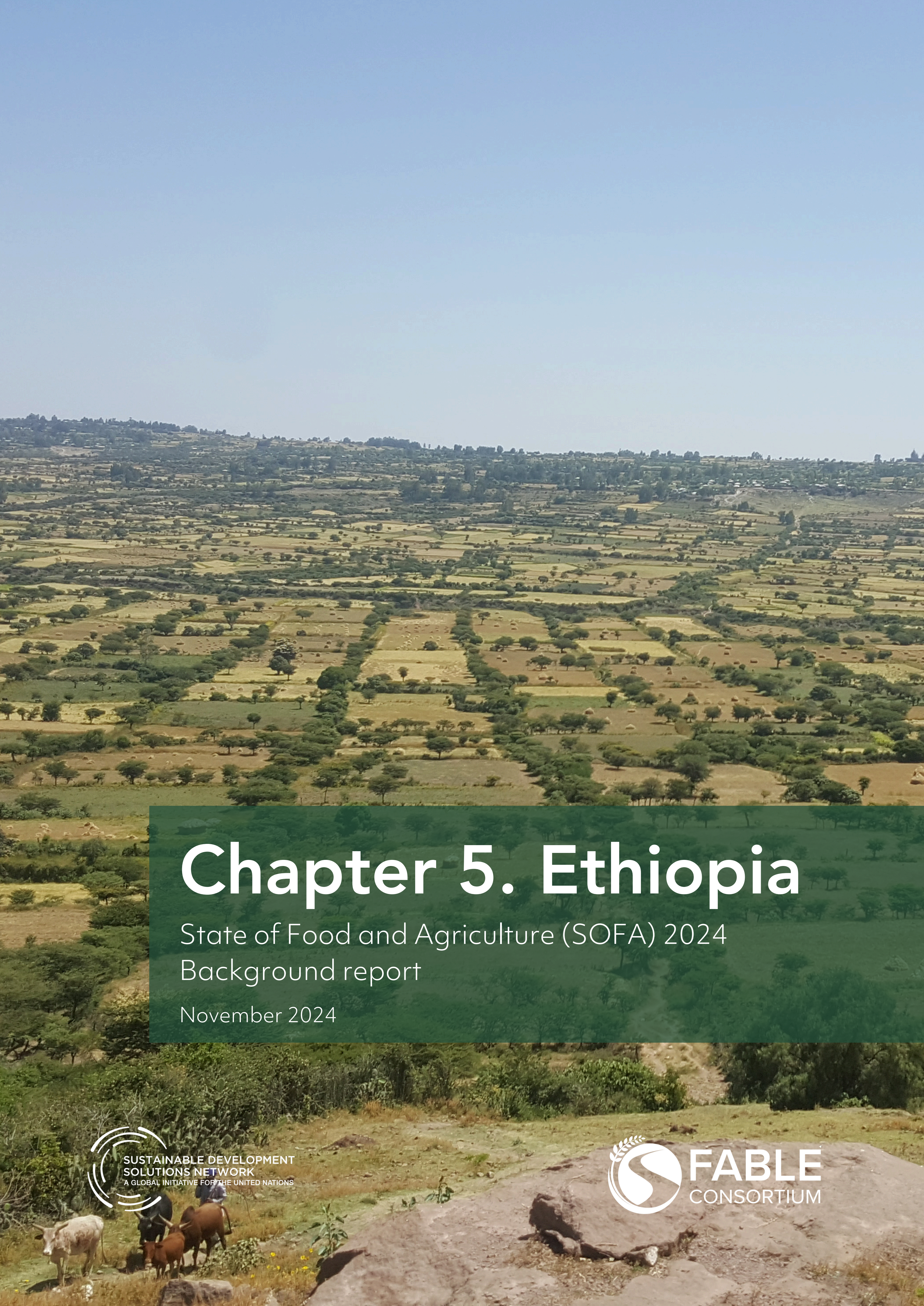

Chapter 5. Ethiopia

State of Food and Agriculture (SOFA) 2024
Background report

November 2024

SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK
A GLOBAL INITIATIVE FOR THE UNITED NATIONS

FABLE CONSORTIUM

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Highlights

- Despite the significant role of agriculture in Ethiopia's economy, the economic damage caused by negative externalities within the agri-food system has been largely unknown due to the intangible nature of these impacts.

