

A photograph of a lush green hillside in Rwanda. The foreground is dominated by a dense field of banana trees. In the middle ground, a small, simple house with a thatched roof is visible, partially obscured by the banana trees. The background shows a steep, green hillside with more vegetation. The overall scene is vibrant and rural.

2023 Scenathon results

Pathways for food  
and land-use systems  
in Rwanda



**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/>

### **About the authors**

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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 2020

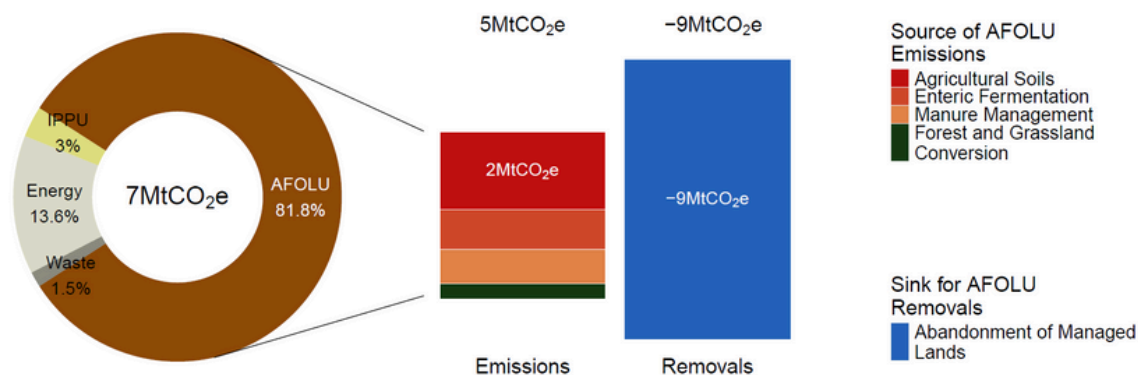
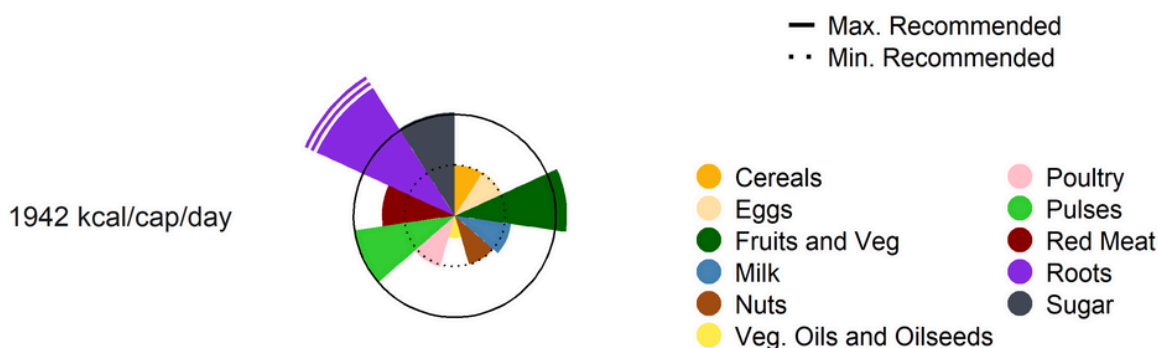







Figure 2. Daily average kilocalorie intake per capital per food category in 2020



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
 2 ZERO HUNGER	Undernourishment	Reduction from 33% in 2020 to 19% by <u>2024</u> .
	Overweight / obesity	Reduce overweight and obesity in adults to below 17% by <u>2024</u> .
	Self-sufficiency	Ending hunger by <u>2030</u>
 13 CLIMATE ACTION	Total GHG emissions reduction	Reducing by <u>38%</u> by 2030 compared to business as usual- 4.6 million tonnes of carbon dioxide equivalent (tCO <sub>2</sub> e).
	Land use and land use change GHG emissions reduction	Sustainable intensification of agriculture: 100% of the households involved in agriculture production will be implementing agroforestry sustainable food production by <u>2030</u> .
	Agriculture GHG emissions reduction	49% of the total reduction potential of 4.6 M tCO <sub>2</sub> e by <u>2030</u> .
	Other climate mitigation related targets	Target a total area of 200,000 ha for <u>agroforestry</u> .
 15 LIFE ON LAND	Reduce or halt loss of natural ecosystems	Safeguard at least 50 percent of natural ecosystems, and significantly reduce their degradation and fragmentation by <u>2020</u> .
	Promote afforestation	30% sustained forest cover of the total national land surface by 2030, from 28.8% in <u>2013</u> .
	Expand protected areas or 'Other effective area-based conservation measures'	37.7 % of Rwanda's surface has to be set aside for conservation <u>purposes</u> .
 8 DECENT WORK AND ECONOMIC GROWTH	Employment in the agricultural sector	60 – 80,000 new entrants each year into <u>agriculture</u>
	Agricultural exports	An export growth of 28% per <u>year</u>
	Farmers' income	Percentage increase in agricultural production measured by production volumes and fixed prices in 2014, with a target increase of 10% in <u>2024</u> .
 14 LIFE BELOW WATER	N and P related targets	"Enhance farmers' access to improved seeds, from <u>52%</u> (2016) on consolidated sites to 75% by 2024 and fertilizers application (kg/ha/annum) from 32 kg/Ha (2016/17) to 75kg/ha by <u>2024</u> "

## Model

Using the open-access [FABLE Calculator](#) 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.

