

2019 Report of the FABLE Consortium

Pathways to Sustainable Land-Use and Food Systems



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The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is convened as part of the Food and Land-Use Coalition (FOLU). It is led by the International Institute for Applied Systems Analysis (IIASA) and the Sustainable Development Solutions Network (SDSN), working closely with EAT, the Potsdam Institute for Climate Impact Research (PIK), and many other institutions.

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List of Acronyms

AFOLU	Agriculture, Forestry and Other Land Use	INDC	Intended Nationally Determined Contributions
BAU	Business As Usual	IPCC	Intergovernmental Panel on Climate Change
DEFRA	Department for Environment, Food and Rural Affairs	LEDS	Low (greenhouse gas) Emission Development Strategies
CBD	Convention on Biological Diversity	LULUCF	Land Use, Land-Use Change, and Forestry
CCC	Committee on Climate Change	MAGPIE	Model of Agricultural Production and its Impact on the Environment
COP	Conference of the Parties	MDER	Minimum Dietary Energy Requirement
DDPP	Deep Decarbonization Pathways Project	NDC	Nationally Determined Contributions
EU	European Union	PIK	Potsdam Institute for Climate Impact Research
FABLE	Food, Agriculture, Biodiversity, Land-Use, and Energy Consortium	R&D	Research and Development
FAO	Food and Agricultural Organization	RoW	Rest of the World regions, covering countries that do not currently participate in the FABLE Consortium
FOLU	Food and Land-Use Coalition	SDG	Sustainable Development Goals
G20	Group of 20 countries (Argentina, Australia, Brazil, Canada, China, France, Germany, India, Indonesia, Italy, Japan, México, Russia, Saudi Arabia, South Africa, Korea, Turkey, the United Kingdom, United States and European Union)	SLB	the Share of Land which can support Biodiversity
GFW	Global Forest Watch	SDSN	Sustainable Development Solutions Network
GLOBIOM	Global Biosphere Management Model	SSP	Shared Socioeconomic Pathways
IAM	Integrated Assessment Model	UNFCCC	United Nations Framework Convention on Climate Change
IIASA	International Institute for Applied Systems Analysis		
IDDRI	Institut du Développement Durable et des Relations Internationales		



Contents

Preface	8
Executive Summary	10
The need for global pathways towards sustainable land-use and food systems	12
Why the FABLE network is needed	14
The FABLE approach	15
Key findings and policy implications	16
Next steps for the FABLE Consortium	18
1. The challenge of unsustainable land-use and food systems.....	20
1.1. The environmental crisis	21
1.2. Today's food makes people sick	22
1.3. The livelihoods crisis	22
1.4. Highly vulnerable food system.....	22
1.5. How FABLE is addressing each crisis	23
2. Organizing the transformation of land-use and food systems.....	24
2.1. An integrated framework for action	25
2.2. Targets for sustainable land-use and food systems.....	27
2.3. Pathways as a method for problem solving	29
3. The FABLE approach to developing pathways.....	32
3.1. The FABLE Consortium	33
3.2. Data and tools for pathways towards sustainable land-use and food systems.....	35
3.3. Developing national pathways consistent with global objectives	41
3.4. Technology and policy roundtables	47
4. Key findings from FABLE pathways	48
4.1. Key country-level drivers	49
4.2. Performance against global FABLE targets	54
4.3. Impacts of trade adjustment	60
4.4. Discussion of results	63
5. Policy implications and next steps	66
6. Country Analyses and Pathways	72
Argentina	74
Australia	88
Brazil	108
Canada	124
China	138
Colombia	152
Ethiopia.....	166
European Union.....	180
Finland	192
India	206
Indonesia	220
Malaysia.....	234
Mexico.....	248
Russian Federation	264
Rwanda.....	278
United Kingdom	290
United States	304
7. References	322



Preface

The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a collaborative initiative, operating as part of the Food and Land-Use Coalition, to understand how countries can transition towards sustainable land-use and food systems. In particular, we ask how countries can collectively meet associated Sustainable Development Goals (SDGs) and the objectives of the Paris Agreement. These objectives include food security and healthy diets for all, decent rural livelihoods, keeping the rise in average global temperatures to well below 2°C above pre-industrial levels, halting and reversing the loss of biodiversity, ensuring sustainable water use, and containing the pollution of water and air, including through excessive use of fertilizers. These objectives must be met in the context of the need for socioeconomic development and other competing demands on land for urbanization, industrial development, and infrastructure. In many countries indigenous peoples' land rights are being undermined by other groups. Moreover, countries need to consider spillovers of their food and land-use systems on other countries since trade has become a leading driver of environmental degradation and rising greenhouse gas emissions.

