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# Trend of cereal crops production area and productivity, in Ethiopia

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**Although Ethiopia is endowed with diverse agro-ecologies suitable for cereal production, the success of the production relies more on climate condition. Therefore, this study is initiated to analyze the trends of; cereal crops production area and productivity in Ethiopia. Data of meher season cereal crops productivity (qt/ha) and area of production (ha) were collected from Central statistical Agency (CSA) of Ethiopia. Trend test was carried out using the non-parametric Mann-Kendall's trend test packaged in XLstat. The result of this study indicated that the area of cereal crops production for teff, wheat, maize, finger millet and rice showed significant increasing trend. But only sorghum production area indicated non-significant increasing trend. Moreover, Barley indicated non-significant decreasing trend. Moreover, the productivity of all cereal crops indicated significant increasing trend, except rice which decreased non-significantly. Productivity of Barley significantly increased despite non- significant decreasing production area. Similarly, productivity of Oat's significantly increased despite significant decreasing production area; while the productivity of the rest crops (teff, wheat, maize, finger millet and rice) increased significantly with significant increasing trends of production area. However, differently from the others: Productivity of sorghum significantly increased despite non-significantly increasing area of sorghum production.**

**Key words:** Cereal crops, trend Analysis, area of production and productivity.

## INTRODUCTION

Agriculture is the fundamental driver for Ethiopia's economy and long-term food security as it offers about 80-85% of employment, more than 61% of the total export and 38.5% of gross domestic product of the country (Degaga and Angasu, 2017). Ethiopia has diverse agro-ecology that permits different agricultural systems and production of different crops. The existence of this diverse agro-ecology together with diverse farming systems, socio-economic, cultures and climate zones provided Ethiopia with various biological wealth of plants, animals, and microbial species, especially crop diversity (Atnaf et al*.,* 2015).

Cereals are the most important food crop which provides daily food calories to people. Hence, cereal production and marketing are the means of livelihood strategy for millions of smallholder households in Ethiopia (Taffesse et al*.,* 2012). Teff, wheat, maize, sorghum and barley are the major cereals that occupy almost three-

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quarters of the total area cultivated (Taffesse et al*.,* 2012), and households spend an average of 40% of their total food budget on cereals (GAIN, 2014). Cereals are the major food crops for ensuring food security in Ethiopia as they constitute the major component of staple diet for majority of the population and contribute approximately 70% of the average Ethiopian calorie intake (Solomon, 2011). The 2004/2005 National Survey of Consumption Expenditure indicated that maize accounted for 16.7% of the national calorie intake followed by sorghum (14.1%) and wheat (12.6%) in descending order (Berhane et al., 2011).

In Ethiopia, wheat grain is used in the preparation of different traditional as well as modern processed food products such as injera and other industrial processed products like pasta and macaroni (Nigussie et al., 2015). Wheat is one of the most important food grain crop; people use the grain for food utilization in different forms like bread, porridge, soup and roasted grain ("*Kolo"), enjira,dabokolo, nifro, tella, arki.* In addition, farmers use wheat grain for marketing (selling purpose) to generate income and cover other required costs. Its straw is also important for animals feed, thatching house roof and bedding. Wheat with low yield leads to wheat varieties with low yield, moisture stress, and wheat rust disease (Arega and Setu, 2014).

Barley (*Hordeum vulgare* L.) is an important crop in Ethiopian cereal production and in food security (Berhanu et al., 2005). Food barley is principally cultivated in the highland areas of Ethiopia where the highest consumption is in the form of various traditional foods and local beverages from different barley types (Zemede, 2000). Teff (Eragrostis tef (Zucc.) Trotter) is a small-grained cereal that has been grown as food crop in East Africa for thousands of years (D'Andrea, 2008). It is a staple food for the majority of the population in Ethiopia and Eritrea. Teff is adapted to a large variety of environmental conditions and widely grown from sea level up to 2800 m above sea level (a.s.l.) under various rainfall, temperature, and soil conditions (Seyfu, 1997). The average teff grain yield of 1228 kg/ha (Anonymous, 2010) is low compared to other cereals, which is attributed to nutrient limitations, drought and water logging (Tulema et al., 2005).

Farmers using improved cultivars and management practices, however, can obtain yields up till 2500 kg/ha (Tefera and Belay, 2006), while the yield potential under optimal management and when lodging is prevented, is as high as 4500 kg/ha (Teklu and Tefera, 2005). Finger millet (*Eleusine coracana* (L.) Gaertn) subspecies *coracana* belongs to the family Poeceae (Hilu et al., 1976). The archaeological findings of finger millet from Ethiopia date to about the third millennium BC (Hilu et al., 1979). The crop is mainly grown in the northern, north western and western parts of the country, especially during the main rainy season.

The national annual production area of finger millet in 2016/2017 cropping season is estimated at around 456,171 hectares, with a total production of 10.3 million quintals (CSA, 2017). In Ethiopia, the grain is used for making native bread, *injera*, porridge, cake, soup, traditional breakfast called "*Chachabsa*" malt, local beer, and distilled spirit (*Areki*) alone or in mixture with *teff*, maize and barley (Adugna et al., 2011; Wedajo, 2015). Its productivity is very low mainly due to shortage of improved varieties (Birhanu, 2015), weeds, insect (termite), diseases (blast), rat damage, shortage of rainfall worm attacks improper application of inputs (fertilizers and seed) and traditional management practices (Tefera and Adane, 2013). Ethiopia is the primary center of origin and center of diversity for sorghum. In lowland areas of Ethiopia, where moisture is the limiting factor, sorghum is one of the most important cereal crops planted as food insurance, especially in the lowlands of eastern Ethiopia and in the north and north-eastern parts of the country where the climate is characterized by unpredictable drought and erratic rainfall (Degu et al., 2009).

