2023 Scenathon results

Pathways for food and land-use systems in Ethiopia

FABLE CONSORTIUM

About FABLE
The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a collaborative initiative to support the development of globally consistent mid-century national food and land-use pathways that could inform policies towards greater sustainability. The Consortium brings together teams of researchers from 24 countries and international partners from the UN Sustainable Development Solutions Network (SDSN), the International Institute for Applied Systems Analysis (IIASA), the Alliance of Bioversity International and CIAT, and the Potsdam Institute for Climate Impact Research (PIK). https://www.fableconsortium.org/

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Our food and land-use systems are critical for staying within our planetary boundaries and the Earth's system resilience. Among the six Transformations required to achieve the Sustainable Development Goals (SDGs), the fourth Transformation—focusing on food, land, and water—is crucial. This Transformation is key to achieving SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land). Moreover, it significantly supports the remaining SDGs, underscoring its crucial role in fostering a sustainable future.

In this document, we present the results of the 2023 'Scenathon', a modelling exercise by the FABLE Consortium exploring three alternative futures for national and regional food and land-use systems. The term 'Scenathon' stands for 'a marathon of scenarios' and refers to FABLE's iterative process for ensuring that national and regional pathways have coherent trade assumptions and align with global sustainability targets (see the 2024 Sustainable Development Report for more information).

Through these long-term pathways, we can identify trade-offs and synergies between different goals and see the impact of various actions, as well as key levers for guiding sustainable development policies through 2030 and 2050. These results, together with our modelling tools and methods, are designed to support decision-making and the development of better policies and targets to drive the transformation of our food and land-use systems.

Figure 1. Historical share of GHG emissions from Agriculture, Forestry, and Other Land Use (AFOLU) to total AFOLU emissions and removals by source in 2013
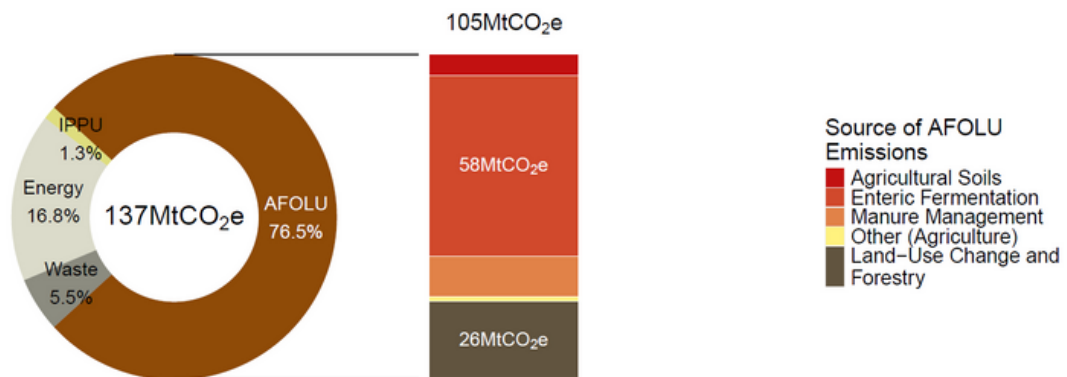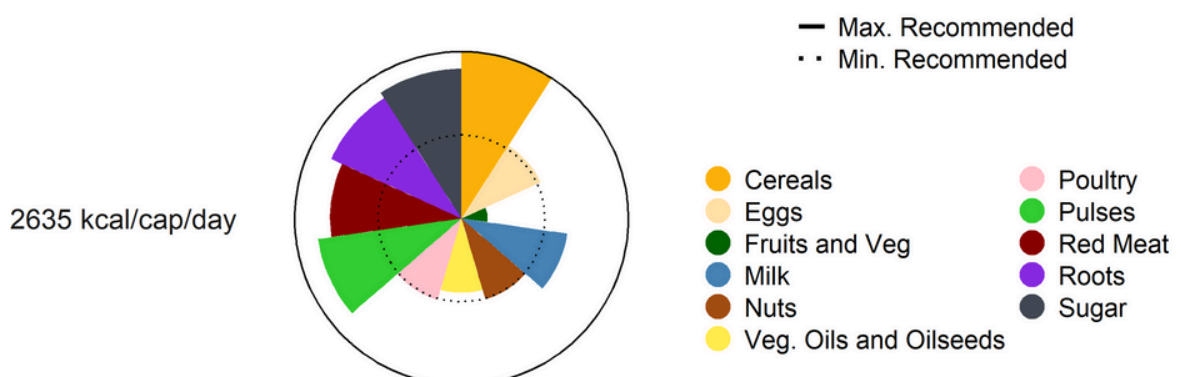

Figure 2. Daily average kilocalorie intake per capital per food category in 2020

National context   Ethiopia

This table summarizes national targets for food and land use, derived from national commitments, policies, and strategies. It provides an overview of the country's current ambitions to transform its food and land-use systems. Where countries lacked quantitative national targets, we have estimated targets based on qualitative pledges.