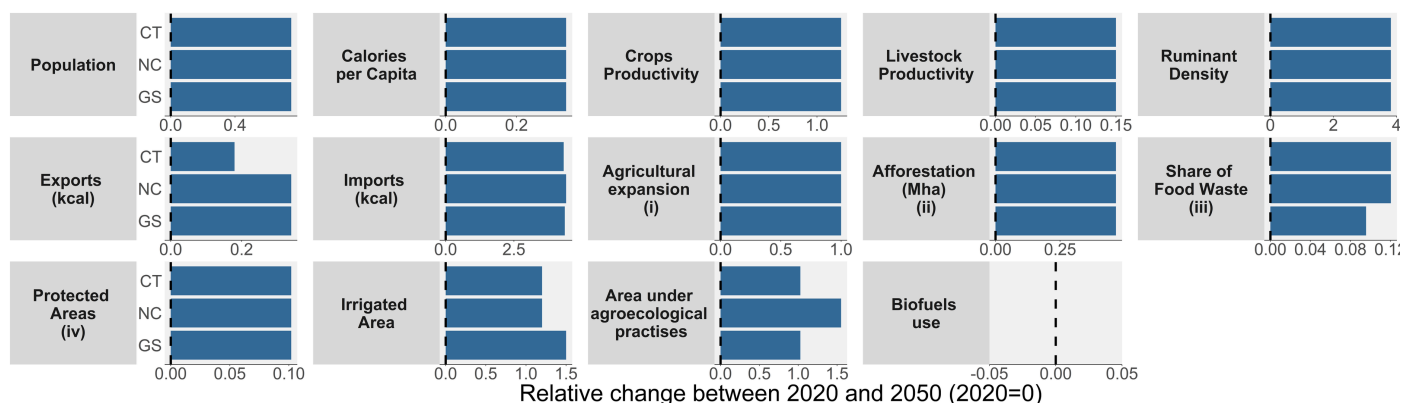
## Pathway narratives

**Current Trends:** Represents a low-ambition trajectory primarily shaped by historical trends and existing policies, offering a glimpse into a future heavily reliant on the current level of implementation and enforcement.

**National Commitments:** Attempts to predict how food and land systems will evolve if national strategies, pledges, and targets concerning climate, biodiversity, and food systems are met. This is based on a review of policy documents that describe the national climate and biodiversity strategies, the UN food system pathway, the national dietary guidelines, and other relevant policy documents for food and land systems.

**Global Sustainability:** Identifies additional actions to help closing the gap between the collective outcome of the National Commitments pathway and the global sustainability targets. There may be large overlaps between the 'National commitments' pathway and the Global Sustainability pathway, depending on how ambitious country teams and local stakeholders think the current national commitments are.

