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Working Paper

# The hidden costs of Indonesia's food system

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## Highlights

- Indonesia's food system imposes social cost of negative externalities and inefficiencies in food production and consumption that are not reflected in market prices.
- These hidden costs are burdened to and paid by society in the form of reduced health, loss of productivity from poor diets, environmental degradation, pollution, food waste, agrarian conflict, and others.
- This working paper estimates these costs at US$210.7–$622.3 billion (roughly 28.5–45.4 percent of Indonesia's GDP in 2023). The scale of these costs reveals the dire consequences to society of the current food system, underscoring the need to reform it.

# Executive summary

## Introduction

Agriculture and food production are critical to Indonesia's economy. Between 2018 and 2023, the agriculture, forestry, and fisheries sector contributed 13 percent to the country's total GDP, and the food and beverage manufacturing industry contributed 6.5 percent (BPS 2024a; BPS 2024b). The agricultural sector employed up to 30 percent of Indonesia's productive workforce, employing about 50.2 million workers in 2023 (BPS 2024c), 56 percent of them women (FAO 2019a).

Despite their economic contributions, these sectors produce hidden negative effects that harm both the economy and the well-being of the Indonesian population.. Indonesia is experiencing both undernutrition and obesity. In 2022, a national nutritional survey reported that 21.6 percent of children under five suffered from stunting (Kemenkes 2022)—well above the 2024 target, set in the National Medium-Term Development Plan 2020–2024, of 14 percent. The prevalence of obesity among adults also increased, rising from 10.5 percent in 2007 to 23.4 percent in 2024 (Kemenkes 2023). Both undernutrition and obesity are signs of malnutrition and co-exist in areas of rural transition, as a result of changes in the availability of traditional and wild food, market access, and women's use of time (Purwestri et al. 2019).

The agriculture and food production sectors also contribute to deforestation, rapid land use change, uncontrollable peat fires, loss of biodiversity, and water and air pollution. The World Bank (2016) estimates the total cost of land and forest fires in Indonesia in 2015 at $16.1 billion or 1.9 percent of 2015 GDP. Kiely et al. (2021) provide a higher estimate, of $28.0 billion (3.3 percent of 2015 GDP).

In 2020, the government articulated a low-carbon development agenda in its National Medium-Term Development Plan (2020–2024), which included measures to improve food systems and land-use management in Indonesia. However, the proposed policy reforms have so far fallen short.

## About this working paper

This paper estimates the monetary value of the hidden costs of Indonesia's food system, in order to better understand the impact of Indonesia's food and agriculture sector on national development. Hidden costs are defined as the social costs of negative externalities—the indirect costs experienced by third parties of economic activity—and inefficiencies that arise from the production and consumption of food, which place a burden on society (FAO 2023b; FOLU 2019). These hidden costs include health, environmental, and social costs (Figure ES.1).

This paper estimates the monetary values of these costs using various economic valuation techniques. They include the use of direct market values for market goods and services; proxy market values for nonmarket goods and services; and cost-based methods to estimate productivity losses, the cost of sickness, the cost of abatement, and the loss of economic value from inefficient resource use. Assumptions and proxies are made based on publicly available data from Indonesia's National Bureau of Statistics (BPS); the World Bank's World Development Indicators; the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease Result Tools; and many other sources.

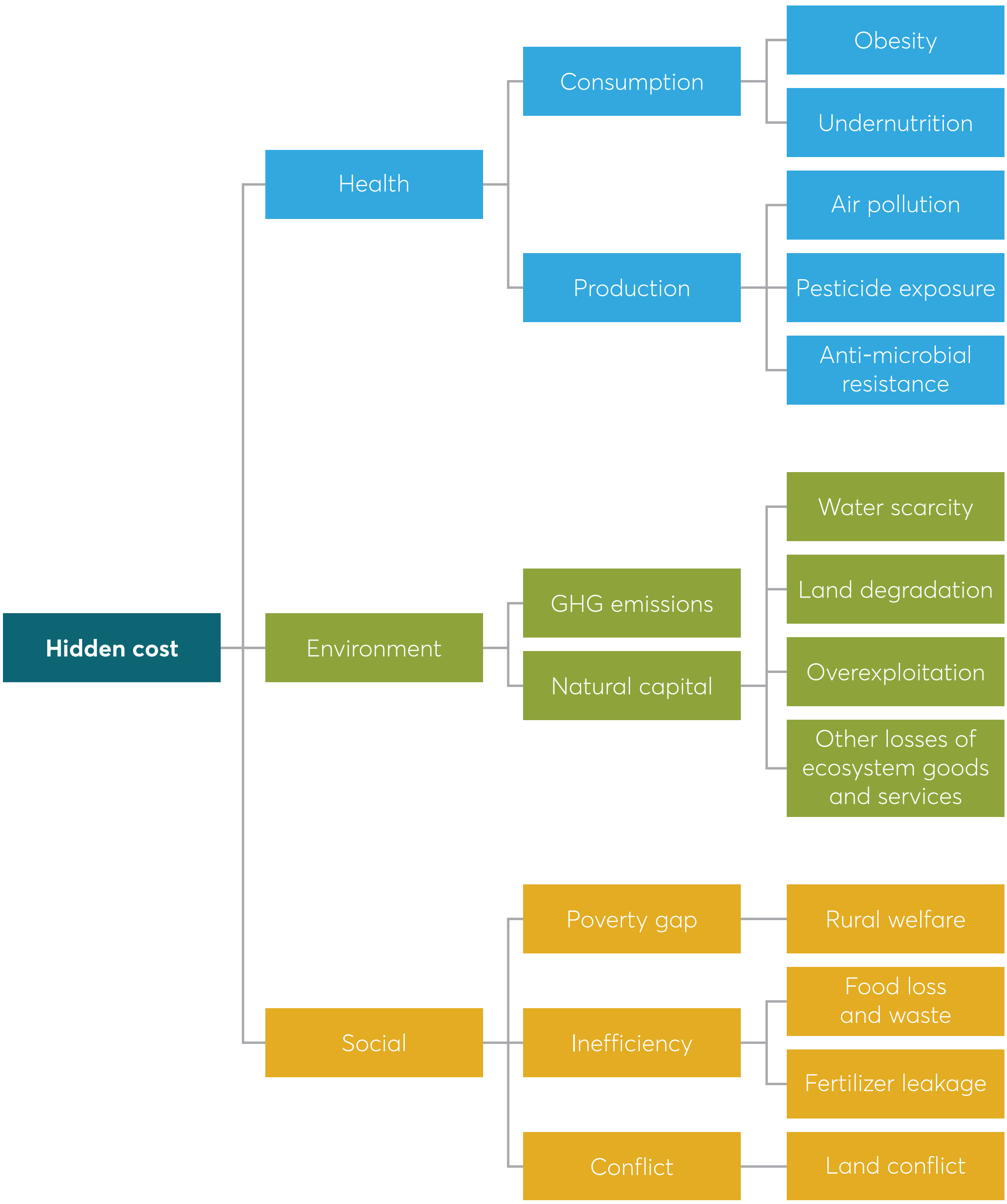
## Key findings

**The hidden costs of Indonesia's food system are estimated at $210.7–$622.3 billion equivalent to 28.5–45.4 percent of Indonesia's GDP in 2023** (we provide a range to incorporate uncertainty). Even the lower value of 28.5 percent of GDP suggests an alarming health, environmental, and social impact of the food system. The largest cost categories are air pollution, obesity, undernutrition, water scarcity, greenhouse gas emissions, and food loss and waste (Figure ES.2).

**Understanding these hidden costs is essential to transforming Indonesia's food system.** This paper emphasizes the importance of incorporating comprehensive costs, including societal losses from health, environmental, and social problems that are the result of food production and consumption and land-use practices but are not reflected in the market prices of the sector and therefore require policy reforms.

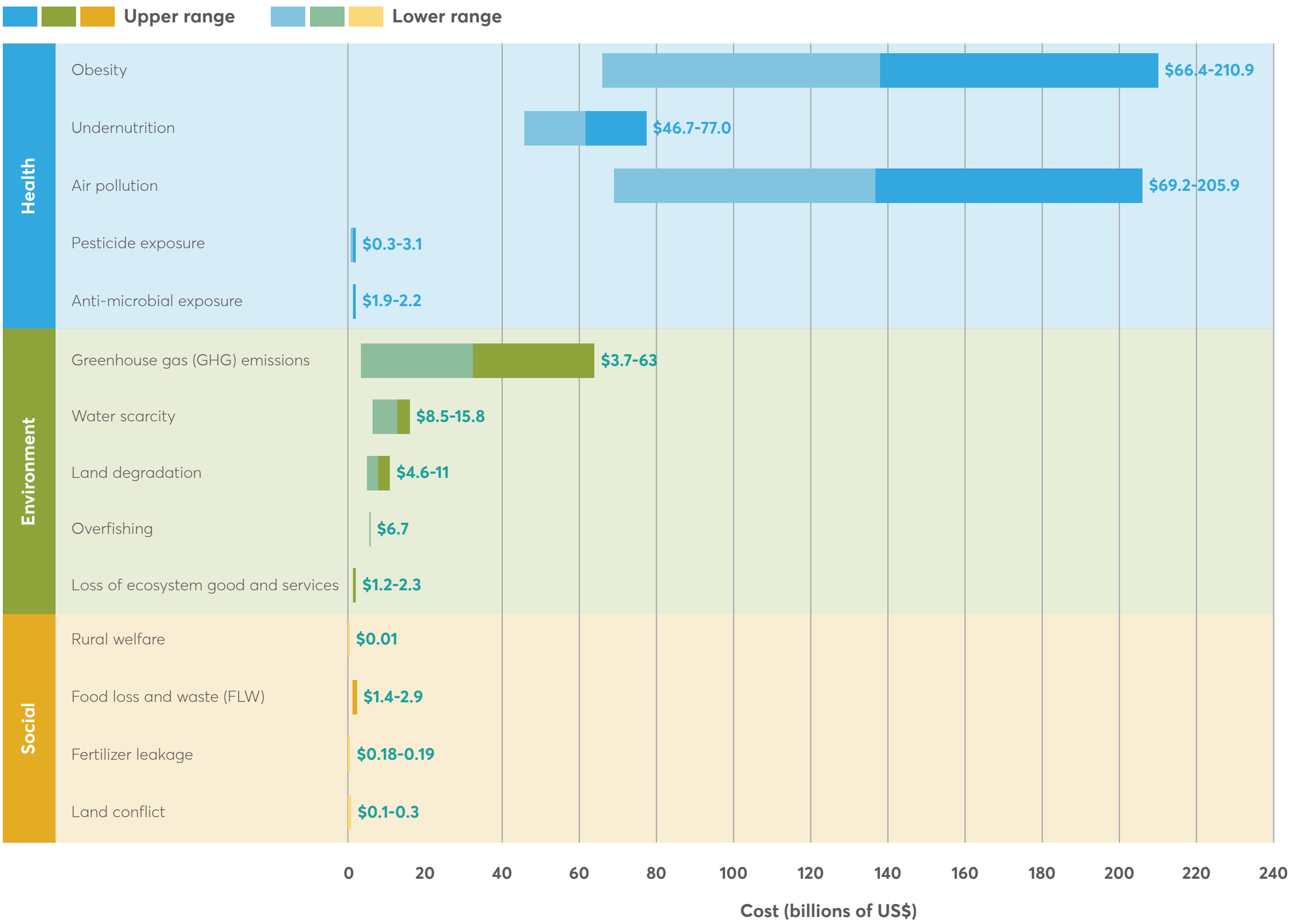
**Understanding these hidden costs is critical to informing policy decisions aimed at mitigating the impacts of the food system and reducing unintended consequences as a result of intervention.** Health costs contribute the most to hidden cost, but environmental and social costs are also significant. For example, food choices are shaped by land-use change, particularly in rural transition areas, where shifts in land use affect food availability, access to markets, and women's time use—all of which influence household food choices. (Purwestri et al 2019).