SDG	Indicator	National Target (OS) Official source, (A) Assumption by the team.
2 ZERO HUNGER	Undernourishment	Support diversified food production to increase the supply of nutrient-dense foods (i.e., animal-sourced and plant-based foods). Reduce maternal malnutrition, child wasting, and stunting by 2030. Sustainably improve the availability, accessibility, and utilization of adequate, diversified, safe, and nutritious foods for all citizens at all times.
	Overweight/obesity	Reduce the prevalence of childhood overweight and obesity lower than 5%. To reduce the prevalence of Overweight and obesity in school-aged children and adolescents from 12% to 6% by 2030.
	Diet-related disease	Support diversified food production of nutrient-dense foods. Promote fortified nutrient-dense staple foods through public and private partnership initiatives. National food-based Dietary Guidelines: to provide dietary recommendations for the Ethiopian population for increased diet quality.
	Other food related targets	Increase consumption of meat from 1.2 days per week to 3. Increase the per-capita meat consumption to 31Kg/ year, from its current level of 10Kg/year (approximate estimation). Increase the production of meat, eggs, fish, and dairy from 3.97 million tons to 11.37 million tons by 2030. Increase household dietary diversity score from 20% to 70%.
	Self-sufficiency	To increase crop production to 92.5 million tons/year (+70%) by 2030. Ensuring high per capita income through rapid economic growth. Reverse food insufficiency into surpluses. Reduce poverty level from 19% in 2020/21 to 7% in 2029/30.
13 CLIMATE ACTION	Agriculture GHG emissions reduction	Livestock sector: emission reduction target ranges from -1.9 Mt CO2e (-1%) to -14.8 Mt CO2e (-8%). Managed soils: emission reduction target range from -0.1 Mt CO2e (-1%) to -0.4 Mt CO2e (-4%). Crop production: enhance GHG emission reduction from 7.23 million metric tons to 37.8 million metric tons.
	Land use and land use change GHG emissions reduction	Reduce forest loss using efficient cooking technologies with a total Increase Forest cover by 2030 from 15.5% to 30% of the country's area. Reduce carbon emissions by 255 million tons CO2e per year by 2030, with 130 million tons of those reductions coming from the forestry sector.
	Reduce or halt deforestation	No deforestation beyond 2030 (OS)
	Total GHG Emissions	Unconditional commitment to reduce 56.2 Mt CO2eq by 2030 and a conditional commitment to reduce 277.7 Mt CO2eq by 2030.

15 LIFE ON LAND	Promote afforestation	Increase the coverage of wildlife habitats from the present area of 8.6% to 14% by 2030. 15 million hectares committed area to restore by 2030.
	Expand protected areas or 'Other effective area-based conservation measures'	By 2020, area coverage of ecologically representative and effectively managed PAs will increase from 14% to 20%. The total protected areas will reach 30% by 2030.
	Expand cropland area under agroecological practices	Enhance crop productivity using agroecological-related soil and water conservation practices. Increase agrobiodiversity index by 3%. Increase area under improved land management practices by 8 % each year.
	Reduce or halt use of agrochemicals and other agricultural practices that harm biodiversity	Make substantial efforts to reduce the demand for chemical fertilizers by promoting widespread utilization of natural fertilizers such as compost and by improving land management methods
	Reduce or halt the loss of natural ecosystems	By 2020, habitat conversion due to the expansion of agricultural land will reduce from 10% to 5% per year. By 2030, to increase the coverage of protection against illicit activities in wildlife habitats from 62% to 92%.
14 LIFE BELOW WATER	Other water related targets	Increase the national water supply coverage to 100% at the end of 2030. And an 8% annual increase in arable land irrigated.
	Limit water use	Reduce water loss from 39% in 2020 to 20% by 2030.
8 DECENT WORK AND ECONOMIC GROWTH	Agricultural exports	The merchandise export revenues from agriculture will reach 6.7 billion by 2030, it is envisaged a 10% of an annual increase in agricultural product export items
	Farmer's income	8% annual increase in rural household income, consumption, and expenditure levels by 2030
	Employment in the agricultural sector	5% annual increase in the number of rural labor force employed in rural non-farm enterprises

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Model

Using the open-access <u>FABLE Calculator</u> and the FABLE decentralized modelling infrastructure, we have developed three alternative pathways —Current Trends, National Commitments, and Sustainable Pathway— to explore the impact of various practices and policies on achieving sustainability targets through 2050. We compare our results with targets across food security and nutrition, GHG emissions reduction, forest and biodiversity conservation, and sustainable use of water, nitrogen, and phosphorus.

For each of these pathways, we have established various assumptions regarding the evolution of several model parameters. These parameters include population growth, dietary patterns, food waste, food import and export levels, crop and livestock productivity, agricultural expansion, afforestation, livestock density, protected areas expansion, post-harvest losses, biofuel demand, urban expansion, agricultural practice coverage, and irrigation area expansion. These assumptions detail the extent to which these factors will drive changes in food and land systems from 2020 to 2050.

Pathway narratives

Current Trends: We considered the Business-as-usual pathway for the current trends, which assumes relatively high population growth and moderate economic growth, with continued increasing rates of inflation. Under this pathway, the agricultural land expansion will continue (specifically in the lowlands), and the net balance of deforestation-afforestation rates will remain net forest loss. Cereal will still be the dominant diet, and agricultural productivity will continue increasing moderately. The country is projected to achieve the average daily energy intake per capita requirement by 2030.

National Commitments: We considered a sustainability pathway for the national commitments. It assumes slighter population growth than current trends and high economic growth. Massive irrigation agriculture expansion coupled with rapid agricultural productivity growth will lead the country towards food self-sufficiency and a net exporter of major food crops by 2030. In the dietary composition, we expect a moderate increase in the intake of vegetables, fruits, and animal-source products. Massive afforestation efforts will lead to a net increase in forest areas, an expansion of protected areas, and increased biodiversity conservation.