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

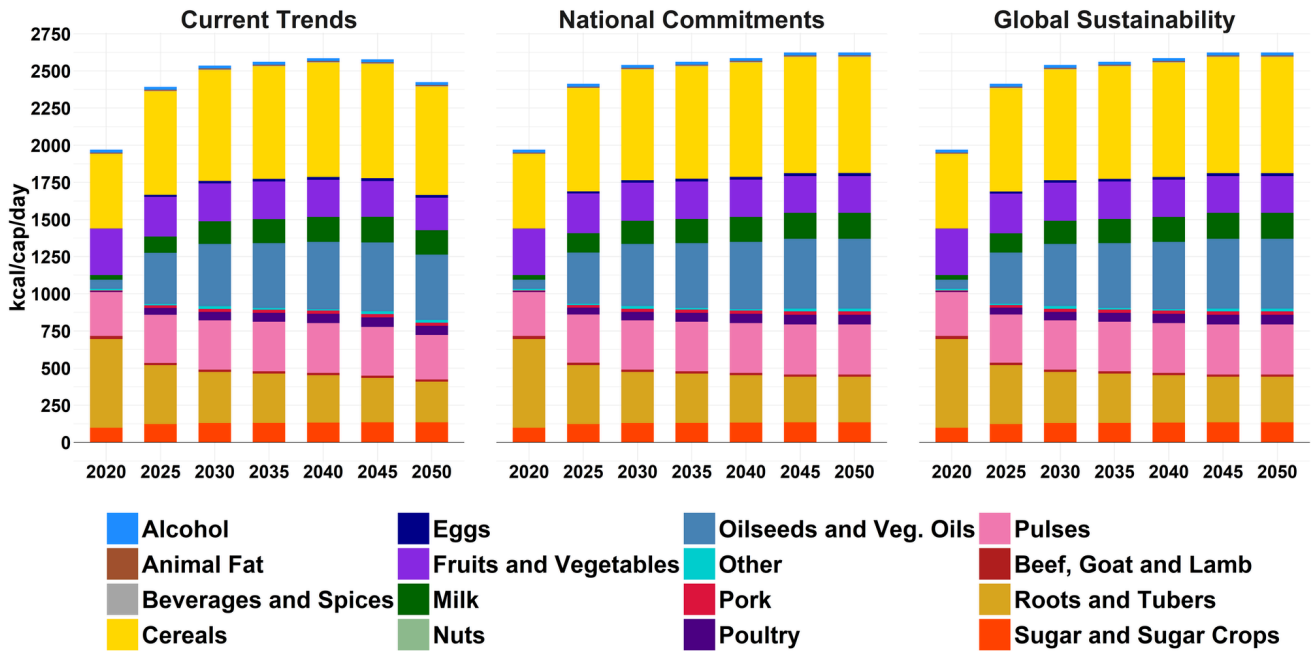


Figure 5. Comparison of the computed daily average kilocalorie intake per capital per food category across the three pathways and the prevalence of undernourishment in 2050

