Global Food Security 24 (2020) 100353

Contents lists available at ScienceDirect

Global Food Security

journal homepage: www.elsevier.com/locate/gfs

Agricultural growth and sex-disaggregated employment in Africa: Future perspectives under different investment scenarios

Aymen Frija[a,*], Ali Chebil[b], Khondoker Abdul Mottaleb[c], Daniel Mason-D'Croz[d,e], Boubaker Dhehibi[a]

[a] Center for Agricultural Research in the Dry Areas (ICARDA), Tunis, Tunisia
[b] Institut National de Recherche en Génie Rurale, Eaux et Forêts (NRGREF), Ariana, Tunisia
[c] International Maize and Wheat Improvement Center (CIMMYT), El Batan, Mexico
[d] International Food Policy Research Institute (IFPRI), Washington D.C., USA
[e] Commonwealth Scientific and Industrial Research Organization (CSIRO), Brisbane, Australia

ARTICLE INFO

Keywords:
Africa
Employment elasticities
Investment scenarios
GDP growth
IMPACT model

ABSTRACT

Literature is scanty on how public agricultural investments can help reducing the impact of future challenges such as climate change and population pressure on national economies. The objective of this study is to assess the medium and long-term effects of alternative agricultural research and development investment scenarios on male and female employment in 14 African countries. We first estimate the effects of agricultural investment scenarios on the overall GDP growth of a given country using partial and general equilibrium models. Secondly, using employment elasticities to GDP growth, we estimate the impact of GDP growth on overall employment in the economy. Results show that, increased investments in agriculture could generate higher overall employment and reduce gender disparities in labor participation. In 8 out of 14 sampled countries, female employment increased more than male employment in response to agricultural investments. Investment in infrastructure had higher impact on female employment growth compared to productivity scenarios.

1. Introduction

One of the most effective ways to eliminate poverty is to allow the poor to use their abundant labor into productive purpose. As agriculture is the dominant sector in the poverty-stricken developing SSA countries, appropriate agricultural investments to boost up agricultural productivity can be instrumental in increasing overall employment in the economy, and thus reducing poverty and hunger in the agriculture-dependent regions (Collier and Dercon, 2013; Diao et al., 2010). It has been widely recognized that agricultural growth, particularly in Africa is more pro-poor than industrial growth because it allows for greater participation of the poorest smallholders in the growth process (Diao et al., 2010; Cervantes-Godoy and Dewbre, 2010). This is particularly relevant when agriculture is the dominant sector in the economy. Agriculture on average contributes more than 17% to the overall GDP in SSA (World Bank, 2017) and is considered as one of the largest source of employment in this region (FAO, 2017b). Growth in agricultural employment in SSA accounted for half of all employment growth between 1999 and 2009 (FAOstat), which can be a major driver for eradicating extreme poverty. It is, however, important to consider that the increase in employment would result in poverty reduction only if accompanied by an increase in income as well as appropriate mechanisms for equitable income distribution.

This potentiality of the agricultural sector to employment generation in SSA is, however, impeded by several factors. Due to population pressures, per capita arable land has been declining in the region from 0.57 in 1961 to 0.22 ha in 2015 (World Bank, 2017). Rapid depletion of arable land is a major barrier of access to land, especially for the most marginalized populations. This constraint is expected to be even higher knowing that the population in SSA is projected to increase to 1.92–2.33 billion by 2050 (from the current level of 962 million) (UN, 2015). Furthermore, low levels of public investments in agricultural research and extension services, and other related infrastructure are also among the most relevant constraints, which need to be released through appropriate and targeted investments. Low labor productivity and market failure are other structural barriers for enhancing the contribution of agriculture to employment in SSA (Larson et al., 2016; Collier and Dercon, 2013).

Usually, government expenditure and investments in the agricultural sector are highly and positively associated with the agricultural

* Corresponding author.
E-mail address: a.frija@cgiar.org (A. Frija).

https://doi.org/10.1016/j.gfs.2020.100353
Received 30 May 2018; Received in revised form 2 January 2020; Accepted 17 January 2020
2211-9124/

capital formation, and growth exhibits the decisive role of the government expenditure in creating an enabling environment and thriving agricultural outputs. Infrastructural investments, in addition to contributing to narrowing yield gap, can also open vent-for-surplus within and beyond the agricultural sector (Cervantes-Godoy and Dewbre, 2010) with high social implications. Accordingly, it is highly important to prioritize agricultural investments based on their social returns, especially in terms of poverty alleviation and employment creation.

The objective of this study is to build on previous work by analyzing the impact of a set of agricultural investment scenarios for agricultural productivity enhancement and infrastructure development on male and female employment in 14 countries of Africa. The present study is built on existing literature by proposing a foresight study, which includes "overall employment generation" as an indicator for evaluating future agricultural investments. By "overall employment generation," we mean employments created in the whole economy and not only in the agricultural sector. In the process, the investment scenarios of this study are taken from Rosegrant et al. (2017), who developed different types and respective levels of investment on agriculture and food security,[1] through their associated effects on agricultural productivity. Based on that, we propose that such productivity enhancement would positively contribute to achieving higher GDP growth (agricultural and other sectors) and employment generation in the agricultural sector and beyond. The scope of such contribution will be demonstrated in the remaining of this study.