**Figure ES.1** | Categories and subcategories of hidden costs of Indonesia's food system




*Source:* Authors, based on information from FOLU (2019) and FAO (2023b).

**Figure ES.2** | Estimated range of annual hidden costs of food system in Indonesia, by category and subcategory




**Estimating the cost of the food system is difficult because of data limitations and uncertainties in cost calculation methods.** There is also the problem of setting boundaries on what a food system encompasses. Similar problems are cited by global studies, including the State of Food and Agriculture 2023 flagship report by the Food and Agriculture Organization (FAO 2023b) and The Global Consultation Report by the Food and Land Use Coalition (FOLU 2019).

## Conclusion

The estimated hidden costs of Indonesia's food system to health, environment, and social amount to 28.5–45.4 percent of Indonesia's GDP. To reduce these costs, policy priorities need to focus on integrated approaches that support small family farms and smallholders; reduce pollution; improve resource efficiency; and support accessible, healthier diets rooted in Indonesia's rich biodiversity and diverse practices surrounding food.

Addressing these hidden costs also requires overcoming structural inequalities within the food system and beyond, particularly through land reform and social safety nets. Incorporating ecological principles and innovations—whether policy, institutional, and/or technological—can help decouple agricultural and food production practices with environmental harm. Future efforts must focus on identifying vulnerable populations disproportionately affected by these hidden costs. to ensure fair and effective intervention. Reshaping Indonesia's food system is key for economic resilience, health, and well-being.

# Introduction

Agriculture and food production are critical to Indonesia's economy, accounting for 19.4 percent of Indonesia's GDP in 2018–23 (12.9 percent from the agriculture, forestry, and fisheries sector and 6.5 percent from the food and beverage manufacturing industry) (Figure 1, panel a). The food and beverage industry grew at least as rapidly as the national economy over this period (Figure 1, panel b). The agriculture and food sector represents up to 30 percent of Indonesia's productive workforce, employing 50.2 million workers in 2023 (Figure 1, panel c) (BPS 2024c), 56 percent of them women (FAO 2019a). The sector supports poverty alleviation and boosts prosperity (World Bank 2022).

These figures fail to capture the hidden costs of the sector, which include pollution, food waste, and the health consequences resulting from market, institutional, and policy shortfalls (FAO 2023b). Incorporating policy tools to reduce the hidden costs of damage imposed on society would yield better results for human well-being, the economy, and the environment (FAO 2023b).

Indonesia is facing a triple burden of malnutrition that includes stunting, micronutrient deficiencies, and obesity (Rah et al. 2021). In 2023, a national nutritional survey reported that 21.5 percent of children under five suffered from stunting (Kemenkes 2024)—well above the 2024 target set in the Mid-Term National Development Planning 2020–2024 of 14 percent.[1] This trend is likely to persist, given that about 28 percent of pregnant women suffer from anemia (Kemenkes 2023).

The health impacts from the quality of food intake and other factors is also seen in the prevalence of obesity among adults over 18, which more than doubled between 2007 and 2023, increasing from 10.5 percent to 23.4 percent (Kemenkes 2024). Indonesia faces a growing public health problem from the consumption of ultra-processed foods and sugar-sweetened beverages, which increase the risk of noncommunicable diseases such as stroke, diabetes, and hypertension (Nurwanti et al. 2019). Undernutrition and overnutrition co-exist in areas of rural transition, because of changes in the availability of traditional and wild food (less access to fruits and vegetables); changes in market access (more access to ultra-processed and sugary foods); changes in women's use of time (Purwestri et al. 2019); and other factors.

**Figure 1** | Importance of agriculture and food beverages sector in Indonesia's economy, 2018–23


*Source:* BPS (2024a, 2024b, 2024c).

[1] The World Health Organization (WHO) defines children as stunted if their height-for-age is more than two standard deviations below the WHO Child Growth Standards median.

The production side of food is beset by environmental problems, including water and air pollution, which are largely a consequence of unsustainable food production practices. As the demand for food increases, so does demand for pesticides and chemical fertilizers. Indonesia's consumption of fertilizer in 2022 was 5.5 million tonnes, 30 percent more than in 2010 (FAOSTAT 2024a). The increase exacerbates water pollution, as the impact of nitrogen-based pollutants originates largely from the agricultural sector and untreated wastewater. In 2018, 46 percent of irrigation water and over half of Indonesia's rivers—including the Citarum River, one of the most polluted rivers in the world—were heavily contaminated. Once water pollution in these rivers exceeds a threshold, it is difficult to reduce the pollutant load (Khalil et al. 2021).

Air pollution from food production starts with deforestation and land conversion. Annual deforestation in Indonesia averaged 1.37 million hectares (Mha) in 2001–15 and 1.22 Mha in 2015–23 (University of Maryland and World Resources Institute n.d.). Primary drivers of deforestation include the conversion of land for large-scale industrial plantations, agricultural expansion, mining, and illegal logging (Santoro et al. 2023). Levels of deforestation are particularly high in Sumatera and Kalimantan, mainly because of land conversion for oil palm plantations (Gaveau et al. 2016). Land clearing by burning increases the negative environmental impact of agriculture and food production. The biomasses left from deforestation serve as fuel during land (peat) fires (Goldstein et al 2020). The World Bank (2016) estimates the cost of uncontrollable land fires in 2015 at $16.1 billion (1.9 percent of 2015 GDP), with a burnt area of 2.8 million ha. Kiely et al. (2021), who include the long-term health impact of fire, estimates the cost at $28.0 billion (3.3 percent of 2015 GDP).

Deforestation also affects wildlife ecosystems, as forests and high tree canopies are habitat to various forms of wildlife, including critically endangered species like orangutans, tigers, elephants, rhinoceroses, and endemic birds. For example, between 2000 and 2015, deforestation caused 39 percent of Sumatran endemic babbler *(Trichastoma buettikoferi)* birds to lose their habitat (Symes et al. 2018). Deforestation and forest degradation, including forest conversion for food production, also affect other forms of wildlife that provide biological pest control, pollination, seed dispersal, and other services (Prabowo et al. 2016).

In 2020, the government for the first time set out a low-carbon development agenda in its National Medium-Term Development Plan (RPJMN) 2020–2024. It includes planning for protecting the environment and improving disaster and climate resilience. Policy reforms—including implementation of the agrarian reform policy, which is driven by the government's continued control over land that promotes corporate land ownership and obstructs the fair distribution of land ownership (Iqbal and Rahangiar 2020)—have fallen short. The agenda to redistribute land control is expected to safeguard against the impact of exploitative activities and rapid, high-risk land use change and inspire collective commitment for equitable land use (Faoziyah et al 2024).

## Methodology

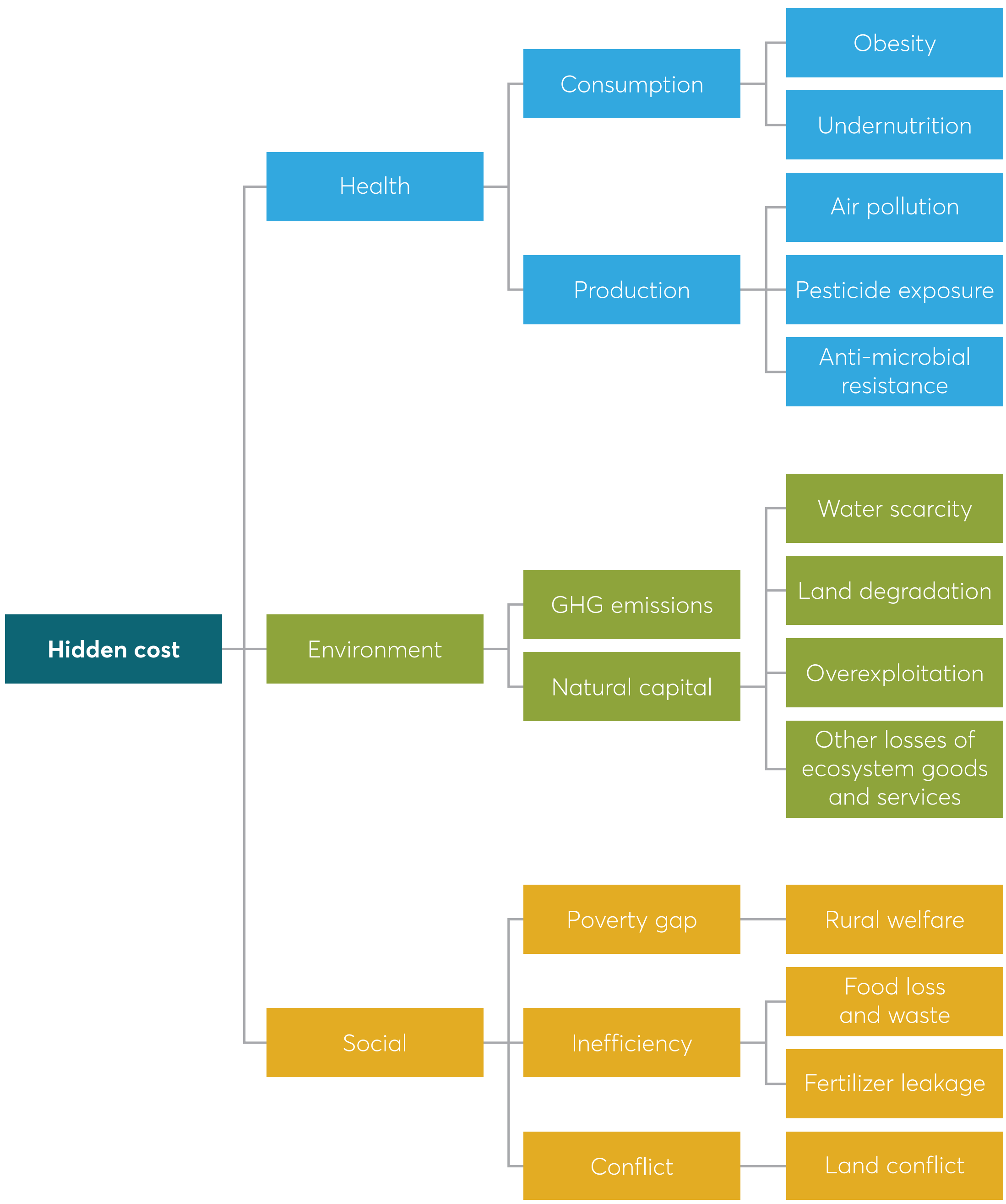
This paper estimates the hidden costs of the food system in Indonesia, in order to better understand the impact of the food and agriculture sector on the country's development. It adopts the methodology used by The Global Consultation Report of the Food and Land Use Coalition (FOLU 2019). Assumptions and proxies are based on publicly available data from Statistics Indonesia, maintained by the National Bureau of Statistics (BPS), the World Bank's World Development Indicators; the Institute for Health Metrics and Evaluation (IHME)'s Global Burden of Disease Result Tools (GBD), and many other sources. The data used are the best available up to 2025, which we converted into real value with prices in 2023. We excluded anomalous values that result from a specific event, including recessions, massive forest fires, and the COVID-19 pandemic.

We adopt the FAO (2023b) definition of hidden cost as any cost to an individual or society that is not incorporated in the market price of a product or service. Hidden costs are thus the negative externalities and inefficiencies that arise from the current means of production and consumption in the food and land-use system (FOLU 2019).

We estimated three categories of hidden costs: health, environmental, and social. Our calculations include estimates of productivity losses, the cost of illness, abatement costs, social costs, and the loss of economic value from inefficient resource use (Figure 2).