Meeting these targets at local, national, and global levels will require a profound transformation of land-use and food systems in every country. Such a transformation must cover many different sectors and proceed over the long-term, at least through

to the middle of the century. The aim of the FABLE Consortium is to understand how such long-term transformations can be designed, what knowledge gaps must be filled, and how the transformations can guide shorter-term strategies towards sustainable land-use and food systems.

The international community has recognized the need for such long-term strategies. Governments around the world are preparing their mid-century, low-emission development strategies that were adopted in the Paris Agreement (Article 4.19). Our work directly supports these strategies. Members of the Consortium seek ways to raise the level of ambition in every country by demonstrating the feasibility of rapid progress towards the SDGs and the Paris objectives.

The FABLE Consortium currently comprises research teams from 18 countries, including the European Union. The teams are independent, so the analysis presented in this report does not necessarily reflect the views of their governments. Each country team develops the data and modeling infrastructure to promote ambitious, integrated strategies towards sustainable land-use and food systems. In particular, every team is preparing integrated, long-term “pathways” that describe the changes needed to achieve mid-century objectives. Collectively, consortium members aim to ensure alignment of these pathways with the global objectives under the 2030 Agenda for Sustainable Development and the Paris Agreement, as well as additional national objectives.

International trade leads to spillover effects which may increase or reduce the long-term sustainability of food and land systems. The strength of the FABLE Consortium lies in its capacity to consider the role of trade between a large number of countries and to test for alternative trade pathways that are compatible with national and global goals.

The FABLE project is led by the International Institute for Applied Systems Analysis (IIASA) and the Sustainable Development Solutions Network (SDSN), working closely with EAT, the Potsdam Institute for Climate Impact Research (PIK), and many other institutions. Members of the FABLE Consortium provide training and technical support to each other, and they collaborate to fill knowledge gaps in building FABLE pathways.

This first report was written collectively by members of the FABLE Consortium to outline initial findings. These include a shared approach towards framing and analyzing integrated strategies for land-use and food systems, an initial set of global targets to be achieved by mid-century, as well as preliminary country pathways for achieving these targets. The country pathways do not yet achieve all global targets, and we have identified the need for substantial improvements in data and analytical methods. In spite of its preliminary nature, the report represents the first coordinated effort by researchers from most G20 countries and other nations to chart long-term pathways towards sustainable land-use and food systems.

This report focuses on the feasibility of long-term transformation. It does not aim to address the policies needed to implement these transformations. These and other issues will be addressed in the global report of the Food and Land-Use Coalition, which will be released in New York in September 2019.

Over the coming years, members of the FABLE Consortium will improve data systems, analytical tools, and analyses of policy options for land-use and food systems. As part of the Food and Land-Use Coalition, we are working with interested governments to help improve policies and to develop long-term transformation strategies, including low-emission development strategies

required under the Paris Agreement. Our work shows that these strategies need to target a range of objectives, including net-zero greenhouse gas emissions and protecting and restoring biodiversity. We plan to issue a second global report in 2020 in the run-up to the Conference of the Parties (COP) of the Convention on Biological Diversity (CBD) in China and the COP of the UN Framework Convention on Climate Change, when countries will submit their long-term low-emission development strategies.

We welcome comments and suggestions for improving the work presented in this first report. And we invite research teams and other partners to join this consortium.

Executive Summary



The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a new knowledge network comprising research teams from 18 countries, including the European Union, that operates as part of the Food and Land-Use Coalition (www.foodandlandusecoalition.org).

The FABLE project is led by the International Institute for Applied Systems Analysis (IIASA) and the Sustainable Development Solutions Network (SDSN), working closely with EAT, the Potsdam Institute for Climate Impact Research (PIK), and many other institutions. Each FABLE country team is responsible for its own analysis, and all coordinate to share lessons, ensure consistent trade flows, and align the sum of national pathways with the Sustainable Development Goals (SDGs) and the objectives of the Paris Agreement. A critical focus of the Consortium is to

strengthen country teams' capacity to advise their governments on the design and implementation of long-term strategies towards sustainable land-use.

