Food and Agriculture Organization of the United Nations

GOVERNANCE AND POLICY SUPPORT
REPORT

Modelling the impacts of policy interventions

for food systems transformation in Indonesia

CAU Kiel University Christian-Albrechts-Universität zu Kiel

IFPRI INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

IIASA International Institute for Applied Systems Analysis www.iiasa.ac.at

IISD International Institute for Sustainable Development

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Contents

Boxes

Figures

Tables

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Abbreviations

BAPPENAS	Ministry of National Development Planning, Government of Indonesia
CAU	Christian-Albrechts-University of Kiel
CGE	computable general equilibrium
CGPE	general political economy equilibrium
FAO	Food and Agriculture Organization of the United Nations
FIA	Food Industry Asia
FOLU	forestry and other land use
FVC	Flexible Voluntary Contribution
GDP	gross domestic product
GHG	greenhouse gas
GLOBIOM	Global Biosphere Management model
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIASA	International Institute for Applied System Analysis
IISD	International Institute for Sustainable Development
IPB	Bogor Agricultural University
LTS-LCC	Long-Term Strategy for Low Carbon and Climate Resilience 2050
MoA	Ministry of Agriculture
NDCs	Nationally Determined Contributions
PoU	prevalence of undernourishment
RPJMN	Medium-Term Development Plan (RPJMN) 2020–2024
SDGs	Sustainable Development Goals
UNFCCC	United Nations Framework Convention on Climate Change
UNFSS	United Nations Food Systems Summit
UNICEF	United Nations Children's Fund
WB	World Bank
WFP	World Food Programme
WHO	World Health Organization

Source: UN Geospatial. 2004. Map of Indonesia. In: United Nations. New York, USA, UN. [Cited 9 January 2024]. https://www.un.org/geospatial/content/indonesia

Executive summary

Modelling to support food systems transformation in Indonesia

To support food systems transformation in Indonesia, the Food and Agricultural Organization of the United Nations (FAO) has coordinated a food systems modelling project involving the International Food Policy Research Institute (IFPRI), International Institute for Applied Systems Analysis (IIASA), International Institute for Sustainable Development (IISD), and Christian-Albrechts-University of Kiel (Kiel University). This modelling project pilots an innovative modelling approach that aligns three different economic models (MIRAGRODEP,[1] GLOBIOM[2] and a CGPE model[3]) to analyse the impacts, synergies, trade-offs, and political feasibility of various policy interventions for food systems transformation in Indonesia.[4] This modelling is intended to inform the Government of Indonesia's medium- and long-term development planning by identifying technically sound and politically feasible policy interventions to achieve multiple policy objectives related to food systems transformation.

The modelling was organized around three broad policy goals of the Indonesian Government relevant to food systems transformation: promoting healthy diets; ensuring sustainable (local) supply of agrifood products; and promoting environmental sustainability, including with respect to climate change. To assess the impacts of policy interventions and packages over the medium term (2030 or 2035) and long term (2045), the modelling uses indicators taken or adapted from policy documents and commitments adopted by the Indonesian Government. These include indicators on poverty, undernourishment, value added in agriculture, food self-sufficiency, forest cover and greenhouse gas (GHG) emissions.

A baseline "business-as-usual" scenario and stylized scenarios representing the implementation of policy interventions (or packages of interventions) to achieve specific policy objectives were modelled, and the results analysed to identify impacts, trade-offs and synergies. A survey was conducted with government and non-governmental stakeholders participating to identify their beliefs and preferences.

[1] MIRAGRODEP is a global computable general equilibrium (CGE) model based on MIRAGE (Modelling International Relations under Applied General Equilibrium), which was developed and improved under the support of the African Growth and Development Policy Modeling Consortium (AGRODEP). It provides a national-level picture of food-system performance and assesses impacts of policy interventions over the medium-term (to 2035). https://www.ifpri.org/publication/miragrodep-model

[2] The Global Biosphere Management Model (GLOBIOM) focuses on the agriculture, forestry and bioenergy sectors, at national and sub-national levels, providing the representation of land use and its dynamics, greenhouse gas (GHG) emissions, trade, production, and consumption over the short- and long-term (2030 and 2045).

[3] A computable general political economy (CGPE) model is used to provide a better understanding of the institutional, political, and sociocultural dynamics of the Indonesian food system, including the political feasibility of given policy mixes.

[4] The project supported Indonesia in developing and strengthening innovative governance mechanisms in line with FAO's corporate vision on governance. See: Bojic´, D., Clark, M., and Urban, K. 2022: Focus on governance for more effective policy and technical support – Framework paper. Rome, FAO. https://doi.org/10.4060/cc0240en

The results of the modelling and of the survey were integrated to conduct a political economy meta-modelling analysis to assess the political feasibility of the policy interventions represented in the modelling.

Modelling results

Business as usual

Under a business-as-usual (BAU) scenario, whereby current policies and practices remain unchanged, Indonesia will continue to make steady progress across several policy objectives. Continued economic growth and rising incomes contribute to declining rates of poverty and undernourishment, as well as a decline in the share of the Indonesian population unable to afford a healthy diet. Food production in Indonesia increases under BAU, with self-sufficiency in rice and cereals remaining stable.

The rate of deforestation continues to decline under BAU, but continued land conversion to agriculture leads to losses of primary forest cover. GHG emissions from agriculture increase over the medium term and long term, while emissions from land-use change decline significantly in the medium term, reflecting the declining rates of deforestation. At the subnational level, Indonesia's regions become increasingly specialized in agricultural production under BAU, leading to growing disparities in food self-sufficiency across regions.

Promoting healthy diets

A policy intervention that directly targets poor households (such as a social safety net programme involving food stamps) and a combination of policies involving such interventions, are particularly effective in tackling poverty and food insecurity in Indonesia. They assist in eradicating undernourishment in the medium term and in making healthy diets affordable to all Indonesians. Policy interventions that boost production and productivity also improve food security by increasing farm incomes and making food more affordable, but not by as much as interventions that target undernourishment directly. Policy interventions to promote environmental sustainability, like a carbon tax, are found to make food production costlier, driving up food prices and resulting in slightly higher levels of undernourishment (relative to BAU).

The modelling results also reveal environmental trade-offs from efforts to improve food security and promote healthy diets. Unless paired with other (environmental) policy interventions, interventions that target undernourishment lead to increased land conversion for food production, decreased forest cover and increased GHG emissions relative to BAU. A package of policy interventions that include social safety nets as well as interventions to enhance agricultural productivity and reduce the environmental impacts of agricultural production is found to be effective in tackling undernourishment, while avoiding harmful environmental impacts and rising food prices (and associated costs to the government).

Ensuring sustainable (local) supply of agrifood products

Agricultural production in Indonesia can be boosted through various policy interventions, including on the production side (e.g. interventions to promote agricultural intensification) or the demand side (e.g. a social safety net). Interventions focused on enhancing farm productivity sustainably, and policy packages that combine such interventions with measures to incentivize production of healthier and more sustainable agricultural products, as well as social safety nets, generate significant increases in food production, as well as increases in real farm incomes. But they also lead to substantial decreases in farmers terms of trade due to lower prices.

Different interventions lead to different production patterns. Interventions that incentivize production of nutritious and sustainable products (e.g. by repurposing farm subsidies) or disincentivize unsustainable production (e.g. by taxing emissions) lead to greater production of more nutritious and sustainable products, like fruit and vegetables, relative to emissions-intensive products, like meat. When interventions are introduced that promote agricultural productivity indiscriminately, commodity crops (e.g. coffee) and crops used for livestock feed (e.g. soybeans) expand the most. Over the long term, a carbon tax leads to a decline in Indonesia's self-sufficiency in rice and in cereals, while interventions that boost agricultural intensification generate increased self-sufficiency relative to BAU in the long term.

Promoting environmental sustainability, including with respect to climate change

Environmental policy interventions such as a carbon tax, land use regulations, or interventions to promote sustainable productivity, as well as packages that contain such interventions, are most effective in limiting deforestation. By contrast, a social safety net or other intervention to address undernourishment leads to reduced forest cover (as well as reduced natural land cover and reduced biodiversity) relative to BAU. An intervention focused on conserving forest cover leads to the conversion of other potentially biodiverse types of natural land to agriculture, but combining such an intervention with an intervention to boost agricultural productivity conserves forest cover as well as natural land and biodiversity.

Increasing demand for food in Indonesia is projected to lead to a substantial increase in food production, with corresponding increases in GHG emissions from agriculture. Interventions to promote sustainable agricultural production lead to lower GHG emissions per unit of agriculture value added (emissions intensity), but they also lead to increased production (due to improved cost efficiency), resulting in higher total GHG emissions from agriculture. The introduction of specific environmental policy interventions on forest conservation or GHG emissions is found to be critical for reducing GHG emissions from land use change in Indonesia. Combining a moratorium on the conversion of primary forests and peatland with interventions to boost agricultural productivity is most effective in reducing total GHG emissions from agriculture and land use change in the medium term. A carbon tax is most effective in reducing total GHG emissions from agriculture and land use change over the long term though, reflecting the declining contribution of deforestation, and increasing contribution of agricultural production to Indonesia's GHG emissions in the long term.

Combining policy interventions to mitigate trade-offs and capitalize on synergies

Policy interventions to achieve specific economic, social, or environmental outcomes generate trade-offs and synergies across different outcome areas. For example, an intervention targeting undernourishment – such as a social safety net programme –

is effective in reducing undernourishment (primary aim) and boosting agricultural production and farm incomes (synergies); but it leads to increased cropland expansion, which in turn results in greater losses of primary forests and biodiversity (trade-offs). It also leads to higher food prices, increasing the cost of the intervention for the government (trade-off).

Combining different policy interventions can help to mitigate trade-offs and capitalize on synergies. For example, combining an intervention on undernourishment with an intervention to promote agricultural intensification leads to reduced undernourishment, but also mitigates the rise in food price. Similarly, combining an intervention on deforestation with an intervention to increase agricultural productivity is found to be particularly effective in promoting increased environmentally sustainable production. Overall, a full package of interventions across economic, social, and environmental policy objectives is found to be the most effective for achieving significant progress across all three axes of sustainable development (economic, social, and environmental), demonstrating the value and critical importance of a comprehensive and integrated approach to policymaking for food systems transformation in Indonesia.