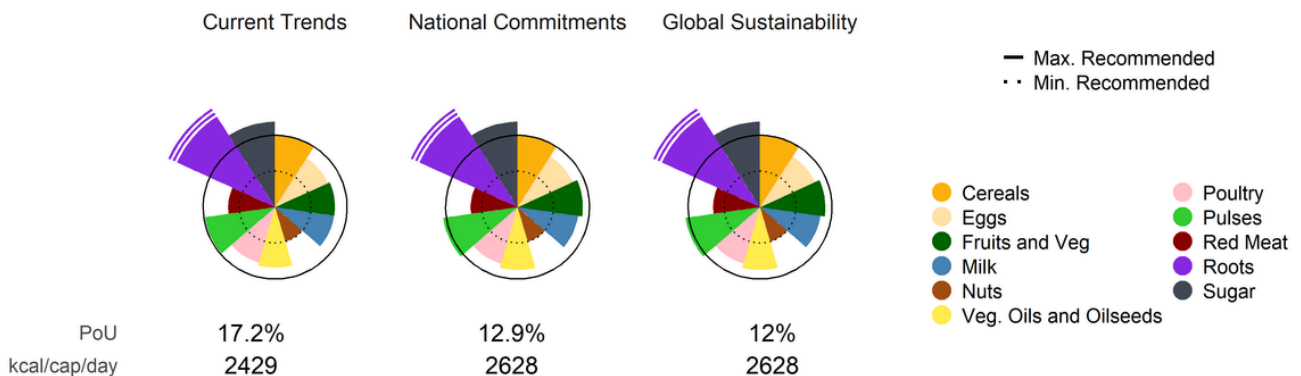


Figure 6. Evolution of land cover 2000-2050

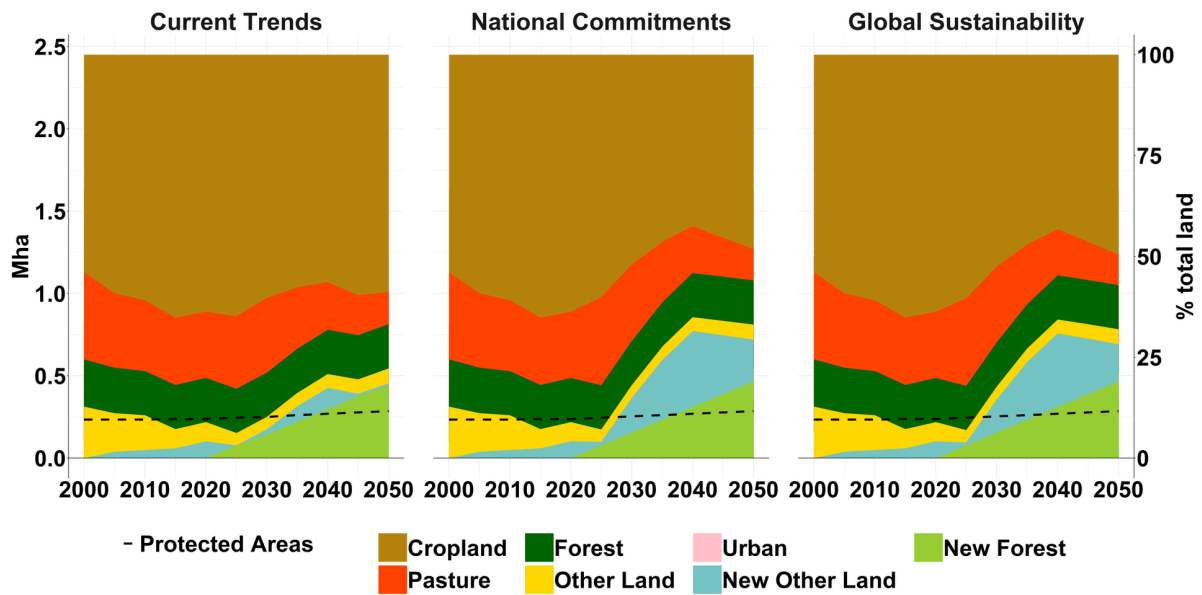


Figure 7. Evolution of the cropland composition 2000-2050

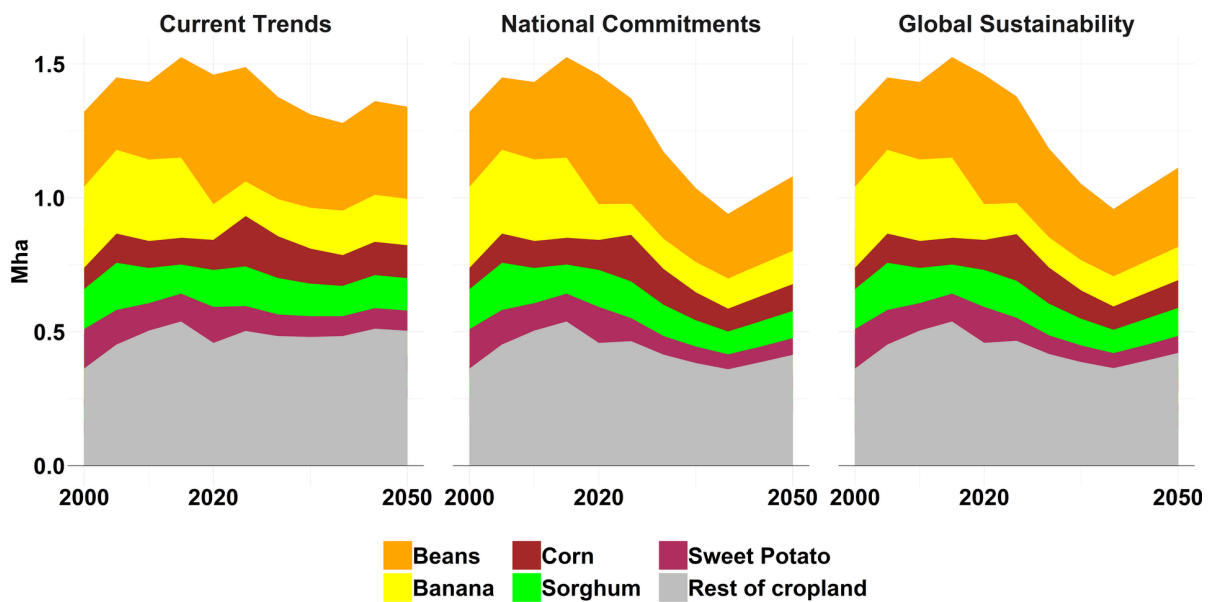


Figure 8. Projected AFOLU emissions and removals between 2020 and 2050 by main sources and sinks across pathways