- This research aimed to evaluate the evolution of hidden costs in Ethiopia's agri-food system by leveraging the 2023 FAO-SOFA flagship report through literature review, stakeholder consultation, and FABLE-based modeling.

- The total hidden costs of Ethiopia's agri-food system were estimated to be 51 billion 2020 PPP dollars per year. The most significant contributor to these hidden costs was the social sector, particularly poverty among agri-food workers, accounting for 24.3 billion 2020 PPP dollars annually. Environmental externalities related to climate change and land-use change were the second-largest contributors, reaching 19 billion 2020 PPP dollars per year.

- The total hidden costs were estimated at 51 billion 2020 PPP dollars annually, with the social sector, especially poverty among agri-food workers (24.3 billion PPP dollars), being the primary contributor. Environmental externalities related to climate change and land-use change followed closely at 19 billion PPP dollars.

- Specific recommendations to reduce hidden costs include a lower population growth path, decreasing livestock numbers, and increasing crop and livestock productivity.

Contents

5.1 Introduction

Ethiopia, a nation of 1.1 million km² in East Africa, supports a population of 110 million. Prior to the global pandemic and ongoing political instability after 2020, Ethiopia stood out as one of Africa's fastest-growing economies, boasting an average annual GDP growth rate approaching 10% between 2009 and 2019 (ESS, 2020). Agriculture is the cornerstone of the Ethiopian economy, with subsistence farming employing over 67% of the workforce and contributing 34% to GDP (Bank, 2018; WB, 2020). The sector forms the core of Ethiopia's agrifood system, which is undergoing transformations in response to recent economic growth (Diao et al., 2023). This report delves into the hidden costs associated with Ethiopia's agrifood system, employing the framework established by the Food and Agriculture Organization's (FAO) 2023 SOFA report (FAO, 2023).

AFS encompasses all interconnected actors involved in producing, consuming, and regulating food and agricultural products and jobs (Fanzo et al., 2020). By analyzing the contribution of each component – primary agriculture, agro-processing, trade and transport, food services, and input supply – we can characterize the structure and economic contribution of all agrifood system stages (Fanzo et al., 2020). Ethiopia's agrifood system reflects a typical low-income country structure, with a high contribution of primary agriculture (48% of GDP) and a low contribution of off-farm components (12.8% of GDP) (Diao et al., 2023).

This heavy reliance on primary agriculture mirrors the vulnerabilities of Ethiopia's agrifood system, posing significant challenges to food security and nutrition. Value added per agricultural worker falls considerably short of other sectors, and major crop productivity remains low on a large portion of farm plots. Additionally, the sector's dependence on rainfed cultivation renders it highly susceptible to climate variability and extreme weather events (Bizikova et al., 2022; Reardon et al., 2019).

Despite these limitations, the primary agriculture sector nourishes the vast Ethiopian population through a subsistence-based production system, minimizing reliance on commercial food imports (FDRE, 2021; Minten et al., 2018). However, this economic mainstay also faces scrutiny for its environmental impact, including deforestation, soil erosion, water pollution, and greenhouse gas emissions. Quantifying the true cost of these negative externalities on the Ethiopian economy presents a significant challenge due to their abstract nature. Hidden cost accounting offers a solution by incorporating these externalities into economic analyses. By estimating the net present value (NPV) of negative externalities like emissions, land use change, pollution, and social damage, hidden cost accounting offers valuable annual snapshots of the agrifood system.

The objective of this chapter is to contextualize the 2023 FAO-SOFA hidden cost estimation for Ethiopia's agrifood system. We analyze the structure of Ethiopia's hidden costs, compare results and input datasets with national databases, and recommend strategies to reduce these costs. This analysis is based on an extensive literature review, stakeholder consultations (both in-person and through phone interviews), and FABLE based modeling results for analysis of evolution of hidden costs under three different scenarios (FABLE, 2024).