Global Sustainability: We considered a green growth scenario for the global suitability pathways, expecting that the government will work to achieve the SDGs. This would involve stable population growth, rapid economic growth, reduced inequities, and inflation rates. Food sufficiency and dietary composition would change based on national commitments. Afforestation rates and expansion of protected areas would be significantly greater than the national commitments, due to the involvement of international agencies as part of the SDGs.

Figure 3. Assumptions on the levers for change in each pathway
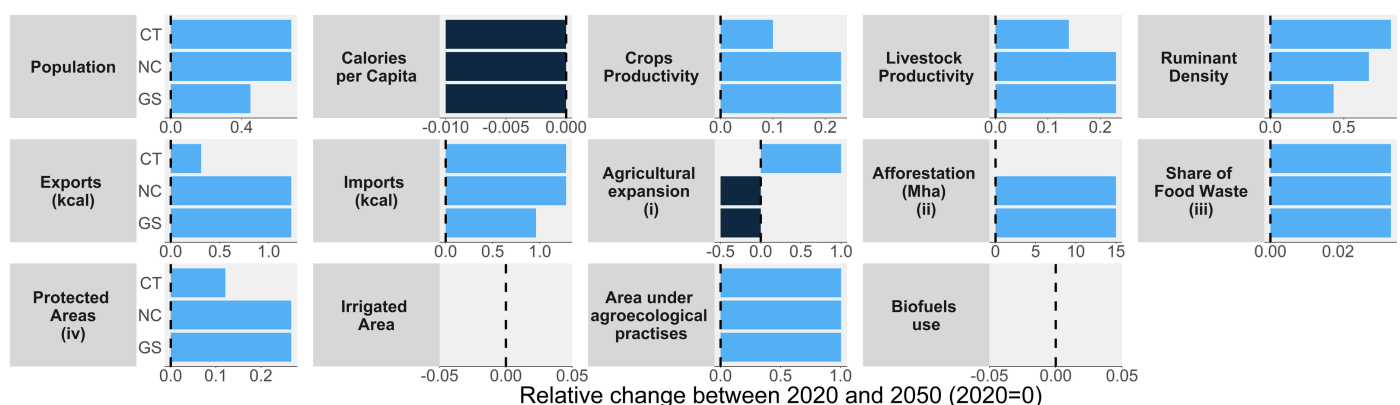
 Notes: (i) Results are expressed in code, taking the value 1 for 'Free expansion scenario', -0.5 for 'No deforestation' and -1 for 'No Agricultural expansion'.
(ii) Results are expressed in a net increase rather than relative change.
(iii) Results are expressed % of consumption that is wasted.
(iv) Results are expressed in % of total land in 2050.

Figure 4. Computed daily average intake per capita over 2000-2050
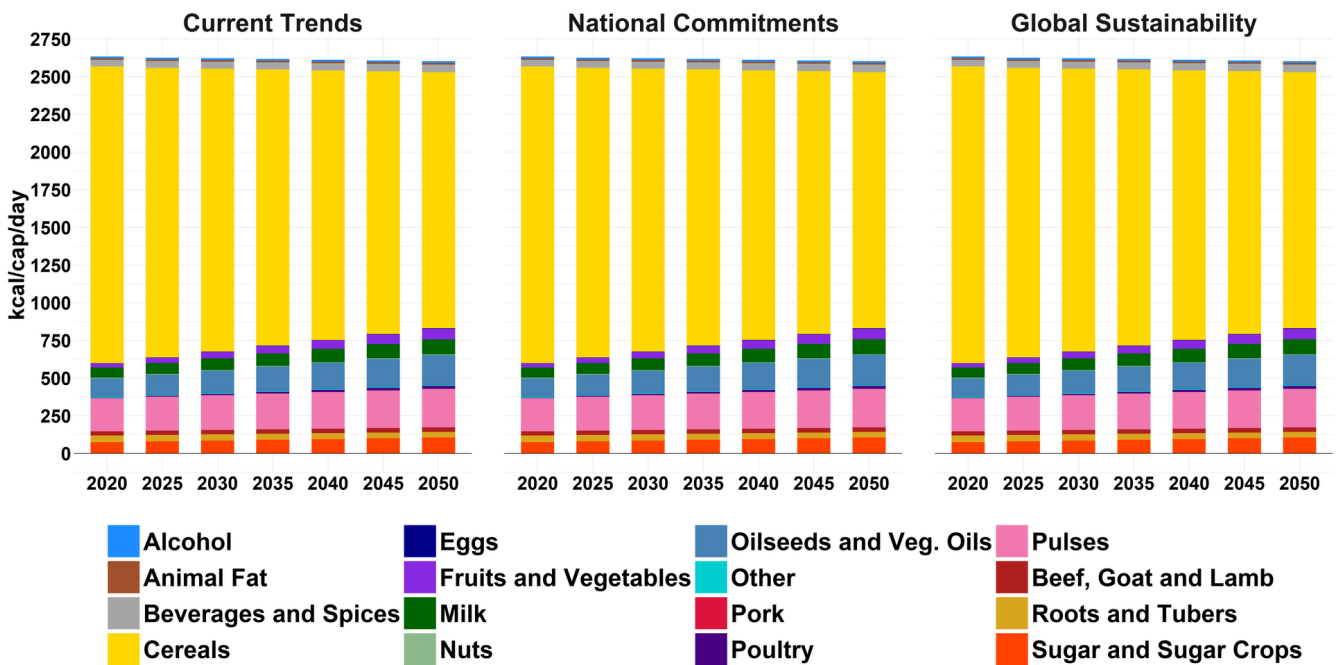
Figure 5. Comparison of the computed daily average kilocalorie intake per capital per food category across the three pathways and the prevalence of undernourishment in 2050
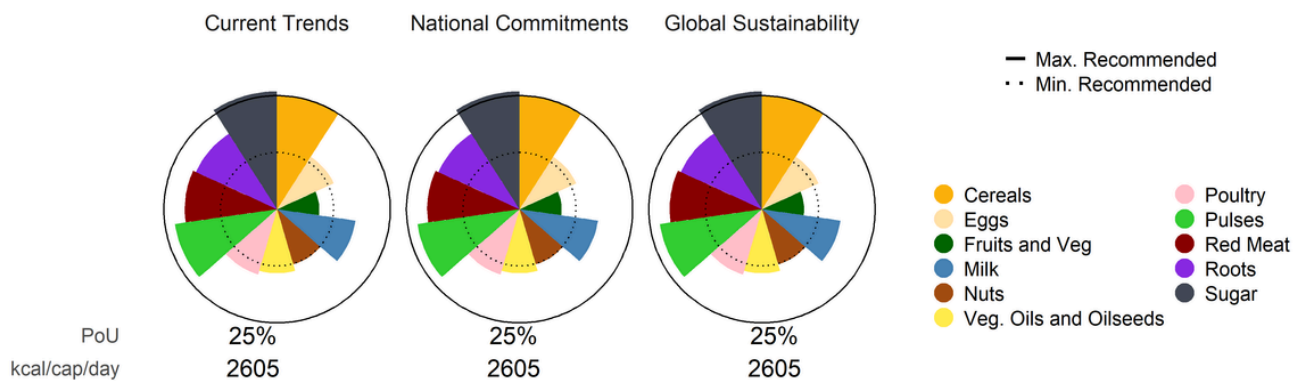
Figure 6. Evolution of land cover 2000-2050