We calculated monetary values are calculated using two economic valuation techniques based on The Economics of Ecosystem and Biodiversity (TEEB 2018). For market goods and services (or proxy market value in the case of nonmarket goods and services), we used market value. We derived these values from market pricing, market-based payment for environmental services, and production function methods. For estimates of productivity losses, the cost of illness, abatement costs, social costs, and the loss of economic value from inefficient resource use, we used a cost-based method. We present the estimates in ranges rather than point estimates in order to increase transparency in communicating uncertainty (Manski 2019).

**Figure 2** | Categories and subcategories of hidden costs of Indonesia's food system




*Source:* Authors, based on information from FOLU (2019) and FAO (2023b).

## Types of impacts

We estimate the hidden cost based on annual impacts of health, environment, and social impacts. To ensure comparability, we adjusted all the costs into 2023 prices

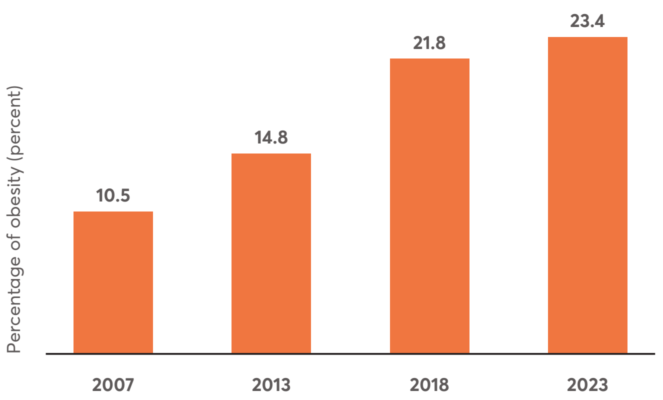
### Health impacts

The health category includes the costs of all health impacts caused by consumption and production activities.

#### Consumption

The prevalence of obesity in Indonesia more than doubled between 2007 and 2023, rising from 10.5 percent to 23.4 percent (Kemenkes 2024) (Figure 3). This trend is alarming, because obesity is a risk factor for co-morbidities such as diabetes and cardiovascular diseases (Lam et al. 2023).

**Figure 3** | Prevalence of obesity in Indonesia 2007–23




*Source:* Kemenkes (2024

*Notes:* The prevalence of obesity is the proportion of the population that has a Body Mass Index (BMI) of at least 27, based on calculations by the Ministry of Health.

Concurrently, Indonesia faces significant undernutrition, particularly among children under five. Although the trend is declining, the prevalence of stunting remains high, affecting 19.8 percent of children under five in 2024 (Kemenkes 2025) (Figure 4). The significance of this health challenges is reflected by the government's decision to transfer roughly IDR 48.8 trillion ($3.2 million) to regions in 2023 to reduce its prevalence (Kemenkeu 2023). The funds were intended to support adequate nutrition for pregnant women, mothers, and babies in their first 1,000 days, in order to optimize child growth and avoid stunting.

**Figure 4** | Prevalence of stunting, wasting, and underweight in Indonesia among children under five 2013–24


*Sources:* Data for 2013–22 are from Kemenkes (2022), data for 2023 are from Kemenkes (2024), and data for 2024 are from Kemenkes (2025).

*Notes:* Stunting is low height for age, wasting is low weight for height, and underweight is low weight for age.

The prevalence of both underdutrition and overnutrition in rural transition areas is, attributable to factors such as the diminished availability of traditional and wild food, reduced access to fruits and vegetables, altered market access and increased availability of ultra-processed and sugary food (Nurhasan et al. 2021). Changes related to the control of land use for agriculture purposes have altered diets. For example, women from traditional households in West Kalimantan consume almost 30 percent more green vegetables than women from plantation worker households (Purwestri et al. 2019).

Nutritional challenges of both over- and under-consumption are estimated on the basis of the total number of annual disability-adjusted life years (DALYs) each causes[2].

[2]DALYs are defined as the sum of all years of life lost due to death or disability from a disease or risk factor. One DALY can be considered a one-year loss in a person's expected healthy life in Indonesia. The data on DALYs for Indonesia are from the University of Washington's Institute for Health Metrics and Evaluation Global Burden of Disease Database 2021 (IHME 2021).

To calculate the cost of obesity and undernutrition, we multiplied each diet-related risk factor by the value of a year of life lost to DALYs. The value of a year of life is the value of statistical life (VSL) between productive year in Indonesia—that is calculated between Indonesia's life median age (27 years) and life expectancy (71 years) (Sweis 2024). It is used to calculate the monetary value of health (Sweis 2022). VSL is a function of three factors:

- The interest cost (at 5 percent) as a share of the of investment in health
- A diminishing marginal utility of consumption of 0.5 (and the assumption that investment in health is greater than investment in wealth)
- Wealth, as a function of wages and the time spent on work and leisure (Sweis 2022). Wages are based on GDP per capita of $15,612 at purchasing power parity (PPP) adjusted for 2023 prices (World Bank 2024).

To estimate the cost of obesity, we multiplied the DALYs for obesity (1.7–5.4 million) (IHME 2024) by the value of a year of life lost to DALYs of $39,047 (in 2023 purchasing power parity [PPP]). This value of statistical life is more than three times the per capita GDP and reflects the perceived social benefits of reducing mortality risk by incorporating not only foregone income but also other factors that contribute to an individual's future well-being. For the cost of undernutrition, we multiplied the DALYs for undernutrition (1.2–2.0 million) by the same value of a year of life lost (Table 1). To estimate the proportion of hidden costs in GDP, we used Indonesia's 2023 GDP ($1,371 billion in 2023 PPP [World Bank 2024]). These calculations yield a hidden cost of obesity and undernutrition of $113.1–$287.9 billion, or 8.2–21.0 percent of GDP (Table 1).

These calculations do not take account of other health costs, such as the effects of the increased consumption of ultra-processed foods and sugar-sweetened beverages, which also contribute to growing rates of noncommunicable diseases, such as stroke, diabetes, and hypertension (Chen et al. 2020). Unhealthy diets also increase the incidence of undernourished and stunted children, slowing economic growth. Our calculation therefore likely undervalues the true economic burden of the current food system to health.

**Table 1 |** Estimated annual health costs of obesity and undernutrition in Indonesia

| Item | Estimate |
|---|---|
| **Obesity** | |
| Loss of productive life (million disability-adjusted life years [DALYs]) | 1.7–5.4 |
| Value of year of life lost to DALYs (dollars) | 39,047 |
| **Hidden cost** | |
| Billions of dollars | 66.4-210.9 |
| Percent of GDP | 4.8-15.4 |
| **Undernutrition** | |
| Loss of productive life (million DALYs) | 1.2–2.0 |
| Value of year of life lost to DALYs (dollars) | 39,047 |
| **Hidden cost** | |
| Billions of dollars | 46.7–77.0 |
| Percent of GDP | 3.4-5.6 |
| **Total hidden costs of obesity and undernutrition** | |
| Billions of dollars | 113.1–287.9 |
| Percent of GDP | 8.2–21.0 |

*Source:* Data on DALYs are for 2021 (IHME 2024).

## Production

In the production subcategory, we look at three health impacts related to agricultural production: the loss of productive life as a result of air pollution, pesticide exposure, and anti-microbial resistance.

### Air pollution

Forest and land fires have become a near annual event in Indonesia. Clearing land by burning associated with agriculture and food production by large, medium, and smallholders is among the main drivers. Biomass left from deforestation serves as fuel during land fires, such as those occurring in peatlands (Goldstein et al. 2020). Two estimates of the impact of the uncontrolled land fires during the 2015 incident, which burned 2.8 million ha, were $16.1 billion (1.9 percent of the 2015 GDP) (World Bank 2016) and $28.0 billion (3.3 percent of the 2015 GDP) (Kiely et al. 2021), with the discrepancy arising from differences in health impact estimation.

We estimated the health impact from air pollution. The IHME database (IHME 2024) estimates the DALYs caused by air pollution from inhalable particles with diameters of 2.5 micrometers or less (PM2.5) at 2.3–5.3 million and the DALYs attributable to pollution from household solid cooking fuels at 1.1–5.4 million. For solid cooking fuel, Indonesians use firewood, largely from agriculture residue, biomass, charcoal, and animal dung (ASTAE 2013). We adjusted these figures to reflect the proportion (58 percent) of particulate matter that comes from the food system (pre-production, post-production, consumption, and waste) and from solid biomass cooking fuel (Balasubramanian et al. 2021). We then multiplied each subcategory by the value of a year of life lost. The estimated hidden costs are $52.7–$121.0 billion for air pollution and $16.4–$85.0 billion for solid household cooking fuels (Table 2). The total hidden costs from pollution in the food system are estimated at $69.2–$206.0 billion.

**Table 2** | Estimated annual health costs from pollution in Indonesia

| Item | Estimate |
|---|---|
| **Air pollution** | |
| Loss of productive life (million disability-adjusted life years [DALYs]) | 2.3–5.3 |
| Proportion of total emissions of PM2.5 from global food system (percent) | 58 |
| Value of year of life lost to DALYs (dollars) | 39,047 |
| **Hidden cost** | |
| Billions of dollars | 52.7–121 |
| Percent of GDP | 3.9–8.8 |
| **Air pollution from solid household cooking fuels** | |
| Loss of productive life (million DALYs) | 1.1–5.4 |
| Proportion of solid cooking fuels from biomass, including agricultural residues, biomass, charcoal, dung, and wood (percent) | 40 |
| Value of year of life lost to DALYs (dollars) | 39,047 |
| **Hidden cost** | |
| Billions of dollars | 16.4–85 |
| Percent of GDP | 1.2–6.2 |
| **Total hidden costs of pollution** | |
| Billions of dollars | 69.2–205.9 |
| Percent of GDP | 5–15 |

*Source:* Data on DALYs are for 2021 (IHME 2024).