2. Perspectives for future investment in food security in SSA

Despite many potential challenges, there are enormous opportunities to revitalize SSA agriculture. One important driver for enhanced agricultural contribution is related to appropriate agricultural investments for closing the yield gap. It is suggested that even a partial narrowing of the yield gap can have a significant impact on local and global food security in the region (Larson et al., 2016). The narrowing of yield gap in SSA is particularly important as it is well known that yield gaps and poverty are highly overlapped in the region (Dzanku et al., 2015). However, this will need additional investments in enhancing research and extension systems performances. In the present study, we are mostly focusing on analyzing research spillovers from investments by the CGIAR (Consultative Groups of International Agricultural Research) system in its priority countries portfolio, also focusing on priority crops and commodities for food security. It has been argued by Renkow and Byerlee (2010) and recently by Lantican Maximina et al. (2016) that the return from CGIAR research in crop genetic improvement, pest management, natural resources management, and policy research is relatively high. Particularly, investments in genetic improvement have been shown to have the highest global positive return, with substantial evidence that other CGIAR investments also generate large local and national benefits.

Another important driver for enhancing agricultural contribution in SSA is through the development and expansion of agricultural land in these countries (Deininger et al., 2011). It is estimated that In SSA countries the potential to expand crop area to more than 200 million ha with an additional 95 million ha of the rainfed area, which could be brought under cultivation with minor infrastructural investments. Agricultural investment to enhance the provision of public goods including infrastructure and land development in Africa would stimulate rural employment (Nolte and Ostermeier, 2017). Furthermore, infrastructure investments can contribute to correcting many market failures (Rosegrant et al., 2017) facing smallholder farmers. This is because infrastructure improvements enhance agricultural productivity throughout better value chains; increase the speed of commodity transportation to markets, as well as improve storage capacity through greater electrification, all of which improve market efficiency and correct market failure by better matching supply and demand over the time (Rosegrant et al., 2017). Transportation infrastructure particularly helps to create substantial positive agglomeration economies affecting enterprise development in rural areas (Foster, 2015), greater economic activity by exploiting gains to trade between different regions, decrease the relative merits of value-added production particularly if there are returns to scale in processing (Donaldson, 2010). Furthermore, access to infrastructure and infrastructure quality also relate to economic growth indirectly via export diversification (trade competitiveness), and cross-border capital flows and trade competitiveness, respectively (Kodongo and Ojah, 2016). Fan, Zhang, and Zhang (2002) document the critical role of infrastructure development—particularly roads and telecommunications—in reducing rural poverty in China between 1978 and 1997. The authors showed that poverty in the studied areas in China fell because of the growth in rural non-farm employment that followed the expansion of infrastructure. Foster (2015) argues that electrification also seems to have important effects on rural employment. In South Africa, Dinkelman (2010) found evidence that electrification leads to increases in labor supply on the part of men and women and decreases in female wages. The provision of electricity, for example, is very important to the development of the manufacturing sector in rural areas (Rud, 2012), and may also induce changes in time allocation for household works for both men and women (Grogan and Sadanand, 2013).

3. Linking agricultural productivity, GDP growth, and employment creation

Implications of agricultural investments on productivity, income, and welfare have been studied widely in the context of developing countries (Binswanger et al., 1993; Diao et al., 2010; Larson et al., 2016). In contrast, empirical studies on the relationship between agricultural productivity and employment are limited. The payoff from investments in agricultural research, development, extension, and education comes in the form of a sustained increase in agricultural productivity (Cervantes-Godoy and Dewbre, 2010). At the national level, increased agricultural productivity can help increase total agricultural production, while enhancing competitiveness. However, one of the most basic issues that are debated in the literature on rural employment is the question of whether agricultural productivity growth is sufficient to generate enough jobs in rural areas, either directly or through its effects on nonfarm employment (Foster, 2015). Foster (2015) concludes this debate by stating that agricultural productivity growth increases nonfarm activity in the services sector by increasing demand for local goods, decreases it in the factory sector by raising wages and thus discouraging capital entry, and increases it in the value-added sector by lowering the price of a key input.

Further, indirect effects of agricultural productivity increase can be related to the reduction in agricultural imports and result in better macroeconomic and trade balances of the overall economy thus allowing to generate higher public expenditures for public goods provisions. At the local level, enhanced agricultural productivity can ensure higher farm incomes, which can improve overall livelihoods of the resource-poor farmers, and enhance their overall investment capacity, which will drive spillover investments in other complementary non-agricultural sectors. In the developing countries, this can contribute to a shift in agricultural production systems from subsistence to commercial farming, which would also have a meaningful impact on generating employment in the agricultural sector and beyond.

Wiggins et al. (2007) highlight that in labor markets, the transaction costs of hiring and supervising workers pushes up the total cost of labor, which leads employers to employ suboptimal levels of labor. This refers to the flexibility of labor regulation as one of the determinants for employment generation due to growth. Economic growth which is

[1] Rosegrant et al. (2017) provide precise description of every investment scenario and their respective amounts in different world regions, including SSA.

Table 1
Summary description of agricultural investment scenarios.