Current Trends — **National Commitments** — **Global Sustainability**

- Protected Areas

Legend: Cropland, Forest, Urban, New Forest, Pasture, Other Land, New Other Land
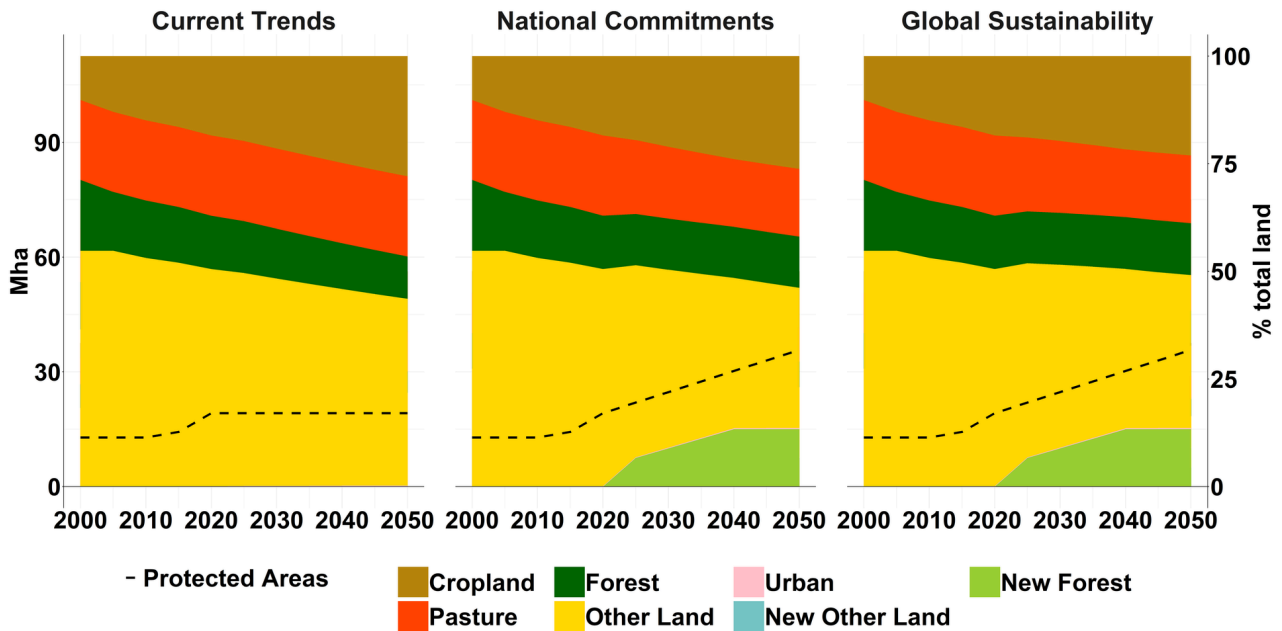
Figure 7. Evolution of the cropland composition 2000-2050

Current Trends — **National Commitments** — **Global Sustainability**

Legend: Other cereals, Sorghum, Barley, Corn, Wheat, Rest of cropland

Figure 8. Projected AFOLU emissions and removals between 2020 and 2050 by main sources and sinks across pathways

Current Trends **National Commitments** **Global Sustainability**

Legend:
- N2O Livestock
- CH4 Livestock
- N2O Crop
- CH4 Crop
- CO2 from Farm
- CO2 Deforestation
- CO2 Other Land Use
- CO2 Abandoned Agr. Land
- CO2 Afforestation
- CO2 Peatland
- Savings from Biofuels

