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A GLOBAL INITIATIVE FOR THE UNITED NATIONS

The Food and Land Use Coalition

2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems

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2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems in Ethiopia by 2050

Ethiopia

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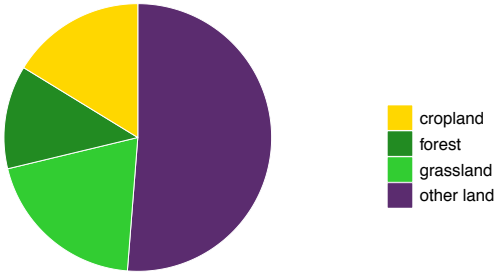
Land and food systems at a glance

A description of all units can be found at the end of this chapter

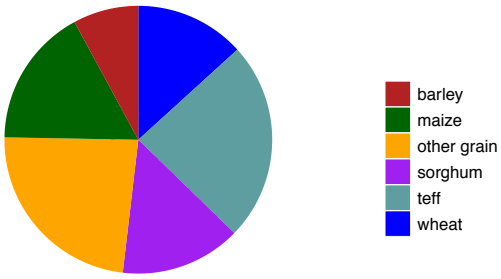
Land & Biodiversity

Fig. 1 | Area by land cover class in 2015



Source: FAOSTAT

Fig. 2 | Share of harvested area by crop in 2015



Source: FAOSTAT

Annual deforestation in 2015:
140 kha = 1% of total forest area

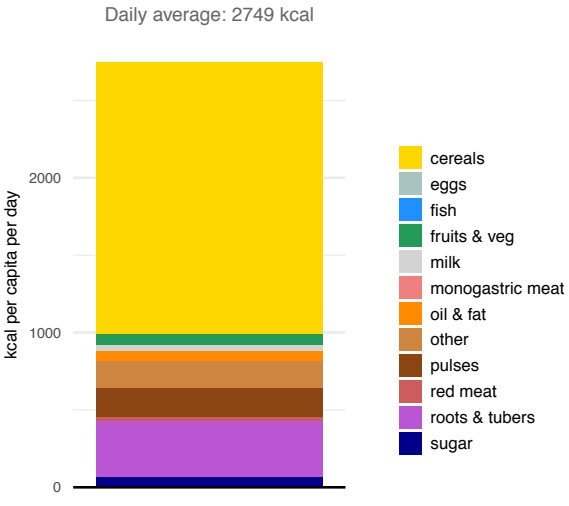
(Bekele, 2001)

Endangered species: 179 threatened species of which 36% are plants, 20% birds, and 20% mammals

(IUCN Red List, 2019)

Food & Nutrition

Fig. 3 | Daily average intake per capita at the national level in 2012



Source: Berhane et al. (2012)

Share of undernourished in 2016:
Children age 0-5 years: 38%

(Gebru et al., 2018)

Share of obese in 2015:
Adult women: 7-8%

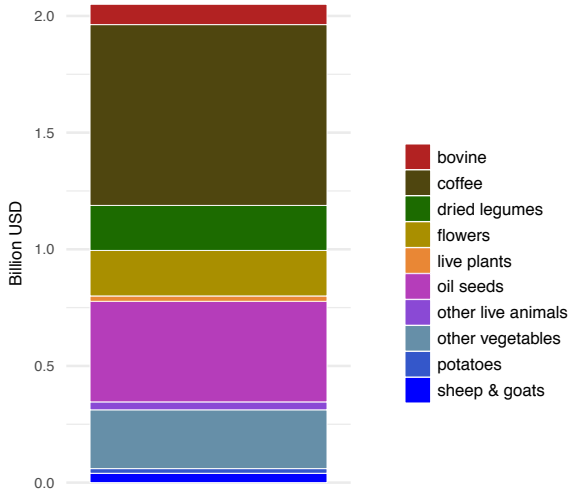
(Gebru et al., 2018)

Adult men: 1.9%

(WHO, 2017)

