2023 Scenathon results

Pathways for food and land-use systems in India

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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Federal Ministry for Economic Affairs and Climate Action

IKI INTERNATIONALE KLIMASCHUTZ INITIATIVE

on the basis of a decision by the German Bundestag

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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

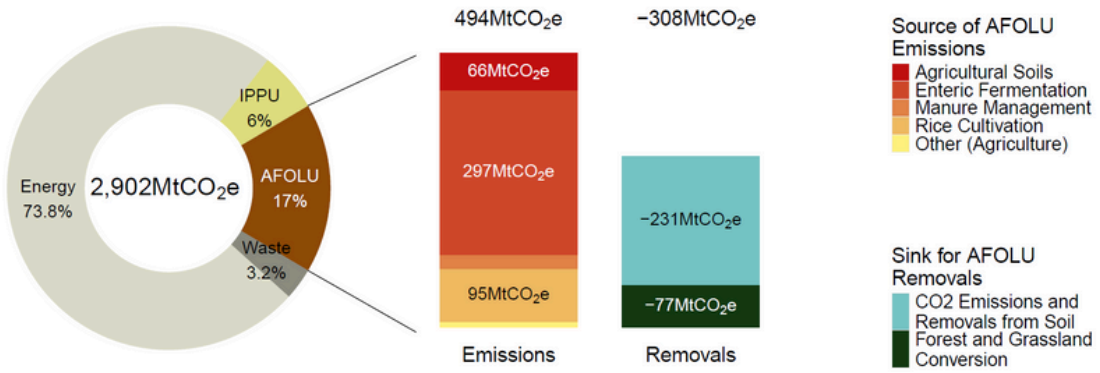
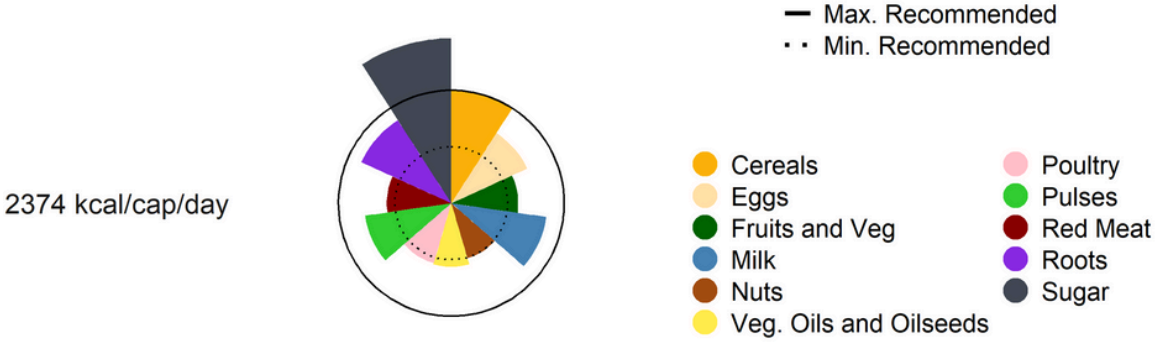


Figure 2. Daily average kilocalorie intake per capital per food category in 2020



National context

India

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	Overweight / obesity	No increase in obesity levels by 2025 for infants, adolescents, and adults.
	Undernourishment	Reduce stunting and undernourishment in children (0-6 years) by 2% per annum up to 6% by 2023.
	Diet-related disease	Reducing the number of global premature deaths from NCDs by 25% by 2025.
	Other food-related targets	Reduce consumption of sugar to zero as per India's National Institute of Nutrition. Increase the intake of pulses and coarse cereals in state government programs by 2022.
13 CLIMATE ACTION	Total GHG emissions reduction	Net-zero by 2070. Emissions Intensity of GDP reduction by 45% by 2030. 50% cumulative electric power installed capacity from renewable energy by 2030.
	Land use and land use change GHG emissions reduction	Convert 10 Mha of forest and non-forest land to boost forest cover and quality, sequestering carbon to 60 Mt by 2020 and up to 100 MtCO2e thereafter.
	Other climate mitigation-related targets	Forest carbon sink by 2.5 to 3 billion tonnes of CO2 equivalent by 2030
15 LIFE ON LAND	Expand protected areas or 'Other effective area-based conservation measures'	As per India's National REDD+, conservation of existing protected areas covering 16 mha of forest land is already underway. 30% of lands, waterways and ocean protected by 2030.
	Promote afforestation	Increase forest and tree cover by 2.5 to 3 billion tons of CO2 equivalent by 2030 and rehabilitate 26 million acres of damaged land by 2030 advocates vast afforestation (Bonn Challenge).
	Reduce or halt loss of natural ecosystems	We assume that deforestation will be halted by 2030, as, no agricultural land expansion into natural forests is allowed under policies such as the Indian Forest Act and Indian Forest Conservation Act.
	Expand cropland area under agroecological practices	Plan to expand the area under agroecological practices (including organic and natural farming) to 2 Mha by 2024.
14 LIFE BELOW WATER	Limit water use	Reduction of 30-37% water use by adopting water efficiency increasing measures such as drip and sprinkler irrigation systems by 2050.
	Limit nitrogen use	20–25% improvement in India's nitrogen use efficiency by 2030, minimizing N fertilizer use on farms farms by 10% to 15%.
8 DECENT WORK AND ECONOMIC GROWTH	Agricultural exports	Double exports from present ~US$ 30+ Billion to ~US$ 60+Billion by 2022 and reach US$ 100 Billion in the next few years thereafter.
	Employment in the agricultural sector	Through a focus on the food-processing sector, the expectation is to add 9 million jobs by 2024 in the agricultural sector.