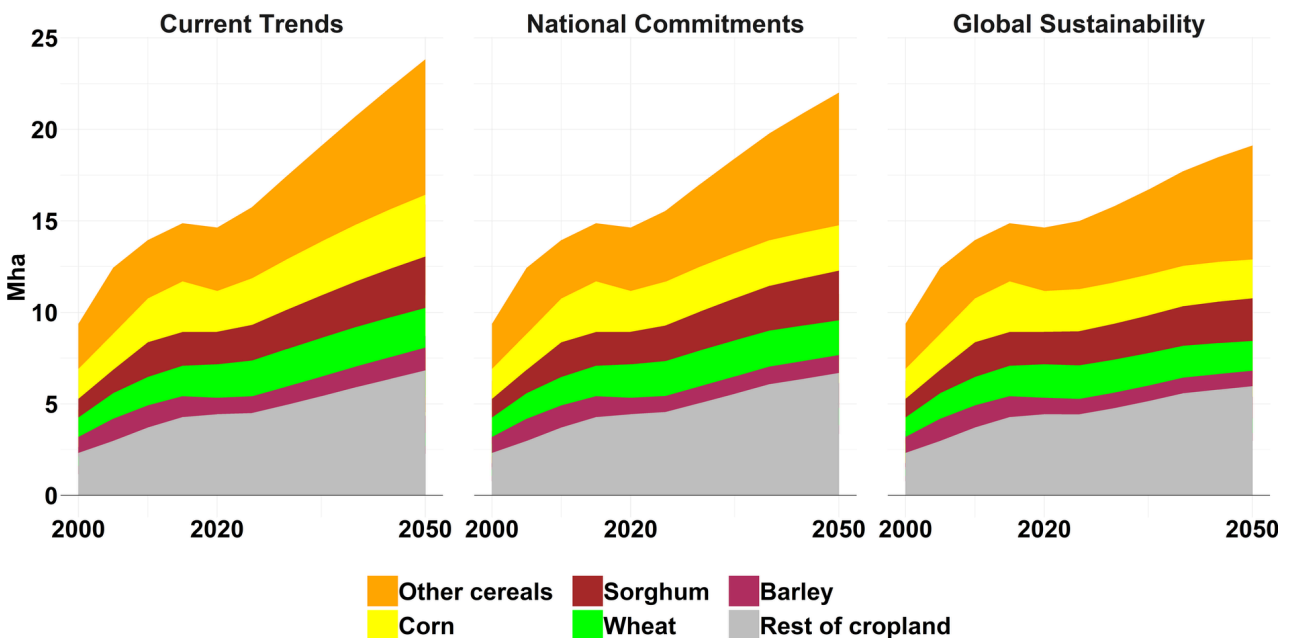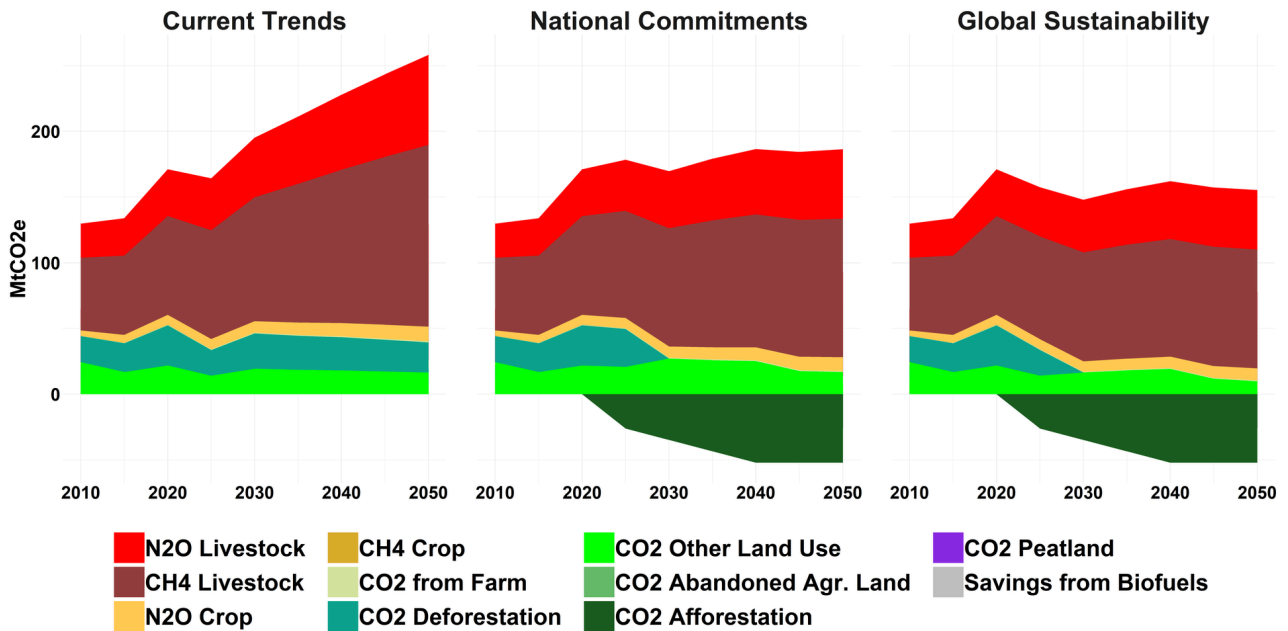## Figure 9. Share of cropland under agroecological practices