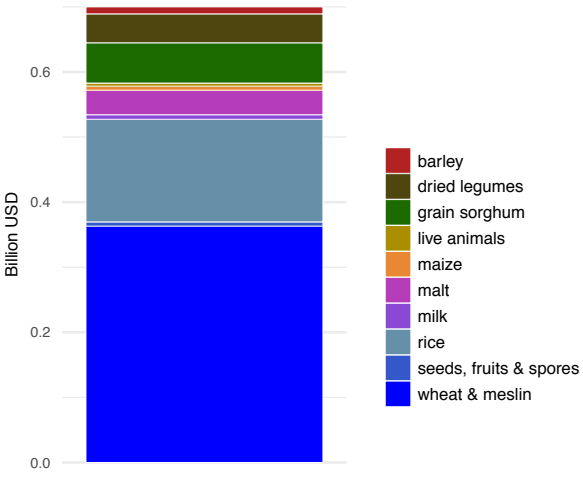
Trade

Fig. 4 | Main agricultural exports by value in 2017



Source: ITC (2016)

Fig. 5 | Main agricultural imports by value in 2017



Source: ITC (2016)

Surplus in agricultural trade balance in 2015: USD 206 mln

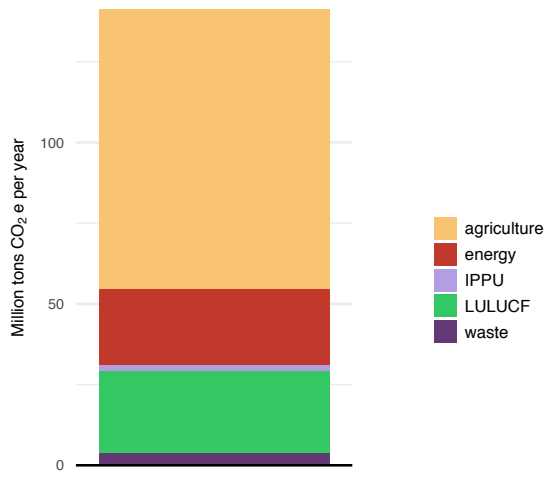
(FAOSTAT, 2019; and authors' computation)

120th/80th most important exporter /importer in the world in 2015

(Central Intelligence Agency, 2017)

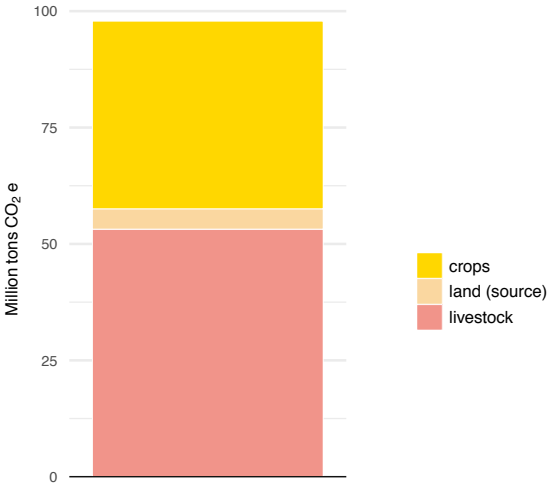
GHG Emissions

Fig. 6 | GHG emissions by sector in 2011



Source: World Resource Institute (2015)

Fig. 7 | GHG emissions from agriculture and land use change in 2013



Source: FAOSTAT

Main assumptions underlying the pathway towards sustainable land-use and food systems

For a detailed explanation of the underlying methodology of the FABLE Calculator, trade adjustment, and envelope analysis, please refer to sections 3.2: Data and tools for pathways towards sustainable land-use and food systems, and 3.3: Developing national pathways consistent with global objectives.