Subnational dynamics

Economic, social, and environmental impacts of policy interventions differ across Indonesia's regions. For example, an intervention aimed at conserving forest cover leads to greater primary forest cover relative to BAU in all regions, except for Bali Nusa-Tenggara. Similarly, an intervention on agricultural intensification leads to increased food self-sufficiency relative to BAU in Sulawesi, but lower food self-sufficiency relative to BAU in the other regions.

There is no single policy intervention or package that achieves optimal socioeconomic and environmental outcomes for all of Indonesia's regions. Instead, different policy interventions or packages are effective in different regions in terms of achieving multiple policy objectives. In Java, for instance, a package of interventions on forest conservation and agricultural intensification leads to significant increases in primary forest cover relative to BAU, slightly lower GHG emissions from agriculture, and higher agricultural value added and food self-sufficiency. In Papua, a combined package that includes an intervention on forest conservation and on agricultural intensification – as well as an intervention to reduce undernourishment – leads to significantly higher food self-sufficiency relative to BAU, increased agricultural value added, and lower GHG emissions from agriculture, without any decrease in primary forest cover relative to BAU.

Stakeholder preferences and the political feasibility of optimal policy interventions

Indonesian stakeholders prioritize economic policy objectives over social and environmental policy objectives and have more ambitious expectations when it comes to economic policy goals, while being more pessimistic about the achievement of environmental policy goals. The survey results reveal significant support among stakeholders for making better use of subsidies and other incentives to encourage sustainable agricultural practices. This would better target support to poorer farmers, increase public investment in agriculture, and offer greater income transfers to poor households. The results also reveal strong support for better measures to enforce and combat deforestation. The results and analysis thereof also reveal potential challenges for food systems governance in Indonesia, including the inadequate administrative capacity to collect taxes and combat illegal deforestation, and the underrepresentation of Indonesian non-governmental organisation (NGOs) and regional stakeholders in multistakeholder processes for food systems policymaking.

The CGPE meta-modelling, meanwhile, shows that the package of policy interventions found by the GLOBIOM-CGE modelling to be "technically optimal" for achieving the food systems transformation objectives prioritized by stakeholders is quite different to the policy mix that is predicted to emerge through a real-world multistakeholder process of political bargaining given the expressed beliefs, preferences and priorities of the stakeholders surveyed. This suggests that the optimal policy mix may not be politically feasible to implement unless current stakeholder beliefs or preferences change.

Implications for policymakers and next steps

The modelling results suggest several implications for Indonesia's policymakers tasked with driving food systems transformation. First, **there is need and scope to accelerate progress on key objectives for food systems transformation through targeted policy interventions**. Progress on undernourishment and nutrition can be accelerated through social safety net measures that target the most vulnerable, improving their ability to afford nutritious foods. To improve progress on agricultural production and productivity, targeted interventions to support farmers are necessary, including public investments in agricultural research and development, technology adoption, and infrastructure. To accelerate reductions in GHG emissions from agriculture and land use change, interventions that target emissions reductions are needed. A carbon tax is found to be effective in bringing down emissions over the long term.

Second, **combining policy interventions can help mitigate negative trade-offs and capitalize on synergies and is crucial for generating positive outcomes across different policy objectives**. Both MIRAGRODEP and GLOBIOM find comprehensive packages of interventions to be the best ways to achieve multiple policy objectives across economic, social, environmental spheres. This highlights the importance of taking a comprehensive and integrated approach to policymaking for food systems transformation in Indonesia.

Third, **the regional dimensions of policy interventions and impacts are significant and need to be addressed, including through adequate involvement of local and regional stakeholders in policymaking processes**. Policymakers should recognize and address the different impacts various policy interventions and packages have in Indonesia's regions and provinces given their differences in biodiversity, production profiles, and poverty levels. They should assess carefully which policy interventions and packages are most appropriate for a given region or province to maximize positive impacts and to ensure distributional justice through measures that mitigate regional inequalities arising from or exacerbated by policy interventions. Ensuring regional representation in policymaking processes and implementation can help with this.

Fourth, **administrative capacity shortcomings need to be addressed to strengthen food systems governance**. For example, improved capacity to collect taxes would result in increased revenue for public spending on agriculture, while increased capacity to enforce forest conservation measures would help curb illegal deforestation in Indonesia.

Fifth, **non-governmental organisations and other stakeholders representing local and regional interests should be included in food systems transformation policymaking processes**. The participation of these stakeholders in food systems policymaking and policy implementation is crucial for bringing specialized and local knowledge to policymaking processes and for ensuring ownership and effective on-the-ground implementation of policy interventions.

Sixth, **policymakers and other food systems stakeholders should continue to engage with the scientific community to develop appropriate policies and policy mixes for food systems transformation**. Further engagement and knowledge exchange between Indonesia's food systems stakeholders and the scientific community (including the economic modelling team) can help address the identified gaps between what stakeholders believe to be the best policy intervention packages to achieve their policy objectives and what the modelling shows to be the optimal packages. It can also help build buy-in for food systems transformation efforts in Indonesia.

Finally, **the importance of productivity growth outside the agricultural sector for food systems transformation must be recognized**. Policy interventions that generate productivity growth outside the agricultural sector will have greater impacts on many policy objectives related to food systems transformation than interventions targeting agricultural productivity. Policymakers should therefore carefully assess the impacts of such interventions on farm incomes, domestic demand for agricultural products, food security, agricultural production, land use change, biodiversity and GHG emissions.

In terms of next steps, there is scope for several activities that would build on and extend the modelling results and address their implications. Further analysis of the modelled policy interventions could be undertaken to assess the optimal design of these interventions given national and local contexts and address questions that were not possible to answer through modelling. The insights derived from this modelling exercize could also be used to undertake an assessment of the coherence of Indonesia's current policies for food systems transformation, identifying pressing areas for policy reform. Steps could also be taken to deepen multistakeholder engagement around the design of policy interventions for food systems transformation in Indonesia, ensuring participation of Indonesian NGOs, local and regional stakeholders, and members of the scientific community.

About this report

The joint programme between the Government of Indonesia and FAO, entitled "Governance Innovation for Sustainable Food Systems in Indonesia," has recognized the need for thorough analysis and modelling of Indonesia's food systems to support food systems transformation efforts in the country. This is needed to provide a better understanding of food systems performance, including the political economy dynamics influencing performance, as well as to identify synergies and trade-offs across different policy goals and optimal policy mixes for achieving multiple policy objectives.

In this regard, FAO facilitated a project to pilot an innovative approach to modelling for food systems transformation. This modelling approach was developed and implemented by a team of researchers from IFPRI, IIASA, IISD and Christian-Albrechts-University of Kiel (Kiel University). It makes use of three different economic models to generate insights that can assist Indonesian policymakers in developing technically sound and politically feasible policy interventions for food systems transformation. These include insights into the impacts of policy interventions on specific policy goals, the trade-offs and synergies that arise across different policy goals, the optimal policy mixes to achieve specific goals, and the political feasibility of these policy mixes.

This report draws on separate reports prepared by IFPRI[5], IIASA[6] and Kiel University[7,8] focusing on the specific modelling activities led by each of these institutions. It provides context for food systems transformation in Indonesia and describes the overall modelling approach before synthesising the results of the individual modelling activities and distilling these into the overall findings of the modelling. It concludes with implications from these findings for policymaking for food systems transformation in Indonesia and some suggestions for next steps.

The results of this modelling and the insights drawn from these results are expected to support efforts to translate Indonesia's commitments on food systems transformation into concrete policy interventions and to inform medium- and long-term development planning by the Indonesian Government.

5 Laborde, D., Olivetti, E., Piñeiro, V. & Illescas, N. (forthcoming). Addressing Food System Transformation, Food Security and Deforestation in Indonesia. Challenges and Initiatives. Washington DC, IFPRI.

6 Boere, E., Augustynczik, A. L. D., Kozicka, M. & Havlík, P. 2024. Food Systems Transformation in Indonesia: Results on baseline and stylized scenarios from GLOBIOM. Laxenburg, Austria, IIASA. https://pure.iiasa.ac.at/19516

7 Henning, C., Grunenberg, M., Khalifa, S. & Ziesmer, J. (forthcoming)a. Modelling the impact of policy interventions for food system transformation in Indonesia: An integrated political economy model approach combining a regionalized agricultural partial equilibrium model GLOBIOM with a national general equilibrium model and a political decision-making model. Kiel: The University of Kiel.

8 Henning, C., Grunenberg, M., Khalifa, S. & Ziesmer, J. (forthcoming)b. Modelling political decision-making outcomes of multistakeholder process on food system transformation in Indonesia: Results Report. Kiel: The University of Kiel.

Agroforestry site in the social forestry community Ciwidey, West Java, Indonesia.

I Introduction

1. Sustainable development context

Indonesia has made great strides over the past couple of decades with respect to economic development. Stable economic growth has led to rising incomes and a significant decline in the share of the population living below the national poverty line, from 19 percent in 2000 to 10 percent in 2021. (World Bank, 2023) However, economic development has occurred unevenly across the country, and incomes remain significantly lower in certain regions. Although the share of agriculture in Indonesia's gross domestic product (GDP) has declined since 2000, the agricultural sector continues to play a vital role in the Indonesian economy, contributing almost 14 percent of GDP and providing employment for around 29 percent of the country's population, including its large cohort of smallholder farmers.[9]

Despite positive macroeconomic trends, the performance of Indonesia's food systems gives rise to several challenges that complicate the country's efforts to achieve sustainable development, including food insecurity, malnutrition, unsustainable agricultural production, and deforestation. While economic growth and poverty reduction have seen Indonesia make great strides in addressing food insecurity and undernourishment,[10] 16.2 million people in Indonesia are still undernourished (FAO *et al.*, 2023), and malnutrition remains a major issue in the country. Rates of child stunting remain stubbornly high,[11] although they do vary significantly across Indonesia's regions and districts (Ayuningtyas *et al.*, 2022).