This first report by the FABLE Consortium presents preliminary pathways towards sustainable land-use and food systems prepared by the 18 country teams from developed and developing countries, including the European Union. The aim of these pathways is to determine and demonstrate the technical feasibility of making land-use and food systems sustainable in each country. They can also inform mid-century low-emission development strategies under the Paris Agreement on Climate Change. FABLE country teams have aimed for consistency with the SDGs and the Paris Agreement objectives. At this early stage, not all target dimensions have

FABLE country teams contributing to this report. A South African team has recently joined the Consortium but did not contribute to this report.



been considered. The report does not discuss policy options for transforming these systems, their implementation, or associated costs and economic benefits. These critical issues will be addressed in the global report by the Food and Land-Use Coalition, which will be published in September 2019 ahead of the Climate Summit convened by UN Secretary-General António Guterres.

This executive summary outlines the need for long-term pathways towards sustainable land-use and food systems and why a global FABLE network is needed. It then presents the FABLE approach, summarizes key findings, and describes the way forward.

The need for global pathways towards sustainable land-use and food systems

Today's land-use and food systems are unsustainable in developed and developing countries alike. Countries face an environmental crisis resulting from rapid biodiversity loss, greenhouse gas emissions, excessive nutrient outflows, chemical pollution, and water stress caused by today's land-use and food systems. The food system does not produce healthy nutrition. More than 820 million people are undernourished while 2 billion are overweight or obese, creating a health crisis. At the same time, agriculture and fisheries do not provide sustainable livelihoods, particularly for many farmers, herders, and fishermen. Finally, land-use and food systems are highly vulnerable to climate change, which threatens food supplies and ecosystem services in many countries.

Three pillars for integrated land-use and food systems must be assessed in the context of integrated land-use planning and sustainable international supply chains (Schmidt-Traub et al., 2019).

Trade and supply chains consistent with sustainable development

Integrated land and water-use planning

PILLAR 1



Efficient and resilient agriculture systems

Increase yields; reduce food loss; limit emissions from agriculture; raise water-use efficiency; reduce release of nitrogen and phosphorus.

PILLAR 2



Conservation and restoration of biodiversity

Limit emissions from deforestation; protect a minimum share of terrestrial land; ensure that land supports biodiversity conservation.

PILLAR 3



Food security and healthy diets

Zero hunger, low dietary-disease risk and reduced food waste.

Solutions exist, but the transformation of land-use and food systems requires long-term strategies, as called for in the Paris Agreement.

While there is a great urgency to act, short-term strategies alone cannot address the drivers of change and are indeed likely to lock countries into unsustainable practices, as has been well documented in the case of energy systems. Recognizing this, Article 4.19 of the Paris Agreement invites governments to submit long-term low-emission development strategies by 2020, which should in turn inform shorter-term strategies, including the Nationally Determined Contributions. Countries need two connected long-term strategies. One for energy systems, as described by the Deep Decarbonization Pathways Project, and a second one for land-use and food systems, which is the focus of the FABLE Consortium. Without these long-term strategies, countries will be unable to align short-term policies and investments with the long-term objectives of the SDGs and the Paris Agreement.

Countries need an integrated framework to understand and address challenges to their land-use and food systems. Following extensive consultations with the FABLE country teams and other experts, the FABLE Consortium proposes three pillars for action: (1) efficient and resilient agriculture systems, (2) conservation and restoration of biodiversity, and (3) food security and healthy diets. They must be complemented by integrated land- and water-use planning to address competing demands on land and water (e.g. from urbanization, industry, and infrastructure). International trade can have profound implications on countries' land-use and food systems, so international supply and demand must be considered in framing national strategies. Each component of this framework is equally important, and all are interdependent and synergistic. They must also operate over the near and long-term. Naturally, the pillars should be

tailored to each country, taking into account local constraints and priorities.