GDP GROWTH & POPULATION

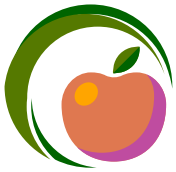
	GDP per capita	Population
Scenario definition	GDP is expected to increase from USD 49 bln in 2015 to USD 471 bln in 2050. GDP per capita is expected to increase from USD 487 in 2015 to USD 2,765 in 2050 (a national scenario of high-speed economic growth as set in the five-year plans of the country was selected).	The population is expected to increase by 70.6% between 2015 and 2050 from 99.87 mln to 170.42 mln (UN low growth scenario was selected).
Scenario justification	The GDP figures are based on projections by the Planning and Development Commission for subsequent five-years. Specifically, according to the vision laid out in various government documents such as Ethiopia's second five-year Growth and Transformation Plan (GTP II) and the Climate Resilient Green Economic (CRGE) plan, real GDP is expected to increase by 11 %/year up to 2025 (Federal Democratic Republic of Ethiopia, 2011; National Planning Commission, 2016). Accordingly, we have assumed an annual average GDP growth rate of 6.7%/year between 2015 and 2050. This is lower than Ethiopia's 11.2% average growth rate observed between 2010/11 and 2014/2015 (National Planning Commission, 2016), but it is higher even compared to the SSP1 scenario.	Based on the UN's population projection database (UNPD, 2015). The primary source of population data is the census which was conducted in 1994 and 2007. Accordingly, the average population growth rate is close to 2.5%/year between 1994 and 2007 – corresponding to the two census periods (Central Statistical Agency, 2013). However, this is expected to go down as a result of the government's focus on increasing the contraceptive prevalence rate of up to 66% by 2015 (Central Statistical Agency, 2013). Accordingly, CSA projects the population to reach 122 mln by 2030 (Central Statistical Agency, 2013). The results that are closest to this figure are found using the UN low growth scenario.

TRADE

	Imports	Exports
Scenario definition	Increased imports scenario for wheat, milk, and corn was selected. The share of total consumption which is imported increases: - from 39% in 2010 to 79% in 2050 for wheat, and - from 0% in 2010 to 1% in 2050 for milk. The share of total consumption which is imported stays constant at 2010 levels for the other commodities.	We have assumed that exports of coffee, sesame, and corn increase by a factor of 1.5 by 2050. Accordingly, the exported quantity for these products is expected to increase: - from 212 Mt in 2010 to 317 Mt in 2050 for coffee, - from 228 Mt in 2010 to 342 Mt in 2050 for sesame, and - from 4 Mt in 2010 to 6 Mt in 2050 for corn.
Scenario justification	We have assumed increased import share for wheat following the pattern of import in the country (Olana et al., 2018). As is also indicated in Olana et al (2018), Ethiopia's wheat imports have been growing fast and it is expected to increase in the future given the high population growth and improvements in the standards of living in the country, which in turn is likely to lead to higher demand for wheat products.	The slower export growth assumption is based on the country's small export base as well as slower growth rate of exports of goods which has been observed in recent years (IMF, 2018).

LAND

	Land conversion	Afforestation
Scenario definition	We assume that there will be no constraint on the expansion of the agricultural land outside beyond existing protected areas and under the total land boundary.	We assume total afforested/reforested area to reach 15 Mha by 2050
Scenario justification	Ethiopia has diverse geographic conditions. Crop production takes place mainly in the highlands and there is little room for cropland expansion in the highlands, but there is potential to expand cropland activities in the low lands (Schmidt and Thomas, 2018). In relation to pastureland, the grey literature identifies the rise in rangeland enclosures (Fekadu Beyene, 2009; Napier and Desta, 2011). Currently, there is no effort that we are aware of aiming to limit agricultural land expansion. Therefore, we have assumed free land expansion to get closer to what is likely to happen in the future.	Considering the commitment towards a Climate Resilient Green Economy that the country has outlined in 2011 and the pledge it has made, we have taken the Ethiopia's Bonn challenge commitment targeting 15 Mha for afforestation by 2020 (Pistorius et al., 2017).



FOOD

	Diet	Food waste
Scenario definition	The daily average consumption per capita at the national level is expected to increase from 1,849 kcal in 2010 to 2,246 kcal in 2050. Between 2010 and 2050, the average daily calorie consumption per capita increases: - by 23% for cereals, - by 311% for pig and poultry meat, - by 139% for eggs, - by 42% for milk, - by 30% for oil and fat, - by 3.2% for red meat, - by 5% for pulses, - by 14% for roots and tubers, and - by 49% for sugar. While the daily calorie decreases for ruminant meat and roots, and it increases for pulses and eggs.	Between 2010 and 2050, the share of final household consumption which is wasted decreases from 10% to 5%.
Scenario justification	We have assumed that diets will follow the FAO's projection (Alexandratos and Bruinsma, 2012). This appears to be the best estimate we were able to find.	We have assumed a reduced share of food waste compared to 2010 as many development partners are looking at food waste as a possible area of intervention (Federal Democratic Republic of Ethiopia, 2011).