Model

Using MAgPIE, 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.

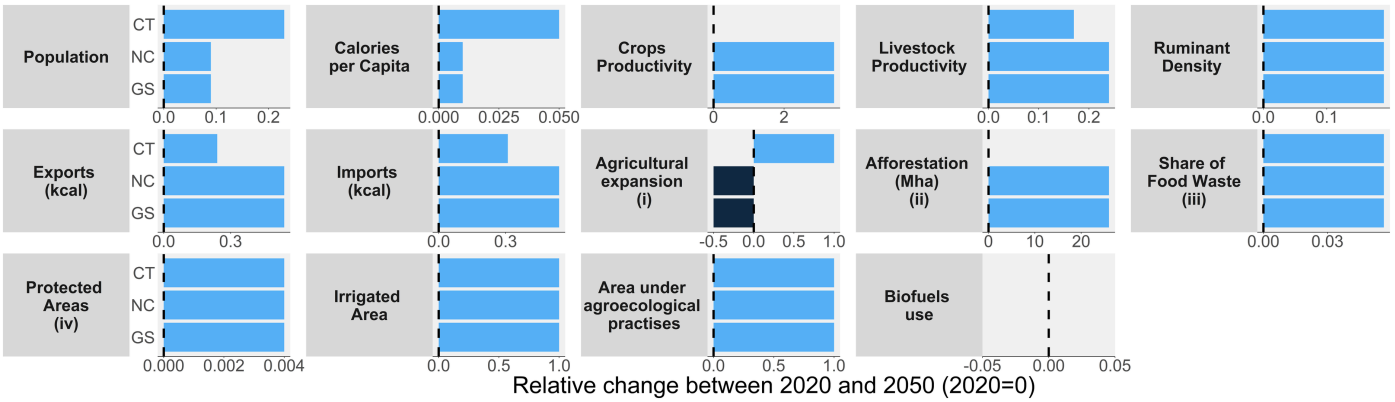
Pathway narratives

Current Trends: We project high population growth and increasing demand for food, moderate economic growth and lower inequality, increased use of fertilizers particularly nitrogen to increase productivity, and moderate mitigation activity to cope with climate change with low enforcement of environmental protection policies. We also assume low targets of renewable and first-generation biofuels. We assume the carbon concentration trajectory to transition towards a 2-degree increase in global temperature (RCP 6.0).

National Commitments: Our national commitments are aligned with national policies that aim to reduce undernutrition and obesity amongst the population along with reduced food loss and waste. We assume high population growth and high demand for food. However, increased economic growth in line with the SSP1 trajectory is assumed. This growth promotes national targets of increased exports and reduced dependence on imports. We assume India's commitment to the Bonn Challenge and expansion of protected areas in the future. We assume the carbon concentration trajectory to transition towards the 1.5-degree increase in global temperature (RCP 4.5).

Global Sustainability: Our global sustainability pathway is aligned with national policies that aim to reduce undernutrition and obesity amongst the population along with reduced food loss and waste. We assume high population growth and high demand for food. However, increased economic growth in line with the SSP1 trajectory is assumed. This growth promotes national targets of increased exports and reduced dependence on imports. We assume India's commitment to the Bonn Challenge and expansion of protected areas in the future. We assume the carbon concentration trajectory to transition towards a 1-degree increase in global temperature (RCP 2.6).

