Review Article
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The link between agricultural production and population dynamics in Ethiopia: a review

Abstract

The interaction between human population and agricultural production is complex. Intense debates have been continued on population growth against agricultural development. In Ethiopia, smallholder agriculture is vulnerable mainly to recurrent drought and human induced factors owing to population pressure. The aim of this paper is to demonstrate trends and controversies of population growth and to examine the link between population and food production in Ethiopia. This review discloses that the growths of population and agricultural production have increased over time. However, production growth shows oscillating trends compared to population growth. Despite the declining of mortality and fertility opens up the window of opportunity to capture the demographic dividend, rapid population growth is one of the major development challenges coupled with land degradation. If this opportunity complements efficient agricultural policies and strategies, the growing population can access adequate yields for home consumption as well as household incomes. Effective population policy, improved land resource management, and integrated strategies can reduce pressure on land resource. Therefore, this review suggests that critical review on agricultural policy and strategies is one of the prospective responses to the rising population.

Keywords: Agricultural intensification, Ethiopia, policy, population dynamics

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Abbreviations: UN, united nations; GDP, growth domestic product

Introduction

Ethiopia is one of the least developed countries in Sub-Saharan Africa with nearly 100 million people, of which 80.5% of the rural population is relied on agriculture for their livelihoods.[1,2] In the country, one-third of rural households cannot produce adequate food to meet their subsistence needs as they cultivate less than half hectares of land per capita.[3] Ethiopia is vulnerable to the twin threats of natural resource degradation and poverty owing to high population growth, dependent on rain fed agriculture, and negative impacts of climate changes.[4] Although anthropogenic and natural shocks resulted in adverse effects on food production, the government has made considerable efforts to produce adequate food for the growing population. As population rises, demand for food, energy and income increases.[5] Increasing population coupled with land degradation aggravates challenges of crop production.[6] Overpopulation resulted in land resource scarcity, fragmentation of farm plots, and ecological degradation such as increasing emissions, soil erosion, deforestation, and the overuse of natural resources.[7–9] Producing adequate food for a rapidly growing population is a prime challenge for development.[10] Despite economic development improved in Ethiopia,[11,12] the country has suffered with multifaceted challenges including land scarcity, malnutrition, recurrent drought and lack of agricultural technologies.[13–15] The existing agricultural land is unable to feed the growing population and thus many Ethiopians remain trapped in vicious circle of poverty, disease and hunger.[7] Rising in food prices, unemployment, lack of pasture for livestock, and intensive removal of natural vegetation aggravates food shortages. Further land redistribution is not anticipated in the near future, because landholdings are already small and subjected to more divisions and fragmentations. Parents redistribute their land to their children when the children establish their own family[16] and have an impact on food shortages and household incomes.[17] consequently, arable land per capita declines while land degradation increases through overuse of land resources. Lands access to irrigation schemes, adjacent to urban centres, access to roads and other basic services have high rental values.[18] Population pressure is the most fundamental driving force for land conversions.[19,20] Even though rural development policies adopted intensification and commercialization strategies, land expansions overshadow intensification. In line with agricultural extensification, pasturelands and the natural vegetation are converted to farmlands and commercial investments in some parts of Ethiopia.[21] On the other hand, the current regime has started to tailor fertilizer distribution based on soil maps so that farmers apply a custom-based fertilizer to mitigate the depletion of soil nutrients based on site-specific soil amendments. This type of agricultural intensification is implemented by means of internally adopted and externally imported technologies. Despite apparent yield improvements has been reported, evidences on the adoption of new technologies particularly animal breeds and crop varieties are not overwhelming.[22–25] This paper presents agricultural implications of population dynamics based on the current evidences of knowledge on agriculture and population. The review helps to understand the link between agricultural growth and population dynamics in Ethiopia. Development theories and empirical literatures are crucial evidences to conceptualize the link between agriculture and population growth.