Scenario signs = no change → small change ↗ large change

	PRODUCTIVITY		
	Crop productivity ↗	**Livestock productivity** ↗	**Pasture stocking rate** =
Scenario definition	Between 2015 and 2050, crop productivity increases: - from 1.36 t/ha to 4.39 t/ha for teff, - from 1.91 t/ha to 6.51 t/ha for wheat, - from 2.64 t/ha to 8.81 t/ha for corn.	Between 2015 and 2050, productivity per head: - increases from 9.3 kg/head to 17.6 kg/head for cattle meat, - will remain the same at 4 kg /head for sheep and goat meat, - increases from 601.7 kg/ head to 7.4t/head for cow milk, and - increases from 41.8 kg/head to 181.8 kg/head for sheep and goat milk.	The average livestock stocking density remains constant at 1.45 TLU/ha of pastureland between 2015 and 2050.
Scenario justification	Despite the assumption of free expansion of agricultural land, we have assumed high crop productivity growth. The reason for assuming high crop productivity growth is based on the country's current relatively low cereal productivity base (Taffesse et al., 2012) and significant improvements in recent years following the government's focus on agricultural transformation through various programs such the agricultural growth program which shows a 16% improvement in yield in five year (World Bank, 2017).	We have assumed a livestock productivity scenario higher than for the period 2000-2010. This is because of the renewed interest among policymakers and development partners towards the livestock sector, as well as the low level of current productivity. Ethiopia's cattle meat production of 14 kg per standing head is lower than neighboring countries like Kenya (21 kg per standing head) and milk production is even less productive 72.5 kg per standing head compared to Kenya's 194.74 kg per standing head (Shapiro et al., 2015).	The livestock density reported by (Tilahun and Schmidt, 2012) is 0.3 TLU/ha but it disregards camel, and donkey.

Scenario signs = no change → small change ↗ large change

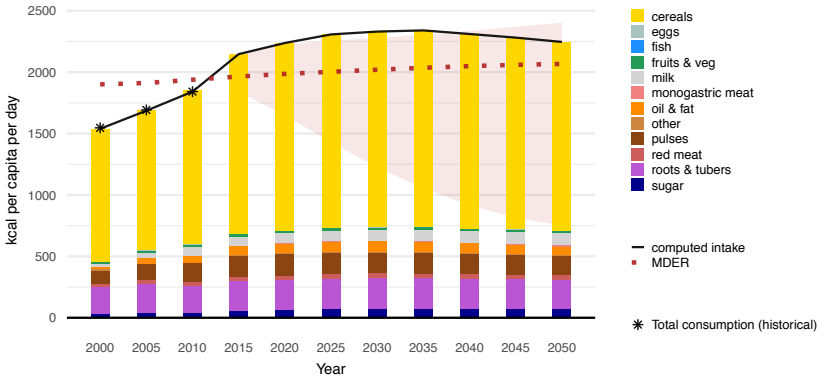
Results against the FABLE targets

The results for FABLE targets as well as "other results" are based on calculations before global trade harmonization.

Food security

Fig. 8 | Computed daily kilocalorie average intake per capita over 2000-2050

Note: The Minimum Daily Energy Requirement (MDER) is computed based on the projected age and sex structure of the population and the minimum energy requirements by age and sex for a moderate activity level. Animal fat, offal, honey, and alcohol are not taken into account in the computed intake.