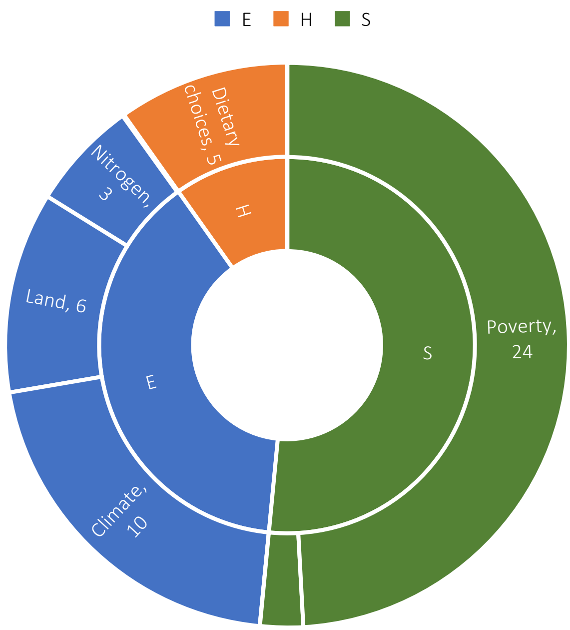
5.2 SOFA 2023 hidden costs analysis

5.2.1 Main cost components and explanation of the results

The breakdown of average annual hidden costs associated with Ethiopia's agrifood system, categorized by major components is presented in Figure 5-1. The combined total from these three sources reaches a staggering 51 billion 2020 PPP dollars, an estimate which sparked debate during the stakeholder consultation. Some stakeholders questioned if it meant half the GDP was lost, or that agriculture produced net losses (considering its 35% GDP contribution). Clarification on the definition led to a consensus: the total cost might not reflect actual economic losses. Instead, stakeholders found unit cost indicators like AEIR, DPIR, and SDIR to be more accurate for assessing the true economic impact.

Notably, the cost structure reveals a dominant burden on the social sector (S), followed by environmental (E) and health (H) components. This pattern aligns with the observed cost structure in many low-income countries, where the social sector often bears the brunt of hidden costs associated with food production

***Figure 5-1**: Hidden costs of Ethiopia's agrifood system by cost type and category based on the FAO-SOFA report*



Source: Authors based on SOFA 2023 results

Within the cost breakdown, poverty among agrifood workers emerges as the most significant contributor, accounting for 49% (approximately 24.3 billion 2020 PPP dollars per year) of total hidden costs. This reflects the high concentration of rural populations living below the poverty line in Ethiopia.

World Bank data indicates that an estimated 83% of the country's total poor population are engaged in agriculture (WB, 2020), providing compelling support for the observed predominance of poverty costs within the agrifood system.

Undernourishment, reflecting productivity losses arising from protein-energy malnutrition (PEM)-related disease burden, constitutes the second category of social hidden costs associated with agrifood system in Ethiopia, after poverty. However, its share of the total cost remains the smallest among all categories. Despite this, undernourishment stands as the most prevalent development challenge within the country's agricultural sector. Current estimates for its associated costs fail to adequately capture the complex and multifaceted impact of this problem on a national level.