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

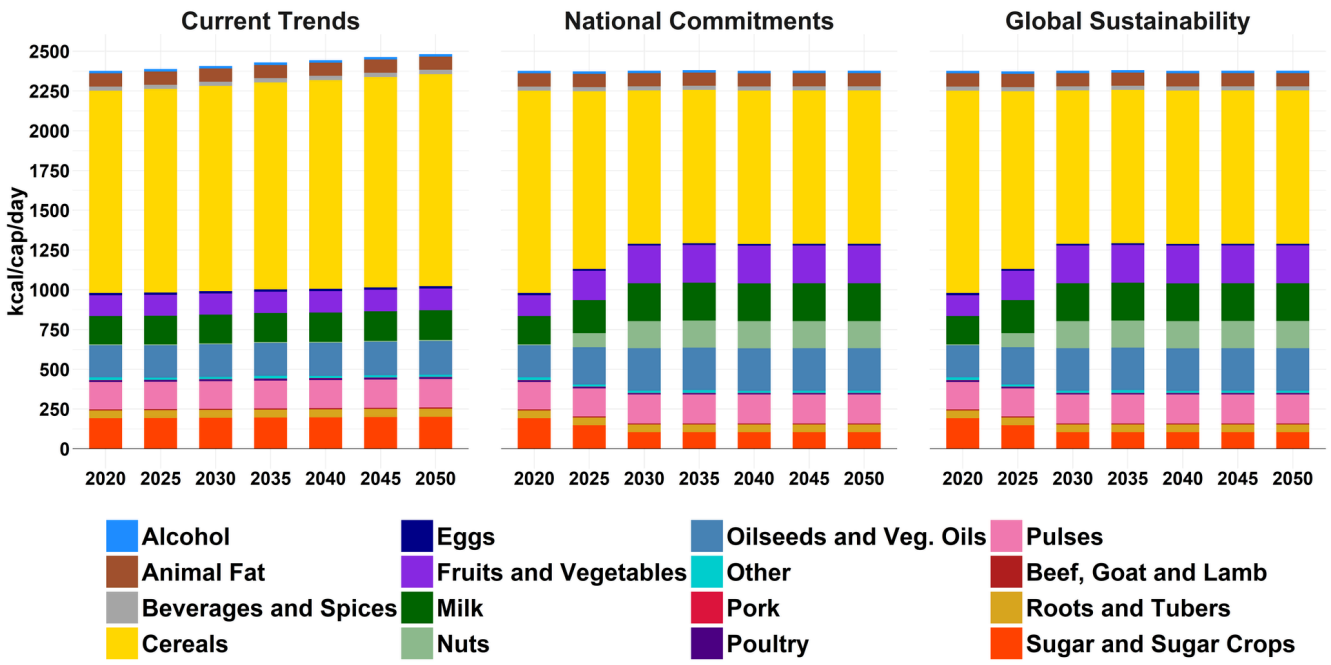


Figure 5. Comparison of the computed daily average kilocalorie intake per capital per food category across the three pathways and the prevalence of undernourishment in 2050