Theoretical perspectives: population-agriculture nexus

Debates on agricultural production in response to population pressure are not a recent discourse. The argument between population growth and subsistence goes back to the classical theory of Malthus. In the 18th century, the speculation of Malthus has made everyone

to believe the negative impact of population on development.[26] The central tenet of Malthus is "the growth of human population always tends to outstrip the productive capabilities of land resources." He further stated 'the influence of population is indefinitely greater than the control of the earth to produce subsistence for man'.[27] According to this theory, the arithmetic increase of subsistence could not feed the exponential growth of population. This dismal hypothesis has strengthened the theory, as human number grows food supply would be insufficient to feed the emerging people so that population pushed back below the carrying capacity of agricultural systems.[28] The debate on 'limits to growth' in relation to population-production nexus is a never-ending discourse. The natural and virtual inequality between population and production has multifaceted links. Adjustments and adaptations towards increasing population and land scarcity were initially possible through land extensification.[6] As opportunities for land expansion disappeared, agriculture has encroached into fragile ecosystems, often without the necessary resource amendments and led to soil degradation, deforestation, and loss of biodiversity. Consequently, Malthus suggested positive and preventive checks to balance the rising population with the existing subsistence. The positive checks include increase of mortality as a result of disease, famine, malnutrition and war while preventive checks are attributable to reducing fertility via delay marriage, abstain, and others.[28] On the word of classical economists, population is a dependent variable determined by preceding changes in agricultural productivity.

According to coale and Hoover,[29] rapid population growth is an obstacle for development that brings burden on public expenditure for education, housing and health services. Neo-liberalists believe that strong economy supports population growth whereas radical ecologists argue for stabilization or even reduction of human population in order to preserve the earth's carrying capacity.[30] These paradigms have in-placed different views towards population growth in relation to human needs. On the one hand, the earth is limited, which can only sustain a certain number of people although no one knows what that exact number may be. In the view of this paradigm, population is one of the development challenges in Ethiopia.[18–31] On the contrary, Boserup[32,33] brought to light that population as an independent determinant and a prime driver of technological inventions. Boserupian theories counteract the contention of classical theory by justifying the growing population would respond to their food demands through land use intensification, increasing farm yields, and new agricultural technologies.[28–32] Despite rapid population growth, food production per capita has increased due to green revolution and agricultural intensification in several counties of the world.[34] Several research findings substantiate the theory of agricultural intensification taking into account population as a driver of development. For instance in China, institutional and land policy reforms are the main causes for agricultural development that intended to support the growing population.[35] In such case, Chinese have put into effect parallel progressive and evolutionary remedies on natural and anthropogenic ills using biotechnology for chemical pollutions, bioengineering for land degradation, and cost budgeting for nitrogen emissions. It implies institutional reforms, policy changes, and technological innovation can influence favourably the relationship between population and subsistence. Thus, population growth is an opportunity for development so that population is not a problem, but government policies, economic structures and organization of the society are a problem.[34] Optimistic scholars argue for agricultural intensification, which may offer capacity for many people to gain adequate and sustainable livelihoods in rural areas and on the land where they depend.[36] The impact of population growth on agriculture is not inherently negative or positive.[7] Hence, population growth can be a threat or an opportunity depending on economic growth, expansion of infrastructure, technological innovation, settlement patterns, and potentials of environments.[37]

Population dynamics in Ethiopia

Population growth

Despite its long history of humankind in Ethiopia, there were no estimates of human population prior to the 1930s except few evidences. The growth rate of population was slow until 1970 and step up thereafter.[17] In the beginning of 1900s, Ethiopia had five million people that have increased by twenty times within one century.[1,11] The first and the second population and housing census were conducted in 1984 and 1994 with equivalent population size of 42.6 and 53.5 million.[38] Nevertheless, the annual growth rate of population has declined from 3.3% in 1984 to 2.9% and 2.6% in 1994 and 2007.[39] The growth rate of population is estimated to be 2.3%.[40] Currently, Ethiopia is the second population giant among ten countries in Africa that account 61% of the total population of the continent (Figure 1). Nigeria and Ethiopia contribute 15.3% and 8.3% of the total population in Africa, respectively. The average growth rate of population is computed using Equation 2. There is lack of concrete evidence on net births and deaths, and net migration in Ethiopia.[39] The following formula is adapted from [41]:

$$r = \frac{2(P_1 - p_o)}{p_1 + p_o}, \text{ or } anti\log\frac{1}{n}x\log\frac{p_1}{p_o} - 1 \quad \text{.....(2)}$$

Where: r is growth rate of population, n is number of years between the two periods, P_1 and P_o are the size of population in recent and base-year. The population size of Ethiopia was 53.5 million in 1994 and 100 million in 2017.[12] Taking into account the two census episodes as a baseline, the estimated average growth rate of population is 2.3% per annum.