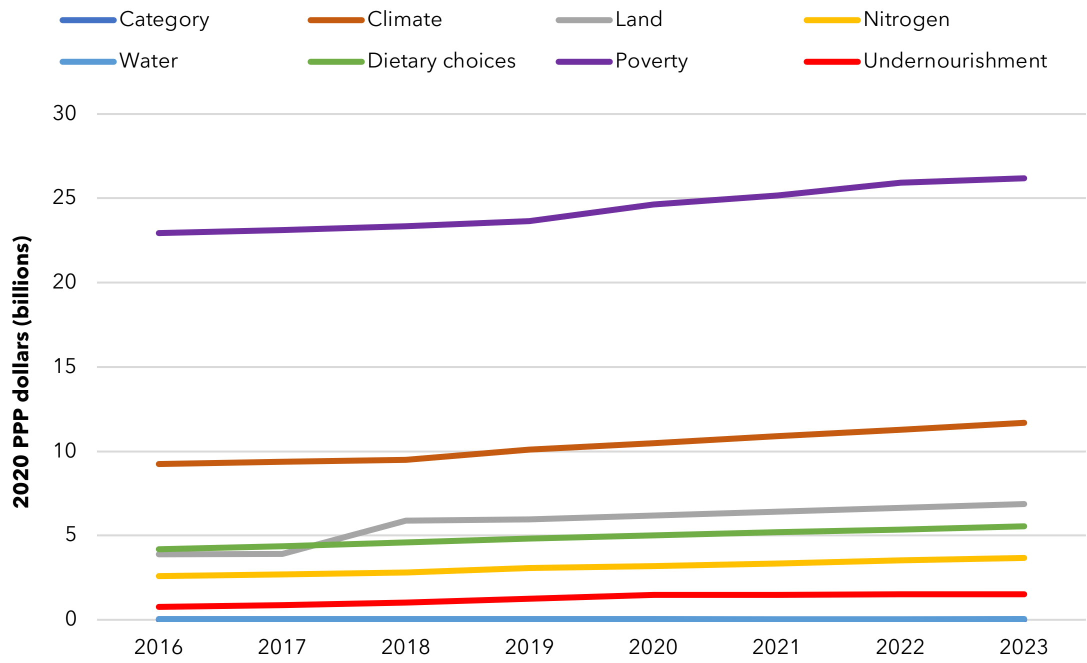
Climate and land-related expenses from the environmental sector follow closely, averaging 10 and 6 billion 2020 PPP dollars annually, respectively, representing 20% and 11% of the total average cost. Dietary choices within the health sector contribute approximately 5 billion 2020 PPP dollars per year. GHG emissions primarily stem from the massive livestock numbers in the country; which is Africa's largest livestock population with 65 million cattle, 40 million sheep, 51 million goats, 8 million camels, and 49 million chickens in 2020 (Mekuriaw and Harris-Coble, 2021). This translates to significant emissions, with the sector estimated to be the largest agricultural emitter, responsible for 146 million tonnes of carbon dioxide equivalent (Mt CO_2e) annually. Further contributing to the environmental cost, ongoing agricultural land expansion in Ethiopia is estimated to contribute 125 Mt CO_2e yearly through land use change. Additionally, rising synthetic fertilizer use fuels nitrogen emissions, which follows land use change in terms of cost contribution among the environmental cost components.

Stakeholders recognized the agrifood system's social cost structure as a realistic reflection of Ethiopia's poverty challenge. Millions of smallholder farmers are trapped in a cycle of poverty due to low returns on their products. This can be attributed to factors like low market value for crops, inefficient and fragmented market chains, unequal access to land and resources, a gender pay gap, and limited safety nets like agricultural insurance and social programs.

However, health costs present a complex picture. While Ethiopia's traditional cereal-based diet and active rural lifestyles likely contribute to lower dietary-related costs compared to other countries, concerns exist about the accuracy of health data. Relying solely on hospital records might underestimate the true burden of such illnesses, as many people may not seek medical care.

Similarly, environmental costs raise data discrepancy concerns. Differences in CO_2 emission data between national and international databases highlight the need for improved data collection and policy considerations to inform effective climate mitigation strategies.

Figure 5-2: *The temporal evolution of hidden costs of the agrifood system*



Trends in the agrifood system hidden costs reveal a persistently upward temporal trend from 2016 to 2023. No major change was observed in the proportional distribution of different types of costs. Poverty ranks as the highest cost driver in all the periods, followed by climate and land-related costs. Poverty-related costs have risen from 22.9 billion 2020 PPP dollars in 2016 to 26.1 billion 2020 PPP dollars by 2023. Compared to the other categories, the rate of change was relatively stable (average annual growth of 1.92%). Costs from greenhouse gas emissions (GHG) increased from 9.2 billion to 11.6 billion 2020 PPP dollars between 2016 and 2023; with average annual growth rate of 3.42%. The cost from land use change rose from 3.8 billion to 6.8 billion 2020 PPP dollars between 2016 and 2023, which is with the second-highest growth rate (9.5% annually) recorded. Nitrogen emissions, while ranking third in terms of overall cost, experienced the fastest growth rate (5.1%), with costs increasing from 2.5 billion to 3.6 billion 2020 PPP dollars over the study period. Undernourishment, despite having the lowest overall cost, demonstrated the highest growth rate (10.6% annually), increasing from 765 million 2020 PPP dollars in 2016 to 1.5 billion 2020 PPP dollars by 2023. The cost from agricultural blue water use remains the lowest with little sign of change throughout the study period (Figure 5-2).