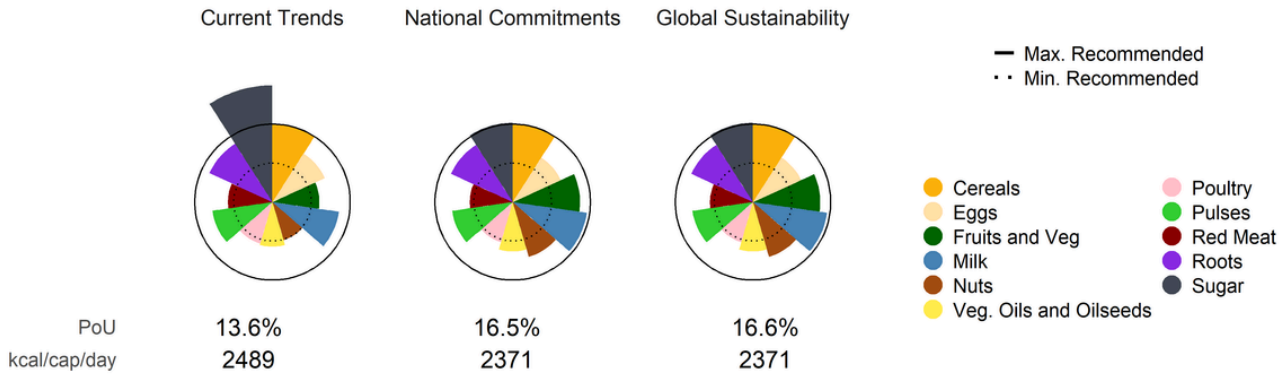


Figure 6. Evolution of land cover 2000-2050

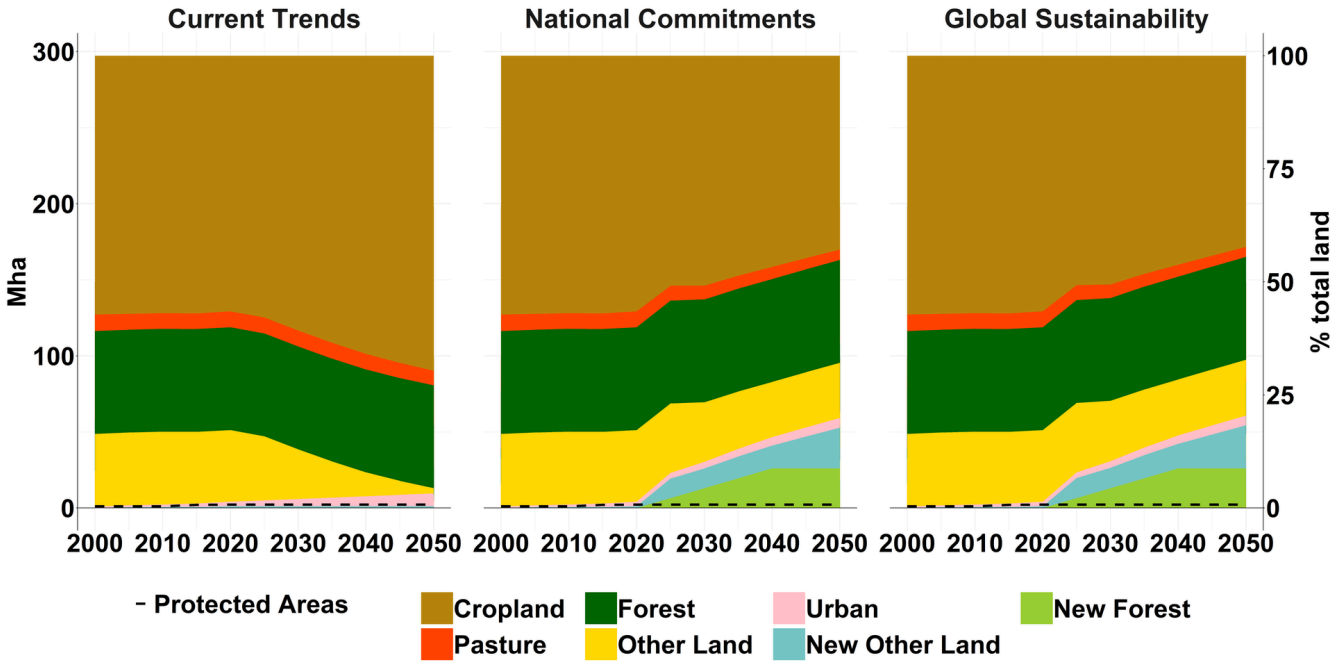


Figure 7. Evolution of the cropland composition 2000-2050

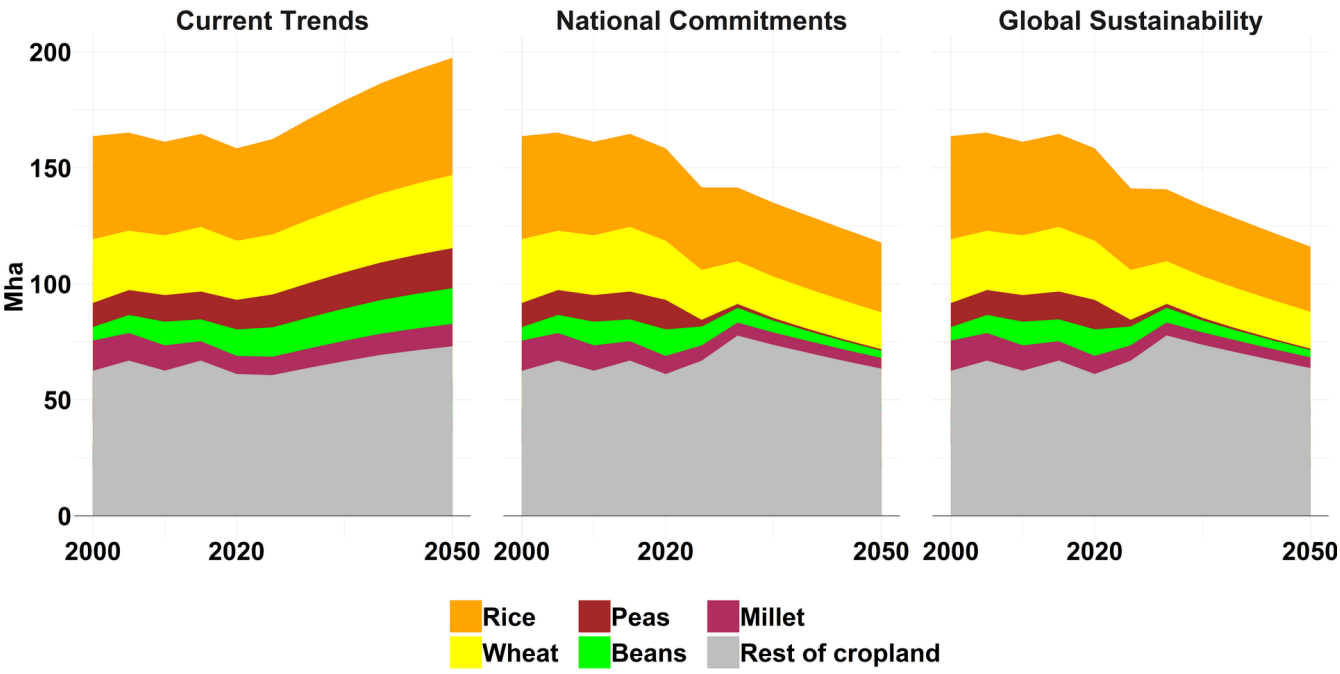


Figure 8. Projected AFOLU emissions and removals between 2020 and 2050 by main sources and sinks across pathways