Maize is one of the most important cereals broadly adapted worldwide (Christian et al., 2012). In Ethiopia, it is grown in the lowlands, the mid-altitudes and the highland regions. It is an important field crop in terms of area coverage, production and utilization for food and feed purposes. However, maize varieties mostly grown in the highlands at an altitude ranging from 1,700 to 2,400 m.a.s.l of Ethiopia are local cultivars with poor agronomic practices (Beyene et al., 2005). In Ethiopia, its total annual production and productivity exceeds all other cereals (23.24% of 13.7 Million tons), and second after tef (*Eragrostis tef*) in area coverage (16.12% of the 8.7 000 000 ha); maize is one of the most important crops grown in Ethiopia (Wende et al., 2007).Rice is currently considered as a strategic food security crop in Ethiopia (Teshome and Dawit, 2011). Relatively, it has higher productivity as compared to other main staple crops. It can be used in a range of traditional food recipes. It provides by-products such as straws and husks that are fed to livestock and/or used as an alternate source of fuel (Dawit, 2015). Oat (Avena sativa) is widely utilized in the highland farming system of Ethiopia. One of the bottlenecks of livestock production in Ethiopia is feed shortage. Integration of food and forage crops is a useful practice in area where both crop and livestock farming are simultaneously practiced (Leulseged et al. 1986). Ethiopia is endowed with diverse agro-ecologies suitable for cereal production. Cereals crop productions in Ethiopia were under rain fed production system. However, the success of this production system relies more on climate condition. The facts about land use at the national level have potentially imposed limits on the areas sown as a major source of increase in production. This causes inverse relationship between area and production because expansion area which is unsuitable for agriculture. Therefore, this study is initiated to analyze

**Table 1.** Average area of cereal production for 2007-2018.

| Year | Teff | Barley | Wheat | Maize | Sorghum | millet | Oats | Rice |
|---|---|---|---|---|---|---|---|---|
| 2007 | 2404674 | 1019314 | 1473917 | 1694522 | 1464318 | 374072 | 32798 | 39376.85 |
| 2008 | 2565155 | 984943 | 1424719 | 1767389 | 1533537 | 399268 | 30556 | 24434 |
| 2011 | 2761190 | 1046555 | 1553240 | 1963180 | 1897734 | 408110.3 | 30858.76 | 29866.16 |
| 2012 | 2731112 | 951993.2 | 1437485 | 2054724 | 1923717 | 432561 | 30568.39 | 30649.3 |
| 2013 | 2730273 | 1018753 | 1627647 | 2013045 | 1711485 | 431506.9 | 26514.1 | 41811.25 |
| 2014 | 3016522 | 1019478 | 1605654 | 1994814 | 1677486 | 454662.3 | 35617.76 | 33819.65 |
| 2015 | 3016063 | 993938.7 | 1663846 | 2114876 | 1834651 | 453909.4 | 27899.64 | 46832.21 |
| 2016 | 2866053 | 944401.3 | 1664565 | 2111518 | 1854711 | 465508.3 | 22105.72 | 45454.18 |
| 2017 | 3017914 | 959273.4 | 1696083 | 2135572 | 1881971 | 456171.5 | 24040.94 | 48418.09 |
| 2018 | 3023284 | 951993.2 | 1696907 | 2128949 | 1896389 | 456057.3 | 25896.22 | 53106.79 |

Source; CSA 2007,CSA 2008, CSA 2011, CSA 2012, CSA 2013, CSA 2014,CSA 2015, CSA 2016, CSA 2017, CSA 2018

trends of; cereal crop production area and productivity in Ethiopia.

## MATERIALS AND METHODS

Data of *meher* season for cereal crops productivity (qt/ha) and area of production (ha) in Ethiopia for the period 2007-2018 were collected from Central Statistical Agency (CSA). Trend test was carried out using the non-parametric Mann-Kendall's trend test which is less sensitive to outliers and test for a trend in a time series without specifying whether the trend is linear or non-linear (Partal and Kahya, 2006; Yenigun et al., 2008; Hadgu et al.,2013). The Mann-Kendall's test statistic is given as:

$$S = \sum_{i=1}^{N-1} * \sum_{j=i+1}^{N} sgn\left(x_j - x_i\right) \quad (1)$$

Where S is the Mann-Kendal's test statistics; $x_i$ and $x_j$ are the sequential data values of the time series in the years *i* and *j* (*j* > *i*) and *N* is the length of the time series. A positive *S* value indicates an increasing trend and a negative value indicates a decreasing trend in the data series. The sign function is given as,

$$sgn(x_j - x_x) = \begin{cases} +1 \; if & (x_j - x_i) & > 0 \\ 0 \; if & (x_j - x_i) & = 0 \\ -1 \; if & (x_j - x_i) & < 1 \end{cases} \quad (2)$$