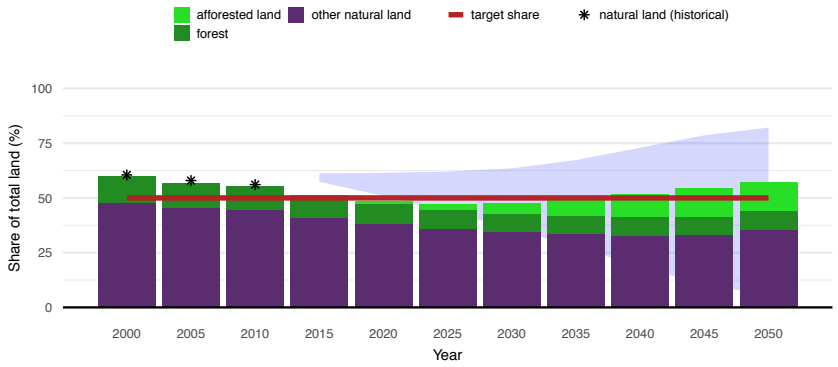
Historical data source: FAOSTAT

Our results show the average daily energy intake per capita increases between 2000 and 2030 and remains stable after that. Calorie intake reaches 2,330 kcal by 2030 and shows a slight decline thereafter. In terms of recommended diet, our results show higher consumption of animal-based proteins, sugar and fat but the initial levels were very low compared to other countries.

The computed average calorie intake is higher than the minimum requirement (MDER) at the national level from 2015 onwards (average calorie intake of 2,246 compared to MDER of 2,067 in 2050). The national nutrition plan aims to reduce the percent of newborns with weights less than 2.5 kg from 11% in 2014 to 5% by 2020 and reduce the number of overweight women of reproductive age from 9% in 2014 to 6% in 2020.

Biodiversity

Fig. 9 | Computed share of the total land which could support biodiversity over 2000-2050



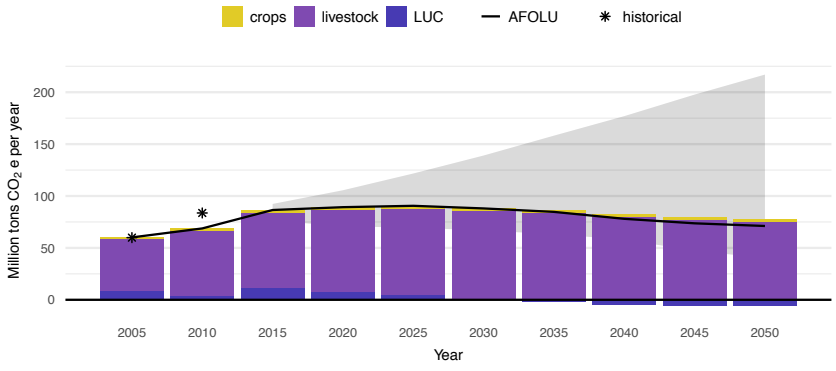
Historical data source: FAOSTAT

Our results show that the Share of Land which could support Biodiversity (SLB) decreased between 2000-2030 from 60% to 47%. After reaching its lowest level of 47% in 2030, the computed SLB increased thereafter reaching above 60% in 2050 thanks to afforested land.

Compared to the global target of having at least 50% SLB by 2050, our results are above the target. As indicated in the Institute of Biodiversity Conservation (2005), the Ethiopian government has established at different levels close to 193,600 km2 of land for wildlife protection.

GHG emissions

Fig. 10 | Computed GHG emissions from land and agriculture over 2000-2050



Historical data source: FAOSTAT

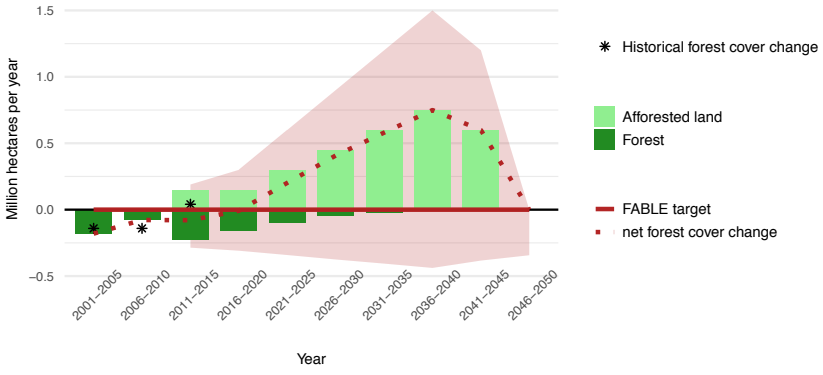
Note: AFOLU (Agriculture, Forestry and Other Land Use) is the sum of computed GHG emissions from crops, livestock and Land Use Change (LUC), emissions and sequestration from forestry are not included. Historical emissions include crops and livestock.