Scenario Grouping	Scenario	Scenario Description
Reference	REF_HGEM	Reference scenario with RCP 8.5 future climate using HadGEM GCM. This scenario is considered as the BAU one.
	REF_NoCC	Alternate reference with no climate change (constant 2005 climate).
Productivity Enhancement	MED	Medium increase in investment across the CGIAR portfolio. This scenario provides an indication of the sensitivity of outcomes to levels of investment, specified to have an intermediate level of investment between the BAU and the HIGH scenario (below).
	HIGH	High increase in investment across the CGIAR portfolio. The HIGH scenario costs approximately 70 percent more than MED.
	HIGH + NARS	This scenario simulates high increase in investment across the CGIAR portfolio in addition to complementary NARS investments.
	HIGH + RE	High increase in investment across the CGIAR portfolio plus increased research efficiency. This scenario simulates higher CGIAR research efficiency so that the yield impact of investments is 30 percent higher and the maximum improvement is achieved by 2040, (five years earlier than in the HIGH scenario).
Improved Infrastructure	RMM	Infrastructure improvements to improve market efficiency through the reduction of transportation costs and marketing margins. This scenario assumes a mix of infrastructure improvements throughout the economies of developing countries, focusing primarily on improvements to transportation infrastructure (road building, road maintenance, and railroads) and increased rural electrification.

Note: The monetary value of each of these investments in the considered regions/countries can be found in Rosegrant et al., (2017).

biased towards labor-intensive sectors, such as smallholder agriculture, are more likely to lead to faster employment growth than growth patterns that are biased towards the capital, natural resource or other factors of production (Sen and Kirkpatrick, 2011). However, in the long run, most economies will reach to a turning point where secondary and tertiary sectors become a greater part of the economy and pull in more labor with jobs with the higher marginal return and better salaries and stability (Sumedh, 2012). This can also be expressed by a declining share of the agricultural employment within the total labor market.

About Gender, the sex-disaggregated effects of GDP growth on employment can vary significantly by country (Bloom and McKenna, 2015). A number of influencing factors can be identified as potential sources of variation of employment impacts among regions (or countries). The dominant farm type and production characteristics, for example, can be the most influential factors, where some countries are characterized by the dominance of self-employment subsistent type farming systems, and others by the rise of larger scale commercial production system characterized by higher labor productivity. Empirical studies also demonstrate that gender wage inequality will have an impact on the level and types of "investment as a share of GDP." The level of wage inequality in a given economy would stimulate specific types of investments, where mostly women provide the bulk of the labor. The example of women employment in agribusiness can be cited in this regard. While women can face discrimination in agriculture, including in larger agribusiness, agribusiness can, nevertheless, provide new and unique employment opportunities for women (Sumedh, 2012). Generally, sex-disaggregated employment elasticities to GDP growth between 1990 and 2010 have shown more volatility for women than for men (Anderson and Braunstein, 2013). This may relate to the fact that women in agriculture tend to suffer disproportionally more from seasonal shocks than men (World Bank, 2011), as women are mainly tied to casual participation in all seasonal agricultural activities, while male participation is mostly continuous throughout the agricultural season (Sumedh, 2012). It is, however, important to note that the analysis in this paper doesn't distinguish between types of jobs in which women are involved neither women contribution to the subsistence/family farming sectors.

4. Materials and methods: approach for quantifying the impact of alternative scenarios on employment

The present section includes the methodological approach used to translate overall GDP growth resulting from higher productivity of agricultural commodities into employment figures. The section also presents the agricultural investment scenarios considered and specifies sources of data. The elasticity-based approach followed in this study to calculate employment figures from future GDP growth rates are based on Alene et al. (2009). For each country and scenario, the CGE simulations of the scenarios consist of chocking the GLOBE (CGE) model with the resulting agricultural commodities supply changes resulting from different IMPACT model scenarios simulations. Thus, for each of the investment scenarios, the GLOBE model provides GDP growth figures (Appendix 7), which we translate into employment growth rates using the set of equations presented in Appendix 1. These CGE simulations already capture the cross-sectors effects on overall GDP growth. Employment elasticity to growth is defined as a numerical measure of how employment varies with the economic output (e.g., percentage change in employment due to 1% growth in GDP) (Kapsos, 2005). This macroeconomic elasticity concept refers to the growth of the overall economy (all sectors included) or to an individual sector, such as agriculture. This indicator is also reflected by the endogenous structure of the economy and its embedded capacity (institutions performances, including labor laws, and other revenue distributions mechanisms) to translate growth into jobs. This is why we can find similar countries in terms of size and economic growth but would have different elasticities figures. Kapsos (2005) performed a series of estimates of overall employment elasticities for the period 1991–2003, disaggregated by gender, age, sector, and region. The estimates of Kapsos (2005) is used in the present study as the primary source of elasticities data, which are further complemented with most recent estimates from literature (Table 3). Appendix 1 provides a detailed description of how these elasticities have been used for the projection of future employment.

4.1. Agricultural investment scenarios

In our empirical setting, each of the investment scenarios considers increases of investments in one specific area of agricultural research and development investments (see Rosegrant et al., 2017). The reference scenario (REF_HGEM) used in this analysis for comparison of alternative investment portfolios assumes "middle-of-the-road" changes in population and income and rapid climate change. These assumptions are based on the IPCC's (Intergovernmental Panel on Climate Change) Shared Socioeconomic Pathway 2 (SSP2). Under the SSP2 scenario, the global population is expected to reach 9.2 billion by 2050 with an average income of USD 25,000 per person. We also consider the Representative Concentration Pathway 8.5 (RCP8.5), as modeled by the HadGEM general circulation model (GCM) for climate-related scenarios simulations. More details about both SSP and RCP scenarios can be found in van Vuuren et al., 2007); and IIASA, 2013; with a comprehensive summary in Rosegrant et al. (2017). Key areas of investment considered in the reference scenarios are related to agricultural research and infrastructure development (See Rosegrant et al., 2017 for

Table 2
General characteristics of agricultural sectors in the considered countries.