Population growth and urbanization are driving changing dietary patterns in Indonesia, raising concerns about diet quality in the country.[12] Being overweight and obesity are becoming increasingly significant public health issues.[13] Changes in agricultural production systems from traditional farming practices to more intensified, specialized, and commercialized farming have contributed to economic growth and poverty reduction but have also led to the diets of rural households becoming less diverse and less nutrient rich (Mehraban and Ickowitz, 2021). Moreover, over 70 percent of Indonesians cannot afford a healthy diet (FAO *et al.*, 2023).

Increased demand from Indonesia's growing – and increasingly urban and wealthy population – coupled with strong global demand for several of Indonesia's agricultural commodities, has led to significant amounts of land being converted to agriculture

[9] The broader agrifood sector, encompassing food and beverage manufacturing and distribution has been estimated to contribute around 35 percent of Indonesia's GDP and accounts for almost half of total employment in the country.

[10] The prevalence of undernourishment decreased from 19.2 percent in 2004–06, to 5.9 percent in 2020–2022. (FAO *et al.*, 2023).

[11] 31 percent of children under 5 years of age experience stunting, indicating chronic undernutrition. (FAO *et al.*, 2023).

[12] The country's population of over 270 million is expected to grow to around 311 million by 2050; 69.1 percent of the population by 2045, up from 49.9 percent in 2010. (Republic of Indonesia, 2021a).

[13] Overweight children under 5: 9.2 percent (2012) to 10.6 percent (2020); Obesity across all age groups: 5.5 percent (2012) to 6.9 percent (2016). (FAO *et al.*, 2023).

(World Bank, 2023). This has been a major driver of the high levels of deforestation and biodiversity loss that Indonesia has experienced since 2000. Agriculture, forestry, and other land use also contribute to approximately 42 percent of Indonesia's total greenhouse gas (GHG) emissions, which increased by over 50 percent between 2000 and 2020, and account for almost 2 percent of global GHG emissions (FAO, 2023a).

2. Food systems transformation in Indonesia

The Government of Indonesia has made food systems transformation a national priority under its Medium-Term Development Plan (RPJMN) 2020–2024. The government's vision is for the country's food systems to become healthier, more equitable, more sustainable and more resilient. Key priorities for food systems transformation include: (i) ending hunger and improving diets, including through promoting consumption of locally produced food; (ii) protecting and restoring natural resources, including through reducing the rate of land conversion for agriculture; (iii) ensuring food systems generate income and welfare for small scale producers, women, youth and rural communities; (iv) making food systems more resilient to climate change, natural disasters and other shocks; and (v) ensuring more inclusive and decentralized (regionalized/localized) food systems governance (Republic of Indonesia, 2021a). Under the RPJMN, the Indonesian Government has introduced various policy interventions and programmes to increase food availability, access and quality, and to improve the sustainability of agricultural production in Indonesia.

Food systems transformation in Indonesia is intended to support broader sustainable development objectives and the achievement of the Sustainable Development Goals (SDG) targets including those related to environmental sustainability and climate change (Republic of Indonesia, 2021a). Relevant policy objectives in this regard include a commitment to reduce GHG emissions unconditionally by 31.89 percent by 2030 (Republic of Indonesia, 2022), and the ambition for forestry and other land use (FOLU) in Indonesia to become a net sink (i.e. contribute negative emissions) by 2030 (Republic of Indonesia, 2021b). To achieve these goals, the Indonesian Government has put in place a moratorium on clearing primary forests and peatlands to improve the sustainable management of forests and to reduce fire-induced GHG emissions (Ministry of Environment and Forestry, Republic of Indonesia, 2022).

The Ministry of National Development Planning (BAPPENAS) is leading the Government of Indonesia's efforts on food systems transformation to achieve the SDGs. For the United Nations Food Systems Summit (UNFSS) in 2021, BAPPENAS organized national and subnational dialogues that culminated in the development of a Strategic National Pathway for Food Systems Transformation (Republic of Indonesia, 2021a). These dialogues highlighted the importance of governance innovation for food systems transformation in Indonesia, especially given the diverse and complex challenges affecting food systems across the country.

Table 1. Selected policies and strategies relevant to food systems transformation in Indonesia

Title	Policy objectives
Indonesia Strategic National Pathway for Food Systems Transformation (2021)	1. End hunger, improve diets, promote coastal and ocean-based food; 2. Protect and restore natural resources; 3. Inclusive business; 4. Resilient and local food systems; 5. Inclusive governance.
Presidential Regulation No. 18/2020 on the 2020-2024 National Medium-Term Development Plan (National RPJMN)	1. Improving human development; 2. Productive, Independent, and Competitive Economic Structure; 3. Equitable and just development; 4. Achieve environmental sustainability; 5. Cultural progress that reflects national characteristics; 6. Dignified and trusted judiciary free from corruption; 7. Providing protection and security for all citizens; 8. Managing a clean, effective and reliable government; 9. Synergy of regional governments in the framework of a unitary state.
Presidential Regulation No. 22/2009 on Acceleration of food consumption diversification based on local resources	Diversify food consumption and strengthen a diverse, balanced, and safe food consumption pattern to meet nutritional needs.
Nationally Determined Contribution (Submitted 2015; updated July 2021 and September 2022)	Emission reductions (carbon dioxide, methane, nitrous oxide) by 2030 Total unconditional reduction target: 31.89% Total conditional reduction target: 43.2% Unconditional agriculture emissions reduction target: 0.3% Conditional agriculture emissions reduction target: 0.4% Unconditional FOLU emissions reduction target: 17.4% Conditional FOLU emissions reduction target: 25.4%
Indonesia's Long-Term Strategy for Low Carbon and Climate Resilience 2050 (LTS-LCCR)	Priority is to achieve forestry and land-use as net carbon sink by 2030, referred to as FOLU Net Sink 2030; specific measures include: 1. Control forest and land fires, 2. Permanent moratorium on primary forests and peatlands, 3. Development of weather modification techniques, 4. Efforts of rehabilitation and reforestation, and successful replication of the ecosystem and eco-riparian rehabilitation, 5. Development of urban green spaces, 6. Demarcation of protected areas and high conservation value forest within concession areas, the efforts to cope with habitat fragmentation, and 7. Efforts to strengthen law enforcement.

Group of farmers in Brebes, Indonesia, harvesting shallot.

II A novel approach to food system modelling

BAPPENAS has recognized the need for quantitative analysis and modelling to inform food systems transformation efforts in Indonesia by providing a better understanding of food systems performance, including relevant political economy dynamics. Quantitative analysis and modelling are crucial to help policymakers identify and evaluate synergies and trade-offs across different policy objectives and optimal policy choices for achieving multiple policy objectives.

FAO has coordinated a collaborative food system modelling project to support governance innovation for food systems transformation in Indonesia and to inform policy interventions to operationalize Indonesia's Strategic National Pathway for Food Systems Transformation. Under this project, FAO brought together researchers from IFPRI, IIASA, IISD and Christian-Albrechts-University of Kiel (Kiel University) to pilot an innovative modelling approach that aligns three different models to analyse the impacts, synergies, trade-offs and political feasibility of various policy interventions for food systems transformation. The results of this modelling are intended to inform the Government of Indonesia's medium- and long-term development planning by identifying technically sound and politically feasible policy interventions to achieve multiple policy objectives related to food systems transformation.

1. Aligning three models

The modelling approach involves the use of three models to generate complementary insights into the impacts of different policy interventions, across a range of priority policy objectives for the Government of Indonesia. The first model, MIRAGRODEP, provides a national-level picture of food system performance in Indonesia, identifying and analysing synergies and trade-offs associated with policy interventions over the medium term – in this case, to 2035.[14] MIRAGRODEP covers all economic sectors and focuses on the economic and social impacts of policy interventions. The second model, the Global Biosphere Management Model (GLOBIOM), provides a national and subnational picture of food systems performance within the agriculture and forestry sectors in Indonesia, evaluating synergies and trade-offs associated with policy interventions over the medium and long term, in this case to 2030 and to 2045.[15] The third model, a computable general political economy equilibrium (CGPE) model, analyses the institutional, political, and sociocultural dynamics of the Indonesian food system.[16] With input provided through a stakeholder survey, the CGPE meta-modelling analyses policy decisions and preferences to assess the political feasibility of specific policy interventions and combinations of interventions.

[14] For information on the MIRAGRODEP model and its application for this modelling exercize, see Laborde *et al.* (forthcoming).

[15] For more information on the GLOBIOM model and its application for this modelling exercise, see Boere *et al.* 2024.

[16] For more information on the CGPE model and its application for this modelling exercize, see Henning *et al.* (forthcoming)a.

Table 2. Key features of the three models

	MIRAGRODEP	GLOBIOM	CGPE
Type of model	Computable general equilibrium (CGE)	Partial equilibrium model (PE)	Computable general political economy equilibrium (CGPE)
Sectors covered	Whole economy, 19 sectors of agrifood activities	Agriculture, forestry and bioenergy	Adapted to GLOBIOM
Granularity	Country level modelling; One Agroecological zone	Indonesia at 50x50 km; Additional assessment of trends across six regions of the country was included	Adapted to GLOBIOM
Application	Business as usual baseline and four scenarios	Business as usual baseline and seven scenarios	Policy preferences and political feasibility of policy interventions
Base year	2019	2020; for calibration, trends from 2000 are considered	2020
Time horizon	Medium-term: 2035	Medium-term: 2030 Long-term: 2045	Medium-term: 2030 Long term: 2045
Data sources	Population and economic growth estimates (UN, IMF); FAO datasets for Indonesia; Enhanced NDC of Indonesia	Statistics for area and production for 19 crops over 2000-2009 and for livestock at *kabupaten* level for Indonesia from MoA portal; GLC2000 land cover map based on the Ministry of Forestry land cover map (2000); data on oil palm plantations from literature	Interview data collected from 65 experts and policymakers with IBP University of Indonesia

Notes: Republic of Indonesia. (n.d.). Ministry of Agriculture - Agricultural Statistics Database. [Cited 22 February 2024]. https://bdsp2.pertanian.go.id/bdsp/id/home.html

Sources: For Sumatra and Papua for 2000: **Gunarso, P., Hartoyo, M.E., Agus, F. & Killeen, T.J.** 2013. *Oil palm and* from Gaveau *et al.* 2016 for *land use change in Indonesia, Malaysia and Papua New Guinea.* Reports from the technical panels of the 2nd greenhouse gas working group of the Roundtable Sustainable Palm Oil (RSPO): 29-63.