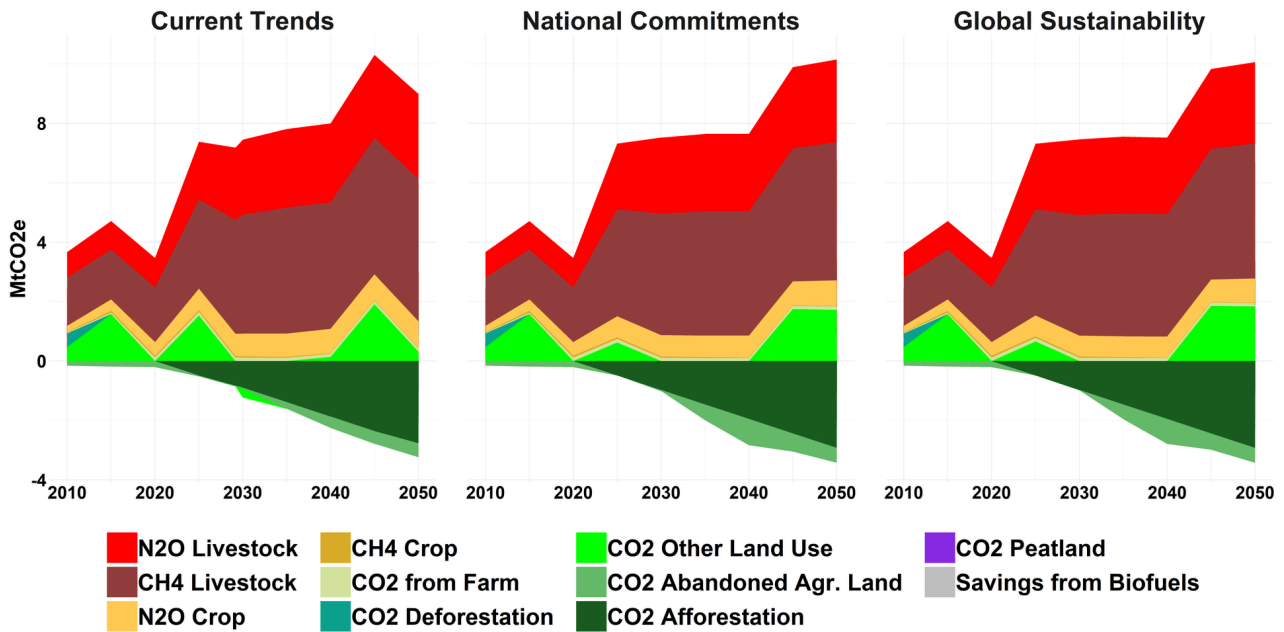


Figure 9. Share of cropland under agroecological practices

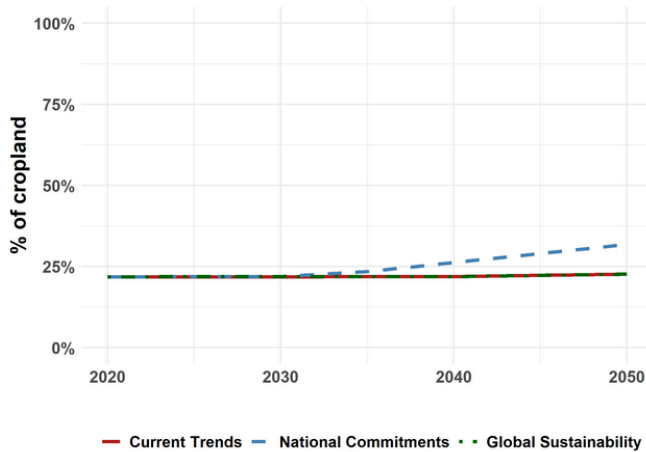
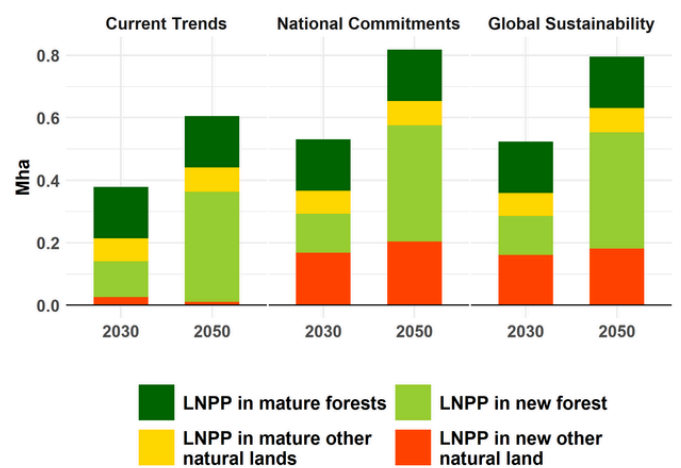


Figure 10. Total area of land where natural processes predominate (LNPP)



Agroecological practices included: Cover crops, cultivar mixtures, diversified farming systems, embedded natural, organic farming, no/minimal tillage.



Figure 11. Nitrogen application

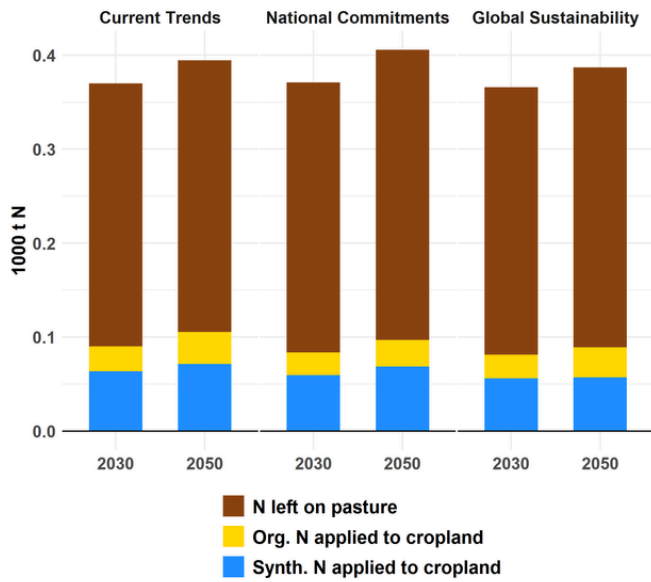
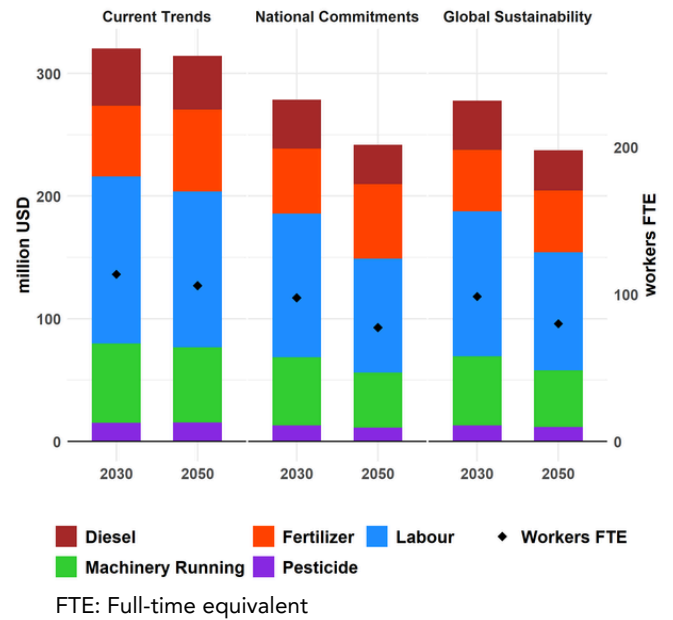