		Aggregated crop yield (2010 values)[a]	% of agricultural land (2009)[b]	% of permanent crops (2009)[b]	Share of agricultural GDP (2009) [b]	Food availability per capita (2010)[b]
Western Africa	Nigeria	4.01	81.8	3.3	32.7	580
	Ghana	4.06	68.1	12.3	31.7	718
	Niger	0.51	34.6	0	39.6	401
	Mali	1.25	33.7	0.1	36.7	378
	Senegal	1.72	49.4	0.3	16.6	345
Eastern Africa	Ethiopia	2.07	35	1	50.7	307
	Kenya	3.7	48.1	1.1	22.6	411
	Sudan	1.69	57.5	0.1	29.7	516
	Uganda	3.9	69.9	11.3	24.7	555
	Tanzania	2.2	40.1	1.7	28.8	481
North Africa	Tunisia	1.7	63	14.3	7.8	757
	Morocco	3.36	67.3	2.2	16.4	646
	Algeria	3.8	17.4	0.4	11.7	671
	Egypt	14.7	3.7	0.8	13.7	697

[a] Rosegrant et al. (2017).
[b] FAO data.

more details).

The present study considers two reference scenarios (Table 1): REF_HGEM and REF-NoCC. As alternative agricultural investment scenarios, we consider agricultural productivity enhancement, and infrastructural improvement investments (RMM). Specifically, in the productivity enhancement scenarios, the present study considers medium (MED) and high (HIGH) international research investments, high investment combined with national governments complementary investments (HIGH + NARS), and also a high level of investment combined with investment on increased research efficiency (HIGH + RE). Productivity enhancement scenarios presented in Table 1 are research oriented and consider enhanced productivity through higher CGIAR agricultural research investments with and without a significant contribution from the NARS. The last scenario considers improved marketing efficiency through increased investment in infrastructure. Description of the considered scenarios is presented in Table 1. Each of these scenarios is associated with a given assumption of investment amounts in the sampled countries (See Rosegrant et al., 2017 for more details).

4.2. Selection and background information on sampled countries

Western, Eastern and North Africa regions have been selected in this study. The western African countries include Nigeria, Ghana, Niger, Mali, and Senegal; Eastern African countries includes Ethiopia, Kenya, Sudan, Uganda, and Tanzania; and North Africa countries include Tunisia, Morocco, Algeria, and Egypt. Note that economies of the western and eastern African countries are dominated by agriculture, with high contribution of this sector to national GDPs: (between 22% and 50%) (FAO, 2017a). Accordingly, it is expected that agricultural investments would have high implications for employment in these regions (Diao et al., 2010). The North African region was included to serve as a benchmark, given that agriculture contributes with a much lower share to total employment in this region compared to West and East African countries (FAO, 2017a). As economic development theory suggests the share of agriculture in the overall GDP declines with economic growth, the impact of our scenarios on North African countries can thus provide useful information about possible future trends of SSA countries. More background information about the considered countries can be found in Tables 2 and 3

Table 3
Infrastructure, research, and labor productivity indicators of the considered countries.
Source: The World Bank Open Data (https://data.worldbank.org/indicator)

Country Name	Electric power consumption (kWh per capita)- 2014 data	Access to electricity (% of population) – 2016 data	Labor force, female (% of total labor force)- 2017 data	Research and development expenditure (% of GDP) -	GDP per person employed (constant 2011 PPP $) – 2017 data
Algeria	1356.2	99.43957	18.2	0.066[e]	52990.3
Egypt	1657.7	100	23.0	0.722[a]	37586.5
Ethiopia	69.7	42.9	47.3	0.604[b]	3647.1
Ghana	354.7	79.3	49.5	0.376[c]	9113.0
Kenya	166.7	56	48.4	0.785[c]	8651.9
aMorocco	901.1	100	26.0	0.714[c]	23668.0
Mali	na	35.0	43.0	0.583[c]	6045.3
Niger	51.4	16.2	43.4	na	2350.1
Nigeria	144.4	59.3	45.4	0.219[d]	18612.2
Sudan	190.2	38.5	25.7	0.298[e]	18416.4
Senegal	223.4	64.5	41.3	0.541[c]	7920.7
Tunisia	1444.1	100	26.4	0.631[a]	35945.5
Tanzania	99.1	32.8	48.8	0.528[b]	5777.6
Uganda	na	26.7	47.9	0.475[c]	4871.0

[a] 2015 value.
[b] 2013 value.
[c] 2010 value.
[d] 2007 value.
[e] 2005 value.

Table 4
Average elasticity values used for the sensitivity analysis.