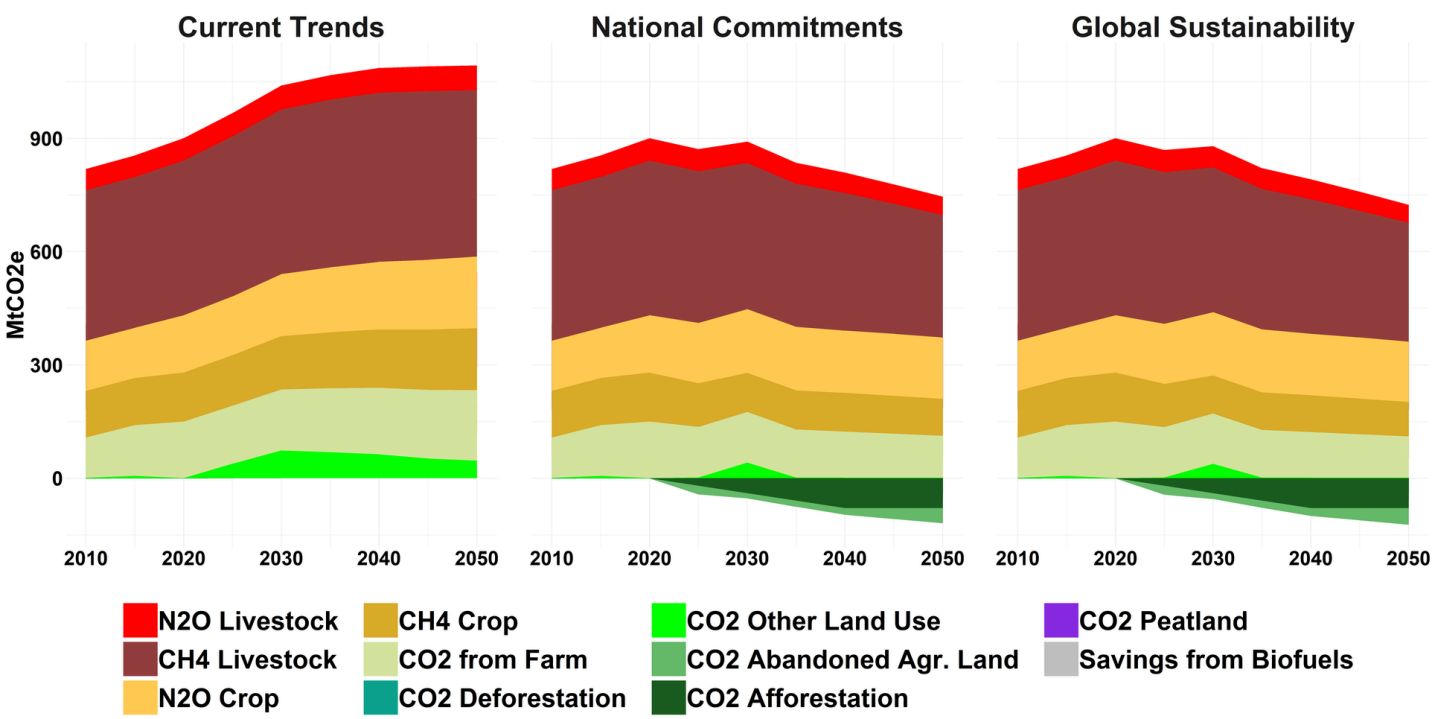
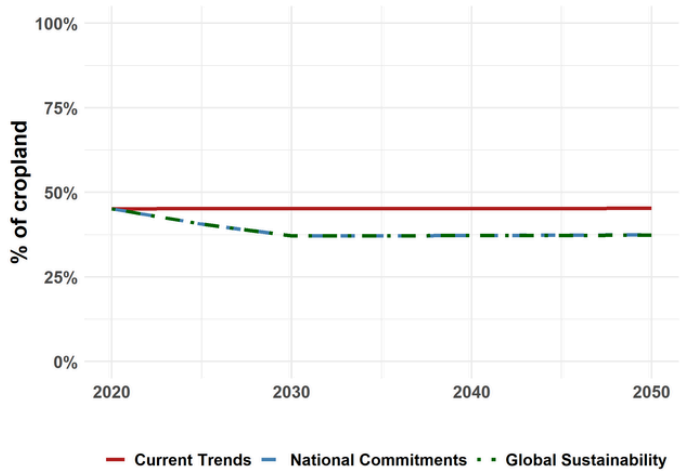


Figure 9. Share of cropland under agroecological practices



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)