$$anti\log\frac{1}{n}x\log\frac{p_1}{p_o} - 1 = [(anti\log\frac{1}{23}x\log\frac{100}{53.5}) - 1]$$

$$n = \frac{\log 2}{\log(1+r)} \quad \text{.....(3)}$$

The growth rate will decline further to 1.5% from 2015 to 2025.[1] The number of years that the population will double is nearly 47 years. Consistent with this projection, the size of population in Ethiopia is estimated to be 188.4 and 200 million in the mid of 2050 and the 2060s, respectively.[1,42] Hence, the estimate of Equation 3 is in agreement with the UN projection. The growth rate of population can be also calculated exponentially.[43]

$$N_t = N_o e^{rt} \quad \text{.....(4)}$$

Where: N_t is the number of individuals in the population after some time t, N_o is the initial population size, r is the exponential growth rate, t is time (in years), and e is the base of natural logarithm (2.72). Subsequently, the size of population in 2050 is projected from 2017 (100 million) taking the average growth rate for 2.3% and 1.5%.

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$$(e)^{\frac{2.3\%+1.5\%}{2}*33} = 187.2$$

The result of this projection is comparable with the growth trends of empirical finding in (Figure 2). Conveniently, this evidence reveals that the explanation of some empirical studies[39] is in conformity with the theoretical projection of Malthus.[27] Population growth has continued at declining rate of growth.[47] In the coming decades, Ethiopia will be one of the eight countries (Nigeria, India, Tanzania, the Democratic Republic of Congo, Niger, Uganda, Ethiopia and the United States of America) that expected to account for over half of the world population.[40] Ethiopia is among the least urbanized countries in Africa while the most urbanized country is Gabon followed by Libya and Congo (Figure 3). In the continent, the size of rural and urban population will be almost equal by 2038.[1] In Ethiopia, the size of urban population has increased from 6% in the 1960s to 19.5% in 2015 and is expected to reach 27% by 3035.[39] The rate of urbanization will be expected to increase in the coming years, averaging 3.9% between 2015 and 2020 and (*Ibid*).

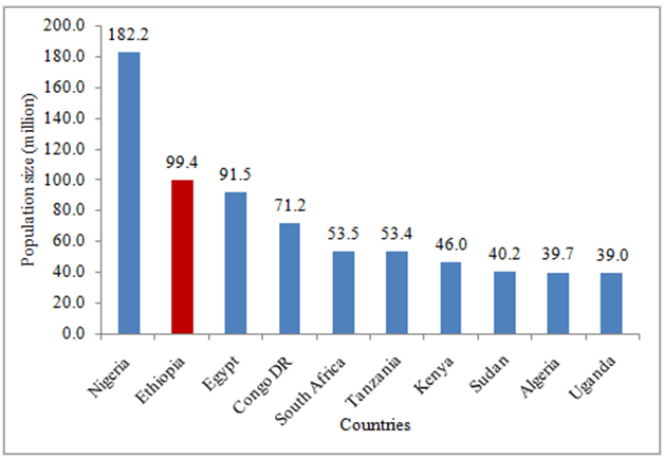

Figure 1 Size of population in ten selected countries of Africa.

Source: ECA[1]

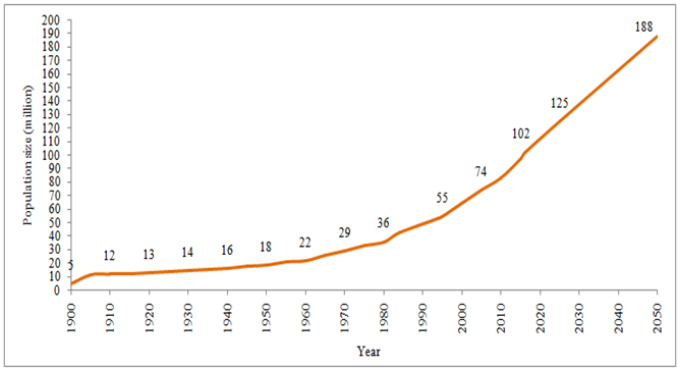

Figure 2 Trend of population growth in Ethiopia (1990-2050).

Source: Bielli[17]; Bilsborrow[44]; Campbell[45]; CSA38, 46; ECA[1]

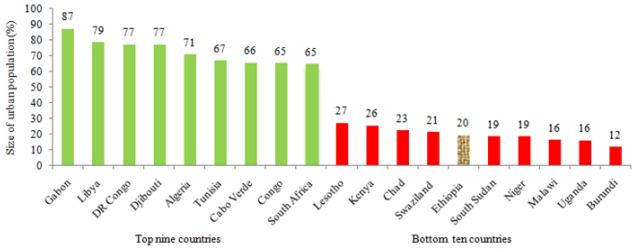

Figure 3 Extent of urbanization in selected countries of African.