For Kalimantan for 2000: **Gaveau, D. L. A., Sheil, D., Husnayaen, Salim, M. A., Arjasakusama, S., Ancrenaz, M., Pacheco, P. & Meijaard, E.** 2016. Rapid conversions and avoided deforestation: examining four decades of industrial plantation expansion in Borneo. *Scientific Reports*, 6, 32017.

2. Modelling priority policy objectives for Indonesia

To ensure relevance and usefulness for Indonesian policymakers, the modelling was organized around three "axes" which corresponded to three broad policy objectives of the Indonesian Government with respect to food systems transformation, as set out in the RPJMN and other key policy documents (see e.g. Table 1). Organizing the modelling in this way allows for the mapping of synergies and trade-offs within and across these different policy areas using the modelling results. The three axes are:

1. **Healthy diets** – In line with the RPJMN, Food Law (No. 18 of 2012), and the Strategic National Pathway for Food Systems Transformation, this axis reflects the policy objective of improving diets in Indonesia through lessening poverty and higher household (per capita) incomes, reduced food insecurity (undernourishment), and greater affordability and consumption of foods necessary for a healthy diet, as reflected in the EAT-Lancet "Planetary Health Diet" (i.e. relatively low in animal source foods, and high in fruits, vegetables, nuts and legumes).[17]

[17] The Planetary Health Diet is flexible by providing guidelines of food groups for an optimal diet and environmental sustainability. It emphasizes a plant-forward diet where whole grains, fruits, vegetables, nuts and legumes comprise a greater proportion of foods consumed. Meat and dairy constitute important parts of the diet but in significantly smaller proportions than whole grains, fruits, vegetables, nuts and legumes. In addition, the dietary targets of 2500 kcal per day for the average adult. Report: EAT-Lancet Commission Summary Report - EAT (eatforum.org).

2. **Socioeconomic sustainability of agrifood supply** – In line with the RPJMN goal of sustainably increasing food availability, this axis reflects the policy objective of sustainably increasing local production of food (particularly healthier and more sustainable foods) to meet the needs of a growing population and improve food self-sufficiency in Indonesia.

3. **Environmental sustainability, including climate change** – In line with RPJMN goals of strengthening the environment, improving climate resilience, and promoting low-carbon development, and Indonesia's commitments under its Enhanced Nationally Determined Contribution (Republic of Indonesia, 2022), this axis reflects the policy objective of improved environmental sustainability and climate resilience through reduced land conversion, reduced deforestation, reduced biodiversity loss and lower GHG emissions.

To analyse and evaluate outcomes across these three axes, the modelling focuses on several indicators taken or adapted from policies and commitments adopted by the Indonesian Government. These include "**prevalence of undernourishment**" (for healthy diets), "**agriculture value added**" (for socioeconomic sustainability of agrifood supply), and "**forest cover**" and "**GHG emissions**" (for environmental sustainability, including climate change). Several other relevant and related indicators are also modelled to deepen the analysis. A sample of these indicators is displayed in Table 3.

Table 3. Selected indicators used in the modelling

Axis	Indicators	MIRAGRODEP	GLOBIOM	CGPE
Healthy diets	Share of population living in poverty	X		X
	Prevalence of undernourishment (PoU)	X	X	X
	Food availability (selected products)	X		
	Energy intake (calories per capita per day)	X	X	
	(Un)affordability of a healthy diet	X		
	Share of calories by food group (selected foods) groups)		X	
Socioeconomic sustainability of agrifood supply	Agriculture value added		X	X
	Real farm income per worker	X		
	Agricultural production, volume (selected products)	X		
	Agricultural production, value added (selected products)		X	
	Self-sufficiency (selected products and food groups)		X	
Environmental sustainability, including climate change	Forest cover	X	X	X
	Primary forest cover		X	
	Natural land cover		X	
	Biodiversity intactness		X	X
	GHG emissions from agriculture	X	X	
	GHG emissions from land use change	X	X	
	GHG emissions from agriculture and land use change	X	X	X
	GHG emissions per unit of agricultural value added	X		

3. Applying the models for Indonesia

To apply the modelling for Indonesia, MIRAGRODEP and GLOBIOM were used to develop a baseline illustrating the evolution of selected indicators under a BAU scenario. This scenario assumes a continuation of current policy and production trends based on projected changes in Indonesia's population and projected economic growth. The two models were then used to model the evolution of the selected indicators under scenarios representing the implementation of policy interventions to achieve (i) healthy diets, (ii) socioeconomic sustainability of agrifood supply, or (iii) environmental sustainability, including climate change, and under "combined scenarios" representing the implementations of combinations of policy interventions to achieve policy objectives in more than one of these axes. These scenarios include scenarios are described in Box 1.

BOX 1. SCENARIOS MODELLED WITH MIRAGRODEP AND GLOBIOM

MIRAGRODEP scenarios

1. **"Social Safety Net"** – A social safety net programme involving food stamps (income transfers for food purchases) is introduced to improve the ability of households to afford food and thereby reduce undernourishment and improve diets.
2. **"Socioeconomic Incentives"** – Farm subsidies are repurposed to support farmers' earnings and encourage production of healthier and more sustainable products.
3. **"Sustainable Production"** – A package of policy interventions related to land use regulation, reduction of food loss and waste, and climate change mitigation is introduced to foster improved knowledge, innovation, technology adoption by farmers to improve farm productivity while simultaneously reducing environmental impacts.
4. **"Full Package"** – The policy interventions and programmes from the Social Safety Net, Socioeconomic Incentives and Sustainable Production scenarios are implemented simultaneously.

GLOBIOM scenarios

1. **POU** – A scenario where the prevalence of undernourishment (PoU) is reduced to 2.5 percent by 2030, and the Indonesian population has transitions towards healthier diets.
2. **INT** – A scenario where agricultural intensification leads to increased productivity on cropland through better cultivars and an increased use of water and fertilize.
3. **GHG050** – A carbon tax of USD 50/ton is introduced for agriculture and land use emissions.
4. **CONS** – A moratorium on primary forest and peatland conversion is extended.
5. **CONS_POU** – A scenario where PoU is reduced to 2.5 percent by 2030, Indonesian diets have become healthier and a moratorium on primary forest and peatland conversion has been extended.
6. **CONS_INT** – A scenario where agricultural intensification leads to increased productivity and a moratorium on primary forest and peatland conversion has been extended.
7. **INT_POU** – A scenario where agricultural intensification leads to increased productivity, PoU is reduced to 2.5 percent by 2030, and Indonesian diets have become healthier.
8. **CONS_INT_POU** – A scenario where a moratorium on primary forest and peatland conversion has been extended, agricultural intensification leads to increased productivity, PoU is reduced to 2.5 percent by 2030, and Indonesian diets have become healthier.

The modelling reveals the likely impacts of policy interventions and combinations of interventions over the medium term (2030 or 2035) or long term (2045) across the different axes (broad policy objectives). The modelling identifies any synergies (where a particular intervention or combination of interventions helps achieve multiple policy objectives) or trade-offs (where an intervention or combination of interventions helps achieve a specific policy objective while also making the achievement of another objective more difficult) involved. The MIRAGRODEP and GLOBIOM modelling thereby provides Indonesian policymakers with technically-sound guidance to inform the optimal selection of policy interventions for food systems transformation in Indonesia.

The CGPE modelling complements the results of the MIRAGRODEP and GLOBIOM modelling by providing an assessment of the political feasibility of policy objectives given the interests of key stakeholders. These interests were identified through a survey of 65 key governmental and non-governmental stakeholders conducted in cooperation with IBP University of Indonesia. The results of this survey provide an overview of the relative importance these stakeholders attached to different economic, social, and environmental policy objectives associated with food systems transformation in Indonesia, as well as their preferences with respect to policy interventions. The results also provide the data required for an evaluation of the political influence of the stakeholders surveyed and how likely they are to influence policy choices. Building on the survey results and the results of the GLOBIOM modelling (and of a national CGE model), a comprehensive political economy modelling framework was built to help gauge the political feasibility of the policy interventions analysed through the MIRAGRODEP and GLOBIOM modelling.

A meal being prepared with Barbodes binotatus fish captured in Cibareno River in Sukabumi District, West Java, Indonesia.

III Findings from the modelling

This section presents an overview of the findings from the modelling. It describes the evolution of the selected indicators at a national level under business as usual, and under the various scenarios modelled by MIRAGRODEP and GLOBIOM, over the medium term (2030 and 2035), and the long term (2045). The section also highlights the benefits of combining policy interventions to address trade-offs and synergies that result from the various policy interventions modelled. It then highlights selected regional (subnational) findings emerging from the modelling. Finally, the section addresses the political economy dynamics of food systems transformation, drawing on the stakeholder survey and CGPE meta-modelling.

1. Business as usual

Under the BAU scenario, the poverty rate in Indonesia continues to fall in the medium term due to projected economic growth and increasing incomes.[18] By 2035, 8.2 percent of the Indonesian population is projected to live on less than USD 3.2 per day, with 0.7 percent of the population living on less than USD 1.9 per day. With growing incomes and declining poverty, undernourishment also continues to decrease in the medium and long term, with the PoU in Indonesia declining from around 9 percent in 2020 to approximately 5.7 percent in 2030, 1.6 percent in 2035, and 1.4 percent in 2045. The share of the Indonesian population unable to afford a healthy diet also declines under the BAU scenario.