The FABLE Consortium has identified global mid-century targets for sustainable land-use and food systems, that are based on existing international commitments and the latest science. We do not propose national-level targets, since these will need to be determined by countries themselves. Instead we focus on global benchmarks that must be met in order to ensure that food and land-use systems around the world become sustainable. Most of the proposed targets are biophysical in nature because they define a safe operating space for social and economic objectives which are highly country specific and which should become a globally compatible national narrative of change. Meeting all the targets will require profound transformations in every country's land-use and food systems in a short period of time. As the work of the FABLE Consortium progresses, members aim to ensure that the sum of their national pathways will achieve all targets outlined in the table (Proposed global targets for sustainable land-use and food systems)..

Long-term pathways are a method for problem solving for countries to understand how the targets can be achieved and to build consensus for strategies to achieve them. Pathways work backwards from the mid-century targets and specify the interventions needed to achieve them. They help in three critical ways: (1) they provide a framework for engaging stakeholders (governments, businesses, civil societies and the scientific community), to review, pose questions and suggest improvements for how to achieve the targets, which can build a societal consensus for the transformations; (2) without a long-term perspective countries risk locking themselves into unsustainable infrastructure and land-use systems, which would make achieving the mid-century targets far more costly if not impossible;

Proposed global targets for sustainable land-use and food systems.

AREA	GLOBAL TARGET
Food security	Zero hunger <i>Average daily energy intake per capita higher than the minimum requirement in all countries by 2030</i>
	Low dietary disease risk <i>Diet composition to achieve premature diet related mortality below 5%</i>
Greenhouse gas emissions	Greenhouse gas emissions from crops and livestock compatible with keeping the rise in average global temperatures to well below 1.5°C <i>Below 4 GtCO₂e yr⁻¹ by 2050</i>
	Greenhouse gas emissions and removals from Land Use, Land-Use Change, and Forestry (LULUCF) compatible with keeping the rise in average global temperatures to below 1.5°C <i>Negative global greenhouse gas emissions from LULUCF by 2050</i>
Biodiversity and ecosystem services	A minimum share of earth's terrestrial land supports biodiversity conservation <i>At least 50% of global terrestrial area by 2050</i>
	A minimum share of earth's terrestrial land is within protected areas <i>At least 17% of global terrestrial area intact by 2030</i>
Forests	Zero net deforestation <i>Forest gain should at least compensate for the forest loss at the global level by 2030</i>
Freshwater	Water use in agriculture within the limits of internally renewable water resources, taking account of other human water uses and environmental water flows <i>Blue water use for irrigation <2453 km³yr⁻¹ (670-4044 km³yr⁻¹) given future possible range (61-90%) in other competing water uses</i>
Nitrogen	Nitrogen release from agriculture within environmental limits <i>N use <69 Tg N yr⁻¹ total Industrial and agricultural biological fixation (52-113 Tg N yr⁻¹) and N loss from agricultural land <90 Tg N yr⁻¹ (50-146 Tg N yr⁻¹) by 2050</i>
Phosphorous	Phosphorous release from agriculture within environmental limits <i>P use <16 Tg P yr⁻¹ flow from fertilizers to erodible soils (6.2-17 Tg P yr⁻¹) and P loss from ag soils & human excretion <8.69 Tg P yr⁻¹ flow from freshwater systems into ocean by 2050</i>

(3) they help identify mid-term technology benchmarks needed to achieve the targets, such as increases in agricultural productivity or efficiency gains in livestock, which can then guide business action and innovation challenges. Long-term pathways are critical for success, and FABLE's mission is to develop the tools to prepare them.

Why the FABLE network is needed

A global network of national knowledge institutions is needed to support countries in making their land-use and food systems sustainable. Three major challenges stand out for why we have come together as the Food, Agriculture, Biodiversity, Land-Use, and Energy

(FABLE) Consortium as part of the Food and Land-Use Coalition.

First, countries need to build domestic capacity to develop integrated pathways covering the three pillars. Strategies and long-term pathways towards sustainable land-use and food systems must integrate across agronomy, nutrition, ecology, hydrology, climatology, economics, infrastructure engineering, the social sciences, and of course the local politics. Yet, most countries do not have such integrated policies and to our knowledge none have long-term pathways towards sustainable food and land-use systems covering all three pillars. Many lack the analytical tools to understand the complex synergies and trade-offs across these areas and to determine which short-term measures must be undertaken in order to achieve long-term objectives. Just as it is impossible to design and implement economic policies without sound macroeconomic models, countries will not be able to make their land-use and food systems sustainable without robust tools to model the integrated impacts of policies. Some countries undertake isolated measures, but these do not add up to a strategy for making land-use and food systems sustainable.