### Pesticide exposure

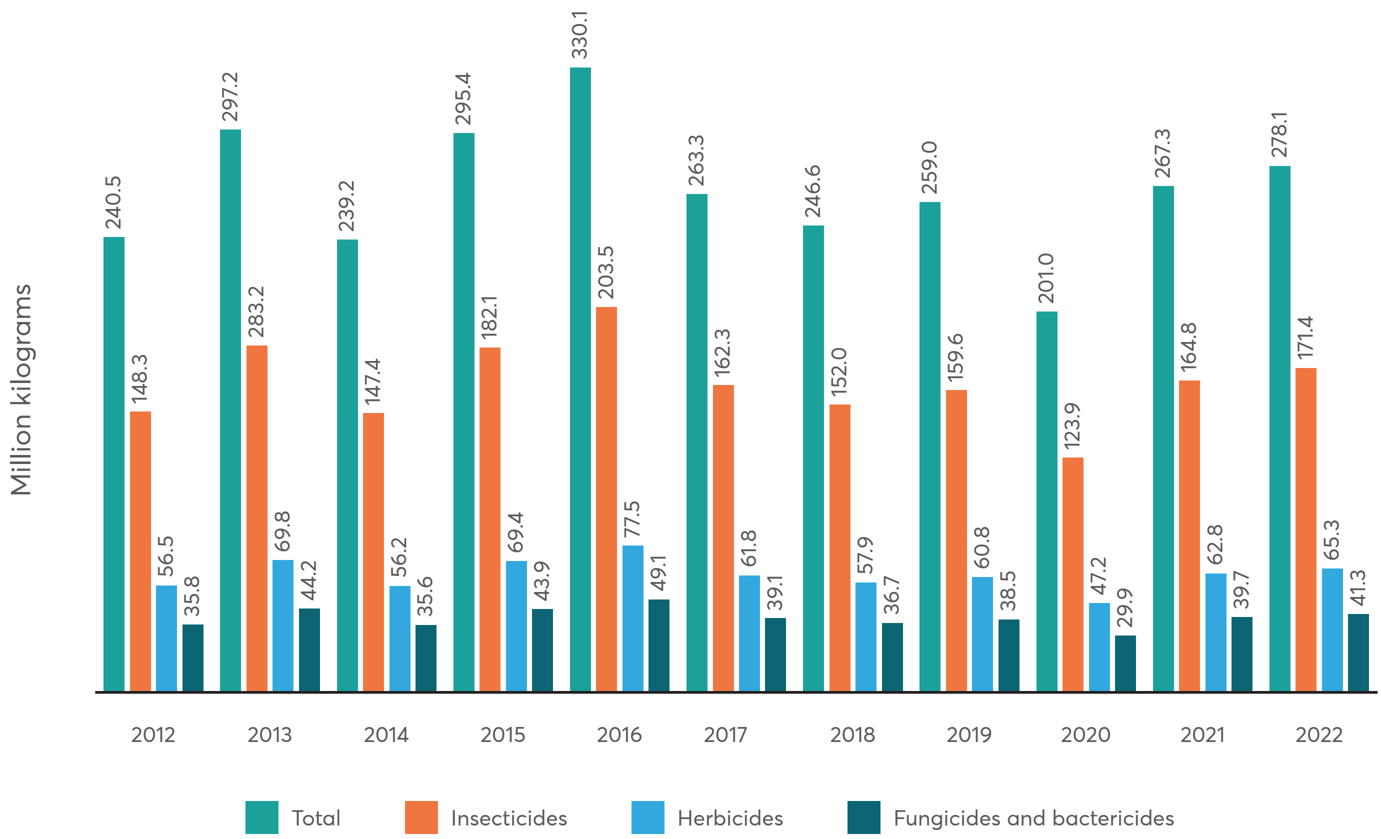
Around the world, pesticides are used to sustain crop production and meet food demand. They can harm human health if residues remain on the crops and are ingested. Pesticide residue can cause DNA damage, chronic immune system disorder, cancer, endocrine disruptions, and other health-related issues that can reduce human well-being and productivity (Munir et al. 2024). The extent of human health exposure to pesticides depends on the timing of application: More frequent and recent applications before harvest may result in higher residues in crops, posing greater health risks (Bajwa and Sandhu 2014).

In 2021, Indonesia was the world's third-largest user of pesticides, with usage of 280,000 tonnes in agriculture (FAO 2023a). Over the years usage has remained high, with insecticides the most heavily used type (Figure 5).

We estimated the impact of pesticide use on human health using DALYs/kilogram (kg) of pesticides applied per kg paddy at 0.0001–0.001 (Fantke and Joliet 2016). The calculation includes three categories of pesticides: insecticides, herbicides, and fungicides/bactericides. Rice was selected as the basis for the calculation because it accounts for the largest share of per capita staple food consumption in Indonesia (51 percent), averaging 79 kg per capita per year (BPS 2024d).

To estimate the hidden cost from pesticide exposure, we multiplied DALYs by the quantity of pesticides used. Nationally, the total annual use of pesticides was 278.1 million kg (FAOSTAT 2022b). We adjusted the total by the proportion of paddy area relative to total cropland, which is about 20 percent (Kementan 2024), to yield an estimate of 54.2 million kg of pesticide use per year. The hidden cost of pesticide exposure in Indonesia is $0.2–$2.1 billion (Table 3). The lower range is close to the empirical findings for Thailand (Mankong et al. 2022).

**Figure 5** | Agricultural use of insecticides, herbicides, and fungicides and bactericides in Indonesia, 2012–22 (million kilograms)




*Source:* FAOSTAT (2024b).

**Table 3** | Estimated annual health cost of pesticide use in Indonesia

| Item | Estimate |
|---|---|
| **Pesticide exposure** | |
| Loss of productive life (million disability-adjusted life years [DALYs]/kg) from specific crop of paddy | 0.0001–0.001 |
| Volume of pesticides applied (million kg) | 54.3 |
| Value of year of life lost to DALYs (dollars) | 39,047 |
| **Hidden cost** | |
| Billions of dollars | 0.2–2.1 |
| Percent of GDP | 0.02 |

*Source:* Estimates of the value of loss of productive life are from Fantke and Joliet (2016).

### Anti-microbial resistance

Anti-microbial resistance (AMR) is a global health challenge, affecting human and animal health, food safety, and the environment. It refers to the ability of micro-organisms (such as bacteria, viruses, and some parasites) to develop mechanisms that protect them from the effects of anti-microbials (such as antibiotics, antivirals, and antimalarials), especially the misuse of anti-microbials.

To calculate the economic cost of AMR, we used the estimate derived from Taylor et al. (2014), which is based on the cost of loss of labor productivity caused by four categories of disease: HIV; tuberculosis; malaria; and infections caused by *E. coli, K. pneumoniae, and S. aureus.* Taylor et al. use a dynamic general equilibrium model to estimate the impact of AMR on labor by world regions.

Their model does not provide estimates for Indonesia. However, it does provide an estimate for Eurasia, which includes Indonesia. We used the estimated annual GDP loss attributable to AMR in Eurasia ($22.2–$159.6 billion) based on 0–40 percent resistance. Indonesia's labor force accounts for 27.5 percent of the Eurasian labor force (ILO 2018). To estimate the loss of GDP attributable to AMR in Indonesia, we multiplied Indonesia's labor share by the total GDP loss attributable to AMR in Eurasia. The result is $6.1–$43.9 billion in 2011 (the year of the estimates in Taylor et al. 2014). We then inflated the figures to 2023 prices, yielding a range of $9.8–$113.7 billion.

To estimate the share of AMR associated with the food system, we used a meta-analysis of the global prevalence of foodborne pathogens that exhibit antibiotic resistance (Tao et al. 2022), which reports a prevalence of AMR foodborne pathogens in human clinical specimens of about 19 percent. To estimate the health cost attributable to AMR, we multiplied the total GDP loss attributable to AMR in Indonesia by 19 percent (Table 4).

**Table 4** | Estimated annual health cost of anti-microbial-resistant foodborne pathogens in Indonesia

| Item | Estimate |
|---|---|
| **Anti-microbial resistance (AMR) exposure** | |
| Total loss of GDP in Indonesia attributable to AMR (billion $) | 9.8–113.7 |
| Percent of AMR related to a food system in Indonesia | 19 |
| **Hidden cost** | |
| Billions of dollars | 1.9–2.2 |
| Percent of GDP | 0.1-1.6 |

*Sources:* Indonesia's GDP loss attributable to AMR is from Taylor et al. (2014), the 2011 price inflated to 2023 price. The share of AMR related to a food system in Indonesia is from Tao et al. (2022).

## Environmental impacts

The environmental category includes the costs of greenhouse gas (GHG) emissions from food production and consumption and natural capital impacts (i.e., water scarcity, land degradation, overexploitation of natural food production, and other losses in ecosystem goods and services).

### Greenhouse gas (GHG) emissions

The food system contributes a substantial proportion of GHG emissions. These emissions come from agriculture processes, land use changes, food processing, transportation, food and other waste, and many other sources.

To estimate the volume of GHG emissions from the food system, we used total annual GHG emissions from agriculture production, deforestation, the food supply chain, and the application of urea fertilizer. To approximate the cost of emissions, we applied two carbon pricing benchmarks. The lower estimate uses a carbon price of $5/tonne of carbon dioxide equivalent (t $CO_2$-eq), based on Norway's payment for GHG reduction from deforestation and forest degradation to Indonesia between 2016 and 2017 (Mongabay 2020; Groom et al. 2022). The upper value reflects the social cost of carbon dioxide (SC-$CO_2$) of agriculture, defined as the monetized value of societal damages from an incremental metric tonne of $CO_2$ at $84/t $CO_2$-eq (Rennert et al. 2022). We then multiplied the estimated carbon cost by our estimate of annual GHG emissions to yield an estimate of the hidden cost of GHG emissions from the food system of $3.7–$63.0 billion (Table 5).

## Natural capital impacts

We highlight the environmental impact of nature as natural capital, including water, land, environmental resources for food production, and other services of ecosystem to food production.

### Water scarcity

Water scarcity is the lack of sufficient water resources to meet demand, as a result of, among other factors, insufficient infrastructure. Agricultural water use imposes substantial costs on other current and potential users, particularly when it is unsustainable (Irianto 2007). In Indonesia, for example, water lost through irrigation leakage affects other users, with the agricultural sector accounting for 74 percent of the country's freshwater use (Tirtalistyani et al. 2022).

To estimate the cost of water scarcity, we multiplied the share of unsustainable use of water by the drinking water tariff ($0.18/cubic meter [$m^3$]/year, according to OECD 2023) by the total volume of annual freshwater withdrawals for agriculture (189.7 billion $m^3$/year, according to FAO 2018). The share of agricultural freshwater withdrawals that are unsustainable is estimated at 25–46 percent. The lower estimate (25 percent), from FOLU (2019), represents the share of global freshwater withdrawals for agriculture that are unsustainable or at risk of becoming so. The higher estimate (46 percent), from Khalil et al. (2021) represents the percentage of freshwater wasted as a result of poor irrigation system for agriculture sector in Indonesia. Our estimate of the hidden economic cost of water scarcity is $8.5–$15.7 billion (Table 6).

**Table 5** | Estimated annual environmental costs of greenhouse emissions in Indonesia

| Item | Estimate |
|---|---|
| **Greenhouse gas (GHG) emmisions** | |
| Total annual greenhouse gas emissions in Indonesia from food and land use system, including agricultural production, deforestation, food supply chain, and urea fertilizer application (billion t $CO_2$eq) | 0.75 |
| Carbon cost (dollars/t $CO_2$-eq) | 5–84 |
| **Hidden cost** | |
| Billions of dollars | 3.7–63 |
| Percent of GDP | 0.3–4.6 |

*Sources:* Total Indonesia annual greenhouse gas emissions from the food and land use system are from KLHK (2018). Estimate of carbon cost in Indonesia is from Groom et al. (2022) and Rennert et al. (2022).

**Table 6** | Estimated annual environmental cost of water scarcity in Indonesia

| Item | Estimate |
|---|---|
| **Water scarcity** | |
| Total annual water withdrawals for agriculture in Indonesia (billion $m^3$) | 189.7 |
| Indonesia average scarcity cost of water proxied by drinking water tariff in Indonesia (dollars per $m^3$) | 0.18 |
| Share of freshwater withdrawals for agriculture that are unsustainable (percent) | 25–46 |
| **Hidden cost** | |
| Billions of dollars | 8.5–15.8 |
| Percent of GDP | 0.6–1.1 |

*Sources:* Total Indonesia annual water withdrawals for agriculture are from FAO (2018). Indonesia average scarcity cost of water proxied by drinking water tariffs are from OECD (2023). The share of freshwater withdrawals for agriculture in Indonesia that are unsustainable or at risk of becoming so is from FOLU (2019). The share of poor irrigation in Indonesia used to estimate the upper value of unsustainable freshwater withdrawal is from Khalil et al. (2021).

### Land degradation

Degraded land is land that was once used for agriculture activities but has become unproductive and/or abandoned and reverted to shrubland or bare land (Wardhana 2013). To estimate the extent of degraded land in Indonesia, we used data on the area of shrubland or bare land in agriculture cropland zoning area reported by the Ministry of Agriculture in 2019 (Kementan 2024). To calculate the land degradation cost, we summed the cost of yield and soil biodiversity losses.

To estimate the cost of yield loss, we multiplied the total degraded cropland area in Indonesia by the annual value of production/ha and the share of yield loss from land degradation (4–12 percent). The lower value (4 percent) is derived from the share of farmers in Indonesia that experience degradation of agricultural land, in the form of soil erosion, reduced soil fertility, or salinization of irrigation land (Wardhana 2013). The upper value (12 percent) is based on soil erosion observed in the European Union of 4–12 percent, based on a review of the studies summarized in Panagos et al. (2018).