The variance of *S*, for the situation where there may be ties (that is, equal values) in the *x* values:

$$\mathrm{var}(S) = \frac{1}{18}\left[N(N-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i - 1)(2t_i + 5)\right] \quad (3)$$

Where, *m* is the number of tied groups in the data set and $t_i$ is the number of data points in the $i^{th}$ tied group. For n larger than 10, $Z_{MK}$ approximates the standard normal distribution (Partal and Kahya, 2006; Yenigun et al., 2008) and computed as follows,

$$Z_{MK} = \begin{cases} \frac{S-1}{\sqrt{var\,(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \frac{S+1}{\sqrt{var\,(S)}} & if \quad S < 0 \end{cases} \quad (4)$$

The presence of significant trend is evaluated using the $Z_{MK}$ value. In a two-sided test for trend, the null hypothesis *Ho* should be accepted if $Z_{MK} < Z_{1-\alpha/2}$ at a given level of significance. $Z_{1-\alpha/2}$ is the critical value of $Z_{MK}$ from the standard normal table.

## RESULTS AND DISCUSSION

Sen's slope value in Tables 1 to 4 indicated that the country level area of cereal crops production for most of the cereal crops showed significant (P < 0.05) increasing trend by different factors (63718.13, 27651.44,37924.15, 10262.44, 3091.988) ha/year for teff, wheat, maize, finger millet and rice respectively for 2007-2018 production year. But only sorghum production area indicated non-significant (P = 0.108) increasing trend. Oats and barley production area have indicated decreasing trend. Oats production area indicated significant (P = 0.047) decreasing trend by factor of -816.39 ha/year. In contrary, barley indicated non-significant (P = 0.127) by the factor of -7505.08 ha/year.

Sen's slope value in Table 4 indicated that the country level of all cereal crops production in Ethiopia showed significant (P < 0.0001) increasing trend by different factor from 2004- 2018 production period, except rice productivity that indicated non-significant (P = 0.15) decreasing trend. Productivity of barley significantly increased despite non- significant decreasing production area. Similarly productivity of oat's significantly increased despite significant decreasing production area; while the productivity of the rest crops (teff, wheat, maize, finger millet and rice) increased significantly with significant increasing trends of production area. However, differently from the others, productivity of sorghum significantly increased despite non-significantly increasing area of sorghum production.In general, the analyses of this study have indicated increasing trends of production area for most the cereal crops in Ethiopia. In agreement with this result, MEDaC (1999) indicated that in Ethiopia, changes in areas sown constitute the major sources of production

**Table 2.** Average yield of cereal production for 2007-2018.

| Year | Teff | Barley | Wheat | Maize | Sorghum | Millet | Oats | Rice |
|---|---|---|---|---|---|---|---|---|
| 2007 | 10.14 | 13.27 | 16.71 | 22.29 | 15.82 | 12.95 | 11.05 | 28.58 |
| 2008 | 11.67 | 13.76 | 16.25 | 21.22 | 17.34 | 13.47 | 11.97 | 29.19 |
| 2011 | 12.62 | 16.28 | 18.39 | 25.4 | 20.87 | 15.56 | 15.41 | 30.27 |
| 2012 | 12.81 | 16.72 | 20.29 | 29.54 | 20.54 | 15.07 | 16.18 | 28.91 |
| 2013 | 13.79 | 17.49 | 21.1 | 30.59 | 21.06 | 17.2 | 16.46 | 28.95 |
| 2014 | 14.65 | 18.72 | 24.45 | 32.54 | 22.83 | 18.67 | 17.31 | 27.31 |
| 2015 | 15.75 | 19.65 | 25.43 | 34.31 | 23.69 | 20.17 | 18.21 | 28.16 |
| 2016 | 15.6 | 19.66 | 25.35 | 33.87 | 23.31 | 20.2 | 18.22 | 27.9 |
| 2017 | 16.64 | 21.11 | 26.75 | 36.75 | 25.25 | 22.3 | 20.46 | 28.09 |
| 2018 | 17.48 | 21.57 | 27.36 | 39.44 | 27.26 | 22.6 | 20.32 | 28.44 |

Source; CSA 2007,CSA 2008, CSA 2011, CSA 2012, CSA 2013, CSA 2014,CSA 2015, CSA 2016, CSA 2017, CSA 2018.

**Table 3.** Mann-Kendall Trend statistics for area of production for 2007-2018.

| Crop | $Z_{mk}$ | MK statistic(S) | alpha | Sen's slope | p-value |
|---|---|---|---|---|---|
| Teff | 0.73 | 33 | 0.05 | 63718.13 | 0.002 |
| Barley | -0.40 | -18 | 0.05 | -7505.08 | 0.127 |
| Wheat | 0.82 | 37 | 0.05 | 27651.44 | 0.000 |
| Maize | 0.77 | 35 | 0.05 | 37924.15 | 0.001 |
| Sorghum | 0.42 | 19 | 0.05 | 42621.42 | 0.108 |
| Finger millet | 0.77 | 35 | 0.05 | 10262.44 | 0.001 |
| Oats / ‘Aja’ | -0.51 | -23 | 0.05 | -816.39 | 0.047 |
| Rice | 0.73 | 33 | 0.05 | 3091.98 | 0.002 |