— Current Trends — National Commitments ··· Global Sustainability

Agroecological practices included: Cover crops, cultivar mixtures, diversified farming systems, embedded natural, organic farming, no/minimal tillage.
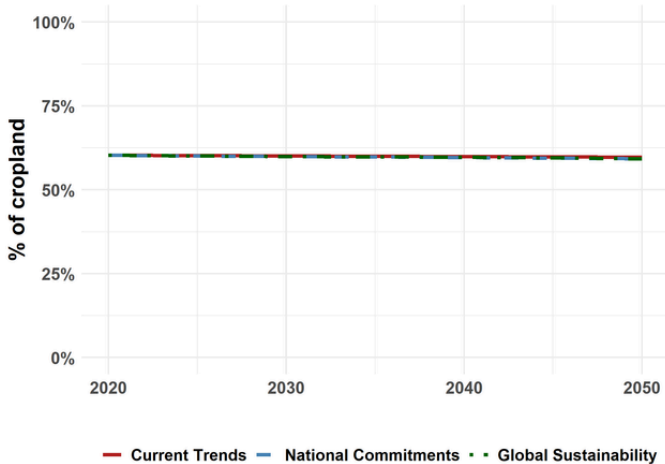
Figure 10. Total area of land where natural processes predominate (LNPP)

Legend:
- LNPP in mature forests
- LNPP in mature other natural lands
- LNPP in new forest
- LNPP in new other natural land

Figure 11. Nitrogen application
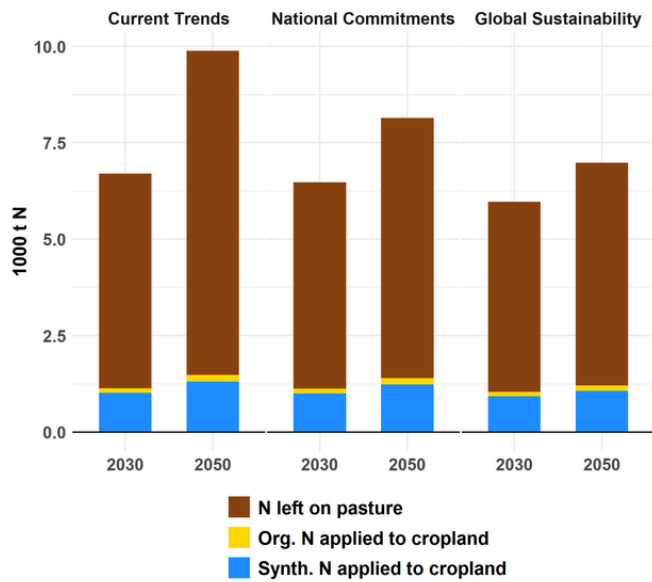
Figure 12. On-farm production costs

FTE: Full-time equivalent
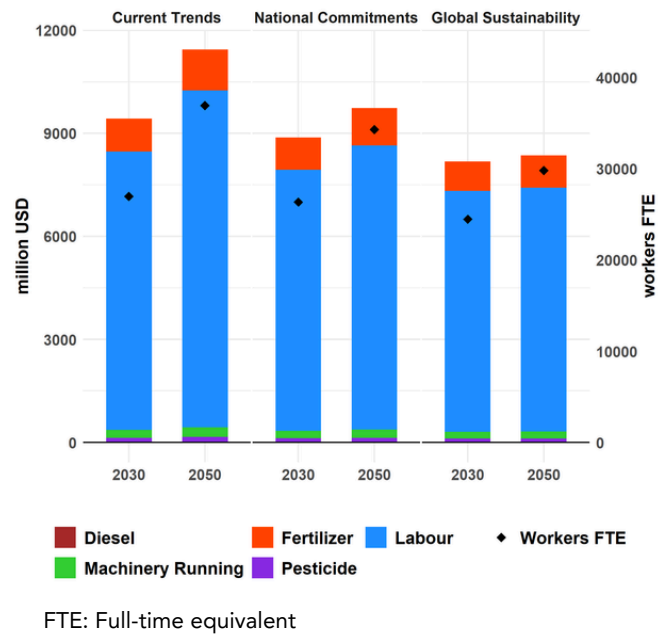
For more detailed results and visual data, visit www.scenathon.org

Achieving Sustainable Food Systems:

Ethiopia faces significant challenges in meeting targets for climate mitigation, biodiversity conservation, and sustainable use of natural resources like land, water, and nutrients. The report's finding that only the most ambitious "Global Sustainability" scenario achieves 5 out of 16 sustainability targets highlights the scale of the transformation needed.

Boosting Productivity and Sustainability:

Increasing crop and livestock productivity while minimizing environmental impacts is critical for Ethiopia. Promoting agroecological practices like organic farming, cover cropping, and diversified production systems could help achieve this balance. Supporting smallholder farmers to adopt these approaches will be essential.

Transitioning to Healthy, Sustainable Diets:

Ethiopia grapples with the double burden of malnutrition - undernutrition coexists with rising overweight and obesity. Policies and investments to improve access to affordable, nutritious foods like fruits, vegetables, and plant-based proteins will be crucial to address these disparities and make progress on SDG 2.

Protecting Natural Ecosystems:

Ethiopia has ambitious targets for increasing forest cover, but curbing deforestation driven by agricultural expansion remains a major challenge. Strengthening monitoring and enforcement, as well as incentivizing sustainable land use practices, will be key to preserving Ethiopia's remaining natural ecosystems.

Aligning with National Priorities:

The key messages align closely with Ethiopia's Climate Resilient Green Economy strategy and other national development plans focused on sustainable, climate-smart agriculture. Leveraging the insights from the FABLE Scenathon could help inform Ethiopia's policies and programs to transform its food and land-use systems.