To estimate the cost of soil biodiversity loss, we multiplied total degraded cropland in Indonesia by the economic value of soil ecosystems services/ha and the loss of soil biodiversity resulting from land degradation. We used an economic value of soil ecosystem services/ha of $410/year in 2020, based on the systematic review by Brander et al. (2024). We then inflated the figure to reflect 2023 prices, yielding a figure of $452/ha. We derived the share of loss of soil biodiversity caused by land degradation (25 percent) from expert review estimations used to calculate the hidden cost of the global food and land use system (FOLU 2019).

We estimate the total environmental cost of land degradation in Indonesia at $4.6–$11.0 billion (Table 7).

### Overexploitation of natural food production

Overexploitation of natural food production takes many forms. As a proxy for overexploitation, we used data on illegal, unregulated, and unreported (IUU) fishing, which depletes the fish stock (Jensen et al. 2017).

IUU fishing takes various forms in Indonesia. The most important violaters are foreign boats that have (a) fishing license but understate the size of their vessels in order to avoid inspection and taxes, (b) hide their ownership under local names in order to benefit from the Indonesian government's fuel subsidy, and (c) forge fishing licenses and enter waters designated for small-scale regional fishers.[3]

**Table 7** | Estimated annual environmental costs of land degradation in Indonesia

| Item | Estimate |
|---|---|
| **Cost of yield loss** | |
| Total area of shrubland or bare land in agriculture purposed area Indonesia, 2019 (million ha) | 11.8 |
| Annual value of crop production/ha of cropland, proxied by agriculture GDP 2023 divided by total cropland area, 2019 ($/ha) | 6,860 |
| Yield loss from land degradation (percent) | 4–12 |
| **Hidden cost** | |
| Billions of dollars | 3.2–9.7 |
| Percent of GDP | 0.2–0.7 |
| **Cost of soil biodiversity loss** | |
| Total area of shrubland or bare land in agriculture purposed area in Indonesia, 2019 (million ha) | 11.8 |
| Economic value of soil ecosystem services per hectare ($/ha) | 452.2 |
| Loss of soil biodiversity from land degradation (percent) | 25 |
| **Hidden cost** | |
| Billions of dollars | 1.3 |
| Percent of GDP | 0.1 |
| **Total hidden costs of land degradation** | |
| Billions of dollars | 4.6–11 |
| Percent of GDP | 0.3–0.8 |

*Sources:* The total area of degraded cropland in Indonesia in 2019 is from Kementan (2024). The annual value of crop production/ha of cropland, as proxied by agriculture GDP in 2023 divided by total cropland area in 2019, is based on data from the World Bank (2023), BPS (2023c), and Kementan (2024). Yield loss from land degradation is from Wardhana (2013) and Panagos et al (2018). The economic value of soil ecosystem services/ha is from 2020 data in Brander et al. (2024), inflated to 2023. Loss of soil biodiversity from land degradation is from FOLU (2019), based on expert opinion.

Indonesia is the world's second-largest producer of marine wild catch fish and the top producer of tuna. The country loses billions of dollars of revenue annually as a result of IUU fishing. Palma, Tsamenyi, and Edeson (2010) estimate these losses at $4 billion a year for tuna alone. The total global annual economic cost of illegal fishing is about $10–$23 billion—18 percent of the estimated global fisheries catch (Agnew et al. 2009).

As data on these forms of IUU fishing are not available, we used the global 18 percent (Agnew et al. 2009) figure of IUU fishing and applied it to Indonesia's total annual fisheries product ($37 billion), to yield a figure of $6.7 billion (Table 8).

**Table 8** | Estimated annual natural capital costs of overfishing in Indonesia

| Item | Estimate |
|---|---|
| **Overfishing** | |
| Contribution of fisheries sector to GDP, 2023 (billion $) | 37 |
| Share of fisheries catch that is illegal and unreported (percent) | 18 |
| **Hidden cost** | |
| Billions of dollars | 6.7 |
| Percent of GDP | 0.5 |

*Source:* The contribution of fisheries sector to GDP 2023 is from World Bank (2023) and BPS (2023c). The estimate of global fisheries catch that is illegal and unreported is from Agnew et al. (2009).

### Other losses of ecosystem goods and services

We estimated the cost associated with losses in ecosystem goods and services from estimates of the cost of forest clearance for agriculture, mangrove clearance for agriculture, and the destruction of pollinators. To estimate the loss of forest clearance for agriculture, we multiplied the annual rate of deforestation for agriculture (0.14 million ha) (BPS 2019) by the economic value of ecosystem services provided by tropical forest ($179/ha) (UNORCID 2015 and BPS 2025). To estimate the cost of mangrove clearance for agriculture, we multiplied the economic value of mangroves ($3,625–$26,735/ha) (Rizal et al. 2018) by the annual mangrove loss caused by aquaculture (18,209 ha) (Arifanti et al. 2021). To calculate the economic costs of the destruction of pollinators, we multiplied Indonesia's annual value of food crop production reliant on pollinator services by the estimate of the share of food crops in Indonesia that rely on pollination ($3.9–6.4 billion) (Khalifa et al. 2021). Indonesia's average yield reduction from loss of pollinators is from Olschewski et al. (2006). The estimated environmental cost of loss ecosystem goods and services in Indonesia is $1.2–2.3 billion.

Table 9 is not an exhaustive list of losses in ecosystem goods and services. It relies on subjective judgment and the limited information available with which to convert losses into monetary terms (IPBES 2022; OECD 2018). The objective of including it is not to provide a definite cost estimate but to help clarify trade-offs in public policy—the fact that some economic activity in the food system imposes costs on society. We discuss this issue further in the results and discussion section.

[3]Policy can reduce the effects of IUU. In 2016, for example, the government of Indonesia imposed a moratorium on foreign vessels over 30 gross tonnage (GT). As a result, Indonesia's ranking in the most-fished countries by foreign fleet fell from 14th in 2014 to 86th in 2016 (Cabral et al. 2018). The economic impact of IUU fishing is not only the gross profit loss from direct fish catch, however. It also includes the economic loss of value added across the fish value chain, the income loss to fisher households if the catch is sold legally, and the loss of tax income from the entire fish value chain (Sumaila et al. 2020).

**Table 9** | Estimated annual environmental costs of loss of ecosystem goods and services in Indonesia

| Item | Estimate |
|---|---|
| **Forest clearance for agriculture** | |
| Economic value of ecosystem services from tropical forest ($/ha) | 179 |
| Annual deforestation caused by agriculture (million ha) | 0.14 |
| **Hidden cost** | |
| Billions of dollars | 0.03 |
| Percent of GDP | 0.002 |
| **Mangrove clearance for agriculture** | |
| Economic value of mangrove ecosystem considering its direct-use, indirect-use, option, and existence values ($/ha) | 3,624–26,734 |
| Annual mangrove loss caused by aquaculture (ha) | 18,209 |
| **Hidden Cost** | |
| Billions of dollars | 0.1–0.5 |
| Percent of GDP | 0.01–0.04 |
| **Destruction of pollinators** | |
| Annual value of food crop production in Indonesia reliant on pollinator services (billion $) | 3.9–6.4 |
| Average yield reduction from loss of pollinators in Indonesia (percent) | 28 |
| **Hidden cost** | |
| Billions of dollars | 1.1–1.8 |
| Percent of GDP | 0.1–0.13 |
| **Total hidden costs of loss of ecosystem goods and services** | |
| Billions of dollars | 1.2–2.3 |
| Percent of GDP | 0.1–0.2 |

*Sources:* The economic value/ha of ecosystem services from tropical forests is proxied by the 2008–12 economic value of ecosystem data from UNORCID (2015) divided by the total area of tropical forests in Indonesia from BPS (2025). Deforestation caused by agriculture is estimated from data on land cover change from forest area to agriculture from BPS (2019). The economic value of Indonesia's mangrove ecosystem is from Rizal et al. (2018). The annual mangrove loss caused by aquaculture is from Arifanti et al. (2021). The annual value of food crop production in Indonesia that is reliant on pollinator services is from Khalifa et al. (2021). Indonesia's average yield reduction from loss of pollinators is from Olschewski et al. (2006).

## Social impacts

The social impacts include the costs of rural welfare, food loss and waste, fertilizer leakage and palm oil conflicts.

### Rural welfare

The majority of people in developing countries live in rural areas and engage in low-productivity agriculture activities (McCulloh, Timmer, and Weisbrod 2007). Moving out of the agriculture sector is not always the answer to moving out of poverty, however, as farmers often lack the skills needed to work in nonagricultural sectors. This problem is often recognized as a malfunction of the economic system, in which rural people are unable to rise out of poverty because the lack the needed skills and access to jobs that would allow them to do so (Moeis et al. 2020). Therefore, excluding farmers from rural areas to capture the welfare gain potential similar to the urban experience.

Agriculture sector growth in Indonesia slowed in the 2020s, dampening efforts to reduce poverty (Moeis et al. 2020). Agriculture production systems need improvement to help rural people rise above the poverty line.

We define the rural welfare cost as the difference between the current average national poverty line and the rural poverty line. The poverty line in Indonesia is $2.5/day, based on the Cost of Basic Needs (CBN) approach (TNP2K 2020)[4]. The rural poverty line was $1.1/day in 2023 (BPS 2023a). We multiplied the poverty gap ($1.4) by the number of rural people living below the poverty line (14.2 million) and the share of rural poor people who work in agriculture (64 percent) (World Bank 2020). This calculation yields an estimate of about $12.4 million (Table 10).

[4]The national poverty line is based on the Cost of Basic Needs (CBN) approach (Tim Nasional Percepatan Penanggulangan Kemiskinan 2020), which calculates the food consumption expenditures necessary to meet the minimum nutritional requirement of 2,100 calories per person per day.

**Table 10** | Estimated annual cost of gap in rural welfare in Indonesia

| Item | Estimate |
|---|---|
| **Rural welfare** | |
| Poverty gap, proxied by the difference between the national and rural poverty lines, 2023 ($/day) | 1.4 |
| Number of people in rural areas of Indonesia living below the poverty line, 2023 (million) | 14.2 |
| Share of rural poor in Indonesia employed in the agriculture sector, 2018 (percent) | 64 |
| **Hidden cost** | |
| Millions of dollars | 12.4 |
| Percent of GDP | 0.0 |

*Sources:* The poverty gap (the difference between the national and rural poverty lines) is from TNP2K (2020) and BPS (2023a). The number of people in rural areas living below the poverty line is from BPS (2023b). The share of the rural poor employed in the agriculture sector is from World Bank (2020).

### Food loss and waste

Food loss is the reduction in the quantity and quality of good during production, post-harvest, and processing stages. Food waste is waste that occurs during distribution and consumption (FAO 2011). FAO (2019b) reports that 14 percent of the world's food is lost at the postharvest, storage and handling, and distribution levels and 17 percent food is wasted at the retail and consumption levels. In Indonesia, annual food loss and waste in 2000–19 averaged 23–48 million tons (Bappenas 2021), equivalent to 115–184 kg/capita/year. Based on five food sectors in Indonesia, the average annual share of food loss and waste is 15.3 percent of domestic supply[5].

Food loss and waste increase the inequality of the food system. Surplus food that is wasted by people who are better off reduces the resources devoted to and access to healthy food by poor people, increasing inequality. Such inequality of wasted food surplus exists in current unequal economy (Aaron and Budiman 2025). Indonesia has paid little attention to its food rescue program, which involves redistributing surplus food and developing strategies for reducing waste (Aaron and Budiman 2025).