**Table 4.** Mann-Kendall trend statistics for yields of cereal crops for 2007-2018.

| Crop | Zmk | MK statistic(S) | alpha | Sen's slope | p-value |
|---|---|---|---|---|---|
| Teff | 0.95 | 43 | 0.05 | 0.76 | < 0.0001 |
| Barley | 1.00 | 45 | 0.05 | 0.91 | < 0.0001 |
| Wheat | 0.91 | 41 | 0.05 | 1.35 | < 0.0001 |
| Maize | 0.91 | 41 | 0.05 | 1.89 | < 0.0001 |
| Sorghum | 0.91 | 41 | 0.05 | 1.13 | < 0.0001 |
| Finger millet | 0.95 | 43 | 0.05 | 1.14 | < 0.0001 |
| Oats / ‘Aja’ | 0.95 | 43 | 0.05 | 0.90 | < 0.0001 |
| Rice | -0.37 | -17 | 0.05 | -0.10 | 0.155742 |

increase. This can be attributed to the domination ofsmall-scale farmers, characterized by low input and low output rain-fed mixed farming with traditional technologies. Small-scale farmers constitute over 95% of total area sown and over 90% of agricultural output (MEDaC, 1999). Despite the long history of agricultural research in Ethiopia, farmers in the country have benefited little from modern agricultural technologies. Currently, improved seed is used on only 2% of the country's cultivated area (Wolday, 2001). Cereal production is predominantly rain-fed and that fluctuations in rainfall from the long-term average are increasing (Webb et al., 1992). Modern inputs are unlikely to dominate the effect of weather on cereal production. According to Jaeger (1991), cereals are the most susceptible crop to moisture stress, and for most countries, variations in average yields of cereals result primarily from variations in weather. Moreover, the increase in the area cultivated is made possible by the expansion of cultivation to areas that were previously designated as permanent pasture or forests, or land previously categorized as unsuitable for farming. Forests covered 40% of the land area at the turn of the century, but less than 4% today (Alemu, 2002) (Figures 1 to 8).