Second, national strategies must consider international markets for food and non-food commodities since these can have major implications for national land-use choices as well as the affordability of food and animal feed. For example, rising international demand for feed, particularly from Asia, has been driving large-scale land-use change across much of Latin America. Similarly, US and European domestic biofuel mandates are seen as a major driver of the expansion of palm oil plantations in South-East Asia. For country teams to better understand these drivers they need to be part of a global network involving their major bilateral trading partners.

Third, knowledge on the technologies and policies that can make food and land-use systems sustainable must be shared across countries. To develop long-term pathways towards sustainable food and land-use systems, countries need to access deep expert knowledge from a broad range of fields. A global knowledge network of national institutions can share lessons and deepen the understanding in every country of how its food and land-use systems can be transformed to meet the SDGs and implement the Paris Agreement.

The FABLE approach

The FABLE Consortium supports country teams to develop rigorous, transparent pathways towards sustainable land-use and food systems. We aim to demonstrate the feasibility of rapid progress and help raise the level of ambition towards the SDGs and the objectives of the Paris climate agreement. To this end, the consortium pursues three broad sets of activities

1. **Capacity development and sharing of best practices** for data management, simplified models of the three pillars that facilitate engagement with stakeholders, and more complex, spatially-explicit models that cover the three pillars, other uses of land, as well as international trade.
2. **Development of mid-century national pathways** that can collectively achieve the jointly agreed global targets and have consistent trade assumptions.
3. **Analysis of national policy options and support to national and international policy processes** will be undertaken over the coming year.

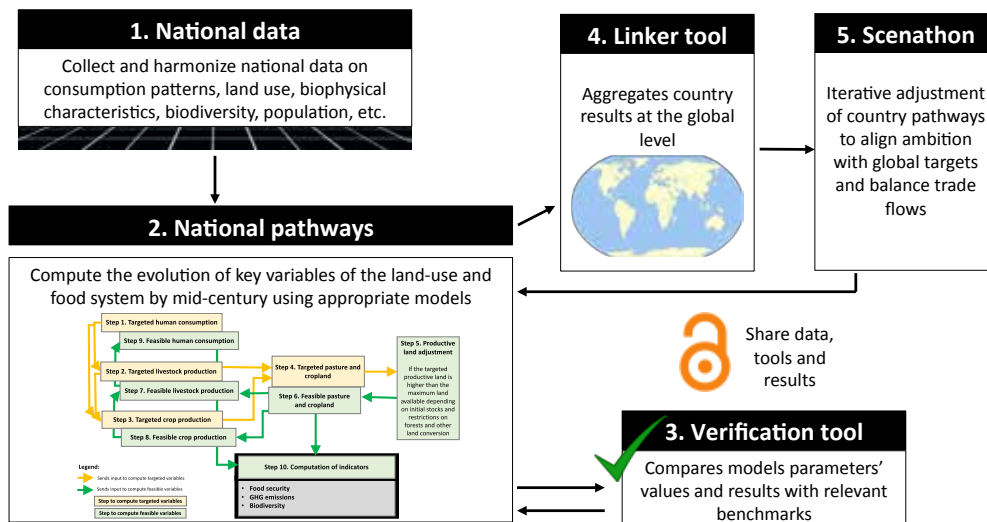
We have developed a new method for preparing national pathways that are consistent with global targets and ensure trade flows balance across countries. It involves five steps described in the figure (The FABLE method for developing national pathways): country teams prepare national data (1) on their food and land-use systems. They develop national pathways (2) using a simplified Excel-based tool, the publicly available FABLE Calculator, or more advanced spatially-explicit partial-equilibrium tools, such as IASA's Global Biosphere Management Model (GLOBIOM) or PIK's Model of Agricultural Production and its Impact on the Environment (MAGPIE) models. Following validation of the data and results (3) the national results are aggregated with a Linker tool (4) to determine whether the sum of projected exports for each commodity equals the sum of imports. The Linker Tool also checks if the sum of national pathways achieves the global targets

for sustainable land-use and food systems. (5) In an iterative process ("Scenathon") country teams adjust their assumptions and pathways to ensure balanced trade flows and to aim towards achieving the global targets.