To estimate the hidden cost from food loss and waste, we multiplied the annual volume of food loss and waste (23-48 million tonnes) by the per tonne cost of waste management in landfills (Soesanto et al. 2021). This estimate likely underrepresents the true cost, as it accounts only for the economic burden of managing food waste that ends up in landfills, and not the forgone loss of resources and nutrition components of the food that was wasted. Based on this approach, the estimated hidden economic cost of food waste and loss amounts to $1.4–$2.9 billion (Table 11).

**Table 11** | Estimated annual cost of food loss and waste in Indonesia

| Item | Estimate |
|---|---|
| **Food loss and waste** | |
| Estimated food loss and waste generated annually in Indonesia, 2021 (million tonnes) | 23–48 |
| Estimated cost of waste management in landfill ($/tonne) | 59.8 |
| **Hidden cost** | |
| Billions of dollars | 1.4–2.9 |
| Percent of GDP | 0.1–0.2 |

*Sources:* Estimate of food loss and waste is from Bappenas (2021). The cost of food waste management to landfill is from Soesanto et al. (2021) and converted in to 2023 dollars.

[5] The report does not break out separate figures for food loss and food waste.

### Fertilizer leakage

The leakage of fertilizer within the food system comes mainly from agricultural runoff. It creates significant environmental and health hazards. The over-application of fertilizers results in nutrient pollution, triggers eutrophication of aquatic environments, promotes harmful algal blooms, and risks contaminating drinking water supplies (Metson, Chaudhary et al. 2021).

Most of the fertilizers used in Indonesia are nitrate- and phosphate-based[6]. We include only these fertilizers in our calculation, because data on other fertilizers were not available.

Paddy farmers in Indonesia tend to use excessive quantities of nitrate to ensure crop productivity, even though crops can absorb no more than a certain amount of fertilizer (Triyono, Purwanto, and Budiyono 2013). According to a study of South Sulawesi, Indonesia (Herniwati and Nappu 2018), the average amount of nitrogen fertilizer needed to achieve maximum paddy production of 7.15 tonnes/ha is 129 kg/ha in the rainy season and 132 kg/ha in the dry season. In Indonesia, farmers average 135 kg/ha regardless of the season, about 3–4 percent more than optimal. For phosphate, we therefore used the figure from Roberts and Johnston (2015) on the average leakage rate of phosphate fertilizer, 50 percent. In 2022, Indonesia farmers used 3 million tonnes (MT) of nitrates and 0.6 million MT of phosphates, at an average price/tonne of $217.2 and $554.4, respectively.

To calculate the cost of fertilizer leakage, we multiplied the total application of nitrates and phosphate in Indonesia by the average share of the unabsorbed fertilizer. We then multiplied this figure by the average price of nitrates and phosphates to come up with an estimate of $180–$190 million (Table 12).

**Table 12** | Estimated annual costs of fertilizer leakage in Indonesia

| Item | Estimate |
|---|---|
| **Leakage of nitrate fertilizers** | |
| Average leakage rate of nitrate fertilizers in Indonesia (percent) | 3–4 |
| Total application of nitrate fertilizers in Indonesia, 2022 (million tonnes) | 3 |
| Average price of nitrates, 2023 ($/tonnes) | 217.2 |
| **Hidden cost** | |
| Millions of dollars | 19.4–25.9 |
| Percent of GDP | 0.001–0.002 |
| **Leakage of phosphate fertilizers** | |
| Average leakage rate of phosphate fertilizers, proxied by global figure (percent) | 50 |
| Total application of phosphate fertilizers in Indonesia, 2022 (million tonnes) | 0.6 |
| Average price of phosphate, 2023 ($/tonne) | 554.4 |
| **Hidden cost** | |
| Millions of dollars | 161.4 |
| Percent of GDP | 0.01 |
| **Total hidden costs of fertilizer leakage** | |
| Millions of dollars | 180.8–187.3 |
| Percent of GDP | 0.013–0.014 |

*Sources:* The average leakage rate in Indonesia is from Herniwati and Nappu (2018) for nitrate fertilizers and from FOLU (2019) for phosphate fertilizers. Total application of nitrate and phosphate fertilizers in Indonesia in 2022 is from FAOSTAT (2022a). The average price of nitrates and phosphates in 2023 are from Bloomberg (2023a, 2023b).

[6] Nitrate fertilizers included in the calculation are urea and ZA types; phosphate fertilizers are represented by SP-36 type.

### Conflicts

We use the case of palm oil conflict to capture agrarian conflict as a result of food production. Palm oil is Indonesia's second-largest export (after coal briquettes), accounting for 8.8 percent of total exports in 2023 (Trademap 2023). The sector directly employed 4.4 million workers in 2018, including about 4 million workers on large national private oil palm plantations and 400,000 workers on state-owned and international private oil palm plantations (Katadata 2019).

**Table 13** | Main causes of palm oil conflicts in Indonesia

| Driver | Main causes |
|---|---|
| Land | • Disputed land claims and property rights<br>• Lack of consent for use of land<br>• Inadequate compensation for land use |
| Plasma[a] or family smallholders | • Disagreements over contractual arrangements<br>• Issues surrounding plasma development and terms |
| Labor | • Migrant populations' disappointment over number of job opportunities available to local people or preferential use of nonlocal labor (coming from outside the plantation area)<br>• Employee recruitment process<br>• Labor conditions/wages |
| Environment | • Environmental degradation and habitat destruction<br>• Pollution of natural resources<br>• Interference with livelihoods due to environmental damage |

*Source:* Barreiro et al. (2016).

*Notes:*
a. Under Government Regulation (PP) 26/2021 concerning the implementation of Agricultural Sector, palm oil companies that receive permits for cultivation are required to build plantation plasma of 20 percent of the land area, meaning they must give the area to family or household smallholder to grow and manage oil palm in those 20 percent of the land.

The industry is subject to conflicts, especially between palm oil corporations and local communities and/or small plantation owners (Berenschot et al. 2024; Barreiro et al. 2016). Table 13 identifies the drivers and main causes of these conflicts, which sometimes involve violence.

To calculate the cost of conflicts in the palm oil industry, we multiplied the cost of conflicts/ha of plantation area by the total area of palm oil plantation owned by the government and private companies (Table 14). Per Barreiro et al. (2016), the cost of conflict includes both tangible costs (such as staff time in negotiating, legal costs, and the loss of business from delays in operations) and intangible costs (such as loss of reputation following involvement in land conflict and negative impacts on future borrowing opportunities or company share price)[7]. They estimate the cost of conflict that has the highest likelihood of occurring at $934–$2,201/ha. We multiplied the estimated cost of conflict/hectare by 127,281 ha subject to conflict originating from palm oil plantations, as estimated by the Consortium for Agrarian Reform (KPA 2025).

**Table 14** | Estimated annual cost of palm oil conflicts in Indonesia

| Item | Estimate |
|---|---|
| **Land conflict** | |
| Cost of oil palm conflicts/ha, 2016 ($) | 933.7–2,201 |
| Reported area of agrarian conflict of palm oil plantation, 2023 (ha) | 127,281 |
| **Hidden cost** | |
| Billions of dollars | 118.8–280.1 |
| Percent of GDP | 0.01–0.02 |

*Sources:* Estimate of cost of oil palm conflict/ha is from Barreiro et al. (2016). Reported area of conflict from palm oil plantations is from KPA (2025).

[7] In 2016, the Roundtable of Sustainable Palm Oil (RSPO), a certification body, terminated 19 companies and suspended 16 because of reports of deforestation and outbreaks of fire in their concession areas. The suspension resulted in significant consequences for at least one major palm oil company, which lost several of its major buyers and saw its share price drop significantly (The Guardian 2016a; Barreiro et al. 2016; RSPO 2016).

## Market value of Indonesia's agriculture and food sector

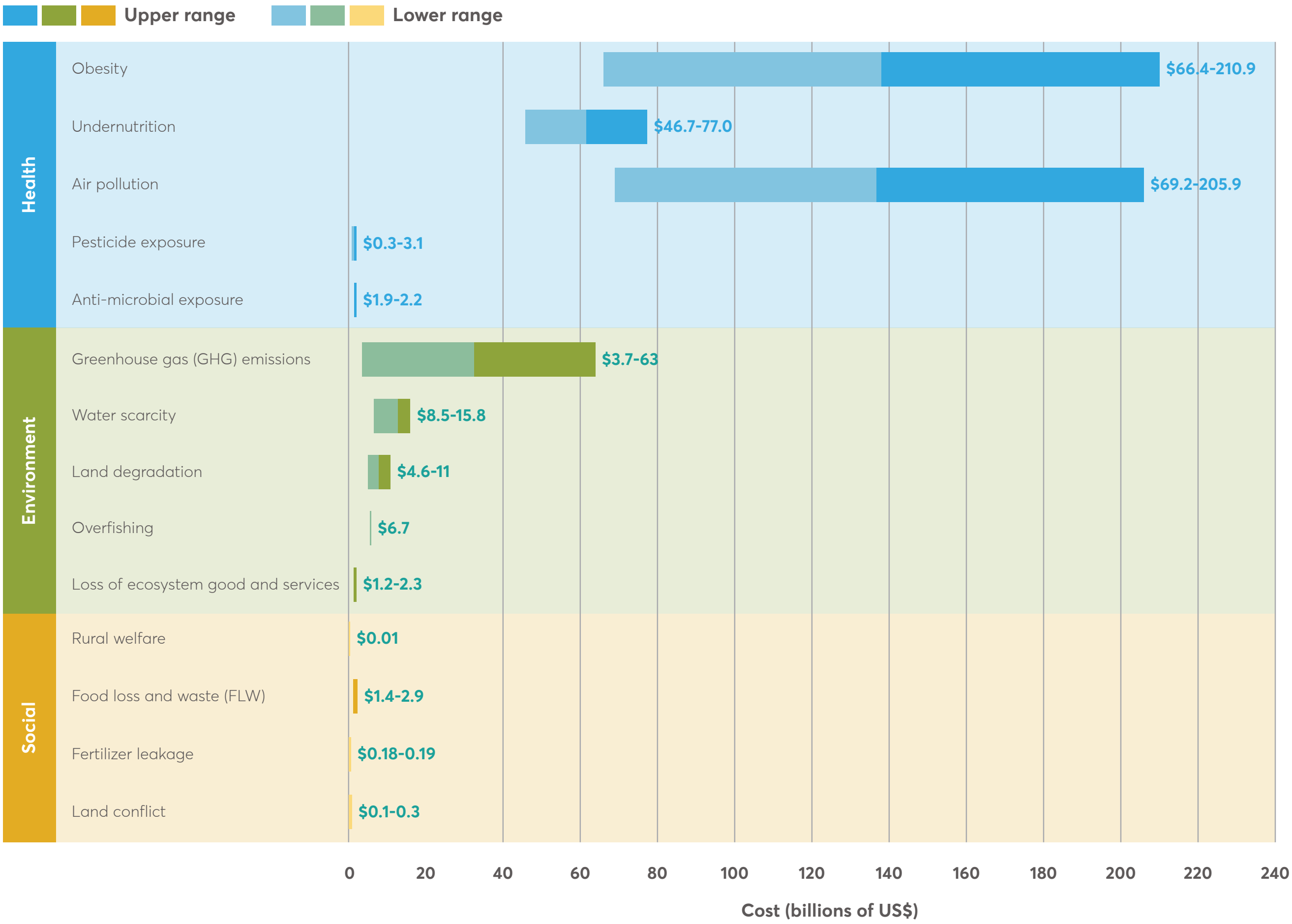
We used total GDP to estimate the market value of Indonesia's food system,[8] which comprises the agriculture sector (ISIC 0111–0322) and the food and beverage sector (ISIC 1010–1104) (Table 15). We then added the cost of logistics. Santoso et al. (2021) estimate that logistics in Indonesia accounted for 23.6 percent of GDP in 2015. We multiped this figure by the share of agriculture and food sectors in GDP to estimate the logistics cost in the sector.