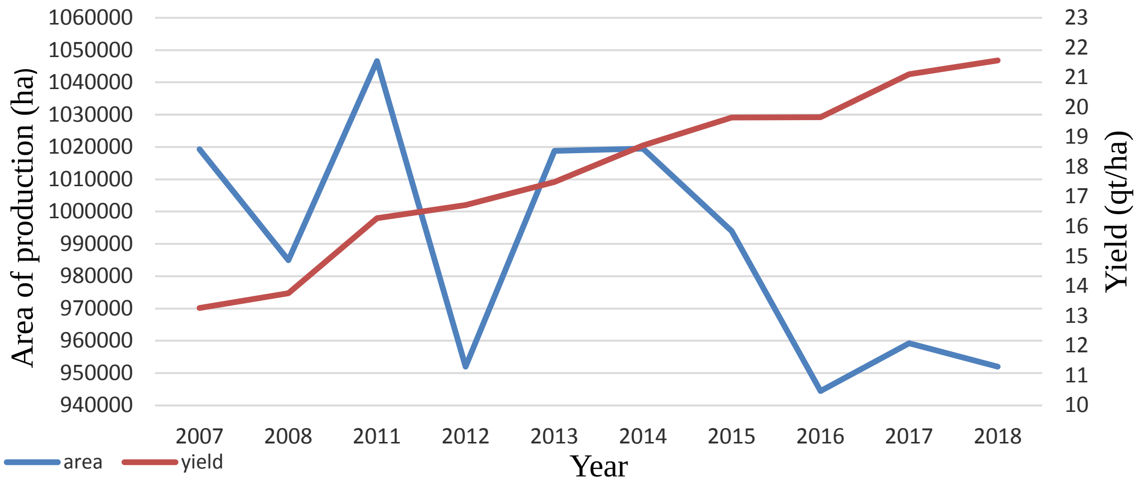


**Figure 1.** Barely production area and yield.

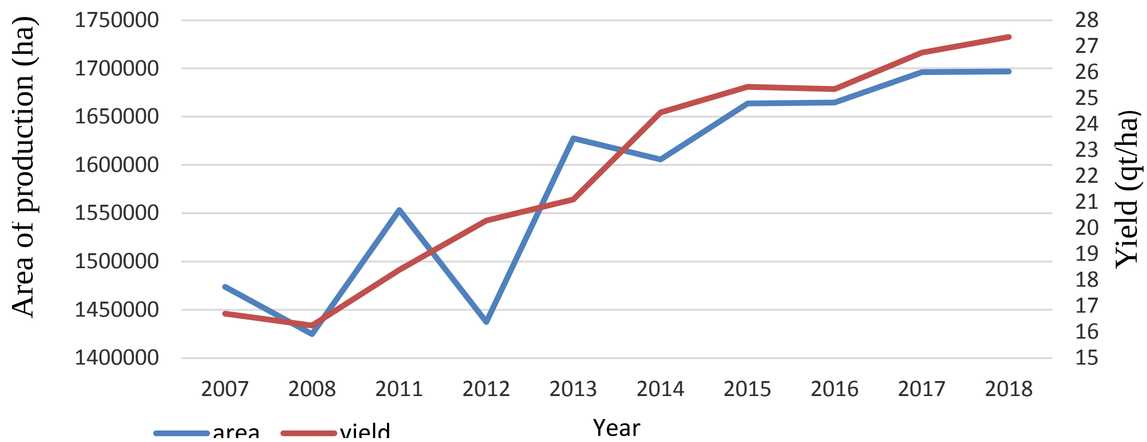


**Figure 2.** Wheat production area and yield.

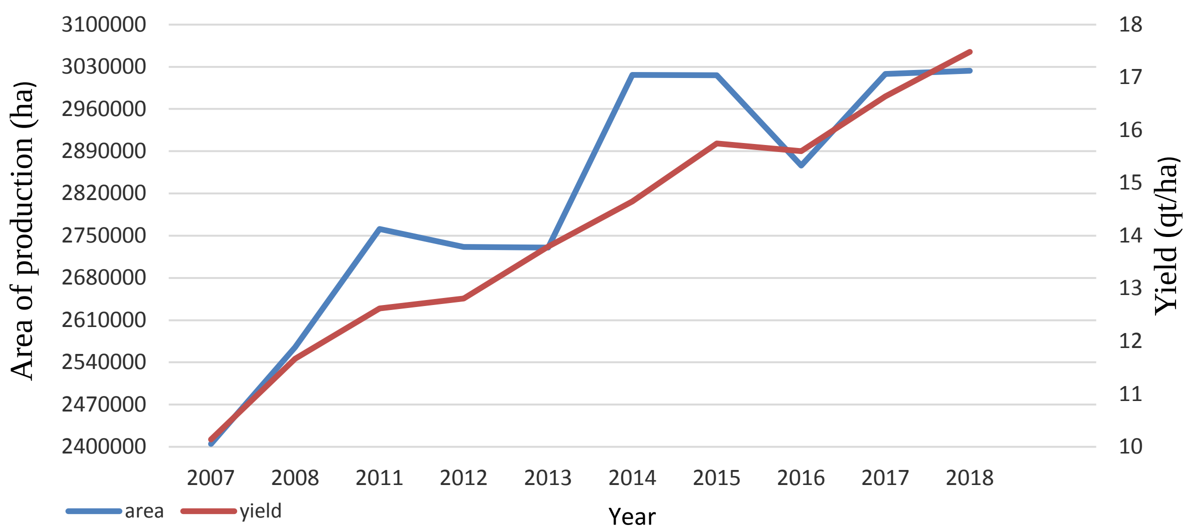


**Figure 3.** Teff production area and yield.

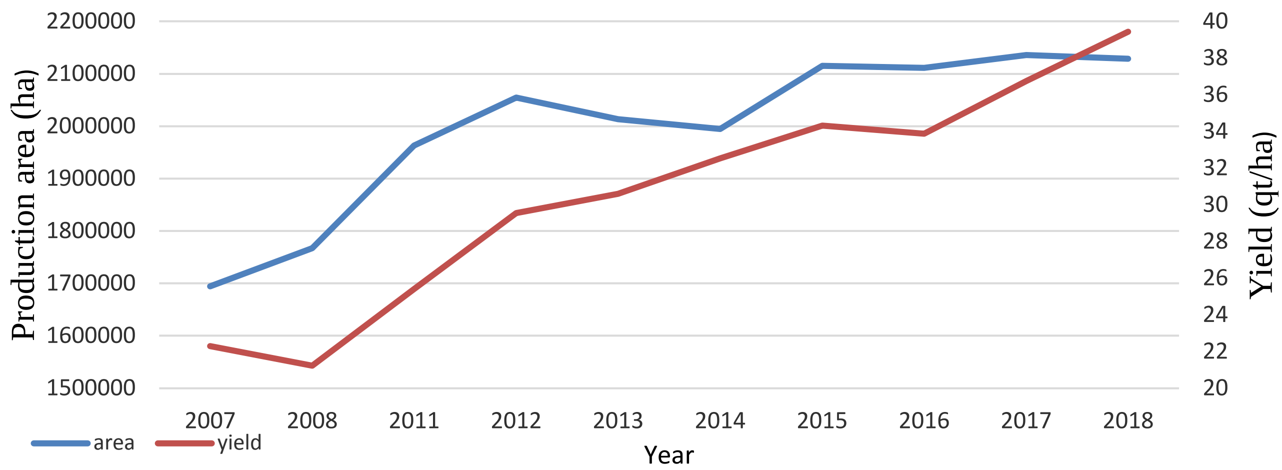


**Figure 4.** Maize production area and yield.

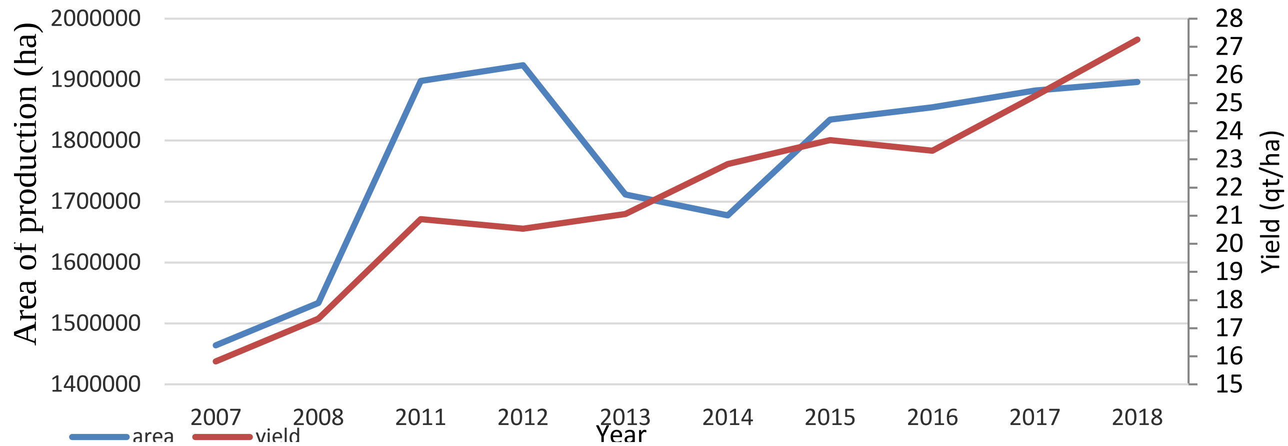


**Figure 5.** Sorghum production and yield.

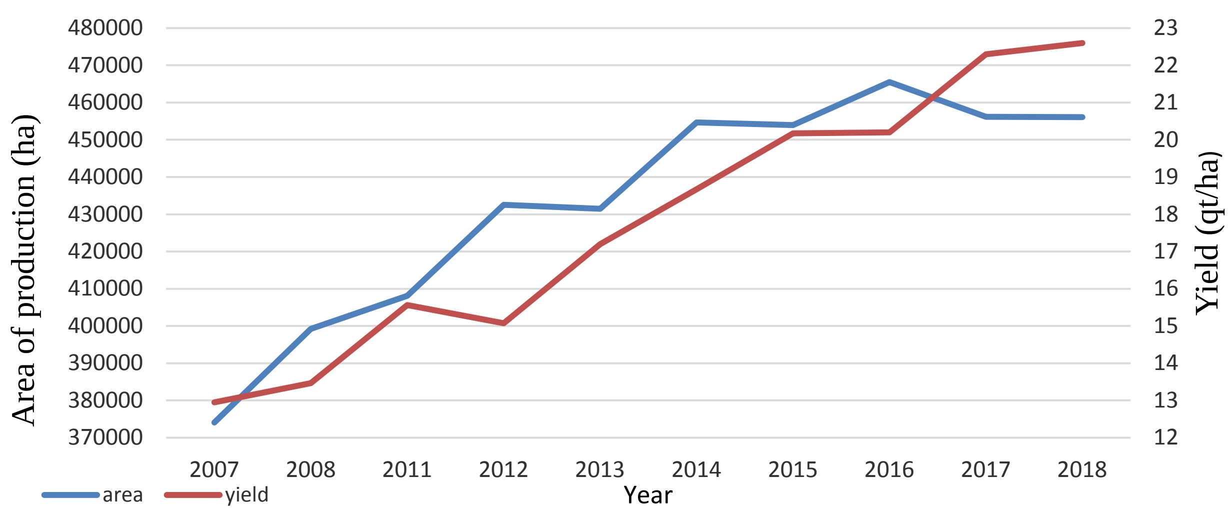


**Figure 6.** Millet production area and yield 2004-2018.

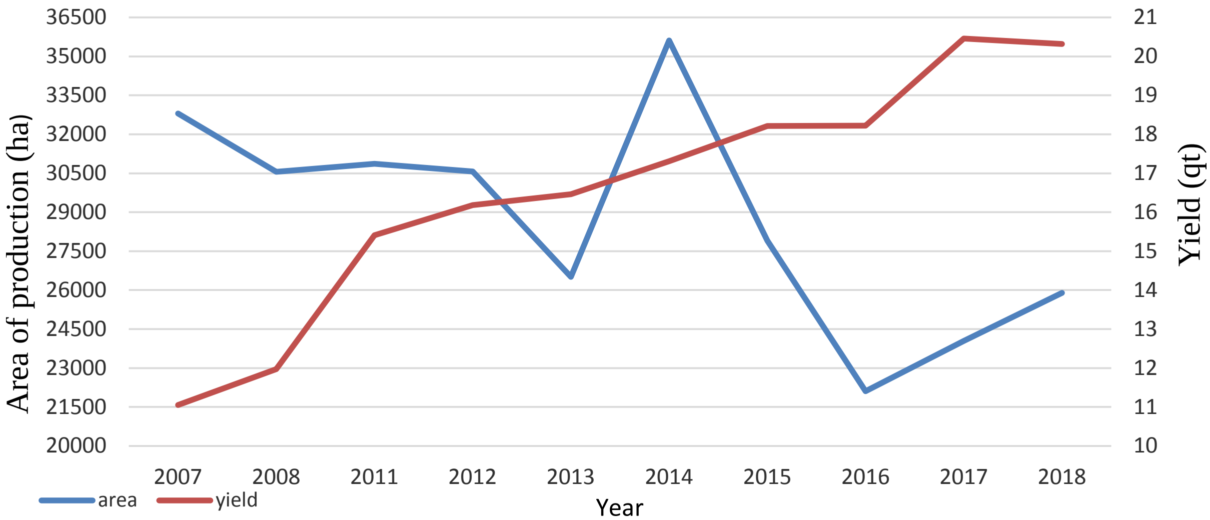


**Figure 7.** Oat's production areas and yield 2004-2018.

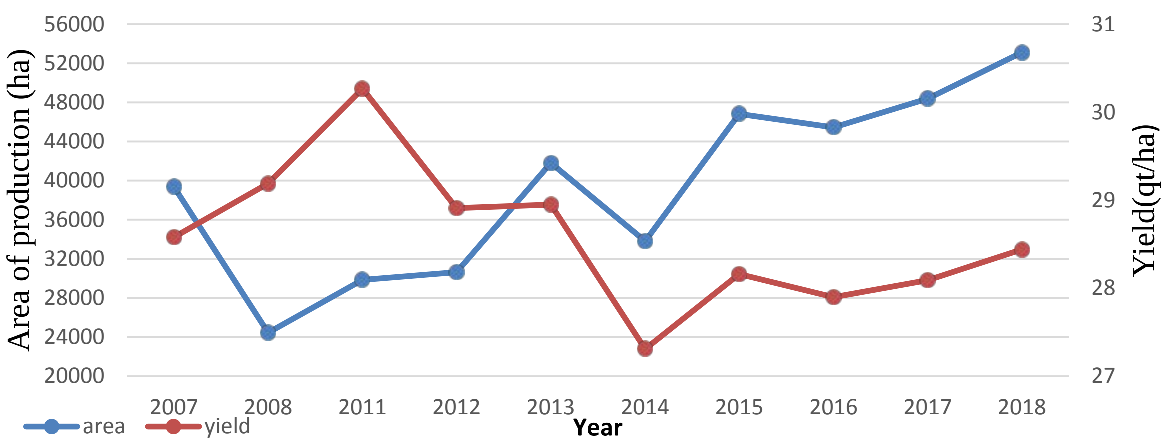


**Figure 8.** Rice production area and yields 2007-2018.

## Conclusion

Sen's slope analysis indicated that the country level area of cereal crops production for most of the cereal crops showed significant (P < 0.05) increasing trend by different factors (63718.13, 27651.44,37924.15, 10262.44, 3091.988) ha/year for teff, wheat, maize, finger millet and rice respectively for 2007 - 2018 production year. But, only sorghum production area indicated non-significant (P = 0.108) increasing trend. Oats and barley production area have indicated decreasing trend. Oats production area indicated significant (P = 0.047) decreasing trend by factor of -816.39 ha/year. But, barley was non-significant (P = 0.127) by the factor of -7505.08 ha/year.

The result of this study indicated country level of all cereal crops productivity in Ethiopia showed significant (P < 0.0001) increasing trend by different factor from 2007-2018 production years, except rice productivity which indicated non-significant (P = 0.15) decreasing trend. Productivity of barley significantly increased despite non-significant decreasing production area. Similarly, productivity of oat's significantly increased despite significant decreasing production area; while the productivity of the rest crops (teff, wheat, maize, finger millet and rice) increased significantly with significant increasing trends of production area. However, differently from the others, productivity of sorghum significantly increased despite non-significantly increasing area of sorghum production.