Key findings and policy implications

This is the first time that a broad group of country teams have collaborated to develop integrated national pathways towards sustainable land-use and food systems that are consistent with global objectives. To ensure global coverage, results have been computed as the sum of results extracted from the 18 national FABLE Calculators and seven Rest of the World regions. Using the Linker tool trade imbalances were identified and adjusted through a "Scenathon" involving all FABLE country teams.

Major steps in the FABLE method for developing national pathways.

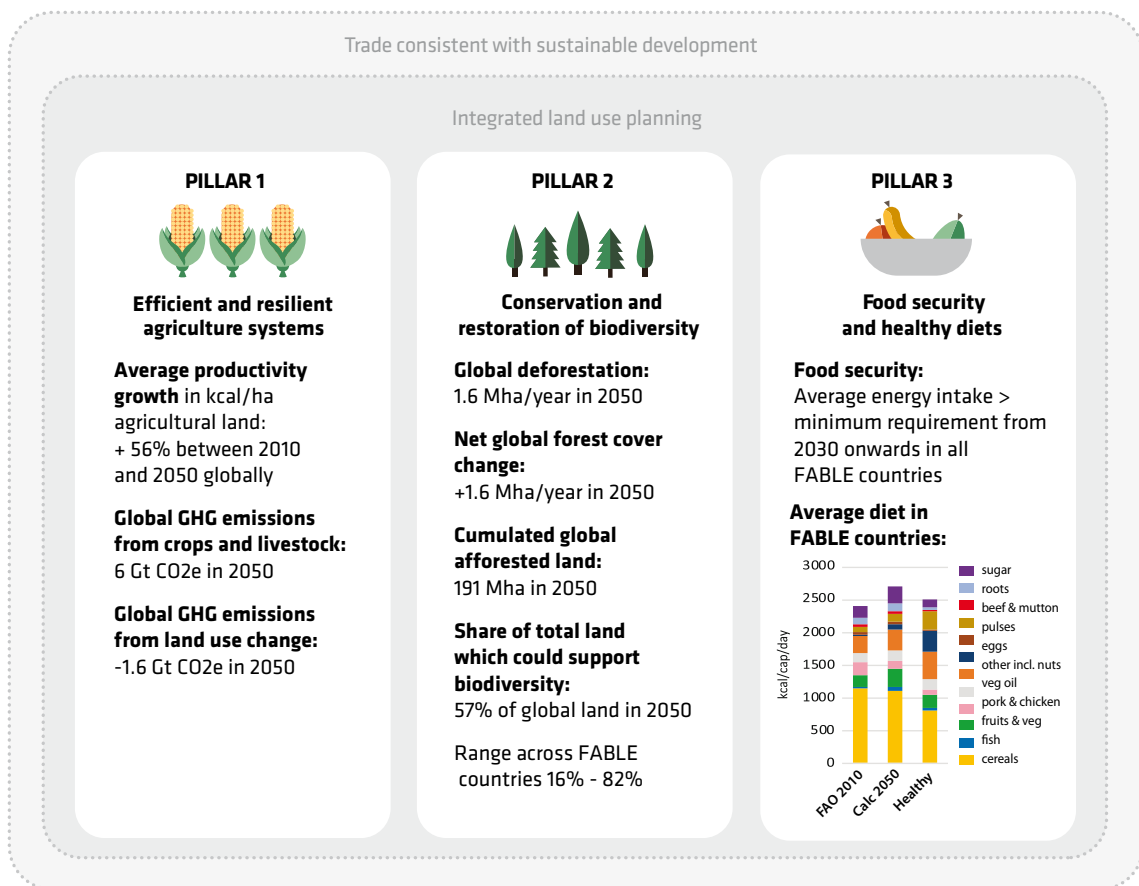


Though preliminary and incomplete, our findings show that tremendous progress can be made towards the FABLE targets. The pathways presented in this report suggest that it is feasible to achieve four out of the five targets considered: average energy intake can be above the minimum dietary energy intake in all FABLE countries by 2030; zero net global deforestation can be achieved from 2030 onwards; by 2050 net greenhouse gas emissions from land use change can be negative; and more than 50 percent of the global terrestrial land can be spared to conserve

and restore biodiversity. This first iteration of country pathways makes insufficient progress towards reducing greenhouse gas emissions from agriculture. Closing this achievement gap will be a major priority of future work by the FABLE Consortium.