**Table 15** | Estimated market value of agriculture and food sector Indonesia, 2023

| Item | Value (billions of dollars) |
|---|---|
| Agriculture output, 2023 | 171.8 |
| Food and beverage output, 2023 | 89.9 |
| Logistics cost for both sectors, 2021 | 61.7 |
| Total | 323.4 |

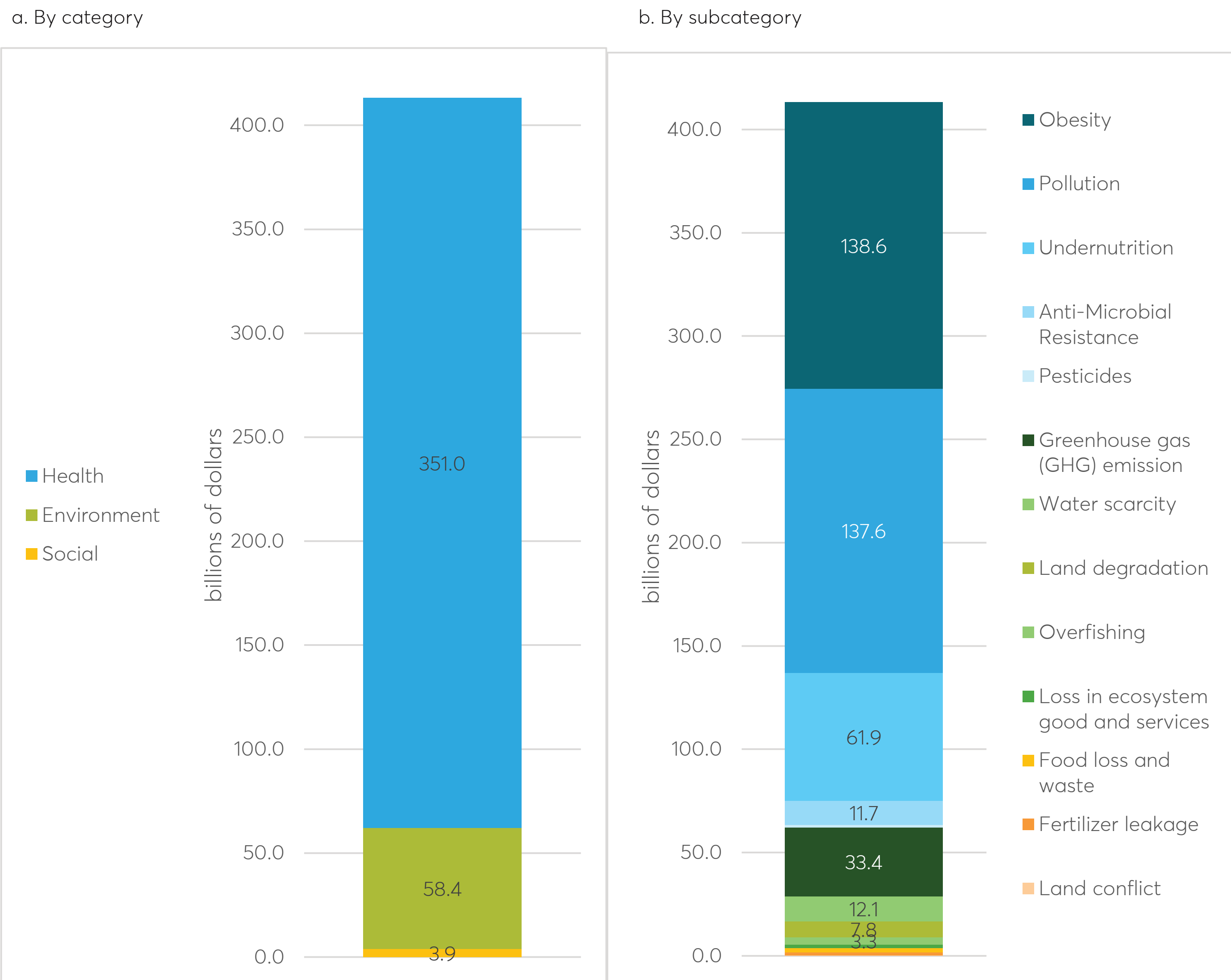
*Sources:* World Bank (2023) and detail distribution per sector from BPS (2023c). Logistics cost for both sectors are from Santoso et al. (2021).

**Figure 6** | Estimated range of annual hidden costs of food system in Indonesia, by category and subcategory




[8]Total GDP is the sum of gross value added by all producers in an economy plus any product taxes minus any subsidies not included in the value of the products (World Bank 2020).

**Figure 7** | Estimated median annual hidden costs of food system in Indonesia, by category and subcategory




Notes: Figures not displayed include loss from ecosystem food and services ($1.7 billion), food loss and waste ($2.1 billion), land conflict ($0.2 billion), and rural welfare ($0.01 billion).

## Results and discussion

The total hidden economic costs of agriculture and food and beverage production in Indonesia in 2023 was $210.7–$622.3 billion, or 28.5–45.4 percent of GDP. Our findings are of similar magnitude to estimates by the FAO (2023b), which estimates the cost to society at $319.5 billion. Annex 1 includes all of the estimates and the sources on which they were based.

The costs by category include the following:

- **Health**
  $184.3–$517.6 billion (13–38 percent of GDP)
- **Environment**
  $24.7–$98.7 billion (2–7 percent of GDP)
- **Social:**
  $1.7–$6.0 billion (0.1–0.4 percent of GDP)

Figure 6 shows the range of hidden costs for each subcategory. Figure 7 presents the median costs for each category and subcategory. Most of the hidden costs come from health costs, air pollution, obesity, undernutrition, other high sources are water scarcity and food loss and waste.

The agriculture and food manufacturing sector provides food, including for export; creates jobs for both women and men; reduces poverty; and has other beneficial effects. However, it also imposes huge costs on society that are not reflected in market prices, as Figures 6 and 7 show. Recognizing these costs is key to transforming Indonesia's food system.

Some policy actions that could be taken include the following:

- Encouraging consumption of healthier foods and beverages (e.g., by imposing taxes on sugary drinks) (Panggabean and Simamora 2024)
- Using revenue from new taxes to mitigate social costs (e.g., by imposing a carbon tax) and repurposing government assistance for agriculture (Ding et al. 2021)
- Raising labor productivity and work opportunities (e.g., by using public procurement to support participatory development strategies that increase the productivity of household farmers and smallholders [Colnago and Dogliotti 2020] and developing digital technologies such as market access apps [Ruggeri Laderchi 2024])
- Expanding safety nets to keep food affordable for the poorest (FOLU 2019; FAO 2023b).

Identifying hidden costs can help policy makers avoid policy siloes and take advantage of the synergy between food, ecological, and economic systems (Napitupulu et al. 2021a, 2021b). As one of the world's most biodiverse country, Indonesia has huge potential to be supported by its biodiversity and healthy environment (Napitupulu et al. 2021b). However, government programs tend to be fragmented and disconnected (Napitupulu et al. 2021b).

Some ideas for policy discussion include the following:

- Health costs contribute most to hidden costs, but it does not mean that environmental and social costs are to be addressed less. In fact, the emphasis of policy support to pursue agrifood policy that not only provide nutritious food, of diverse and fair provision, but also by design produce in ways that regenerate the environment.
- Policy tools such as polluters pay mechanisms could reduce social costs. Doing so is not straightforward, because taxing farmers (especially those that lack innovation and access to resources) could cause them to lose competitiveness and struggle to make a living (Brooks and Diaz-Bonilla 2025). Instead, a mechanism could be adopted in which large-scale farmers pay for the pollution they cause and the revenues generated are used to help smallholders and household farmers reduce risk, by, for example, buying insurance (Glauber et al. 2021).
- Decouple agricultural production growth from the degradation of natural resources and increased GHG emissions. One way to raise agriculture productivity without causing environmental damage or increasing GHGs emissions would be to intensify agriculture through agroecology approaches (Susanti et al. 2024) or the application of ecological principles in agricultural practices. Example of such practices include the use of biomass from plants or animal dung as fertilizer, crop rotation to ensure soil health (Izumi et al. 2004), the use of tobacco as insecticide (Harahap et al. 2020), and local practices such as subak (cooperative use of irrigation) (Rahman et al. 2021).

The hidden costs of the food system reveal structural inequalities that need to be overcome. The gap in rural welfare largely reflects a wider economic and social problem that requires policy decisions from outside the agriculture and the food system. For example, as food choices may be a result of agrarian change and rural transition (Purwestri et al. 2019), policy interventions such as land reform food security-by, for example, ensuring the availability of and access to meaningful livelihood and direct access to nutritious traditional and wild food sources through social forestry land reform program.

Structural inequalities may also be specific to the food system. Food surpluses that ultimately become food waste reflects the disparities in economic access to food. The cost of food waste for wealthy individuals is insignificant to them. But the resource depletion of producing food that is wasted imposes a social cost (Brooks and Diaz-Bonilla 2025). Countries such as France have encouraged major sources of food waste, such as supermarkets, to redistribute the food through partnership with food banks and other charities (The Guardian 2016).

## Limitations

This study does not examine the distribution of hidden costs within the food system. The results of other studies suggest that these burdens are often disproportionately borne by vulnerable populations (Goldstein 2016; White and White 2012; Medrilzam et al. 2013; Merten et al. 2021; Murray Li 2009; Rowland et al. 2022; Santika et al. 2019). For example, smallholder farmers and their households face both heightened health risks and reduced access to cultivable land as a result of air pollution caused by land burning. Future research should prioritize the identification of the vulnerable groups most affected by these hidden costs within Indonesia's food system. A deeper understanding of the distributional impacts can inform more equitable policy interventions, enabling governments, private sector actors, and civil society to better internalize externalities and design appropriate compensation mechanisms for affected communities.

Data limitations and calculation challenges also affect our results. For example, measures of the social cost of carbon (as both direct and opportunity cost of losses caused by carbon), are available, but they account only for the cost of abatement of damages (e.g., the cost of managing food waste in landfill). Other opportunity cost of resource depletion are not incorporated.

There is also the problem of setting boundaries on what food systems encompass—that is, the extent of the carbon cost from deforestation and land use change that is a result of agriculture and food production. Food loss and waste calculation that includes only the cost of managing waste in landfill likely undervalues the true cost, as food loss and waste may impose additional losses (e.g., in the form of abatement).

Our results are consistent with global studies, including The Global Consultation Report by the Food and Land Use Coalition (FOLU 2019) and the FAO's State of Food and Agriculture 2023 (FAO 2023b). Both cite the challenges in data and measurement and the problems associated with setting boundaries on the food system.

Other challenges affecting our estimates include the following:

- To estimate the effect on health, we used DALYs, which do not distinguish by gender, age, co-morbidities, or the intersectional impact on particularly individuals or communities.
- To estimate the impact of pesticides, we looked only at a single crop of paddy (rice), because of the dearth of data on other crops.
- To assess the cost of conflict, we looked only at the palm oil sector, because data were not available on other sectors. Although, land conflicts occur in other food production activities as well e.g., infrastructure development for food production purposes.
- Where we could not find data on Indonesia, we used global figures.

## Conclusion

The hidden costs of Indonesia's food system to health, environment, and social are substantial, amounting up to 28.5–45.4 percent of Indonesia's GDP. Policy priorities need to focus on integrated approaches that support small family farms and smallholders, reduce pollution, improve resource efficiency, and encourage consumers to adopt healthier diets rooted in Indonesia's rich biodiversity and diverse practices surrounding food.