Source: ECA[1]

Population pyramid

Population structure shows the composition of people into age and sex. The broad base of population pyramid (14.4%) shows a large proportion of under-five children while 26% are teenagers between 5 and 14 years old (Figure 4). Old age groups account 3.5% of the total population. The majority of population (56.1%) is under the category of working age groups. Sex and age provide useful information about fertility, human resource and the proportion of population by sex. Males are slightly higher (50.1%) than females (49.9%). The proportion of male and female population is almost the same with the finding of Amare.[48] The nature of population pyramid depicts rapid population growth and high proportion of younger population. The distribution of population further shows the decline of young generation (under-five) from 49.8% in 1984 to 45.0% in 2007 and 43.9% in 2014. The working age group (15-64 years old) has increased from 50.2% in 1984 to 51.9% and 56.1% in 1994 and 2014, in that order. The proportion dependent population with age of 65 and above has increased from 3.2% in 1994 to 3.5% in 2014.

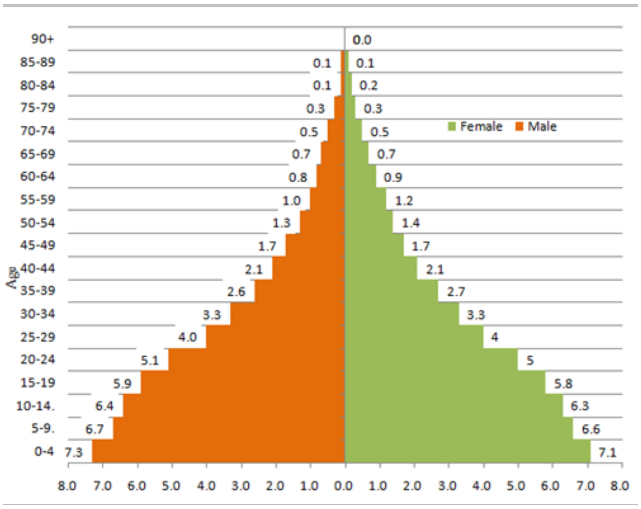

Figure 4 Population pyramid of Ethiopia.

Demographic changes

The temporal dimension of population changes in terms of size and structure, and spatial distribution of population due to births, deaths, migration, and settlement patterns refers to demographic change. Since 1970, child and adult mortalities have declining trends for three decades.[38] Considerable change is observed for maternal

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mortality from 1250 in 1990 to 353 for every 100, 000 live births in 2015.[1] More than 70% Ethiopian population is under 30 years of age while close to 50% are under the age of 15. A women's fertility rate has declined steadily from 7.4 children in 1980s[1] to 5.9, 5.4, 4.8, 4.1 children in corresponding years of 2000, 2005, 2011 and 2014.[47] The fertility rate is expected to decline by 3.11 and 1.99 in the 2020s and 2060s, respectively.[1] Reductions in fertility, child mortality, crude birth and death rates have accelerated the transition and demographic dividend.[11] A substantial difference exists among administrative regions of Ethiopia and the total fertility rate is ranging from 1.7 children per women in Addis Ababa to 6.4 children in Somali region (*Ibid*). The crude birth and death rates were 34.6 and 9.7 per 1000 people in 2012. The rate of natural increase (difference between crude birth rate and crude death rate) is 1.9 in 2012 and the replacement of total fertility rate would reach 2.1 in 2040s.[47] Ethiopia's window of opportunity for demographic dividend is projected to peak around 2040. Thus, reproductive health services, education, family planning, and infrastructure are notable accelerating factors in order to capture the demographic dividend.