The temporal evolution of most of the cost categories aligns with scientific records and national level databases. Agricultural expansion is a continued process in the country, which aligns with the highest growth rate of land use change induced hidden costs. The increasing trend in nitrogen usage, GHG emissions, and dietary-related costs are all explainable with ongoing environmental changes in the country related to agricultural production process. An exceptional contradiction is the trend of undernourishment, which was found to be the highest growing hidden costs across time, contradicting ongoing reports of reduced undernourishment and food insecurity levels in the country. The other exception is the cost from agricultural blue water consumption. Despite seemingly constant blue water consumption costs reported in the FAO-SOFA report, it appears to contradict contemporary observations of rising irrigation water withdrawals within the country.

Stakeholders acknowledged the seemingly realistic trends in hidden costs over the past five years align with Ethiopia's recent political and climatic challenges. The rapid rise in undernourishment costs suggests a potential reversal of food security gains made before 2020, raising concerns about renewed deterioration after 2020.

5.2.2 Comparison of SPIQ data with national datasets

Poverty

The FAO SOFA report calculated poverty-related externalities using poverty headcount data from the World Bank. However, this data shows a discrepancy with Ethiopia's national poverty database. According to the World Bank, roughly 50 million individuals, or 11.6 million households (77% of agricultural households), lived below the national poverty line in 2016. This figure appears inflated when compared to a 25.6 % estimate of the national poverty report (FDRE, 2012). Their 2019 report indicates that 25.6% of total households (roughly 15 million individuals, from the total 75 million individuals who rely on farming activities for their livelihood) fall below this absolute poverty line. This translates to approximately 3.7 million households (18.7 million individuals) within the agricultural sector living in poverty. Several factors contribute to these discrepancies, including:

- **Different poverty lines:** While the World Bank poverty estimates include a range of thresholds, the FAO SOFA report appears to have adopted the higher USD 3.65 per day threshold, compared to the national poverty line of USD 1.90 per day. This has resulted in a higher number of poverty figures than the national poverty line of USD 1.90 per day.
- **Headcount unit disparities:** The national data relies on household headcounts, potentially capturing agricultural households more accurately than the FAO-SOFA estimate based on average individual income.
- **Self-employment and land ownership**: Ethiopia's prevalence of self-employed agricultural workers, often owning their land, may not align well with FAO-SOFA's accounting system, which might require information on working-age individuals within each household, often unavailable in Ethiopian data.

Therefore, considering the distinct methodologies and data sources, the household-based poverty headcount from the national data may provide a more realistic picture of rural poverty in Ethiopia.