Our results show annual GHG emissions increase from 37 to 91Mt CO_2e between 2000 and 2025. Peak AFOLU GHG emissions are computed for the period 2021-2025 at 91 Mt CO_2e /year. This is mostly driven by GHG emissions from the livestock sector. AFOLU GHG emissions reach 71 Mt CO_2e over the period 2046-2050: 77 from agriculture and -6 from land use change.

Our results meet the target of zero or negative emissions from land use change by 2050 but the reduction in emissions from agriculture is limited. Overall emissions are considerably less than what is estimated by the Climate Resilient Green Economy (CRGE) strategy – 150 Mt CO_2e total GHG emissions as of 2010 of which 130 MtCO_2e is from agriculture and forestry. However, the composition of sectoral contribution is consistent as the agricultural sector is the major contributor to emissions (Federal Democratic Republic of Ethiopia, 2011).

Forests

Fig. 11 | Computed forest cover change over 2000-2050



Historical data source: FAOSTAT

Our results show annual deforestation between 80 kha and 230 kha/year from 2000-2015. It decreases over time after 2015. Deforestation peak is computed in 2015 at 230 kha/year. This is mostly driven by pasture expansion and to cropland expansion (until 2025). Deforestation reaches 43 kha/year over the period 2031-2035 and becomes less than 1 kha/year over 2035-2050. Afforestation is computed from 2015-2045 and leads to a positive net forest cover change from 2025 to 2045 with a peak of afforested area over 2036-2040 at 750 kha/year.

Compared to the global target of having zero or positive net forest change after 2030, our results are above the target. Ethiopia has set a target of increasing forest cover from 15.5% in 2014/15 to 20% by 2019/20 (National Planning Commission, 2016). In other words, the plan aims to increase forest cover from the current 17 Mha to 22 Mha (Ethiopia's total land area of 110 Mha) between 2015 and 2020. The model predicts that net forest cover change will still be negative for the year 2020 but very low (i.e. -9 kha/year).

Other relevant results for national objectives

Table 1 | Other Results

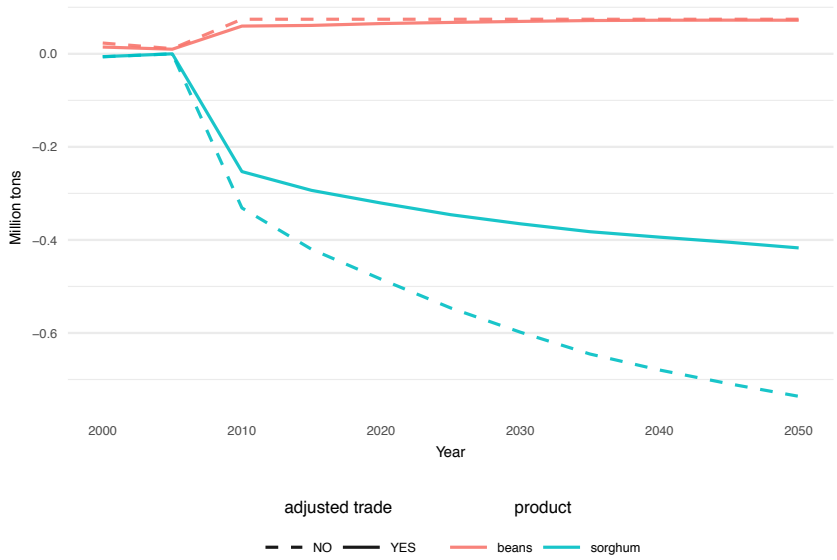
Variable	Unit	2000	2005	2010	2015	2020	2030	2040	2050
Coffee production and export									
Production	kt	229.2	171.6	369.7	316.3	349.0	450.0	465.5	478.6
Export	kt	118.9	172.2	211.7	216.9	238.1	317.5	317.5	317.5
Sesame production and export									
Production	kt	15.6	115.4	327.7	240.6	264.8	352.3	353.2	353.5
Export	kt	26.9	219.0	228.0	233.7	256.5	342.1	342.1	342.1