In general, the analysis of this study has indicated increasing trends of production area for most cereal crops in Ethiopia except barley and oats which showed decreasing trend. Moreover, productivity of all cereal crops showed significant increasing trend except rice which showed non-significant decreasing trend in Ethiopia for 2007-2018 production year.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

### REFERENCES


Anonymous (2010). Agricultural Sample Survey (2009/2010). Report on Farm Management Practices, Statistical Bulletin pp. 468-15. http://www.csa.gov.et/survey/Agricultural_Sample_Survery (January, 2011).

Adugna A, Tesso T, Degu E, Tadesse T, Merga F, Legesse W, Tirfessa A, Kidane H, Wole A, Daba C (2011). Genotype-by-environment interaction and yield stability analysis in finger millet (*Elucine coracana* L. Gaertn) in Ethiopia. American Journal of plant sciences 2(3):408-415.

Alemu ZG (2002). How successful the Agricultural Development Led Industrialization Strategy (ADLI) will be by leaving the existing landholding system intact? Economic Focus, a publication of the Ethiopian Economic Association 4(4).

Atnaf M., Tesfaye K., Dagne K (2015). The importance of legumes in the Ethiopian farming system and overall economy: An overview. American Journal of Experimental Agriculture 7(6):347-358. doi:10.9734/AJEA/2015/11253.

Arega, G, Setu B (2014). Prevalence, Incidence and Severity of Wheat Rust, an Response of Wheat Cultivars to Rust Infection. International Journal of Agronomy and Plant Production 5 (1):13-19.

Beyene Y, Anna-Maria B, Alexander A (2005). A comparative study of molecular and morphological methods of describing genetic relationships in traditional Ethiopian highland maize. African Journal of Biotechnology 4(7):586-59.

Birhanu A (2015). Trends, Growth and Instability of Finger millet Production in Ethiopia. Research Journal of Agriculture and Environmental Management 4(2):078-081.

Christian R, Angelika C, Christoph GJ, Frank T, Albrecht EM (2012). Genomic and metabolic prediction of complex heterotic traits in hybrid maize. Nature Genetics 44(2):217-220.

Central statistical Agency (CSA) (2007). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey 2006/2007 (1999 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 588. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2008). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2000 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 417. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2011). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2003 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2012). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2004 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 532. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2013). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2005 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 532. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2014). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2006 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 532. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2015). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2007 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 578. Addis Ababa, Ethiopia

Central statistical Agency (CSA) (2016). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2008 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 584. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2017). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2009 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 584. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2018). The federal democratic republic of Ethiopia central statistical agency, agricultural sample survey (2010 E.C.), volume I, report on area and production of major crops (private peasant holdings, meher season) statistical bulletin 586. Addis Ababa, Ethiopia.