Addressing these hidden costs also requires overcoming structural inequalities within the food system and beyond, particularly through land reform and social safety nets. Incorporating ecological principles and innovation—policy, institutional, and/or technological—offers pathways to decouple agricultural and food production practices with environmental harm. Future efforts must focus on identifying vulnerable populations disproportionately affected by these hidden costs to ensure fair and effective intervention. Reshaping Indonesia's food system is key for economic resilience and people's health and well-being.

## Abbreviations

| | |
|---|---|
| **AMR** | anti-microbial resistance |
| **BAPANAS** | Badan Pangan Nasional (National Food Agency) |
| **BAPPENAS** | Badan Perencanaan Pembangunan Nasional (National Development Planning Agency) |
| **BPS** | Badan Pusat Statistik (National Bureau of Statistics) |
| **CBN** | cost of basic needs |
| **$CO_2$-eq** | carbon dioxide equivalent |
| **DALY** | disability-adjusted life year |
| **FAO** | Food and Agriculture Organization of the United Nations |
| **FOLU** | the Food and Land Use Coalition |
| **GDP** | Gross Domestic Product |
| **GHG** | greenhouse gas |
| **GT** | gross tonnage |
| **ha** | hectare(s) |
| **IDR** | Indonesian rupiah |
| **IHME** | Institute for Health Metrics and Evaluation |
| **ILO** | International Labour Organization |
| **IPBES** | Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services |
| **ISIC** | International Standard Industrial Classification |
| **IUU** | illegal, unregulated, and unreported |
| **Kemenkes** | Kementerian Kesehatan (Health Ministry) |
| **Kemenkeu** | Kementerian Keuangan (Finance Ministry) |
| **Kementan** | Kementerian Pertanian (Agiculture Ministry) |
| **KPA** | Konsorsium Pembaruan Agraria (Agrarian Reform Consortium) |
| **$m^3$** | cubic meter |
| **MT** | million tonne(s) |
| **$PM^{2.5}$** | inhalable particles with diameters of 2.5 micrometers or less |
| **PPP** | purchasing power parity |
| **RPJMN** | Rencana Program Jangka Menengah Nasional (National Medium-Term Development Plan) |
| **RSPO** | Roundtable of Sustainable Palm Oil |
| **TEEB** | The Economics of Ecosystems and Biodiversity |
| **TNP2K** | Tim Nasional Percepatan Penanggulangan Kemiskinan (National Team for Poverty Reduction Acceleration) |
| **UNORCID** | United Nations Office for REDD+ Coordination in Indonesia |
| **VSL** | value of statistical life |
| **WHO** | World Health Organization |

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# Annex 1: Estimated hidden costs of the food system in Indonesia

Table A.1 | Estimated annual hidden costs of the food system in Indonesia, by category and subcategory

| | Estimated Cost | | |
|---|---|---|---|
| **Category** | **Low** | **High** | **Source** |
| **Health[a]** | | | |
| **Obesity** | | | |
| Disability-adjusted life years (DALYs) caused by high Body Mass Index in 2021 (million) | 1.7 | 5.4 | IHME (2024) |
| **Cost of obesity (billion $)** | **66.4** | **210.9** | |
| **Undernutrition** | | | |
| Loss of productive life caused by under-consumption, as proxied by child stunting, wasting, and underweight (million DALYs) | 1.196 | 1.973 | IHME (2024) |
| **Cost of undernutrition (billion $)** | **46.7** | **77.0** | |
| **Air pollution** | | | |
| Loss of productive life caused by ambient particulate matter (million DALYs) | 2.3 | 5.4 | IHME (2024) |
| Percent of particulate matter of $PM_{2.5}$ that is a result of the global food system (pre-production, post-production, consumption, and waste) | 58 | — | Balasubramanian et al. (2021) |
| **Cost of air pollution (billion $)** | **52.7** | **121.0** | |
| **Pesticide exposure** | | | |
| Loss of productive life caused by application of pesticides (DALYs/kg of insecticide, herbicide, and fungicide and bactericide applied) | 0.0001 | 0.001 | Fantke and Joliet (2016) |
| Annual insecticides, herbicides, fungicides and bactericides applied (million kg) | 271.8 | | FAOSTAT (2022b) |
| Paddy field as share of total agricultural land in 2019 (%) | 20 | | Kementan (2024) |
| **Cost of pesticide exposures (million $)** | **215.6** | **2,151.6** | |
| **Anti-microbial resistance (AMR)** | | | |
| Net present value of GDP lost between 2010 and 2050 as a result of AMR[b] (billion dollars) | 9.8 | 113.7 | Taylor et al. (2014) |
| Percent of AMR related to food systems | 19 | | Tao et al. (2022) |
| **Cost of AMR (billion $)** | **1.9** | **21.6** | |

| | | | |
|---|---|---|---|
| **Environmental** | | | |
| **Greenhouse gas (GHG) emissions** | | | |
| Annual GHG emissions from good and land-use system, including agricultural production, deforestation, and food supply chain (million $CO_2$ eq/year) | 750 | | KLHK (2018) |
| Estimated carbon cost[c] ($/tonne carbon dioxide equivalent [$CO_2$ eq]) | 5 | 84 | Groom et al. (2022), Rennert et al. (2022) |
| **Cost of GHG (billion $)** | **3.8** | **63.0** | |
| **Water scarcity** | | | |
| Total annual water withdrawals for agriculture (billion $m^3$) | 189.7 | — | FAO (2018) |
| Average scarcity cost of water, as proxied by drinking water tariffs ($/$m^3$/year) | 0.18 | — | OECD (2023) |
| Percent of freshwater withdrawals for agriculture that are unsustainable or at risk of becoming unsustainable, as proxied by global number (lower estimate) and percentage of poor irrigation in Indonesia as parameter of risk of unsustainable freshwater withdrawal (upper estimate) | 25 | 46 | FOLU (2019) and Khalil et al. (2021) |
| **Cost of water scarcity (billion $)** | **8.5** | **15.7** | |
| **Land degradation** | | | |
| Area of degraded cropland in 2019 (million ha) | 11.7 | — | Kementan (2024) |
| Annual value of crop production/ha of cropland, as proxied by agriculture GDP divided by total cropland area[d] ($/ha) | 6,859.8 | — | World Bank (2023), BPS (2023c) and Kementan (2024) |
| Yield loss from land degradation (%) | 4 | 12 | Panagos et al. (2017) |
| Area of degraded cropland in 2019 (million ha) | 11.8 | — | Kementan (2024) |
| Economic value of soil ecosystem services ($/ha) | 452.2 | — | Brander et al. (2024) |
| Loss of soil biodiversity from land degradation (%) | 25 | — | FOLU (2019) |
| **Economic cost of land degradation (billion $)** | **4.6** | **11.0** | |
| **Over-exploitation/ overfishing** | | | |
| Contribution of fisheries sector to GDP in 2023 (billion $) | 37.0 | — | World Bank (2023), BPS (2023c) |
| Estimated percent of fisheries catch that is illegal and unreported | 18 | — | Agnew et al. (2009) |
| **Cost of overfishing (billion $)** | **6.7** | — | |

| | | | |
|---|---|---|---|
| **Other loses in ecosystem goods and services** | | | |
| Economic value of ecosystem services from tropical forest (billion$/ha) | 21.5 | — | UNORCID (2015), BPS (2022) |
| Annual deforestation caused by agriculture (ha) | 140,000 | — | BPS (2019) |
| Economic value of ecosystem services from mangroves ($/ha) | 3,625 | 26,735 | Rizal et al. (2018) |
| Annual mangrove loss caused by aquaculture (thousand ha) | 18.2 | — | Arifanti et al. (2021) |
| Annual value of crop production reliant on pollinator services (billion $) | 3.9 | 6.4 | Khalifa et al. (2021) |
| Average yield reduction from loss of pollinators (%) | 28 | — | Olschewski et al. (2006) |
| **Cost of loss of ecosystem goods and services (billion $)** | **1.2** | **2.3** | |
| **Social** | | | |
| **Rural welfare** | | | |
| Poverty gap (difference between average wage for agriculture and poverty line)[e] ($) | 1.4 | — | TNP2K (2020) and BPS (2023a) |
| Percent of rural poor in employed in agriculture | 64 | | BPS (2023b) |
| Number of people in rural areas living below the poverty level (million) | 14.2 | — | World Bank (2020b) |
| **Loss in rural welfare (million $)** | **12.4** | | |
| **Fertilizer leakage** | | | |
| Average leakage rate of nitrate fertilizers (%) | 3 | 4 | Herniwati and Nappu (2018) |
| Application of nitrate fertilizers in 2023 (million tonnes) | 3.0 | | FAO (2022b) |
| Average price of nitrates in 2023 ($/tonne) | 217.2 | | Bloomberg (2023a) |
| Average leakage rate of phosphate fertilizers (%) | 50 | | FOLU (2019) |
| Application of phosphate fertilizers in 2023 (tonnes) | 582,143 | | FAO (2022b) |
| Average price of phosphates fertilizers in 2023 ($/tonne) | 554.4 | | Bloomberg (2023b) |
| **Cost of fertilizer leakage (million $)** | **180.8** | **187.3** | |

| | | | |
|---|---|---|---|
| **Conflict** | | | |
| Cost of oil palm conflicts in 2016 ($/ha) | 934 | 2,201 | Barreiro et al. (2016) |
| Reported areas of 2024 agrarian conflict over palm oil plantations (ha) | 127,281 | — | KPA (2025) |
| **Cost of conflicts (million $)** | **118.8** | **280.1** | |

Notes:

a. All health estimates were multiplied by the value of a statistical life of $39,047 (Sweis 2024; World Bank 2024), using the formula developed by Sweis (2022). It provides an estimate of the value of a statistical life that equals full wealth, adjusted upward for the degree of concavity in the single period utility function (1/c). Total of productive hours 1,900, total hours 5,200 and GDP per capita in 2023 $15,612.

b. Study covers HIV, tuberculosis, malaria, and infections from *E. coli, S.aureus, and K.pneumoniae neumoniae*. Estimated GDP loss attributable to AMR in Eurasia is $22.2–$159.6 billion/year (0–40 percent resistance) (Taylor et al. 2014). The total labor workforce in Eurasia is 629 million, of which Indonesia's labor workforce accounts for 27.5 percent (ILO STAT 2018). To estimate the loss of GDP attributable to AMR in Indonesia, we multiplied Indonesia's labor workforce share by the total GDP loss attributable to AMR in Eurasia. The result is $6.1–$43.9 billion in 2011 (the year of the estimates in Taylor et al. 2014). We then inflated the number to 2023 prices.

c. The lower figure is based on Norway's financial commitment for reducing emissions from deforestation (Groom et al. 2022); the higher figure reflects the social cost of carbon (Rennert et al. 2022).

d. The annual value of crop production/ha of cropland is proxied by agriculture GDP divided by total cropland area. Agriculture GDP is from World Bank (2023) and BPS (2023); total agriculture land is from Kementan (2024).

e. The poverty line is $2.5/day, based on the Cost of Basic Needs (CBN) approach (Tim Nasional Percepatan Penanggulangan Kemiskinan 2020). The rural poverty line was $1.1/day in March 2023, revealing a poverty gap of $1.4.

— No estimate

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## About KSPL

Koalisi Sistem Pangan Lestari (KSPL), part of the global Food and Land Use Coalition (FOLU), is a partnership initiative working to transform Indonesia's food systems through science-based solutions and ambitious collective action. KSPL works with 11 core partners, national and subnational governments, and various local networks to drive the transformation towards healthy, diverse, just, resilient, and sustainable food systems.

FOLU is a global community of country platforms, partner organizations and ambassadors working to advance sustainability, equity and resilience in food and land use systems. Created in 2017, FOLU supports diversity, embraces disruptive thinking and forges consensus through an evidence-based approach. The coalition empowers farmers, policymakers, businesses, investors and civil society to unlock collective action at scale.

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