In terms of sustainably increasing food availability, food production in Indonesia increases under the BAU scenario, with value added in food crops increasing by 29 percent by 2030 and by 65 percent by 2045. Indonesia's self-sufficiency in rice and cereals remains stable over the medium and long term under the BAU scenario.

With respect to environmental sustainability, the rate of deforestation in Indonesia will continue to decline over the long term, but Indonesia's primary forest cover will still be 5.2 percent less in 2045 compared to 2020. This reflects continued land conversion under the BAU scenario, with 26 percent more land converted to forest plantations and 10.9 percent more land converted to cropland in 2045 compared to 2020. GHG emissions from agricultural production are projected to increase over the medium term and long term, while GHG emissions from land use change are projected to decline significantly in the medium term, reflecting declining emissions from deforestation.

[18] Under the BAU scenario, farm incomes grow less rapidly than overall incomes, implying that the rural-urban income gap will increase under this scenario.

2. Healthy diets

The MIRAGRODEP modelling finds that undernourishment in Indonesia is eradicated in the medium term (2035) in three scenarios, namely those involving a social safety net programme, a package of policy interventions for Sustainable Production, and a Full Package of policy. By contrast, in the scenario involving Socioeconomic Incentives in the form of repurposed farm subsidies the PoU in Indonesia is no lower than it would be in the BAU scenario. In the case of the Social Safety Net programme, eradicating undernourishment is achieved by directly providing people with the income to procure the food they need, while in the case of the Sustainable Production package, this is achieved through increased incomes for poor farmers and lower food prices.

The Social Safety Net programme also eradicates poverty in Indonesia by 2035, while the Full Package results in less than 1 percent of the Indonesian population living on less than USD 3.2 per day in 2035. In these two scenarios, healthy diets become affordable to all Indonesians. In all scenarios modelled by MIRAGRODEP there is an increase in calories consumed by the Indonesian population, but this is particularly pronounced in the case of the Sustainable Production package, which leads to an increase of more than 40 percent in 2035 compared to 2019. This is potentially problematic given Indonesia's policy objective of stabilizing energy intake at around current levels.

These results are consistent with the results of the GLOBIOM modelling. Of the scenarios modelled by GLOBIOM, the POU scenario involving the achievement of an undernourishment reduction target coupled with a transition to healthier diets, sees the lowest PoU in the medium term (2.8 percent compared to 5.7 percent under BAU in 2030). The scenario involving a policy intervention to stimulate agricultural intensification through increased use of water and fertilizer (INT) also leads to a lower PoU, but not that much lower than under BAU (5.3 percent in 2030). Over the longer term (to 2045), the POU scenario (1.1 percent) and INT scenario (0.9 percent) also lead to lower PoU than under BAU (1.4 percent).

By contrast, environmental sustainability-related policy interventions like the introduction of a carbon tax (under the GHG050 scenario) or the extension of a moratorium on forest and peatland conversion (under the CONS scenario) are found to lead to slightly higher levels of undernourishment in Indonesia compared to BAU. Under the CONS scenario the PoU in Indonesia is projected to be 5.7 percent in 2030 and 1.5 percent in 2045. Under the GHG050 scenario, the PoU in Indonesia is projected to be 5.9 percent in 2030 and 1.7 percent in 2045. This stems from the fact that these environmental policies limit the amount of land available for agricultural production and raise production costs, leading to food becoming more expensive.

These modelling results show that for the purposes of reducing undernourishment (and poverty) and promoting healthy diets, policy interventions that directly target poor households (e.g. with food stamps) are particularly effective. They also show that policy interventions that focus on boosting production and productivity are not necessarily as effective at tackling undernourishment and promoting healthy diets, while policy interventions aiming to promote environmental sustainability can result in higher levels of undernourishment (compared to BAU), particularly over the long term.

A social safety net programme involving food stamps is found to be most effective at eradicating undernourishment and making healthy diets available to all, while also generating positive synergies in terms of increased agricultural production and higher farm incomes. However, the modelling does reveal some environmental trade-offs. Unless paired with other policy interventions, such a programme is shown to increase land-use change, leading to (slightly) decreased forest cover and increased GHG emissions from agriculture relative to BAU.

3. Socioeconomic sustainability of agrifood supply

In the MIRGRODEP modelling, the Sustainable Production and Full Package scenarios lead to the greatest increases in real farm income per worker relative to BAU (7.5 percent and 10.1 percent higher respectively), reflecting the focus in these scenarios of policy interventions that target the production side. Real farm incomes increase under the Social Safety Net scenario as well, but not by as much (3.6 percent more than under BAU). This increase reflects increased demand indirectly supporting production. Real farm incomes remain unchanged under the Socioeconomic Incentives scenario.

Agricultural production increases over the medium term in all these scenarios, but production patterns differ across the scenarios. In the Social Safety Net scenario, the volume of fruits and vegetables produced in 2035 and the volume of meat produced in 2035 are both greater than under BAU. By contrast, in the Socioeconomic Incentives scenario the volume of fruits and vegetables produced in 2035 is greater than under BAU, but the volume of meat produced is less than under BAU. This reflects the effect of redirecting agricultural support towards nutritious and low-emissions products (like fruit and vegetables) and away from emissions-intensive products like meat. For the Sustainable Production and Full Package scenarios, the pattern is the same as for the Socioeconomic Incentives scenario, but the increase in the volume of fruits and vegetables produced relative to BAU is significantly greater.

Consistent with these findings, the GLOBIOM modelling results show that over the medium term (2030), value added in agriculture and in food crops increase in all scenarios, although in some cases by less than under BAU. Gains relative to BAU are found to be highest in the scenarios targeting undernourishment and a transition to healthy diets (POU). This possibly reflects higher prices resulting from increased demand, implying a higher cost to the government for implementing the specific policy intervention used to target PoU reduction (e.g. a food stamp programme).

The GLOBIOM findings also project different production patterns depending on the interventions introduced. In the scenario with an agricultural intensification (INT) intervention and combined scenarios involving INT, production of cash crops (e.g. coffee) and crops used for livestock feed (e.g. soybeans) increase significantly. In the POU scenario, production of healthy root crops like cassava and sweet potato increases significantly.

Regarding self-sufficiency in rice and cereals, the GLOBIOM modelling finds relatively little impact on self-sufficiency in the medium term under most scenarios, with the introduction of a carbon tax (GHG050) leading to a decline relative to BAU. Over the long term (2045), self-sufficiency in rice and in cereals is significantly lower in the GHG050 scenario compared to BAU, while in all scenarios involving an agricultural intensification intervention, self-sufficiency in rice and in cereals is higher in the long term relative to BAU.

These modelling results show that agricultural production in Indonesia can be boosted through interventions targeting the production side (e.g. agricultural intensification) or the demand side (e.g. a social safety net), but that the choice of intervention will influence resulting production patterns. The results also show that by encouraging greater productivity on existing agricultural land, interventions focused on promoting sustainable intensification can generate positive synergies in terms of preserving forest cover and lowering GHG emissions.

4. Environmental sustainability, including climate change

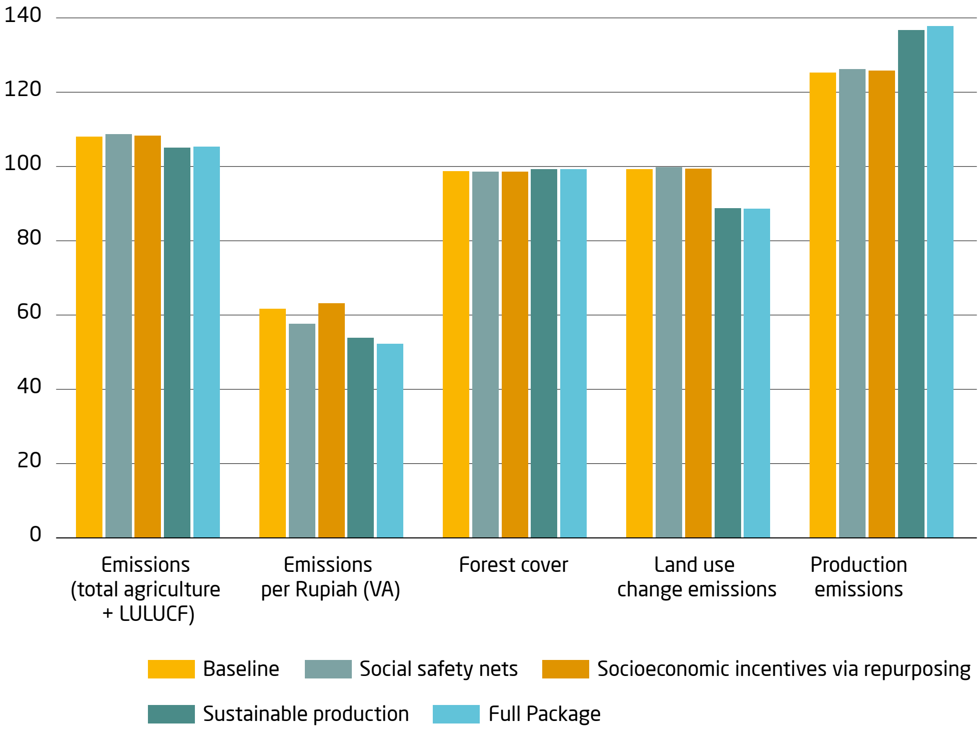
None of the MIRAGRODEP scenarios project changes in forest cover that differ significantly to changes under BAU in the medium term. The scenarios with the Sustainable Production package of interventions (including interventions on land use regulation, climate change mitigation, and sustainable intensification) and the scenario with the Full Package of interventions are found to be most effective in limiting deforestation in Indonesia, leading to reductions in forest cover of 0.8 percent between 2019 and 2035, compared to 1.3 percent under BAU.

The MIRAGRODEP modelling also finds that total GHG emissions from agriculture and land-use change increase in all scenarios relative to the level of emissions in 2019. Under BAU and the Social Safety Net and Socioeconomic Incentives scenarios, GHG emissions from land use change remain relatively stable between 2019 and 2035, while emissions from agricultural production rise due to increasing output and the absence of interventions to reduce emissions per unit of production (emission intensity).