Figure 12. On farm production costs



For more detailed results and visual data, visit [www.scenathon.org](http://www.scenathon.org)

# Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
<b>1. Macroeconomics</b>	<b>1.1) GDP per capita</b>	SSP2	Same as CT	SSP1	<a href="#">Republic of Rwanda (2022): Country Strategy Paper 2022-2026</a>
	<b>1.2) Population</b>	SSP1 The current population of more than 12 million people is expected to be approximately 22 million in 2050 with an assumed population growth rate of nearly 2%	Same as CT	Same as CT	Rwanda is among the most densely populated countries in Africa, with nearly 400 inhabitants per km <sup>2</sup> overall and more than inhabitants 520 per km <sup>2</sup> on agricultural lands. Source: <a href="#">Vision 2050</a>
	<b>1.3) Inflation</b>	N/A	N/A	N/A	The annual inflation rate in Rwanda slowed for the second straight month to 22.4% in May 2023 from 28.4% in the previous month. It was the lowest inflation rate since last August, with the food prices rising the least in nine months (39.6% vs 54.6% in April), of which bread & cereals (15.6% vs 35.1%). Prices also increased at a softer pace for transportation (6.0% vs 6.5%). By contrast, prices continued to rise for both housing (3.6% vs 0.7%) and education (13.9% vs 13.8%). On a monthly basis, consumer prices fell by 2.7% in May, the first monthly decline in five months, reversing from a 1.7% rise in April. Source available <a href="#">here</a>
	<b>1.4) Inequalities</b>	N/A	N/A	N/A	Oxfam Uganda, in the report titled Who is Growing, says that in Rwanda, the gross national income of the richest 10 per cent is 3.2 times more than that of the 40 per cent poorest in the country, compared with Kenya's 2.81, Uganda's 2.33, Tanzania's 1.65 and Burundi's 1.35. Source available <a href="#">here</a> Rwanda's Gini Coefficient Index is 53.9 and was most recently measured in 2019.

# Scenarios and assumptions

		<b>A) CURRENT TRENDS</b>	<b>B) NATIONAL COMMITMENTS</b>	<b>C) GLOBAL SUSTAINABILITY</b>	<b>Justification</b>
<b>2. Land</b>	<b>2.1)</b> Constraints on agricultural expansion/deforestation	Free expansion	Same as CT	Same as CT	The scarce land is predominantly used for agriculture, which dominates Rwanda's employment and contributes with about 55 % of the export earnings. It meets about 80 % of the country's food needs, although there has been a small decline in its contribution to GDP in recent years. The rapid population growth has led to land fragmentation and created severe environmental challenges by causing farmers to push into marginal lands, clear forests, and cultivate steep hillsides without proper soil and water conservation. Source available <a href="#">here</a>
	<b>2.2)</b> Afforestation, and forest plantations targets	30.1% of total area is covered by forest (Bonn Challenge). Forest cover of total area will keep on increasing.	Same as CT	Bonn Challenge	<a href="#">Forest Sector Strategic Plan 2018 - 2024</a>
	<b>2.3)</b> Urban and settlements area	The rate of informal settlements will be reduced from 62% to 52% by 2024. By 2030 it will be one of the regions' most urbanized in the east African Community countries, with an estimated urbanization rate of 30%	Rwanda aspires to achieve 35% rate of urbanization by 2024 and 70% by 2050.	UN_Medium	Reducing the percentage of informal settlements, of course, simultaneously requires the prevention of any new informal urban areas through a variety of measures. (Republic of Rwanda, 2018). Source available <a href="#">here</a> Enabling sustainable urban settlements requires adequate urban planning policy and regulations. Rwanda aspires to achieve 35% rate of urbanization by 2024 and 70% by 2050. (Republic of Rwanda, 2022). Source available <a href="#">here</a> Furthermore, In 1990, it was the least urbanized country in the east African Community countries. But by 2030 it will be one of the regions' most urbanized, with an estimated urbanization rate of 30%. Source available <a href="#">here</a>

# Scenarios and assumptions

		<b>A) CURRENT TRENDS</b>	<b>B) NATIONAL COMMITMENTS</b>	<b>C) GLOBAL SUSTAINABILITY</b>	<b>Justification</b>
	<b>2.4) Protected areas</b>	Expansion of protected areas in the future.	Same as CT	Same as CT	Terrestrial protected areas (% of total land area) in Rwanda was reported at 9.1052 % in 2021, according to the World Bank collection of development indicators, compiled from officially recognized sources. Source available <a href="#">here</a>