The feasibility of rapid progress towards the FABLE objectives is driven largely by six factors: (1) large gains in agricultural productivity; (2) shifts in diets towards less meat consumption, with reductions in food overconsumption; (3) a

Performance metrics of the computed pathways across the three FABLE pillars



slow-down in population growth; (4) reduced food loss; (5) stable per-capita demand for non-food products including bioenergy production; and (6) the resulting fall in demand for pasture and cropland at the global level. These shifts allow for both greater conservation and restoration of ecosystems with resultant impacts on increased carbon sequestration, biodiversity conservation and restoration. It is notable that country teams individually vary in the assumptions they make about the feasibility and desirability of changes to their food systems. For example, teams make different assumptions about desirable and feasible dietary changes across countries, reflecting local traditions, customs, and resource endowments. This demonstrates the importance of country-driven analyses of land-use and food systems as presented in this report.

Our initial results show that it is possible to achieve sustainable land-use and food systems, but countries need to address all three pillars and adopt a long-term perspective. The figure (Performance metrics for the three FABLE pillars) highlights key performance metrics for efficient and resilient agricultural systems, conservation and restoration, and food security and healthy diets. The country teams consider these changes feasible, but they are highly ambitious and will require strong policies and greater investments in food and land-use systems. Results from the FABLE Consortium also show that governments must design analytical instruments and policies to develop their land-use with a long-term perspective to avoid locking themselves into unsustainable land-use and food systems that would be very difficult and costly to reverse later.

The results also demonstrate the critical impact of trade on both importing as well as exporting countries. Relatively small changes in one country's policies can have a profound impact on land-use and food systems in other countries.

Therefore, countries will need to consider trade in their medium and long-term strategies. This, in turn, requires an understanding of what is happening within the national settings of major bilateral trading partners, which the FABLE Consortium provides.

Spatially-explicit analyses are needed to understand and manage competing uses of land from agriculture, livestock, forestry, industry, urban development, disaster risk reduction, and ecosystem services, including biodiversity and the retention and capture of carbon for climate change mitigation.

Countries will have an opportunity to promote integrated strategies for climate and land-use at the September 2019 Climate Summit convened by UN Secretary-General Antonio Guterres. Since food systems and land-use change account for just under one third of greenhouse gas emissions, governments that are developing long-term low-emission strategies under the Paris Agreement will need to consider all three pillars for sustainable land-use and food systems alongside the decarbonization of energy systems. China's recently adopted Ecological Conservation Redlines and its Agricultural Redlines provide an example of the type of spatial policies that should be included in mid-century climate strategies.

Next steps for the FABLE Consortium

Launched some 18 months ago, the FABLE Consortium has become a unique global network of country teams focused on understanding how countries can develop long-term strategies towards sustainable land-use and food systems. With other members of the Food and Land-Use

Coalition we have made substantial progress in understanding how this can be achieved. We now also see more clearly how to strengthen in-country capacity for developing the strategies. The Food and Land-Use Coalition will describe policy options in a global report to be launched in New York in September 2019.

The FABLE Consortium will pursue five steps to strengthen its work and support governments and other stakeholders in making food and land-use systems sustainable.

- 1. Build capacity in countries to improve national pathways using advanced, spatially-explicit data and models, including GLOBIOM, MAgPIE, or other tools.**
- 2. Engage stakeholders at national and sub-national levels around the design of long-term pathways and supporting policies towards sustainable land-use and food systems.**
- 3. Support country teams in applying their models to test policies and improve their design by simulating the impact of policy options across the three pillars of sustainable land-use and food systems.**
- 4. Improve the scope and methodology of the FABLE Scenathon.**
- 5. As part of the Food and Land-Use Coalition, work with partners around the world to launch a Food and Land-Use Action Tracker that helps countries benchmark their policies against those pursued elsewhere and to learn from experiences in other countries.**