In the Sustainable Production and Full Package scenarios where measures are introduced to reduce food loss and promote greener technologies, the emission intensity of agricultural production decreases significantly more than under BAU (due to lower emissions and higher value added); but in these scenarios agricultural production itself increases (due to improvements in the cost-efficiency of production). The impact on emissions of increased production outweighs the impact of lower-emission intensity (and of reductions in the rate of deforestation and resulting emissions from land-use change), leading to higher total GHG emissions from agriculture and land-use change. The emission intensity of agricultural production also declines under the Social Safety Net scenario relative to BAU (but not by as much as under the Sustainable Production and Full Package scenarios). This is mainly because the safety net leads to increased value added in agriculture (total emissions remain higher in this scenario than under BAU).

The GLOBIOM modelling finds that environmental policy interventions such as the introduction of a carbon tax (GHG050) or the extension of a moratorium on the conversion of primary forests or peatland (CONS) significantly reduce deforestation and total GHG emissions from agriculture and land use change relative to BAU over the medium (2030) and long term (2045). Measures to tackle undernourishment involve significant trade-offs with respect to forest cover and biodiversity, as the POU scenario leads to the greatest losses in forest cover, natural land, and biodiversity in both the medium and long term. This reflects the cropland expansion projected under this scenario due to extra demand for food crops.

Figure 1. Selected environmental indicators in the medium term (2035) in MIRAGRODEP scenarios



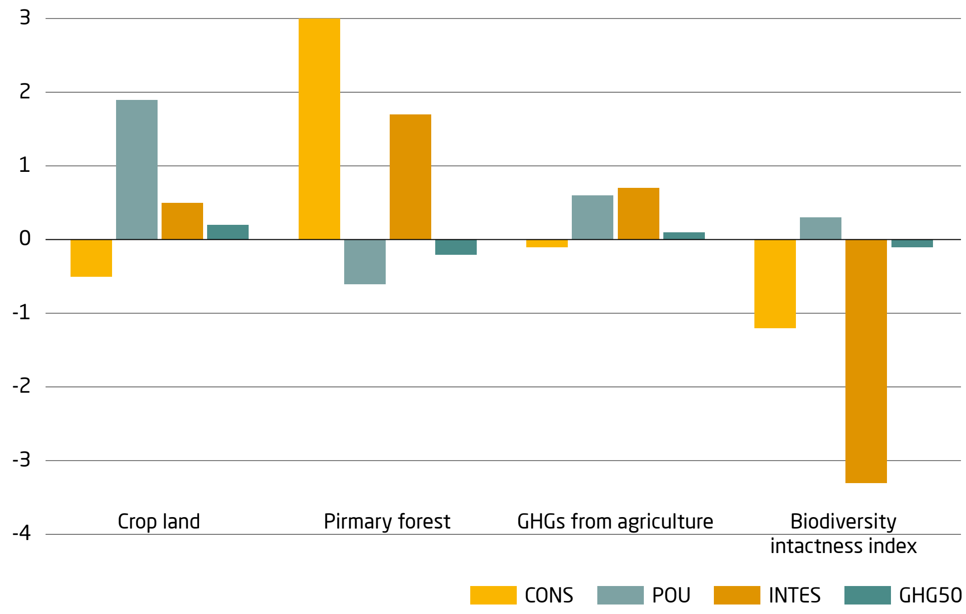
Source: Laborde, D., Olivetti, E., Piñeiro, V. & Illescas, N. (forthcoming). *Addressing Food System Transformation, Food Security and Deforestation in Indonesia. Challenges and Initiatives.* Washington DC, IFPRI.

A moratorium on primary forest and peatland conversion (CONS scenario) leads to significant saving of forests, particularly primary forests, over both the medium and long term, but it doesn't prevent the conversion to agriculture of other non-forest land covers, including potentially biodiversity-rich natural land. In fact, the GLOBIOM modelling finds that the most effective way to save forests, and particularly natural forests, is to combine the moratorium with a policy intervention on agriculture intensification, as under the CONS_INT scenario. This scenario also leads to increased savings of natural land relative to BAU and generates the greatest savings of biodiversity over both the medium and long term.

In the GLOBIOM modelling, the moratorium (CONS) and combined moratorium-intensification intervention (CONS_INT) scenarios are the most effective in reducing GHG emissions from agriculture and land use change in the medium term, reflecting the impact a moratorium while demand for forest commodities like palm oil is high. The introduction of a carbon tax (GHG050) is found to be the most effective intervention to reduce emissions over the long term though, reflecting the declining contribution of deforestation to Indonesia's GHG emissions in the long term. The biggest part of emissions reductions under these scenarios results from reductions in land use change.

While these environmental policy interventions are found by the GLOBIOM modelling to be the best for tackling emissions (and deforestation), they involve trade-offs in terms of tackling undernourishment. Indeed, a carbon tax is projected to make food production more costly (especially products like milk and beef, which generate significant emissions) and lead to a higher PoU relative to BAU in both the medium and long term. The CONS_INT scenario doesn't lead to increased PoU relative to BAU but doesn't significantly improve undernourishment. Combining this scenario with an undernourishment target (which on its own leads to significant increases in cropland and in emissions from rice cultivation), also leads to emissions reductions, albeit lower than in the CONS_INT scenario, but with the benefit of also addressing undernourishment.

Figure 2. Percent changes in selected indicators relative to BAU in 2030 for four GLOBIOM scenarios



Source: Boere, E., Augustynczik, A. L. D., Kozicka, M. & Havlík, P. 2024. *Food Systems Transformation in Indonesia: Results on baseline and stylized scenarios from GLOBIOM.* Laxenburg, Austria, IIASA. https://pure.iiasa.ac.at/19516.

These modelling results paint a complex picture, particularly with respect to GHG emissions. Increasing demand for food in Indonesia will likely lead to a substantial increase in food production, with corresponding increases in emissions from agricultural production. **For Indonesia to meet its GHG emissions reductions targets, it will not be sufficient to introduce new technologies or efficiency improvements to enhance agricultural productivity, specific policy interventions targeting emissions reduction will need to be introduced**. This could be in the form of a carbon tax or conservation policies that further reduce the rate of deforestation in Indonesia. In the case of the latter though, the positive impact on emissions reductions will be partly offset by emissions from peatland already under cultivation. Moreover, while interventions such as these may be effective at bringing down emissions, they will also lead to higher production costs and food prices for consumers, complicating efforts to improve food security and nutrition in Indonesia.

5. Combining interventions to mitigate trade-offs and capitalize on synergies

Trade-offs and synergies arise when introducing policy interventions to achieve specific economic, social, environmental policy objectives. For example, both MIRAGRODEP and GLOBIOM modelling find that an intervention to directly address undernourishment, such as a social safety social safety net programme involving food stamps, is most effective in reducing undernourishment. But also, that type of an intervention leads to higher calorie intake and negative environmental impacts from increased cropland expansion, including loss of forests, natural land, and biodiversity, and higher GHG emissions. Similarly, GLOBIOM modelling finds that environmental policy interventions, such as the introduction of a carbon tax or extension of a moratorium on primary forest and peatland conversion, are most effective in reducing GHG emissions and deforestation, but that by making agricultural production costlier, such interventions lead to higher levels of undernourishment than under BAU.

In terms of synergies, MIRAGRODEP modelling finds that both a social safety social safety net programme and a package of interventions to boost Sustainable Production lead to reduced undernourishment while also boosting food production and real farm incomes. GLOBIOM modelling finds that a moratorium on primary forest and peatland conversion leads to increased savings of forest cover as well as lower GHG emissions. It also finds that an intervention on sustainable intensification leads to higher value added in agriculture, but also increased forest cover and lower GHG emissions relative to BAU.

Combining different policy interventions can help to mitigate trade-offs and generate synergies, demonstrating the value of an integrated approach to policymaking for food systems transformation. For example, combining an intervention aimed at reducing undernourishment – such as a social safety social safety net programme – in addition to an intervention to promote agricultural intensification, generates similar gains in tackling undernourishment as does the social safety social safety net on its own, but has the added advantage of mitigating food price rises, making healthy diets more affordable and lowering the cost of the Social Safety Net programme.

Combining interventions that address deforestation with interventions that increase productivity on existing agricultural land is effective in promoting environmentally sustainable production. GLOBIOM modelling finds the combination of a moratorium on primary forest and peatland conversion, and an intervention to promote agricultural intensification (CONS_INT) to be the most effective way to reduce deforestation and to conserve primary forests and biodiversity in the medium and long term. This combination of interventions is also effective in conserving natural land and in reducing GHG emissions, particularly in the medium term, although it has limited impact on undernourishment. Adding an intervention that directly targets undernourishment to the mix of interventions under the CONS_INT scenario also yields positive environmental and economic outcomes, albeit less positive than in the CONS_INT scenario, but with the benefit of also addressing undernourishment.

This last point is consistent with the finding of the MIRAGRODEP modelling that the Full Package of policy interventions is the most effective for achieving significant progress across all three axes of sustainable development (economic, social, and environmental). Under the Full Package scenario, GDP increases the most, poverty is substantially alleviated, healthy diets become affordable to more people, and emissions per unit of agriculture value added are significantly reduced. However, by making food more available and affordable, this Full Package scenario leads to a significant rise in calories consumed per capita in Indonesia, contrary to the government's ambition of (slightly) decreasing current levels of calorie intake.

Table 4. Percent change in selected indicators between 2020 and 2030 in GLOBIOM and MIRAGRODEP scenarios

	GLOBIOM					MIRAGRODEP
Selected indicators	**BAU**	**CONS_POU**	**INT_POU**	**CONS_INT**	**CONS_ INT_POU**	**Full Package**
Prevalence of undernourishment	-36.7	-68.9	-68.9	-41.1	-68.9	-100.0
Value added, agriculture	13.8	17.1	15.9	13.7	15.9	Not available
Forest cover	-1.0	-1.3	-0.9	-0.3	-0.9	-0.8
GHGs from agriculture	9.6	13.7	13.3	8.2	13.4	14.0*

*GHG emissions from agriculture and land use, land use change and forestry.