The net reproduction rate of surviving a daughter per women has declined from 2.3 in the 1980s to 2.0 in the 2010s and will further decline to 1.4 and 0.9 in the 2020s and the 2060s, respectively.[1] Infant mortality rate has declined from 140 children in the 1980s to 50 children per 1000 in the 2010s. Child mortality is likely to decline from 32 in the 2020s to 15 children in the 2060s, respectively. Females have higher life expectancy (65 years) at birth than males (61.3 years) in the 2010s. All these changes, particularly population's age opens up a window of opportunity to Ethiopia that capture the demographic dividend given that favourable socio-demographic and economic policies and conditions exist.[47] Population growth is accelerating whereas the birth and mortality rates are decelerating. Delay in early marriage, female literacy, youth aspiration, urban expansion, contraceptives, and health services are among the most important factors attributed to fertility reduction.[9,38] This explanation is in-line with the standard theory of fertility decline.[49] Both women fertility and rural-to-urban migration has resulted in growing urban population at the rate of 4.89% per years.[1] School enrolment and expansions of higher learning institutions are also growing. In parallel with job opportunities of industry and technology, other services are important policy implications of employment. If not, robbery, addiction, lack of motivation, unbalanced population density, environmental pollution, diseases and other catastrophic consequences have a chance to happen.

Correlates of population and agriculture: empirical evidences in Ethiopia

Agriculture is the mainstay of Ethiopian economy. The interaction between population and agriculture is complex. Intense debates and widespread discourse have been continued over several decades on population growth against agriculture development.[26] For the past decades, agricultural growth has been achieved partly through an expansion of farmlands [50]. Alemayehu et al.,[13] also reported that crop production has increased due to area expansion although little has been contributed by agricultural inputs. Agricultural intensification and extensification are the two major strategies to raise agricultural output in general and crop yields in particular.[36,51] As farmland increases, pressure on natural vegetation and communal grazing land also increases. Between the 1980s and the mid of 1990s, crop outputs were not exceed 10 million metric tons. To date, the yield has grown with increasing trend to more than 28 million metric tons. However, the growth of crop production is extremely uneven due to shocks, mainly exposed to spatial and temporal rainfall fluctuations. As shown in (Figure 5), during severe drought such as 1984/85 is an evident for crop failure that affected production negatively whereas good weather conditions in some years resulted in bumper harvests.[52]

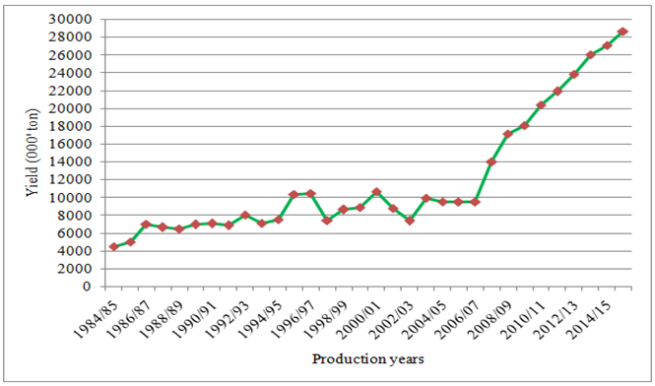

Figure 5: The growth trend of crop production (1984/85-2015/16). Source: Alemayehu et al.,[13]; Dessalegn et al.,[39]; CSA[38,46]

Agriculture showed a downward trend from 4.6% in the 1950s to 3.8% and 1.9% in 1960-1965 and 1966-1973, respectively.[13] One of the main causes for the irregular pattern of agricultural growth is erratic nature of rainfall distribution. In addition, low level of irrigation, inadequate farm inputs, land degradation, and soil erosion are the major constraints of agricultural growth. Despite reduction of pasturelands, low level of agricultural technologies, inefficient extension services, household food insecurity, and soil degradation have been confronted to agriculture, adequate rainfall, improved seeds, fertilizers, and suitable agro-climates are some of the main opportunities of growth for agriculture.[13] The demographic dividend coupled with,[11] indigenous social protection, expansion of infrastructural connectivity,[14] and road networks are encouraging aspects of agricultural growth.[11] The change of regime in 1991 in terms of political, social and economic reforms accompanied by devaluation, trade liberalization, deregulation of market and privatization.[2] Growth in Growth Domestic Product (GDP) is one of indicator of economic development. In 1960s, the share of agriculture to GDP was 70% while in 1973/74 and 2011/12 its contribution declined to 52.3% and 44%.[53] Most recently, service enterprise (45%) is the leading sector followed by agriculture (43%) and industry (12%).[40] The trends of growth rates for GDP and agriculture move back and forth concurrently. In the *Derg* regime (1974/75-1989/90) an average GDP growth rate was -2.3%. In the current regime, subsequent to policy reform in 1991, the growth rate of GDP grew by 3.7% for ten years from 1990/91 to 1999/2000[13,40] and then by 9.1% from 2001/2002 to 2015/16 (Figure 6). Overall, economic growth greatly intensified since 2005 at slightly above 10% per annum for consecutive 10 years, allowing per capita GDP to grow at nearly 8% annually.[2] The lowest GDP is observed in 1991/92 due to shortage of rainfall and war during the downfall of *Dergue*. An average GDP per capita growth rate between 1995 and 2005 is 2.89%.[54] The growth trend of GDP per capita shows irregular pattern similar with the growth of agriculture. The comparable trend of GDP and agriculture implies Ethiopia is a country largely dependent on agriculture. According to Dessalegn et al.,[39] the dependency ratio has declined from 49.8% in 1984 to 45% in 2007; and the work force has increased from 50.2% to 51.9%. Despite these changes, the population will continue to exert immense pressure