Overall, the FABLE Scenathon results provide a valuable global context that can inform and strengthen Ethiopia's efforts to address the interconnected challenges of food security, environmental sustainability, and climate change. Tailoring the report's insights to the Ethiopian context can help guide the country's pathway towards more sustainable and equitable food systems.

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
1. Macroeconomics	**1.1)** GDP per capita	2.5-5% annual growth rate of GDP per capita in the past decade, and the current GDP per capita is about 1,080 USD which will reach 1,477 USD by 2030 and 2,626 USD by 2050.	The GDP per capita is projected to grow parallel with the GDP, at an annual growth rate of 10%, according to government plans. This means that the GDP per capita will reach $1,836 by 2030 and $3,900 by 2050.	Same as the National Commitments pathway	(MoPD, 2021; WB, 2023)
	1.2) Population	We assume it will increase by 2.7% annually. The future population growth of the country is projected to be one of the highest in the world based on its current trend, and the total population will increase by more than 70 million in 2050.	The population will reach 173 million by 2050	Same as the National Commitments pathway	(CSA, 2013; DESA, 2022; UNDP, 2019)
	1.3) Inflation	The inflation rate will continue to increase based on past trends, ranging from 26% to 15%	Inflation will remain lower than 10% between 2020-2030	Same as the National Commitments pathway	(MoPD, 2021; National Bank of Ethiopia, 2021; Telaye, 2021)
	1.4) Inequalities	Inequality is expected to increase moderately based on its current trend, with a Gini coefficient value of 0.3 and 0.35, and an annual increasing rate of 1%.	Same as Current Trends	Inequality will tend to fall as countries commit to achieving equitable distribution of wealth.	(Cornia & Martorano, 2019; MoPD, 2021; WB, 2020)
2. Land	**2.1)** Constraints on agricultural expansion/deforestation	Agricultural land will continue expanding at historical average rates (2.6% expansion rate annually) but will tend to reduce in the highlands because of land scarcity and possible interventions of agricultural intensification and dry season production of major	A higher expansion of agriculture is expected in the lowlands because of government plans indicated in the Development Policy document. More than 3.3 million ha of land could be developed for crop production, mainly in the lowlands for irrigation practices.	The government will focus on agro-ecological practices to increase production and productivity instead of farmland expansion and there will not be free expansion of farmland in the coming decades. The land allocated to the private sector will also increase.	(Katy & Franks, 2022; Tadesse et al. 2022; Schmidt & Thomas, 2020; Seyoum Taffesse et al., 2013)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		cereals in the highlands. For example, in 2021/22, about 400,000ha was cultivated by irrigation mainly in the highlands than the lowlands.	Moreover, the dry season/ irrigated wheat is expected to increase substantially.		
	2.2) Afforestation, and forest plantations targets	The annual forest gain in Ethiopia is estimated to be between 19,000 and 40,000 hectares per year. However, the annual forest loss is estimated to be 92,000 ha per year. This means that the net forest loss is 73,000 ha per year. Based on this data, it is unlikely that there will be a net gain in forest areas in the future.	The government of Ethiopia has designed multiple forest recovery strategies, including an annual increase in forest area coverage of 8%, rehabilitation of 3% of degraded land per year, and a plan to increase the proportion of forest cover to 20% by 2020 and 30% by 2025. These strategies are expected to result in the total forest area of the country exceeding 35 million hectares by 2050.	Achieve NDC target to increase forest cover to 30% by 2030.	(Chipeta et al., 2015; EBI, 2020; MEFCC, 2017, 2018)
	2.3) Urban and settlements area	An extensive urban expansion is expected in consideration of rapid population growth and continued massive rural-to-urban migration, with an average annual expansion rate of 3%, exceeding 10,000 km^2 by 2030.	The rate of urban expansion will be higher than the current trend because of government policies to establish new urban centers, enhance the development of existing towns and rural development centers, and economic transition towards industrialization.	A moderate rate of urban expansion is expected since the focus will be on the development of sustainable cities rather than a mere horizontal expansion.	(MacManus et al., 2021; MoPD, 2021)
	2.4) Protected areas	There will not be any expansion of protected areas than the current levels (20%), due to increased land scarcity and intensification of anthropogenic impacts on protected ecosystems.	The proportion of protected areas will reach 30% by 2030 owning to ambitious government plans to expand protected areas and increase afforestation	Same as the National Commitments pathway	(EBI, 2020; MoPD, 2021)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
3. Productivity and management	**3.1)** Crop productivity for the key crops	Yield is expected to increase based on historical trends (of 1.9 annual growth rate for major cereals). Accordingly, by 2030, the yield for the major crop will be 23, 30, 35, 50, and 34 quintals per hectare for Teff, Barley, Wheat, Maize, and Sorghum respectively.	A 4% annual increase in productivity (value outputs/ value inputs) per crop and livestock unit is expected in the future.	By 2030, double the agricultural productivity and incomes of small-scale food producers.	(Chipeta et al., 2015; MoPD, 2021)
	3.2) Cropland under agroecological practices	The implementation of many agroecological practices other than lowland irrigation will remain insignificant in the coming decades as prevailing government plans lean towards the use of increased artificial farm inputs instead of organic agriculture practices.	The proportion of cropland under agro-ecological practices will increase slightly owing to strategies to reduce the demand for chemical fertilizers, ongoing initiates that promote agro-ecological practices such as Climate Resilience Strategy (CRS) Climate Resilient Green Economy (CRGE), and the comprehensive soil improvement strategy.	The proportion of cropland under agroecological practices will be higher than the current trends because of government commitment to achieve SDG goals.	(Araya et al., 2023; CIAT; BFS/USAID, 2017; Mekuria et al., 2022; MoPD, 2021)
