the period of 1993–2019. The findings of our study revealed that harvested area production of Ethiopian coffee during 1993–2019 showed a steeply increasing trend, each with a positive and significant compound growth rate. But, productivity showed a decreasing cyclical trend, with a negative compound growth rate (-0.45%), showing the poor performance of Ethiopian coffee in productivity over this study period. There were also similar results for the pre-AGP (1993–2010) and AGP (2011–2019) periods, but the compound growth rates of harvested area and production were not significant in the pre-AGP period. The increase in coffee production in all three study periods is, therefore, due to the increase in cultivation area. However, the contribution of harvested area to production increase during the AGP period (167.62%) was much higher than during the pre-AGP period (93.93%) and the entire study period (121.01%). In addition, the high contribution of harvested area for production (167.62 and 121.01%) compensated for the negative effects of productivity (-45.99 and -6.93%) and the interaction between productivity and harvested area (21.63 and -14.09%) on production in the AGP and entire study periods. In general, the harvested area, production, and productivity of coffee were more stable during the AGP period than during the pre-AGP and entire study periods, whereas during the pre-AGP and entire study periods, productivity was more stable than harvested area and production. This demonstrates the existence of fluctuations in all studied the variables (harvested area, production, and productivity) and the dependence of fluctuation on variable type and growing period. It also shows a significant contribution of AGP in reducing fluctuations in harvested area and production of coffee in Ethiopia, but not in productivity.

Table 4. Percentage contributions of harvested area, productivity, and their interaction towards changing Ethiopian coffee production over the three study periods.

Effects	Pre-AGP period (1993–2010)	AGP period (2011–2019)	Entire period (1993–2019)
Harvested area	93.93	167.62	121.01
Productivity	3.04	-45.99	-6.93
Interaction	3.03	-21.63	-14.09

If the trends of coffee productivity growth and the impact of interventions on coffee productivity continue in this way, the growth of coffee production in Ethiopia is expected to decline in the future. This is because the harvested area cannot be increased further since land is a scarce resource and is limited in supply. Therefore, government policy to focus primarily on interventions that can enhance coffee productivity (e.g. promoting best agronomic practices, adopting high-yielding and disease-resistant varieties, and enhancing extension services and research capacities) rather than expanding cultivation areas of coffee.

Declarations

Author contribution statement

Assefa Ayele: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Mohammed Worku: Performed the experiments; Analyzed and interpreted the data.

Yadeta Bekele: Analyzed and interpreted the data.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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