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on limited land resources. As population grows, the demand for food also raises as a result the price of agricultural outputs increase. In theory, either an increase in the price of provisions would arise from an increase of population faster than the means of subsistence, or from a different distribution of the money of the society.[27] In fact, the rapid population growth has cleared forest and vegetations to satisfy human needs for food and energy.[17] Landless people have excessive supply of labour that takes the advantage of unemployment or under employment. Both traditional farming and labour intensive activities does not allow the opportunity for new technologies.

In order to feed the growing population, arable lands expand at the expense of pasture and marginal lands. These conditions aggravate the minimal nutritional requirement of poor people who commonly feed substandard diet due to land and financial limitations. As noted by Dessalegn et al.,[39] population pressure is one of the aggravating factors of food insecurity. When population pressure rises, food insecurity and degradation of land resource also increases; and economic problem is still prevalent in Ethiopia. Alemayehu[13] validated that poverty has a positive correlation with household size. Large amount of money is spent on the purchase of consumable goods rather than investment options. Ethiopia has in-placed population policy in 1993. Both preventive and natural population controls have been practiced in Ethiopia. Since 1975, family planning services have been provided through a variety of mechanisms in the country.[55] The rationale for establishment of population policy in Ethiopia is due to rapid population growth that exerts depressing pressure on economic development.[56] Reduction of population growth to small family sizes, increase economic returns, and reducing the rate of rural to urban migration are among the main objectives of the policy. Contraceptives, breast-feeding, and raising the minimum age of marriage are in the midst of policy strategies.

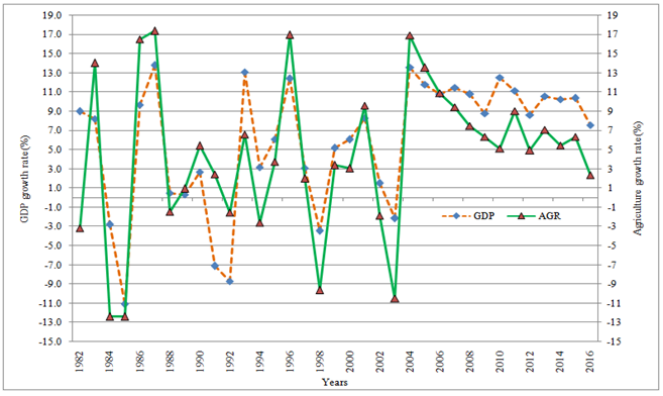

Figure 6: The annual GDP and agriculture growth rate (1982–2016).
Source: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2016 and locations=ET

Conclusion and the way forward

Growth rates for population fertility, mortality, births and deaths are declining in Ethiopia. Agriculture in terms of crop production and population are growing though the growth trends are different as long as population is steadily growing while production is unexpectedly oscillating. Land expansion and agricultural intensification are the two contrasted strategies put into practice in Ethiopia. Neoclassical development theories dictate that more rapid population growth led to low per capita income. As population increases, the share of agricultural contribution for GDP declines. The growing population pressure is a threat for social insecurity and environmental risk on the existing land resources. This problem can be tackled through increasing productivity of land. The productivity levels of major crops have increased significantly through improved cultivation practices and technologies. Therefore, new technologies and sustainable land management are the key opportunities of agricultural production in Ethiopia. In the contemporary world, climate-smart agriculture is the main public discourse that can revert to climate-resilient adaptation mechanisms. Diverse agro-systems stipulate economic reforms in the agricultural sector that geared to productive crop species and animal breeds to feed the growing population. The debates and controversies on population policy, agricultural intensification versus extensification are the way forward for further studies.

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Conflict of interest:

The author(s) declare that there is no conflict of interests in any respect of publication.

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