Sources: Boere, E., Augustynczik, A. L. D., Kozicka, M. & Havlík, P. 2024. *Food Systems Transformation in Indonesia: Results on baseline and stylized scenarios from GLOBIOM.* Laxenburg, Austria, IIASA. https://pure.iiasa.ac.at/19516
Laborde, D., Olivetti, E., Piñeiro, V. & Illescas, N (forthcoming). *Addressing Food System Transformation, Food Security and Deforestation in Indonesia. Challenges and Initiatives.* Washington DC, IFPRI.

These results suggest that in order to achieve its sustainable development objectives, the Indonesian Government needs to implement a comprehensive package of policy interventions for food systems transformation that address the reduction of undernourishment and make healthy diets more affordable to all; that promote sustainable agricultural production through improved productivity; and that address deforestation and loss of natural land, biodiversity loss, and GHG emissions in an integrated way.

6. Subnational dynamics

Indonesia is an archipelagic country that exhibits significant variation across its regional economic corridors (Bali-Nusa Tenggara, Java, Kalimantan, Papua, Sulawesi and Sumatra) in terms of food security and food self-sufficiency, economic development, agricultural production, land cover, and biodiversity. For example, Java and Sumatra have the highest income per capita, and they generate the highest value added in agriculture and are the only two regions fully self-sufficient in rice and cereals. These two regions also exhibit the lowest levels of biodiversity intactness, while Sumatra and Kalimantan contribute to the largest share of GHG emissions from agriculture and land-use change. It is therefore important to consider not just national-level outcomes as described above, but also the impact of policy interventions at the regional level. While this was not the focus of the modelling, the GLOBIOM modelling does reveal some important subnational dynamics over the medium term (2030).

Under BAU, the GLOBIOM modelling projects that regional specialization in agricultural production between food crops and commodity crops will increase as regions with a history of producing food crops intensify food production, and those with a history of producing commodity crops further concentrate production in these crops. This in turn leads to increasing disparities in food self-sufficiency across Indonesia's regions, which could in turn impact local food security. Food self-sufficiency is projected to increase in Java and remain stable in Sumatra, but to decrease in the other four regions.

Increasing regional specialization in production under BAU also leads to regional disparities in terms of environmental impacts. Java experiences the biggest declines in primary forest cover (as a proportion of existing primary forest cover), followed by Sulawesi, Sumatra, and Kalimantan. The proportion of primary forest cover loss experienced in Papua and Bali Nusa-Tenggara, however, is much smaller. GHG emissions from agriculture decline in Sulawesi and Bali Nusa-Tenggara but increase in the other four regions.

The economic, social, and environmental impacts of policy interventions differ across Indonesia's regions, as revealed by the GLOBIOM modelling (see Table 5). For example, an intervention on preserving forests (CONS) leads to greater primary forest cover relative to BAU in all regions, except for Bali Nusa-Tenggara. An intervention on agricultural intensification (INT) leads to increased food self-sufficiency relative to BAU in Sulawesi, but lower food self-sufficiency relative to BAU in the other regions.

Table 5. Percentage change in indicators at regional level relative to BAU in 2030

	CONS	POU	INT	GHG050	CONS_POU	INT_POU	CONS_INT	CONS_INT_POU
Papua								
Value added, agriculture	2.9	-2.2	-2.9	0.9	0.1	-0.8	5.9	6.1
Self-sufficiency (food)	1.7	9.6	-2.9	20.4	1.3	10.4	21.4	21.4
Crop land	1.4	0.0	-0.2	-0.1	-0.1	1.1	0.7	0.7
Primary forest	0.3	-	0.0	0.0	0.0	0.3	0.0	0.0
GHGs from agriculture	0.6	-3.0	0.8	-3.1	-3.1	-2.4	1.5	-2.4
Sulawesi								
Value added, agriculture	3.0	7.1	-0.2	-0.3	7.1	6.5	0.8	6.5
Self-sufficiency (food)	1.7	5.9	5.0	-2.7	5.9	14.0	6.8	14.0
Crop land	0.3	2.5	0.0	-0.4	2.5	3.2	0.0	3.2
Primary forest	2.9	-0.5	1.4	0.1	-0.5	-0.4	4.2	-0.4
GHGs from agriculture	1.0	10.3	2.9	-2.8	10.3	15.6	3.2	15.6
Sumatra								
Value added, agriculture	1.2	5.1	-2.3	0.3	5.1	0.7	-2.9	0.7
Self-sufficiency (food)	-1.4	5.1	-1.0	-0.9	5.1	1.7	-2.1	1.7
Crop land	0.4	1.6	-0.2	-0.6	1.6	1.3	0.7	1.3
Primary forest	3.2	-2.5	1.4	0.8	-2.5	-0.5	3.9	-0.5
GHGs from agriculture	-0.9	8.5	0.7	-4.3	8.5	6.5	-0.5	6.6
Java								
Value added, agriculture	0.6	2.4	1.5	5.6	0.0	3.2	3.3	3.3
Self-sufficiency (food)	0.1	2.0	-0.9	-3.0	0.0	1.9	-6.1	-6.1
Crop land	-1.2	0.0	-0.1	0.9	0.0	-1.1	0.9	0.9
Primary forest	36.9	-	-3.6	-7.4	-2.9	37.0	-8.5	-8.5
GHGs from agriculture	-0.3	1.4	-2.8	-3.9	1.4	-0.3	-3.0	-0.3

	CONS	POU	INT	GHG050	CONS_POU	INT_POU	CONS_INT	CONS_INT_POU
Kalimantan								
Value added, agriculture	-0.3	-5.1	-0.2	-2.6	0.0	-5.0	4.5	4.5
Self-sufficiency (food)	-0.1	-3.6	-3.8	18.5	3.6	-1.7	16.7	16.7
Crop land	-4.1	-0.7	-1.0	3.6	-0.4	-4.6	3.9	3.9
Primary forest	4.0	0.2	0.1	-1.3	0.0	4.2	-1.5	-1.5
GHGs from agriculture	-2.3	10.1	-5.9	-1.6	10.1	7.2	-5.6	7.2
Bali-Nusa Tenggara								
Value added, agriculture	1.6	9.0	-3.2	22.4	-0.5	10.3	13.7	13.8
Self-sufficiency (food)	0.3	5.1	-6.6	29.1	-0.4	6.0	24.8	25.0
Crop land	3.5	1.4	-0.9	6.4	0.0	4.3	6.3	6.3
Primary forest	-3.3	-1.6	0.8	-2.8	0.0	-3.9	-2.9	-2.9
GHGs from agriculture	0.4	19.2	-1.7	-6.8	19.0	17.0	-1.0	17.0

Source: Developed by authors using data from GLOBIOM modelling.

There is no one-size-fits-all policy intervention or package of interventions that achieves optimal socioeconomic and environmental outcomes for all Indonesia's regions. As Table 5 shows, none of the policy interventions or combinations modelled in GLOBIOM lead to improvements over BAU for all the modelled indicators in all six regions. This is true even for the CONS_INT_POU scenario involving a combination of interventions targeting different policy objectives. This scenario leads to positive outcomes across multiple-policy objectives for most of the regions, but it leads to increased GHG emissions from agriculture and lower primary forest cover relative to BAU in most regions, as well as lower food self-sufficiency relative to BAU in Java.

Different policy interventions or packages appear to be more effective in different regions in terms of achieving multiple policy objectives. In Java, for instance, a package of interventions on forest conservation and agricultural intensification (CONS_INT) leads to significant increases in primary forest cover relative to BAU, slightly lower GHG emissions from agriculture, and higher agricultural value added and food self-sufficiency. In Papua, a combined package that also includes an intervention to reduce undernourishment (CONS_INT_POU) leads to significantly higher food self-sufficiency relative to BAU, increased agricultural value added, and lower GHG emissions from agriculture, without any decrease in primary forest cover relative to BAU.

7. Political economy analysis: stakeholder preferences and political feasibility

To integrate a political economy analysis into the modelling approach, a stakeholder survey, policy network analysis, and CGPE meta-modelling were also conducted (Henning et al., forthcoming-a and Henning et al., forthcoming-b). The findings from the stakeholder survey provide insight into the policy priorities and preferences of key stakeholders in Indonesia's food systems transformation. They show that Indonesian stakeholders – including national and regional government representatives and civil society organizations – prioritize economic policy objectives over social and environmental policy objectives and have more ambitious expectations when it comes to achieving economic policy goals. Conversely, these stakeholders are more pessimistic about the achievement of environmental policy objectives such as forest conservation.

The findings of the survey reveal a high degree of consensus among stakeholders regarding the key challenges for food systems transformation in Indonesia and the need for policy reform to promote more sustainable food systems in the country. Four areas of consensus regarding policy reform can be identified from the results: 1) the need to ensure subsidies and other incentives better incentivize sustainable agricultural practices and land use and are better targeted towards poorer farmers; 2) the need for greater public investment in agriculture, particularly for irrigation and agricultural services and infrastructure; 3) better enforcement of regulations on land use and deforestation; and 4) Increased income transfers to poor households to alleviate poverty and undernourishment.

The findings of the survey also reveal the potential challenges for food systems governance in Indonesia. In their responses, stakeholders identified a lack of administrative capacity as a critical challenge. This includes a lack of capacity to effectively collect taxes (needed for public investment in agriculture) and to implement and enforce land-use regulations and control illegal deforestation.

The policy network analysis reveals relatively limited participation of Indonesian non-governmental organizations (NGOs) in multistakeholder processes for food systems policymaking. In addition, the formal institutional setup implies that political decision-making power is concentrated at the national government level. This suggests that local and regional stakeholders may be underrepresented in food systems policymaking and processes which inform policymaking. Such underrepresentation could lead to suboptimal policy choices being made due to lack of knowledge of local conditions, and it poses a risk for effective ownership and implementation of policy interventions on the ground.

The CGPE meta-modelling – which integrates a national CGE model with GLOBIOM – shows that the package of policy interventions found by the GLOBIOM-CGE modelling to be "technically optimal" for achieving the food systems transformation objectives prioritized by stakeholders is quite different to the policy mix that is predicted to emerge through a real-world multistakeholder process of political bargaining – given the expressed beliefs, preferences and priorities of the stakeholders surveyed.