Region	Country	Elasticity values from literature: Kapsos (2005) (1991–2003)	Ben Slimane (2015) (2000–2011)	World Bank (2011) (2000–2008)	UNCTAD (2013) (2000–2008)	Bhorat (2015) (2000–2008)	Average elasticities (from literature)	Standard Deviation	Coefficient of variation	Elasticity values for sensitivity analysis: Mean + 10%	Mean + 30%	Mean - 10%	Mean - 30%
Western Africa	Nigeria	1.11	0.38	n.a	n.a	0.37	0.62	0.43	0.69	0.68	0.81	0.56	0.43
	Ghana	0.73	0.55	n.a	n.a	0.5	0.59	0.12	0.20	0.65	0.77	0.53	0.41
	Niger	0.67	1.14	n.a	0.56	1.11	0.87	0.30	0.34	0.96	1.13	0.78	0.61
	Mali	0.49	0.78	n.a	0.41	0.38	0.52	0.18	0.35	0.57	0.67	0.46	0.36
	Senegal	0.80	n.a	n.a	0.75	0.49	0.68	0.17	0.24	0.75	0.88	0.61	0.48
Eastern Africa	Ethiopia	0.82	0.55	n.a	0.58	n.a	0.65	0.15	0.23	0.72	0.85	0.59	0.46
	Kenya	1.96	0.84	n.a	n.a	0.8	1.20	0.66	0.55	1.32	1.56	1.08	0.84
	Sudan	0.68	0.54	n.a	0.35	n.a	0.52	0.16	0.31	0.57	0.68	0.47	0.37
	Uganda	0.34	0.41	n.a	0.46	n.a	0.40	0.06	0.15	0.44	0.52	0.36	0.28
	Tanzania	0.96	0.54	n.a	0.25	n.a	0.58	0.36	0.61	0.64	0.76	0.53	0.41
North Africa	Tunisia	0.79	0.48	0.49	n.a	n.a	0.59	0.18	0.30	0.65	0.76	0.53	0.41
	Morocco	0.42	0.49	0.45	n.a	n.a	0.45	0.04	0.08	0.50	0.59	0.41	0.32
	Algeria	0.51	1.15	1.41	n.a	n.a	1.02	0.46	0.45	1.13	1.33	0.92	0.72
	Egypt	0.45	0.54	0.7	n.a	n.a	0.56	0.13	0.23	0.62	0.73	0.51	0.39

Average CV value is about 30%. Maximum variation of 30% for the sensitivity analysis is chosen on this basis.

4.3. Source of data

The GDP-employment elasticities for the 14 sampled countries were collected from different literature references and sources (Table 4). While the approaches used for the estimation of these elasticities are mixed, their estimation period ranges between 2003 and 2011 (Table 4). Average elasticities for each country are calculated as the mean of a minimum of three values available from three different sources. It is found that the average coefficient of variation (CV) of elasticities we used in the present study for the set of 14 sampled countries was about 33%. Taking this into account we performed a sensitivity analysis on the elasticities by reviewing results at ± 10% and ± 30% intervals (Table 4). Approach and results of the sensitivity analysis will be presented in Appendixes 5 and 6.

The sex-disaggregated elasticities are collected from Kapsos (2005), which provides the most comprehensive assessment of labor response concerning GDP growth by sex (See Table 5).

5. Trends in future sex-disaggregated employment in Africa: some results from scenarios analysis

5.1. Agricultural investment and employment generation

The impacts of agricultural research and development investments on employment were found to vary significantly across the sampled countries. Among the West African countries, the highest return in terms of employment generation is found in Nigeria, followed by Ghana and Niger. Our simulation exercise shows that higher agricultural research investments combined with enhanced research efficiency in Nigeria can generate better employment outcomes in the medium term (by 2025). However, employment creation under the scenario of high investments across the CGIAR portfolio together with complementary NARS investments (HIGH + NARS) can generate more sustainable impacts in Nigeria in the long term (by 2045) compared to other proposed investment scenarios. Both scenarios HIGH and HIGH + NARS remain highly comparable. Also, it has been shown that highest employment creation in east African countries, as expressed by the number of additional active population generated by the simulated scenarios will be recorded in Ethiopia, Kenya, and Tanzania, respectively. A general remark is that by 2025, an increase in research efficiency can generate the highest impact in the largest African countries (in terms of population size): Nigeria, Ethiopia, and Egypt.

Scenarios analyses show that the impact of agricultural investment scenarios in North Africa is much lower compared to East and West Africa. This indicates the presence of important potential to achieve rapid economic growth and generate employment opportunities through enhanced agricultural investment in the east and West African economies. Within North Africa, both Egypt and Morocco can accrue the benefits of highest employment generation through proposed agricultural investments.

In terms of comparison between scenarios, "High + NARS" and "High + RE" always have comparable long run results in most of the countries. In the medium term (2025), "High + NARS" demonstrates much better results in terms of employment creation in Nigeria, Ghana, Ethiopia, Kenya, Morocco, and Egypt (Fig. 1; Appendixes 2 & 3). Another important result is that the RMM scenario would not, similarly to other scenarios, have a high impact in Nigeria. RMM investments would have the best impact (number of employment) if targeted in countries such as Ethiopia, Kenya, Tanzania, and Egypt. The highest annual increase of employment under this scenario is however observed for Niger, Ethiopia, and Kenya (see Appendixes 2 and 3; Fig. 2). The literature suggests that the impact of similar infrastructure investments would depend on the level of development of manufacturing and food processing sectors in rural areas (Rud, 2012).

To have a better understanding and comparison of the trend and scope for employment generation among regions and countries, Fig. 3

Table 5
Male and Female employment elasticities (Kapsos, 2005) and 2015 active population for the selected countries (FAO data).