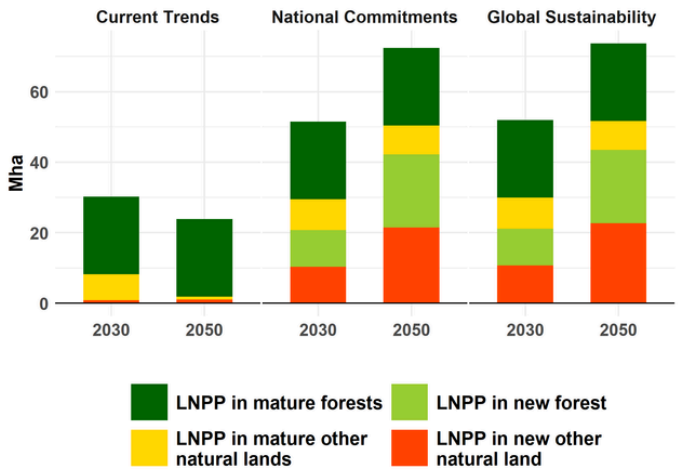


Figure 11. Nitrogen application

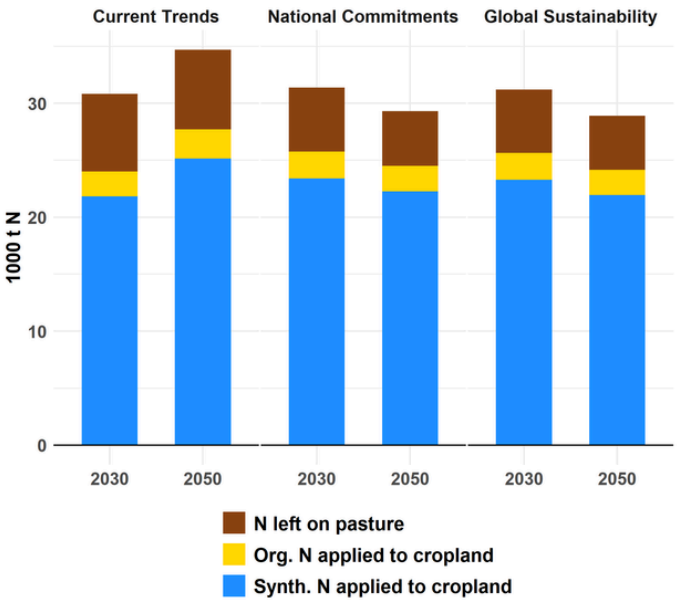
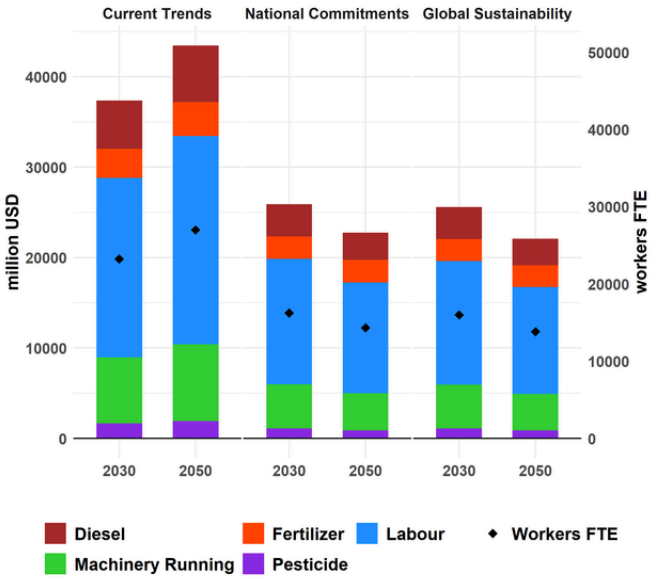


Figure 12. On farm production costs



FTE: Full-time equivalent

For more detailed results and visual data, visit www.scenathon.org

1. **Shift towards healthy diets:**
   - Promotion of healthy food consumption through enhanced production and distribution of coarse grains, legumes and horticultural products
   - Implementation of awareness campaigns and educational programs to disincentivize the consumption of high fat sugars and salts (HFSS) foods

2. **Afforestation for improved environmental outcomes:**
   - Accelerate afforestation efforts by implementing the National REDD+ strategy and Namami Gange Plan to promote afforestation on barren lands, aiming to achieve 50 mha of afforestation or reforestation by 2050. This initiative has the potential to sequester approximately 145 MtCO2e of emissions, significantly contributing to climate change mitigation.
   - Integrating Forestry with Agriculture by focusing on enhancing soil health and sustainable agricultural practices, ensuring long-term environmental and economic benefits.

3. **Increasing Agricultural productivity:**
   - Enhancing resource efficiency in agriculture by implementing policies to increase resource use efficiency focusing on fertilizer, machinery and irrigation use.
   - Integration of natural or traditional agroecological practices in national planning is important.
   - Boosting agricultural productivity through innovations and technologies that are climate-resilient, such as water-efficient crop varieties and precision agriculture.