	3.3) Livestock productivity for the key livestock products	The current average milk (1.54 liters per cow per day) and red meat production rate will remain the same because of complex production and productivity problems in the livestock sector.	The productivity will increase more than the current trend because of government plans to increase total value productivity per livestock unit by 4%.	Same as the National Commitments pathway	(Alemneh, 2019; Chipeta et al., 2015; EWCA, 2012; MoPD, 2021)
	3.4) Pasture stocking rate	No assumption	No assumption	No assumption	
	3.5) Forest management	There is a policy gap and a weak institutional arrangement on forest protection. Existing forest management initiatives	Ongoing forest initiatives, such as participatory forest management (PFM), area enclosures, sustainable land	Same as National Commitments Pathways	(AMENU, 2017; Kassa et al., 2022; MEFCC, 2018; Negassa, 2014)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		will remain limited to some parts of the country.	management programs, and the Green Legacy Initiative will contribute to increasing forest management practices.		
4. Trade	**4.1)** Share of consumption which is imported for key imported products (%)	Wheat is the most imported food commodity in Ethiopia, with net imports accounting for up to 30% of domestic consumption. From the total annual average consumption of 7.17 million metric tons, Wheat imports have increased by an average of 6.6% annually over the past decade. This trend is projected to continue, and wheat imports are expected to reach about 50% of total consumption by 2050. The share of other imported food products is projected to remain zero.	The total share of imported wheat consumption will reach zero level before 2030. This is owning government initiatives to reduce dependence on commercial imports of staple food (Chipeta et al., 2015) and the intervention of import substitution by irrigated (dry season) wheat production.	Same as National Commitments Pathways	(Chipeta et al., 2015; Gebreselassie et al., 2017; Rachel B., 2022)
	4.2) Evolution of exports for key exported products (1000 tons)	Export earnings from agricultural products were increasing by 0.26% annually (with a total import value of 2413 million USD in 2022) and are expected to reach 2513.179 USD by 2050.	The merchandise export revenues from agriculture will reach 6.7 billion by 2030. It is envisaged a 10% annual increase in agricultural product export items.	SDG promotes a diversified global market for food amount and it is expected that countries will use the import of food items as a strategy to fill the food production or supply-demand gap.	(Chipeta et al., 2015; Eshetu & Mehare, 2020; MoPD, 2021)
5. Food	**5.1)** Average dietary composition	The prevailing national level Mean energy intake is 2105 Kcal/day and it is expected to increase to 2141 in 2050. The current dietary composition of the general population is characterized by excessive cereal consumption	The country will achieve the food and dietary recommendation plans by 2030, which recommends calorie intake for children (between 2-5 years) will reach 1,250 kcal/day, calorie intake for youngsters (6-18) and the elderly (>65) will be	It is projected that by 2030, the average daily energy intake per capita will be higher than the minimum requirement of 1830 kcal per day in all countries. In Ethiopia, the average daily energy intake is projected to reach 2360 kcal per day, which is the minimum	(EPHI, 2013, 2022; FDRE, 2021; Sheehy et al., 2019)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		and inadequate consumption of animal-source foods, as well as pulses, fruits, vegetables, nuts, and seeds. Accordingly, we assume that Cereal/grains (Wheat, maize, teff, and sorghum) continue to constitute 70% of the main food, and the contribution of the other food items remained to be less than 10%	2,300 kcal/day and calorie intake for adults will reach 2,700 kcal/day. The food and dietary strategy of the country recommends diversified food intake which promotes increased intake of vegetables, fruits, and animal source products for the general population.	requirement for avoiding undernourishment and optimal health.	
	5.2) Share of food consumption which is wasted at household level	The share of food wastage in Ethiopia is at a low level and will continue to remain low in the future.	Same as current trends	Same as current trends	We do not expect a significant proportion of food loss because food unavailability and food insecurity are critical problems for the majority of households in Ethiopia.
6. Biofuels	**6.1)** Targets on biofuel and/or other bioenergy use	Currently, about 8 million liters of bioethanol are produced annually using molasses as feedstock. The production amounts remain to be the same by 2030.	Ethiopia is the second most suitable country for sustainable biofuel production with estimated energy amounts of 533 PJ, and it is expected a slighter increase in the use of biofuel by 2030.	Biofuels are thought to be environmentally beneficial and highly encouraged in SDG and a moderate increase in the use of biofuel energy is expected.	(Yimam, 2022)
	6.2) Targets on other non-food use	No assumption	No assumption	No assumption	
7. Water	**7.1)** Irrigated crop area	It is not expected a change in the area of irrigated land during the next years based on previous five-year trends (estimates of the current irrigated cropland area vary from 200 to 490 and it is	The total area of small and medium size irrigation schemes will reach 1,000,000 hectares by 2022. It was proposed an 8% annual increase in irrigated arable land. Accordingly, the total irrigated	Irrigation development is one of the prime strategies to adapt agriculture to climate change, in line with the targets of SDG 13, and the area of irrigated cropland will increase by 2030.	(Chipeta et al., 2015; Dejene et al., 2022; MoPD, 2021; MoWIE, 2022)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		expected that it remains the same by 2030 as it was declining during the previous years)	area of cropland will increase by 70% from its current level if the goal is achieved. Raise the construction of medium and large-scale irrigation networks from 490,000 hectares to 1.2 million hectares.		