		Average male elasticity over the period 91-2003	Average female elasticity over the period 91-2003	2015 values (in 1000 persons)		
				Total Active population	Male active population	Female active population
Western Africa	Nigeria	1.08	1.18	59163.00	34077.89	25085.11
	Ghana	0.74	0.71	11958.00	6038.79	5919.21
	Nigeria	0.67	0.67	6465.00	4441.46	2023.55
	Mali	0.49	0.49	5826.00	3571.34	2254.66
	Senegal	0.77	0.83	6711.00	3697.76	3013.24
Eastern Africa	Ethiopia	0.58	1.14	50204.00	26507.71	23696.29
	Kenya	1.90	2.02	18961.00	6314.01	12646.99
	Sudan	0.59	0.93	13035.00	9189.68	3845.33
	Uganda	0.34	0.34	16756.00	8562.32	8193.68
	Tanzania	0.99	0.93	26531.00	13345.09	13185.91
North Africa	Tunisia	0.63	1.35	4162.00	3042.42	1119.58
	Morocco	0.50	0.14	12643.00	9216.75	3426.25
	Algeria	0.37	0.94	13121.00	10824.83	2296.18
	Egypt	0.42	0.54	29507.00	22307.29	7199.71

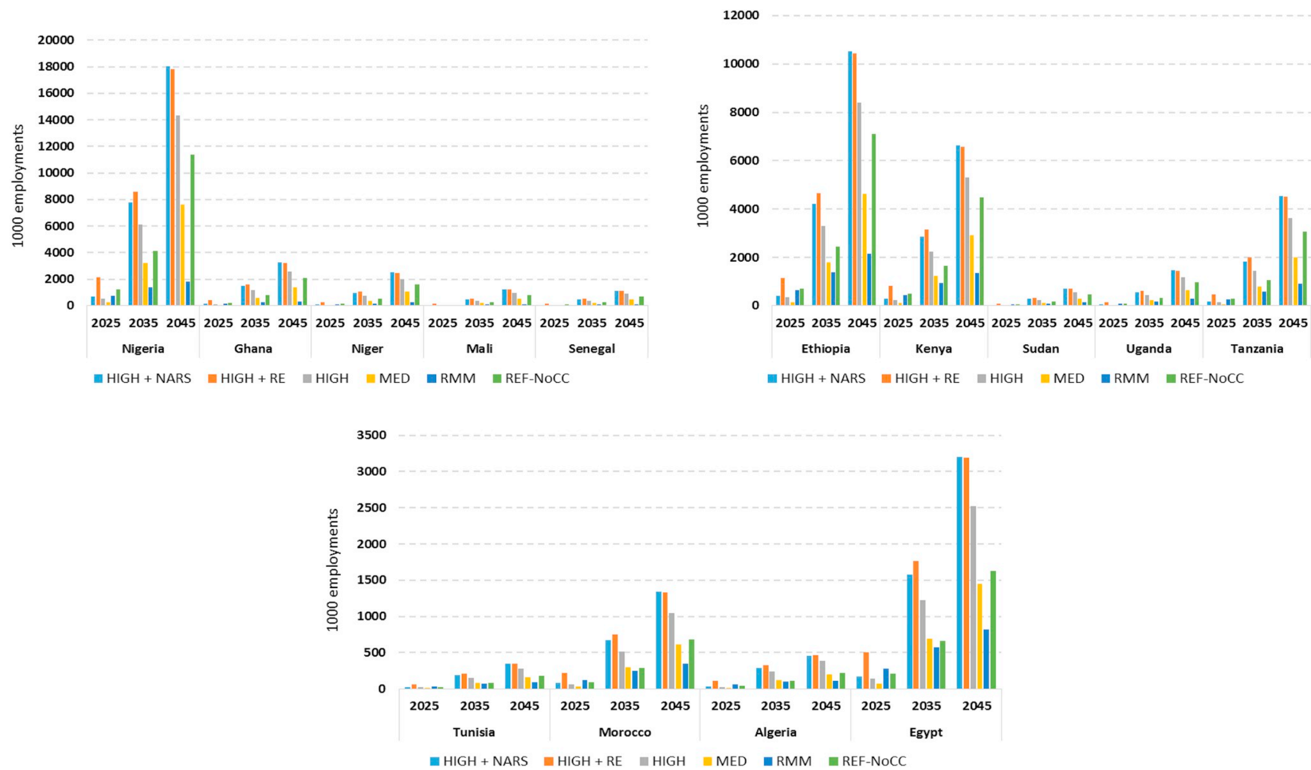

Fig. 1. Cross countries comparison of the effect of different scenarios considered on future employment creation (number of employment exclusively attributed to the respective scenarios adoption) (see also the values in appendix 2).

presents the annual average employment increase over the period 2015–2045, under each investment scenario. In terms of percentage change, Niger in West Africa would have the highest rate of employment increase over the period 2015–45, followed by Nigeria, Ghana, Mali, and Senegal. In East Africa, Kenya would have the highest rate of employment increase over the considered period, followed by Ethiopia and Tanzania. In North Africa, the effect of the considered scenarios would have much lower impact on employment compared to other African regions.

Initial thoughts of low employment generation would refer to the low importance and contribution of the agricultural sector in terms of added value to GDP. However, Fig. 3 shows that this can only be generalized for the North African countries, where the share of agriculture to GDP is reasonably low compared to east and West African countries. In Fig. 3, the empty top-left area is showing that countries with agricultural sector currently contributing with less than 20% to the GDP, have not shown any significant increase in employment (not more than 0.6% annually). However, other African countries having an agricultural sector highly contributing to the overall economy are showing mixed patterns of employment growth under productivity investment scenario. Sudan and Ghana, for example, are having similar employment elasticities (0.5 and 0.53) as well as the similar contribution of agricultural sector to overall GDP (about 30%), but employment outcomes of the same investments in agricultural productivity enhancement generate very distinct results.