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
1. Macroeconomics	**1.1)** GDP per capita	Increase in GDP per capita by 5.9 times in 2050 compared to 2000	Increase in GDP per capita by 7.2 times in 2050 compared to 2000	Increase in GDP per capita by 6.5 times in 2050 compared to 2000	Our assumptions in this case follow the SSPs framework where we assume SSP2 for Current Trends and National, Commitments and SSP1 for the Global Sustainability target (O'Neill et.al., 2014) Supporting for current trends: Summary of the economic survey 2022-23
	1.2) Population	The population is expected to reach 1.71 billion by 2050 based on our underlying assumption of UN - Constant fertility parameterization	The population is expected to reach 1.52 billion by 2050 based on our underlying assumption of UN - Low growth parameterization	The population is expected to reach 1.67 billion by 2050 based on our underlying assumption of UN - Medium growth parameterization	UN Population
	1.3) Inflation	7% until 2023	Projected to be at 4% by 2024	Using prices expressed at current rates	Reserve Bank of India. Monetary Policy Report – April 2021. Reserve Bank of India. Monetary Policy Report – September 2022.
	1.4) Inequalities	Gini Coefficient (a measure of real inequality) has reduced to a level near the lowest recorded – it was 0.292 in 2020-21, while the lowest was recorded in 1993-94 at 0.284. (This is tentative)	Needs to be further investigated	Needs to be further investigated	State of Inequality in India Report 2022 IMF Working Paper
2. Land	**2.1)** Constraints on agricultural expansion/deforestation	Free expansion of agricultural land beyond protected areas	Deforestation will be halted beyond 2030	Deforestation will be halted beyond 2030	India's Nationally Determined Contribution (NDC)

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
	2.2) Afforestation, and forest plantations targets	India made a Bonn Challenge pledge to turn 13 million hectares of degraded land into restoration by 2020 and an additional 8 million hectares by 2030 (a total of 21 million ha) at the UN Framework Convention on Climate Change (UNFCCC) Conference of Parties (CoP) 2015 in Paris.	Revised Bonn Challenge (26 mHA additional afforestation by the year 2030)	Revised Bonn Challenge (26 mHA additional afforestation by the year 2030)	This assumption is based on India's additional commitment of 5 Mha in line with the existing Bonn Challenge commitment (2014). This new commitment was announced by the Government of India at the UN Summit in 2019 (Prime Minister's Office, 2019). India has brought an area of 9.8 million hectares under restoration since 2011, meaning that the restoration work of these landscapes is already underway
	2.3) Urban and settlements area	Urban area will increase by 1.8 times in 2050 compared to 2020 (needs to be further looked into)	Urban area will increase by 1.53 times in 2050 compared to 2020 (needs to be further looked into)	Urban area will increase by 1.21 times in 2050 compared to 2020 (needs to be further looked into)	UN-Habitat Report 2022
	2.4) Protected areas	Protected areas remain stable until 2050: by 2050 they represent 6% of total land.	Expansion to 30*30 by 2030	Expansion to 30*30 by 2030	Indian protected areas were computed using the data from the World Database on Protected Areas (UNEP-WCMC & IUCN, 2020). The assumptions are in line with India's commitment to the CBD. India has exceeded the terrestrial component of 17 percent of the Aichi target 11 which aimed towards conserving at least 17% of terrestrial and inland water, and 10% of coastal and marine areas.

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	Same productivity as of 2020	We assume high productivity growth. Compared to 2020, crop productivity in 2050 increases from 2.98 t/ha to 7.07 t/ha for corn, 3.5 t/ha to 4.02 t/ha for wheat, 0.92 t/ha to 3.41 t/ha for soybeans, etc.	We assume high productivity growth. Compared to 2020, crop productivity in 2050 increases from 2.98 t/hc to 7.07 t/ha for corn, 3.5 t/ha to 4.02 t/ha for wheat, 0.92 t/ha to 3.41 t/ha for soybean, etc.	Our assumptions are based on the National Council of Applied Economic Research (2015) which suggests that due to technological innovation and diffusion through institutional arrangements, growth in yields will be high in the coming decades. NCAER 2015 Report NCAER 2017 report
	3.2) Cropland under agroecological practices	No specific/accurate data. Needs to be looked into further	Plan to expand the area under agroecological practices (including organic and natural farming) to 2 mHa by 2024. No other specific/accurate data. Needs to be looked into further. Targets need to be identified accordingly	No specific/accurate data. Needs to be looked into further. Targets need to be identified accordingly	Patel N., Dorin B., Nagaich R., 2022. A New Paradigm for Indian Agriculture. From Agroindustry to Agroecology, NITI Aayog, New Delhi, 70 p. Post Harvest Management Support to Encourage Organic Farmers Agroecology and Natural Farming Could Accelerate Inclusive Economic Growth in India Organic Farming in the Country Natural Farming NITI initiative Productivity of Dairy Animals
	3.3) Livestock productivity for the key livestock products	We assume that by 2050, livestock productivity will increase moderately based on improvements in feed	By 2050, livestock productivity will increase at a higher rate compared to 2020 based on the improvement in feed baskets	By 2050, livestock productivity will increase at a higher rate compared to 2020 based on the improvement in feed baskets	Productivity of Dairy Animals