# Scenarios and assumptions

<p><b>3. Productivity and management</b></p>	<p><b>3.1) Crop productivity for the key crops</b></p>	<p>Middle</p>	<p>Same as CT</p>	<p>Same as CT</p>	<p>We assumed crop yield for thirteen years starting by 2018 to 2030, from findings, it shows that comparing to the previous series (1990 - 2017), and the agriculture yield will increase and decrease in general. Banana is the most growing yield with an average rate around 80%, Beans will have the worst growing rate with -48.42%, 38.64%, 64.07%, 11.33% and 52.18% for Cassava, Maize, Potatoes and Rice respectively. We found that in these coming years Beans will have a highest yield ever between 1990 and 2030 with 12885.8hg/ha in 2019, Banana 124098.36hg/ha in 2022 and Rice with 130600hg/ha in 2030; in these coming years, the predictions indicate that Banana and Maize will suffer for least productivity with 24115.31hg/ha in 2018 and 4573.08hg/ha in 2026 respectively. By 2030, the most productive home consumable crop we expect will be Banana with 121096.66hg/ha and least productive will be 8102.53hg/ha.</p> <p>This is due to political stability, use of fertilizers, farmers are trained for amelioration of their work, investors will be welcomed and the sector in general will gain strength from different corners, and all these factors will be resulting to the best change in yield to earned in future.</p> <p>From results we mark a high difference between yield of Tea and Coffee comparing to the previous years (1991 - 2017) because in these coming years for all years the difference of Tea for Coffee will be greater to 4680.5846hg/ha. Two crops will achieve their highest yield in this series of years (1990 - 2030) in this coming period with 18716.789hg/ha for Tea in 2020 and 7735.346hg/ha in 2026 for Coffee, even if the</p>
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# Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
					average growth rate for these crop yields will be falling up to -7.44% for Coffee and -3.68% for Tea. Source available <a href="#">here</a>
	<b>3.2)</b> Cropland under agroecological practices	No change	Cover crop	Organic	In a 2007 effort to increase agricultural productivity and address persistent poverty in the countryside, the Government of Rwanda launched the Crop Intensification Program (CIP) to improve land use with a greater focus on the commercialization of food crops ( <a href="#">MINAGRI 2012</a> ). Specifically, CIP sought to increase access to productive inputs (improved seeds and fertilizers), water use (improved irrigation), land use intensification, extension services, and postharvest handling and storage services. To achieve its goals, the program incentivized farmers to monocrop fields and to cultivate six particular crops (maize, wheat, rice, white potato, beans, and cassava) that cover the area where they are cultivated. Available at <a href="https://www.degruyter.com/document/doi/10.1515/jafio-2021-0010/html?lang=en">https://www.degruyter.com/document/doi/10.1515/jafio-2021-0010/html?lang=en</a>

# Scenarios and assumptions

	<p><b>3.3) Livestock productivity for the key livestock products</b></p>	<p>High Growth</p>	<p>Same as CT</p>	<p>Same as CT</p>	<p>Currently, there are about 799 000 crossbreed dairy cattle in Rwanda and it is projected that the number will increase to 1.17 million by 2022 representing an increase of 46 percent, while milk production will grow from 747 million liters of milk produced in 2017 to 2.2 billion liters by 2022, an 18.2 percent boost. The rise in both the number of dairy cattle and milk production will increase the contribution of the dairy value chain to the national gross product to 53 percent. Under the recommended level investment, the increases in red meat production from cattle, sheep and goats from 2017 to 2022 is 32 percent, 33 percent, and 50 percent, respectively. Cattle and goats are the primary sources of red meat in 2022. Total red meat grows from 58 579 tons in 2017 to 79 586 tons in 2022, an increase of 36 percent. The chicken meat and egg production expected to experience substantial increments of 124 percent and 110 percent, would contribute significantly to fulfilling the national meat requirement and would increase per capita egg consumption.</p> <p>Rwanda produced about 58 580 metric tons of red meat in 2016/2017, wherein 74 percent is beef, and the remaining 26 percent comes from sheep and goats. The total chicken meat and egg production from the family and commercial specialized systems is expected to increase from 15 715 tons in 2016/17 to 35 170 tons in 2021/22 for meat which constitutes a 124 percent increase over 5 years. The overall target is to raise pig meat production from the current 19 945 tons in 2016/17 to 67 076 tons by 2022, an increase of 239 percent to be achieved through improving the family mixed pig system and expanded commercial</p>
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# Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
					specialized piglet fattening. Source available <a href="#">here</a>
	<b>3.4)</b> Pasture stocking rate	BAUGrowth	The ruminant density stays constant at 2.35 TLU/ha over 2015-2050.	BAUGrowth	No data on national average livestock stocking densities to compare this value with.
	<b>3.5)</b> Forest management	Well managed	Same as CT	Same as CT	According to a recent assessment by the GoR, 30% of forest area in Rwanda is under forest cover (Rwanda Forest Cover Mapping Report 2019), and is made up of plantations, natural mountain tropical forests, wooded savannah, shrubs and bamboo stands. Recently, Rwanda has partnered with the private sector to ensure the efficient management of the state-owned forests. The Ministry of Environment launched the first Private Forest Management Units in 2019 to safeguard individual forests and boost forest harvesting as a strategy to maintain and manage woodlots effectively. So far, 23,456.15 hectares (equivalent to 38.4% of state forests) are now managed by private investors through long term concession agreements. Source available <a href="#">here</a>
<b>4. Trade</b>	<b>4.1)</b> Share of consumption which is imported for key imported products (%)	Stable imports (I2)	Same as CT	Same as CT	Rwanda's top imported products are oil products (16.8%), unwrought gold (7.6%), medicaments (3.8%), sugar (2.4%) and mobile phones (2.2%), on average from 2015 to 2019. The surge in imported unwrought gold in 2019 may largely be explained by Rwanda's imported gold for processing (World Bank, 2021c). Half of Rwanda's total imports are sourced from five main countries: China, India, UAE, Uganda and Kenya (Sherillyn Raga, 2022). Source available <a href="#">here</a>