Undernourishment

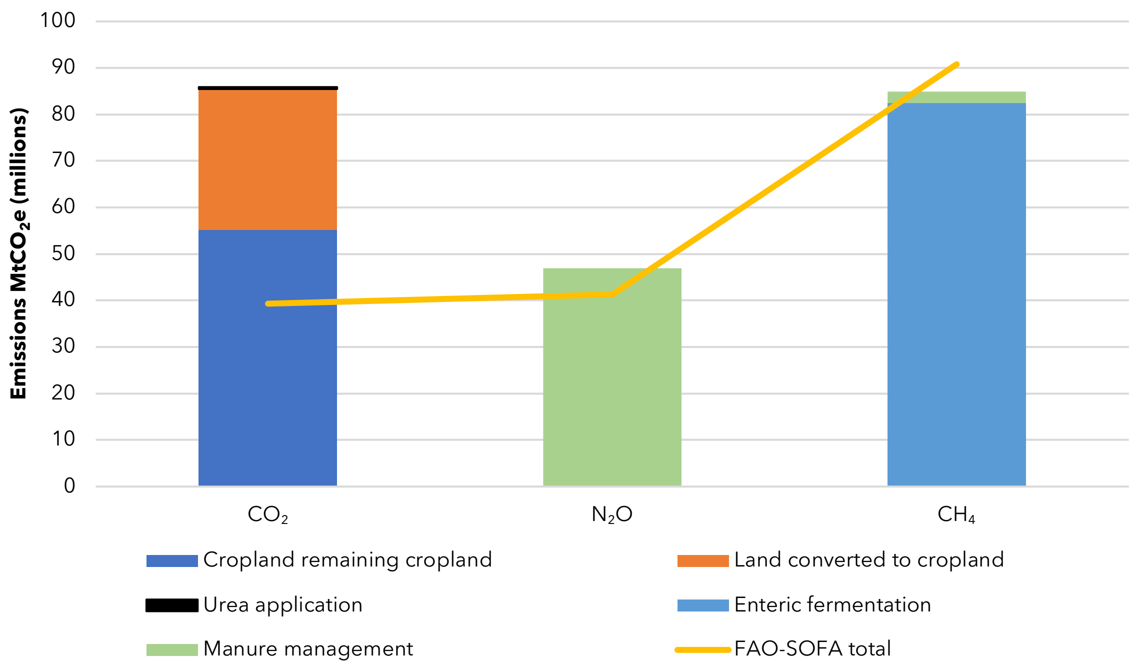
Similar to poverty; estimates of undernourishment prevalence in Ethiopia also show discrepancies between the national database and the FAOSTAT data source used by the FAO SOFA report. The national poverty report (FDRE, 2012) conceptualize undernourishment as "food poverty," defining it as the income shortfall required to meet a predetermined minimum caloric intake (2200 kilocalories per adult equivalent per day). Based on this definition, an estimated 24.8% of households fall below the minimum calorie requirement, translating to approximately 22 million individuals considered undernourished in 2016. This figure is significantly higher than FAO SOFA undernourishment estimates for Ethiopia in the same year, where the undernourished population is estimated to be approximately 14 million. This discrepancy persists even by accounting for the national data's higher caloric threshold for defining undernourishment.

GHG emissions

A comparison of the national GHG assessment report (FDRE, 2022) with the FAOSTAT data used by the FAO SOFA report for estimating GHG externalities reveals a high degree of convergence in emissions estimates for most greenhouse gases. However, a notable exception exists for carbon dioxide (CO_2) emissions. Notably, the national-level assessment estimates CO_2 emissions at 86 Mt CO_2e annually, exceeding the FAOSTAT reports by 54%. This variance primarily stems from the FAOSTAT's exclusion of CO_2 emissions from cropland that remains cropland representing approximately 64% of the national total. This includes emissions and removals of GHG from biomass and soil carbon stock changes of the cropland during the estimation year (Guendehou, 2006). While total N_2O emissions appear broadly comparable in both reports, a closer look reveals inconsistencies. Emissions from manure management in the national database (47 million CO_2e) approximately align with the FAO-SOFA agrifood system report (41 million CO_2e). However, another significant category, "aggregate sources and non-CO_2 emissions on land," encompasses land use change-induced emissions totalling 26 Mt CO_2e. Unfortunately, this category lacks the disaggregation needed to isolate emissions specifically within the agrifood system boundaries, necessitating their exclusion from the comparison with the TCA-FAO report.

Total methane emissions are roughly equivalent in both reports. However, the national database excludes land use change methane emissions, solely accounting for enteric fermentation (82 Mt CO_2e) and manure management (3 Mt CO_2e) emissions.

Figure 5-3*: Comparison of national GHG emissions and TCA-FAO marginal quantities*



Review of unit costs to GDP

The SPIQ-FS model operates on a unit-by-unit basis, calculating the damage inflicted by one unit of an impact (e.g., one tonne of GHG emissions) on GDP. This damage is then expressed in standardized 2020 PPP dollars for global comparability.

GHG costs: GHG costs were estimated using impact data from simulations conducted by the Interagency Working Group on the Social Cost of Greenhouse Gases (IWG-SCGHG). Unlike the usual approach of a general "CO_2 equivalent" value, the IWG-SCGHG provides distinct economic cost estimates for each greenhouse gas (CO_2, CH_4, and N_2O) emitted per tonne. Notably, the marginal cost values are globally applicable, with Ethiopia experiencing similar rates to other nations. Nitrogen exhibits the highest unit cost at 19,279.1 2020 PPP dollars per tonne, followed by methane at 1,491.3 2020 PPP dollars per tonne and carbon dioxide at 51 2020 PPP dollars per tonne. While these estimates appear reasonable, using separate units instead of converting to CO_2

equivalents may present challenges in directly comparing them with existing scientific literature.