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		basket content and livestock production systems.	and livestock production systems.	and livestock production systems.	
	3.4) Pasture stocking rate	By 2050, the average ruminant livestock stocking density is 2.13 TLU/ha. Based on the assumption that The stocking density remains unchanged from the value in 2020 according to FAOSTAT (herd numbers divided by pasture area).	Same as Current Trends	Same as Current Trends	Several initiatives were taken to improve livestock feeding systems because, by 2025, India is likely to experience a fodder deficit of about 65% for green fodder and 25% for dry fodder (Indian Council of Agricultural Research, 2015; Ministry of Agriculture and Farmer's Welfare, 2017; Planning Commission, 2012).
	3.5) Forest management	Minimum one-thirds of total land to be under tree and forest cover	Minimum one-third of total land to be under tree and forest cover	Minimum one-third of total land to be under tree and forest cover	India's Draft National Forest Policy 2018
4. Trade	**4.1)** Share of consumption which is imported for key imported products (%)	By 2050, the volume of imports remains at: • 9.57 Mt of Palm oil • 1.927 Mt of other pulses • 6.087 Mt of soy oil • 1.150 Mt of Nuts	By 2050, the volume of imports remains at: • 8.61 Mt of Palm oil • 1.428 Mt of other pulses • 6.15 Mt of soy oil • 16.76 Mt of Nuts	By 2050, the volume of imports remains at: • 9.397 Mt of Palm oil • 2.413 Mt of other pulses • 7.38 Mt of soy oil • 30.316 Mt of Nuts	Reduced share compared to 2020 for select products - oils (30% reduction)
	4.2) Evolution of exports for key exported products (1000 tons)	By 2050, the volume of exports will reach to: • 3.3 Mt for corn. • 32.4 Mt for Rice • 1.4 Mt for wheat. • 1.01 Mt for groundnut 0.933 Mt for beef.	By 2050, the volume of exports will reach to: • 5 Mt for corn. • 39.6 Mt for Rice • 1.34 Mt for wheat. • 0.91 Mt for groundnut • 0.81 Mt for beef	By 2050, the volume of exports will reach to: • 5.73 Mt for corn. • 35.02 Mt for Rice • 1.2 Mt for wheat. • 0.81 Mt for groundnut • 0.32 Mt for beef	Agriculture Export Policy Exports doubled in comparison to 2020, with targets of diverse products which need to be looked at.
5. Food	**5.1)** Average dietary composition	By 2050, the average daily calorie consumption per	By 2050, the average daily calorie consumption per	By 2050, average daily calorie consumption per	My Plate for the Day

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
		capita is 2672 kcal, out of which 61% is obtained from cereals, 5% from fruits and vegetables, 3.6% from milk, 7 % each from sugar, pulses, and oilseeds, and 4% from animal meat.	capita is 2383 kcal out of which 38.5% is obtained from cereals, 10.5% from fruits and vegetables, 9.5% from milk, 8% from sugar, 6.4% from pulses, 11% from oilseeds and 5% from animal meat.	capita is 2354 kcal out of which 32% is obtained from cereals, 8 % from fruits and vegetables, 6% from milk, 4.7% from sugar, 11% from pulses, 14% from oilseeds and 9% from animal meat	
	5.2) Share of food consumption which is wasted at household level	5% reduction in food waste	Same as CT	Reduced share as compared to 2020 (0% food waste by 2050)	My Plate for the Day
6. Biofuels	**6.1)** Targets on biofuel and/or other bioenergy use	India's average blending rate for ethanol in gasoline is expected to reach a record 5.8%, up from a previous record 4.1% in 2019 (work in progress)	Based on the implementation of India's New Biofuel Policy, 2018. The policy proposes an indicative target of 20% blending of ethanol in petrol and 5% blending of biodiesel in diesel by 2030. (work in progress, to be implemented)	Linear increase after 2030 (work in progress)	Cabinet approves Amendments to the National Policy on Biofuels -2018 National Policy on Biofuels 2018
	6.2) Targets on other non-food use	Needs further discussion	Needs further discussion	Needs further discussion	
7. Water	**7.1)** Irrigated crop area	Same as 2020 (Currently under development)	Need to double irrigated areas as compared to 2020 by improving water use efficiency (currently under development)	Need to double irrigated areas as compared to 2020 by improving water use efficiency (currently under development)	Blue water footprint per person is expected to decrease by 30.3% based on population projections (Indian Ministry of Water Resources, 2011; Milner et al., 2017). Coverage under Drip and Micro Irrigation Evaluation of Centrally Sponsored Schemes in Water

Scenarios and assumptions

		A) CURRENT TRENDS	B) NATIONAL COMMITMENTS	C) GLOBAL SUSTAINABILITY	Justification
					Resources, Environment and Forest Sector