# Scenarios and assumptions

		<b>A) CURRENT TRENDS</b>	<b>B) NATIONAL COMMITMENTS</b>	<b>C) GLOBAL SUSTAINABILITY</b>	<b>Justification</b>
	<b>4.2)</b> Evolution of exports for key exported products (1000 tons)	Exports are multiplied by 1.5 by 2050	Same as CT	Same as CT	Agricultural export for traditional commodities in FY 2021/2022 generally increased by 17.96% by observed decrease in pyrethrum compared to previous fiscal year. The quantities exported for coffee was 15,184.5 MT, which is less than target of 23,241MT. Tea quantities exported were 35,404.7 MT against targets of 35,943 MT. The horticulture targets were USD 39 million of which USD 42.8 million were realized while pyrethrum reached USD 6.3 million against the targeted of USD 7million. Source available <a href="#">here</a>
<b>5. Food</b>	<b>5.1)</b> Average dietary composition	NatHealthyDiet	Same as CT	Same as CT	The Rwandan diet is based primarily on staples (starch) and vegetables. The FCS increases with households consuming more pulses (vegetable proteins) and oil (fats). The acceptable weekly food diet in Rwanda is composed of daily consumption of starches, pulses, vegetables, and oil and consumption of meat, milk products and fruits once or twice a week. It was observed that there was no consumption of animal products, fruits, and sugar by households with poor or borderline consumption (World Food Program, 2018). Source available <a href="#">here</a>

# Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
	<b>5.2)</b> Share of food consumption which is wasted at household level	Increased	Same as CT	Reduced	<p>According to the <a href="#">Food Waste Index 2021 from the United Nations Environment program (UNEP)</a>, every household in Rwanda wastes 164 kg of food every year while 2,075,405 tons of food is wasted at household level per year. Food waste burdens waste management systems, exacerbates food insecurity, making it a major contributor to the three planetary crises of climate change, nature and biodiversity loss, and pollution and waste.</p> <p>According to Rwanda Smart Food Country Diagnostic report, published by World Bank (2020), Rwanda loses and wastes about 40% of its food supply. Reducing food loss and waste would “increase” food yields from the stock of land and water already under farming. Even if food loss and waste were reduced only by half, it would help with food availability without additional environmental impacts on the food supply chain.</p> <p>Thus, Rwanda has made commitments to reduce food loss and waste at both the global level through the Sustainable Development Goals and their Nationally Determined Contribution under the Paris Climate Agreement, as well as regionally through the Malabo Declaration. Source <a href="#">here</a></p>
<b>6. Biofuels</b>	<b>6.1)</b> Targets on biofuel and/or other bioenergy use	Same as National Target	Rwanda is targeting to have reduced the firewood for cooking to 42 percent	OECD_AGLINK	<p>Currently, around 83 percent of Rwandans still use firewood for cooking but by 2024, Rwanda is targeting to have reduced the figure to 42 percent. Hakizimana E., Wali U. G. , Sandoval D., Kayibanda V., (2020). Environmental Impacts of Biomass Energy. Energy and Environmental Engineering 7(3): 62-71, 2020. DOI: 10.13189/eee.2020.070302</p>

# Scenarios and assumptions

		<b>A) CURRENT TRENDS</b>	<b>B) NATIONAL COMMITMENTS</b>	<b>C) GLOBAL SUSTAINABILITY</b>	<b>Justification</b>
	<b>6.2)</b> Targets on other non-food use	N/A	N/A	N/A	N/A
<b>7. Water</b>	<b>7.1)</b> Irrigated crop area	LowGrowth	In line with the Government's target, the developed irrigated area should reach ~100,000 ha by the end of 2024. The investment plan covers the period 2020 to 2050 (30 years) with the objective of achieving 220,000 ha under irrigation by 2050, or roughly 50% of the country's potential based on projected renewable resources.	High Growth	It is assumed that the total irrigated area at the end of 2019 will stand at around 54,000 ha, approximately 4,700 ha higher than in June 2018. Source available <a href="#">here</a>