In line with these results, comparing "average annual increase of employment" vs. "average increase of yields and food availability" in Fig. 4 shows that the countries which will accrue the most of productivity increase in the coming four decades would also have the highest rate of employment generation. However, there are exceptions,

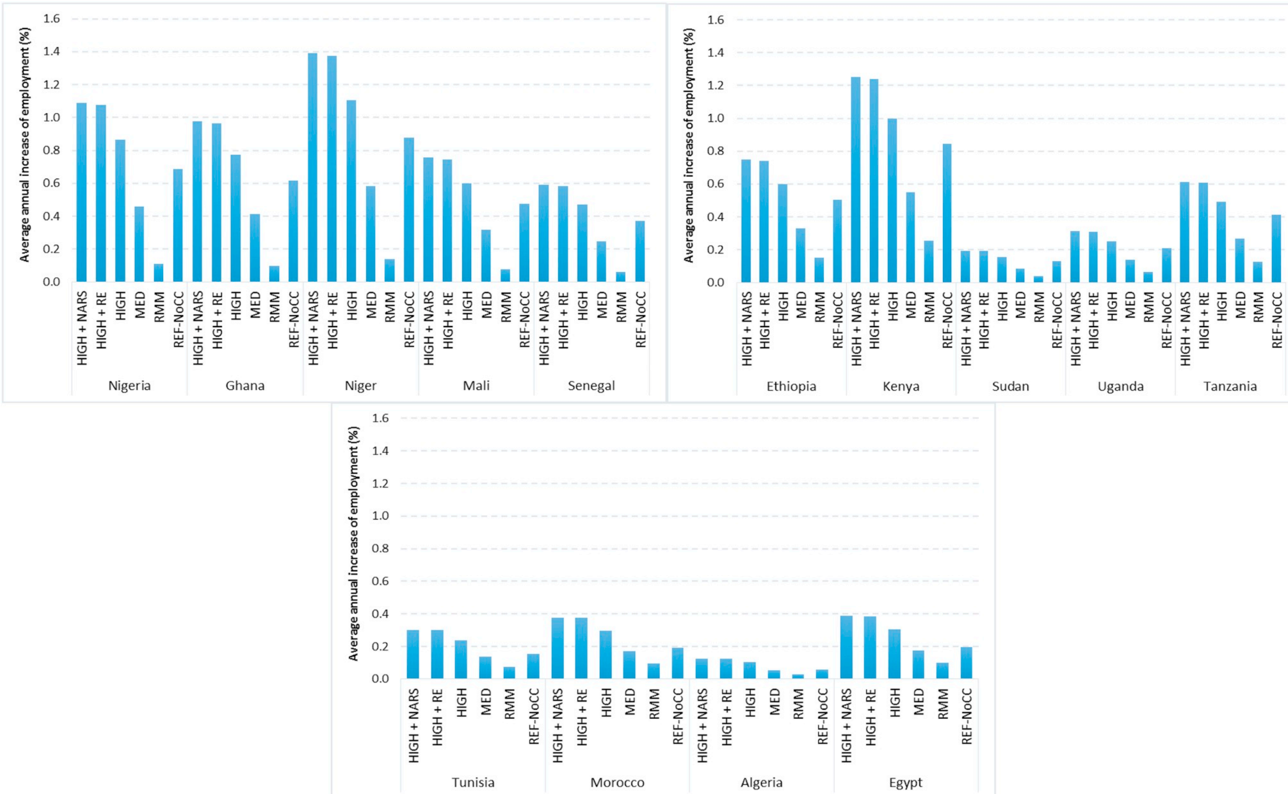

Fig. 2. Average annual employment increase over the period 2015–2045 (in %), under the different scenarios (see more details in Appendix 3).

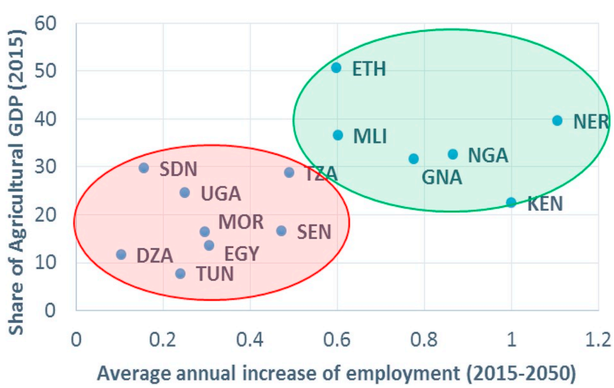

Fig. 3. Average annual increase of employment (between 2015 and 2050) vs the current share of agricultural GDP (2015 values). (Average annual increase of employment considered in this figure are the ones obtained under the HIGH scenario).

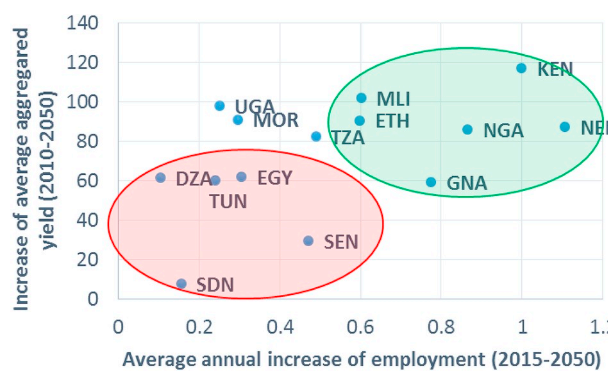

Fig. 4. Average annual increase of employment (between 2015 and 2050) vs average increase of aggregated yields and food availability (between 2015 and 2050). (Values considered in this figure are the ones obtained under the HIGH scenario).

for example, Morocco and Uganda. The projected employment generation in Morocco and Uganda will be low despite the high projected yield. Although low productivity enhancement coincides with low employment generation, Ghana is an exception where a little increase in agricultural productivity can have high effects on employment. Currently, the agricultural sector in Ghana contributes 30% to the total GDP.