Central statistical Agency (CSA) (2013). Population projection of Ethiopia for all regions at *woreda* level from (2014-2017). Central Statistical Agency, Addis Ababa, Ethiopia.

D'Andrea AC. (2008). T'ef (Eragrostis tef) in ancient agricultural systems of Highland Ethiopia. Economic Botany 62:547-566.

Dawit A (2015). Rice in Ethiopia: Progress in Production Increase and Success Factors 6th CARD General Meeting Ethiopia institute of agriculture research.

Degaga J, Angasu B (2017). Assessment of Indigenous knowledge of smallholder farmers on intercropping practices in West Hararghe Zone; Oromia National Regional State, Ethiopia. Journal of Agricultural Economics and Rural Development 3(3):270-278.

Degu E, Debello A, Ketema B (2009). Combining ability study for grain yield and yield related traits of grain sorghum (*Sorghum bicolor* (L.) Moench) in Ethiopia. Agricultural Crop Science 57(2):175-184.

GAIN (2014). Ethiopia grain and food manual report. Ethiopia Grain Trade Enterprise

Hadgu G, Tesfaye K, Mamo G, Kassa B(2013).Trend and variability of rainfall in Tigray, Northern Ethiopia: Analysis of meteorological data and farmers' perception. Academically Journal Environmental Science 1(8):159-171.

Hilu KW, de Wet JMJ, Harlan JR (1979). Archaeobotanical Studies of *Eleusine coracana* ssp. coracana (Finger Millet). American Journal of Botany 66(3):330-333.

Jaeger W. (1991). The impact of policy in African agriculture, an empirical investigation. WB working Paper No. 147.

Leulseged G, Gebremedhin H, Tadesse T (1986). Under sowing of Forage Crops in Cereals. In: Proceedings of the First National Livestock Improvement Conference, 11-13February (1986) Addis Ababa, Ethiopia pp. 74-82.

Ministry of Economic Development and Cooperation (MEDaC) (1999). Survey of the Ethiopian economy. Review of post reform developments (1992/93-1997/98).

Wende A, Mosisa W, Birhanu T, Legesse W, Twumasi A (2007). Performance of CIMMTY maize germplasm under low nitrogen soil conditions in the mid altitude sub humid agro ecology of Ethiopia. African Crop Science Conference Proceedings 18:15-18.

Nigussie A, Kedir A, Adisu A, Belay G, Gebrie D, Desalegn K (2015). Bread wheat production in small scale irrigation users agro-pastoral households in Ethiopia: Case of Afar and Oromia regional state. Journal of Development and Agricultural Economics 7(4):123-130.

Partal T, Kahya E (2006). Trend analysis in Turkish precipitation data. Hydrological.Processes 20(9): 2011-2026.

Seyfu K (1997). Tef. Eragrostis tef (Zucc.) Trotter. Promoting the Conservation and Use of Underutilized and Neglected Crops. 12, p. 35. Institute of Plant Genetic and Crop Plant Research, Gaterstleben/International Plant Genetic Resources Institute, Rome. http://www.underutilized-species.org/documents/PUBLICATIONS/tef.pdf (January, 2011).

Taffesse AS, Dorosh P, Asrat S (2012). Crop production in Ethiopia:

Regional patterns and trends. International Food Policy Research Institute (IFPRI).
Tefera H, Belay G (2006). Eragrostis tef (Zuccagni) Trotter.[Internet] Record from Protabase. In: Brink M, Belay G(eds) PROTA (Plant Resources of Tropical Africa/Ressources ve ´ge ´tales de l'Afrique tropicale), Wageningen.http://database.prota.org/search.htm (December, 2010).
Teklu Y, Tefera H (2005). Genetic improvement in grain yield potential and associated agronomic traits of tef (Eragrostistef). Euphytica 141:247-254.
Teshome N, Dawit A (2011). An Overview of the National Rice Research and Development Strategy and its Implementation. Challenges and Opportunities of Rice in Ethiopian Agricultural Development pp. 1-16.
Tulema, B, Zapta F, Aune JB, Sitaula B (2005). N fertilization, soil type and cultivars effects on N use efficiency in tef (Eragrostis t– ef (Zucc.) Trotter). Nutrient cycling in agroecosystems 71(2):203-211.
Webb P, Von Brown J, Yohannes Y (1992). Famine in Ethiopia: Policy implications of coping failure at national and household levels. IFPRI, Research Report 92.
Wedajo G (2015). The Extent of Finger Millet Production in South Omo Zone in The Case of South Ari Woreda. Current Research in Agricultural Sciences 2(1):1-7.
Wolday A (2001). Agricultural input and output marketing in remote areas: Ethiopia. A study submitted to the policy analysis unit in Harare, FAO.
Yenigün K, Gümüş V, Bulut H (2008). Trends in stream flow of the Euphrates basin, Turkey. Proclamation Institute of Civil Engineering Water Management 161(4):189-198.
Zemede A (2000). The Barley of Ethiopia. pp 77-108. In: Stephen B. Brush (Eds.). Genes in the Field: On farm Conservation of Crop Diversity. IDRC/IPGRI.