Although the historical values of annual production of coffee are quite close to the calculated values (370 vs. 371 kt for 2010), both are a bit higher than the 341 kt reported in official statistics (Ministry of Finance and Economic Development, 2010). On the other hand, for 2015, the 316 kt annual production of coffee calculated by the FABLE Calculator is lower than the 419.98 k/t reported in GTP II (for 2014/15 fiscal year) and 431 kt reported by (USDA, 2018). In a country where slightly less than half of the production is locally consumed, the very narrow gap between production and exports observed in 2005 calls for an explanation. In the case of exports, the 2010 annual export of coffee used in the model (211 kt) is lower than the 320 kt indicated in GTP I baseline (2009/2010).
Both the production and the exports of coffee steadily increase between 2015 and 2030. After 2030, while coffee production continues to gently increase reaching 478 kt in 2050, annual exports of coffee remain flat around 317 kt. Given GTP II's target of producing 1 Mt of coffee by 2019/20, the 2050 projected 478 kt is quite small.

The fact that the historical annual export values of sesame are larger than its annual production values in the FAO database (especially in 2005) is puzzling and calls for a need to further check the data (the gap appears to be too big to be justified based on changes in stocks). Projection of sesame production increases between 2015 and 2030 and remains relatively flat thereafter reaching a bit higher than its historical peak in 2010. Given the traditionally low domestic consumption of sesame, the narrow gap between production and exports is expected. The country has a target of increasing its annual production of oilseeds and pulses, which mostly comprises of sesame, from 373 kt in 2014/15 to 925 kt in 2019/20 (National Planning Commission, 2016). Given this target, the projection of annual production/export for sesame only of approximately 340 kt seems reasonable.

Impacts of trade adjustment to ensure global trade balance

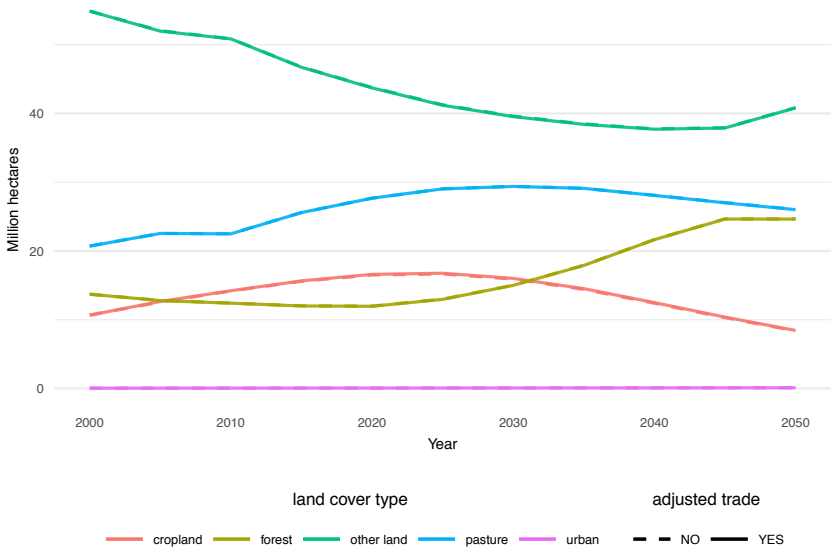
Fig. 12 | Impact of global trade harmonization on main exported/imported commodities over 2000-2050



When we compare trends in Ethiopia's export commodities with and without trade adjustment, no difference appears between exports of the country's major exports (coffee and sesame). However, the evolution of other key export commodities like beans differs when calculated with and without trade adjustment. Specifically, while the trade adjusted exports of beans start out lower than the unadjusted exports, it tends to increase steadily and the two start to converge after 2030. In the case of oilseeds (others), the trade-adjusted evolution of exports remains substantially lower than the export figures calculated without trade adjustment.