The differences are not in policy direction, as both mixes involve increased transfers to poor households, greater public investment in agriculture, and stronger regulation of GHG emissions and land use change, but rather in terms of the relative extent of specific policy interventions. For example, the policy mix predicted to emerge from real-world multistakeholder political bargaining involves a significantly smaller carbon tax, much less restrictive land-use regulation, higher consumer transfers, and greater public investment in agriculture compared to the policy mix identified as optimal by the economic modelling. It also involves greater proportion of public investment going to peripheral regions (such as Papua, Bali-Nusa Tenggara, and Sulawesi), than the optimal mix identified by the modelling, which involves most public investment in agriculture going to central regions, especially regarding Java.

What this means is that the policy intervention package that stakeholders believe is best for achieving their policy objectives does not match what the modelling shows to be the optimal package for achieving those objectives. **This misalignment suggests that the optimal policy mix emerging from the modelling may not be politically feasible to implement unless current stakeholder beliefs or preferences change.** This in turn suggests the need for further communication and knowledge exchange between the economic modelling teams and key stakeholders to bridge this gap between the modelling results and the beliefs and preferences of key stakeholders in Indonesia's food systems transformation.

Another interesting finding of the CGPE meta-modelling is that **policy interventions that promote enhanced productivity and economic growth in Indonesia's non-agricultural sectors are likely to have bigger impacts on policy objectives related to food systems transformation than policy interventions which focus specifically on promoting enhanced productivity and growth**. This is because value added in agriculture represents a much smaller share of Indonesia's GDP than the combined added value of industry and services. The CGPE meta-modelling finds that policy interventions that promote productivity and growth in non-agricultural sectors are likely to lead to better outcomes in terms of increasing farm and non-farm incomes – and in reducing poverty and undernourishment – but will also lead to increased land-use change and GHG emissions, as well as more rapid biodiversity loss.

Fishers transporting their capture by boat to a traditional fish market near Dusun Hilir Subdistrict, Barito Selatan, Indonesia.

IV Implications for policymaking for food systems transformation

The findings of the MIRAGRODEP, GLOBIOM and CGPE modelling provide insights that can inform policymaking for food systems transformation in Indonesia. In particular, the modelling results can assist policymakers in navigating and addressing trade-offs that arise from the implementation of policy interventions aimed at economic, social, or environmental objectives, and in identifying optimal policy mixes to achieve positive outcomes across these objectives. The results also provide insights into the political-institutional dynamics that determine the feasibility of specific (sets of) policy interventions being effectively implemented. Together these results suggest the following implications for Indonesia's policymakers tasked with driving food systems transformation.

1. Implications for policymakers

There is need and scope to accelerate progress on key objectives for food systems transformation through targeted policy interventions. Under BAU, Indonesia is projected to make steady progress across a range of policy objectives including: reducing poverty, improving agricultural productivity and increasing the affordability of healthy diets. Nonetheless, there is significant scope for using targeted interventions to accelerate this progress in pursuit of specific policy goals such as reducing undernourishment, halting deforestation and curbing GHG emissions.

Progress on undernourishment and nutrition can be accelerated over the medium-term through social safety-net measures that target the most vulnerable, improving their ability to afford nutritious foods. Such measures will lead to significantly lower levels of undernourishment in 2030 compared to BAU. Moreover, combining these measures with interventions to boost production sustainably and reduce food loss and waste can help keep the costs of such measures (and food prices) down.

To improve progress on agricultural productivity and production, targeted interventions to support farmers are necessary. Public investment in agricultural research and development, technology adoption, and in infrastructure (including irrigation), is essential to bolster productivity and efficiency in food production. However, targeted interventions to enhance production will not necessarily generate desired outcomes on the consumption side. For example, targeted interventions to promote agricultural intensification may not boost food and nutrition security or promote healthy diets, as they may end up promoting an increased production of cash crops and crops destined for export, rather than products that would contribute towards healthier and more diversified local diets.

To accelerate reductions in GHG emissions from agriculture and land-use change, interventions that target emissions reductions are needed. One such option is a carbon tax, which is found to be particularly effective in bringing down emissions over the long term. However, such interventions are likely to generate increased production costs that will be passed on to consumers, driving up the cost of a healthy diet and negatively impacting efforts to reduce undernourishment. Focusing instead on "greening" production by replacing fossil fuel-based energy with a clean energy mix, can help reduce GHG emissions without as significantly impacting efforts to reduce undernourishment.

Targeted policy interventions generate trade-offs across policy objectives. For example, while interventions aiming to conserve forest cover or lower GHG emissions are effective in realizing environmental policy objectives, they raise the cost of producing food, leading to slight increases in undernourishment relative to BAU. Conversely, policy interventions that directly target undernourishment, such as a social safety net, result in a significant expansion in cropland and corresponding loss of biodiversity and an increase in GHG emissions. However, synergies in terms of positive outcomes across different policy objectives do arise from certain targeted policy interventions. For example, policy interventions that boost productivity sustainably generate improvements in terms of undernourishment as well as increased value added in agriculture.

Combining policy interventions can help mitigate negative trade-offs and capitalize on synergies, and it is crucial for generating positive outcomes across different policy objectives. GLOBIOM modelling finds that a combined package of interventions on forest conservation, agricultural intensification and undernourishment generates positive outcomes on undernourishment, while leading to reduced GHG emissions and deforestation. Similarly, MIRAGRODEP modelling finds that a combined package of policy interventions including those targeting vulnerable consumers, incentivizing production of healthier and more sustainable agricultural products, boosting productivity sustainably, reducing food loss and waste and conserving forests is projected to be most effective in generating positive outcomes across all policy goal areas. They reduce poverty and undernourishment, enhance value added per worker, improve dietary quality, lower emission intensity, and safeguard forest cover. These results highlight the importance of taking a comprehensive and integrated approach to policymaking for food systems transformation in Indonesia.

The regional dimensions of policy interventions and impacts are significant and need to be addressed – including through the adequate involvement of local and regional stakeholders in policymaking processes. Policymakers must recognize and address the different impacts various policy interventions and packages have on Indonesia's regions and provinces given their differences in biodiversity, production profiles, and poverty levels. Policymakers should also carefully assess which policy interventions and packages are most appropriate for a given region or province to maximize positive impacts, and they should take steps to ensure distributional justice through measures that address or mitigate regional inequalities arising from – or exacerbated by – policy interventions. Ensuring strong local and regional representation in policymaking processes and implementation can help with this.

Administrative capacity shortcomings need to be addressed to strengthen food systems governance. For example, improved capacity to collect taxes would result in increased revenue for public spending on agriculture, while increased capacity to enforce forest conservation measures would help curb illegal deforestation in Indonesia.

Non-governmental organisations and other stakeholders representing local and regional interests should be included in food systems transformation policymaking processes. The participation of these stakeholders in food systems policymaking and policy implementation is crucial for bringing specialized and local knowledge to policymaking processes and for ensuring ownership and effective on-the-ground implementation of policy interventions.

Policymakers and other food systems stakeholders should continue to engage with the scientific community to develop appropriate policies and policy mixes for food systems transformation. Further engagement and knowledge exchange between Indonesia's food systems stakeholders and the scientific community (including the economic modelling team) can help address the identified gaps between what stakeholders believe to be the best policy intervention packages to achieve their policy objectives and what the modelling shows to be the optimal packages. Such engagement can also help build buy-in for food systems transformation policy interventions informed by modelling and other scientific input, thereby improving the political feasibility of these interventions.

The importance of productivity growth outside agricultural sector for food systems transformation must be recognized. As demonstrated by the CGPE modelling, policy interventions that generate productivity growth outside the agricultural sector (and rising consumer incomes) will have greater impacts on many policy objectives related to food systems transformation than will interventions targeting agricultural productivity. Policymakers should therefore carefully assess the impacts of such interventions on farm incomes, domestic demand for agricultural products, food security, agricultural production, land use change, biodiversity and GHG emissions.

2. Next steps

While the modelling results and insights and policy implications drawn from these results should be helpful in informing food systems transformation policymaking in Indonesia, there is scope to build on these results and to address their implication.

Further analysis of the modelled policy interventions could be undertaken to assess the optimal design of these interventions given national and local contexts, as well as addressing questions that were not possible to answer through modelling. For example: what specific kinds of interventions boost agricultural productivity in Indonesia most efficiently and effectively? What is the most cost-effective way to implement a social safety net that targets vulnerable households in Indonesia? What is the most effective level of carbon tax to meet Indonesia's emissions reductions targets? And, crucially, what are the perspectives of key Indonesian stakeholders on these specific issues? This analysis could include a more detailed mapping of the barriers to – and the costs of – implementation of these different policy interventions (and intervention packages), identifying the relative ease or difficulty of overcoming these barriers.

The insights derived from this modelling exercize could be used to undertake an assessment of the coherence of Indonesia's current policies for food systems transformation. This could identify the extent of overlaps, contradictions, and gaps in Indonesia's policy framework as well as data and indicators that could be used to track progress on food systems transformation in the country. An assessment of policy coherence for food systems transformation should also assess coherence with global initiatives and commitments, including those relating to the SDGs and to the Paris Agreement.

Steps could be taken to deepen multistakeholder engagement around the design of policy interventions for food systems transformation in Indonesia, ensuring participation of Indonesian NGOs, local and regional stakeholders, and members of the scientific community. This engagement could help identify key issues, objectives, and indicators not addressed in this modelling exercize and could explore options for incentivizing good practices by stakeholders to, for example, address illegal deforestation and farm sustainably. A participatory modelling approach involving further knowledge exchange between stakeholders and modellers could be employed to better align stakeholder knowledge and beliefs with the logic and findings of the modelling. CGPE analysis could also be used to identify institutional setups to strengthen such multistakeholder engagement.

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GOVERNANCE AND POLICY SUPPORT - **REPORT**

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for food systems transformation in Indonesia

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