The mixed results of employment generation under the proposed research investment scenarios in the selected countries can be explained in the literature by many other factors. The impact of agricultural investments, (especially investments to promote technology change/adoption), on employment is skill-biased and more likely to be observed when technology adoption favors product innovation as opposed to process innovation (Ugur and Mitra, 2017). Investments in closing yield gaps through technology adoption are also less likely to be associated with employment creation when the evidence is related to low-income countries as opposed to lower-middle-income or middle-income countries (Ugur and Mitra, 2017). The effect of agricultural GDP growth is indeed mostly channeled through the labor market, but it also affects the overall income and economic welfare of the population, where the distribution of the benefits depends on the overall structure of the economy and the performances of its institutions (Cervantes-Godoy and Dewbre, 2010). Although it indicates the necessity of country-case studies, our analysis also reveals some general patterns. It shows that countries with large agriculture share to GDP, and the countries that will be able to achieve higher productivity growth from agricultural investments, will also be successful to generate more social impacts by generating more employment.

Fig. 5. Effect of different scenarios on future male and female employment creation in selected countries (values are averages calculated over the period 2015–2045) (See all values in Appendix 4).

5.2. Distribution of employment generation by sex

The sex-disaggregated analysis shows that the considered scenarios would result in higher female employment than male employment in 8 out of 14 countries (Fig. 5). Countries, where employment creation for women will be higher due to agricultural investments, are Nigeria, Senegal, Kenya, Ethiopia, Egypt, Sudan, Tunisia, and Algeria. However, the analysis shows that the existing gap between male and female employment generation due to agricultural investments will be widened more in favor of men in Ethiopia, Egypt, Sudan, Tunisia, and Algeria. Tanzania labor growth equally favors male and female. It is again important to remark that by 2025, the RMM scenario (improved infrastructure) in addition to the HIGH + RE scenario are stimulating most of the female employment growth. By 2025, investments in infrastructure seem to be more effective in generating female employment growth compared to the productivity investment scenarios. This confirms the fact that infrastructure development present key opportunities for women's economic empowerment, including direct, indirect and induced job creation within both the formal and informal economy (Mohun and Biswas, 2016; Khan, 2018). This can happen as a result of reduced time burden (reduction in their domestic unpaid tasks), increased mobility (transport options), access to resources (water, energy and land) and markets, enhanced productivity of existing activities, reduced risks of violence, improved household health conditions, and increased agency (Fontana and Natali, 2008; Mohun and Biswas, 2016; Khan, 2018). However, it stated by Khan (2018) that infrastructure projects rarely address this need directly and tend to consider infrastructure to be a universal benefit, which downplays women's economic and social roles in low-income contexts. The design of such investments should be gender-sensitive, minimize displacement of the urban and rural poor, and provide solutions that are affordable to the most marginalized social categories (Mohun and Biswas, 2016).

6. Conclusions and implications

The present study quantifies the impacts of different levels of agricultural investments on the employment generation in 14 selected countries in East, West, and North Africa. This effect on employment was assessed through the GDP growth under each scenario combined with the "employment elasticity to growth" concept. Even though these investments are exclusively related to the agricultural sector, their comprehensive impacts on overall GDP as well as on direct and indirect employment creation in the whole economy are estimated as a more reliable way.

The infrastructural investment demonstrated positive employment growth enhancement impacts only in Ethiopia, Kenya, Tanzania, and Egypt. Interestingly, the present study vividly demonstrates that the higher agricultural research investments combined with enhanced research efficiency (HIGH + RE) can generate better employment outcomes in the medium term particularly in the large economies such as Nigeria. In terms of volume (number of employment), our simulations show that the research enhancing efficiency investment scenario can generate the highest employment in Ethiopia, Kenya, and Tanzania, Nigeria, Ethiopia, and Egypt. This indicates that enhancing research efficiency is the most appropriate strategy to increase employment in the medium terms (2025), while for others, investments in infrastructure are the most appropriate under this time horizon. However, this last type of investment has shown its limits to guarantee sustainable employment generation in the long term (by 2045). Finally, the present study demonstrates that agricultural investments, in general, can generate more employment benefits to the women particularly in Nigeria, Senegal, Kenya, Ethiopia, Egypt, Sudan, Tunisia, and Algeria. Particularly, the infrastructural improvement investment (RMM) can have larger female employment impacts in the sampled SSA countries.

Overall, results demonstrate the existence of some employment trend patterns. These are determined by a combination of factors, including the type of investment, agricultural contribution to GDP growth, level of yield gap, and institutions performances. The simulation results also provide important foresight information about country-specific future employment trends and can be used to set and prioritize agricultural investment strategies to generate higher and more equitable employment.

Declaration of competing interest

None.

Acknowledgment

The authors would like to acknowledge funding for this research, which was provided by the CGIAR Research Program on Policies, Institutions, and Markets (PIM), the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS), the Bill and Melinda Gates Foundation, and the United States Agency for International Development (USAID). This was a collaborative research building off expertise across the CGIAR as a part of the Global Futures and Strategic Foresight Project (Agreement number: 000056-CGIAR Fund).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gfs.2020.100353.

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