When we compare the evolution of key imports like wheat, rice, milk, and palm oil, we do not find any difference between the evolution of imports with and without trade adjustment. However, in the case of two other key import commodities, sorghum and sugarcane, we see import values calculated without trade adjustment are much higher than imports calculated with trade adjustment.

Fig. 13 | Impact of global trade harmonization on land use over 2000-2050



Evolution of land use with and without trade adjustment remains almost the same. This is because exports and imports (and hence production) of major commodities are not affected by the trade adjustment.

Discussion and next steps

The assumptions used to develop this sustainable pathway are based on governmental policy documents - Climate Resilient Green Economy (CRGE) strategy, the Growth Transformation Plan II (GTP II), the Bonn Challenge, the Agriculture Growth Program, observed trends in crop and livestock productivity, recent trends in agricultural trade, and governmental focus on postharvest loss reduction. These policy documents highlight the need for Ethiopia's economy to achieve its ambitious growth target while keeping greenhouse gas emissions low. Accordingly, we have assumed high GDP growth and population growth (although the population growth is the UN's low scenario), high improvement in crop productivity, high livestock productivity, high afforestation effort, higher food consumption, and reduced food waste.

Accordingly, our results show calorie intake to be above the Minimum Dietary Energy requirement after 2015. GHG emissions will peak by 2025 and slightly decline thereafter. The major contributor to GHG emission will be the agricultural sector. In particular, livestock will be the major contributor to GHG emissions. In addition, our results show an increased demand for pastureland as a result of higher demand for animal products (e.g. milk). There will be forest loss, however, the new forest will compensate in greater volumes for the loss of old forest. Natural lands will remain above 50% through 2050. We also find that there will be an increased volume of export of agricultural commodities.

During the period 2015/16 to 2019/2020 agricultural production is expected to increase from 270 million quintals to 406 million quintals – a 50% increase in five years. The GTP II has also specified targets on productivity improvement to 27.3 quintals per hectare by 2019/20 from 21.5 quintals per hectare in 2014/15 for major crops. The land area under major crop production was 12.5 million hectares in 2014/15. Assuming the same crop composition, the area under crop production will have to increase to 14.9 million hectares (National Planning Commission, 2016). As it stands, the FABLE Calculator requires an assumption on increases in agricultural productivity as inputs to compute the agricultural land expansion – without tradeoff. If there is an option to create a tradeoff between the two based on past experience, it will help to better capture the dilemma on the ground.

In relation to crop and livestock productivity, productivity changes have been computed based on historical growth rate and they have been implemented linearly up to 2050. However, considering a period of 35 years, linear growth is unrealistic. Therefore, in the future, we will consider alternative evolutions of agricultural productivity. For example, logistic growth will be preferable.

There are suggestions of shifting the dietary mix away from cattle to poultry as recommended in the Climate Resilient Green Economy strategy - which has been criticized for not taking the cultural aspect into account. Innovations and policy options which would be required to improve the dietary mix to achieve a more sustainable pathway in terms of calorie intake, pressure on land and GHG emission will be examined in the future.

Going forward we will be able to provide a better comparison and analysis of the results computed by the FABLE Calculator with the reality on the ground thanks to consultation with experts, dedicated seminar discussions, comparison with alternative scenarios, and better data.

Units

% – percentage
bln – billion

cap – per capita

CO_2 – carbon dioxide

CO_2e – greenhouse gas expressed in carbon dioxide equivalent in terms of their global warming potentials

GHG – greenhouse gas

Gt – gigatons

ha – hectare

kcal – kilocalories

kg – kilogram

kha – thousand hectares

km^2 – square kilometer

kt – thousand tons

Mha – million hectares

mln – million

Mt – million tons

t – ton

TLU –Tropical Livestock Unit is a standard unit of measurement equivalent to 250 kg, the weight of a standard cow

t/ha – ton per hectare, measured as the production divided by the planted area by crop by year

t/TLU, kg/TLU, t/head, kg/head- ton per TLU, kilogram per TLU, ton per head, kilogram per head, measured as the production per year divided by the total herd number per animal type per year, including both productive and non-productive animals

tln – trillion

USD – United States Dollar

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