Water withdrawal costs: The water withdrawal cost for Ethiopia exhibits the highest value at 4,818 2020 PPP dollars per million cubic meters compared to 440 and 746 2020 PPP dollars per million cubic meters utilized for Colombia and Brazil, respectively. However, the FAO-SOFA report lacks an explanation for these disparities in marginal cost values, hindering further interpretation and comparison across the nations.

Land use change: Ethiopia's marginal costs for forest and other habitat loss amounted to 27,814 and 13,647 2020 PPP dollars per hectare, respectively. Conversely, habitat gain through regeneration yielded marginal profit of 4,264 and 2,314 2020 PPP dollars per hectare for forest and other land transitions.

Nitrogen emission: Marginal costs for nitrogen emissions varied across countries, with Ethiopia exhibiting values of approximately 0.8, 3, and 0.14 2020 PPP dollars per kilogram (kg) for NH_3 emission to the air, NH_3 deposition to the air, and NO_3 leaching to groundwater, respectively. While these values are lower compared to established marginal costs for similar N_2O emissions in other countries, the FAO-SOFA report lacks detailed explanations for the underlying factors contributing to these variations.

Undernourishment and dietary risk: Ethiopia exhibits unique undernourishment unit costs: 4,877.17 2020 PPP dollars per DALY lost due to dietary choices and 51.2 2020 PPP dollars per DALY lost due to undernourishment. Notably, the dietary choice cost stands significantly higher compared to other countries (e.g., 37, 198, and 36,410 2020 PPP dollars for Colombia and Brazil), while the undernourishment cost remains one of the lowest globally, contrasting with values like 111 2020 PPP dollars for both Colombia and Brazil.

The cost of poverty: Ethiopia's cost of poverty ranges (in 2020 PPP dollars) from 456 (2016) to 450 (2023) per poverty headcount, aligning with estimates for other countries like Brazil (558) and Colombia (490).

5.2.3 Recommendations for tailored country hidden costs analysis

The objectives, scope and methodological approach of the FAO-SOFA report best aligned with external costs associated with Ethiopia's agrifood system, focusing on the crucial nexus between social, environmental, and health dimensions.

The FAO-SOFA system, while valuable, overlooks crucial variations in Ethiopia. The use of unit costs and externalities generated based on the context of resource-intensive, large-scale farming system in high-income countries might bias cost assessments for Ethiopia's small-scale farmers, who dominate the landscape with average holdings of two hectares and annual production of 3 tonne per household. Tailored systems considering land use, resource intensity, and socioeconomic factors are needed for accurate cost assessments.

The FAO-SOFA system further overlooks Ethiopia's substantial pastoralist and agro-pastoralist population (over 15%). Their distinct livelihoods require separate cost assessments due to differing marginal units and unit costs compared to crop-based systems.

Beyond generic limitations, the FAO-SOFA system misses crucial Ethiopian costs like soil degradation and biodiversity loss. Ethiopia's severe soil loss (42 t ha–1 y–1) threatens future productivity, while agricultural expansion harms ecosystems and displaces species. Ignoring these critical dimensions underestimates the true cost of Ethiopian crop production and jeopardizes long-term sustainability. Furthermore, FAO-SOFA overlooks significant post-harvest losses (estimated at 30% of production volume). This hidden cost has a significant impact on the food system and overall economy and needs inclusion in future assessments.

The FAO-SOFA system also misses the benefits of Ethiopia's diverse practices: agroforestry, intercropping, organic fertilizers, and conservation tillage. These practices improve soil health, suppress pests, reduce pollution, and control erosion. Additionally, the system ignores the positive externality of *enset*, a staple crop with high carbon sequestration potential (144.30 t CO2-eq/ha). Accounting for these positive externalities is crucial for a more accurate assessment.

Reflections from the stakeholders also show that while the hidden cost accounting system's concept and its ability to reveal unseen aspects of the agrifood system were commended, concerns arose regarding the scope of its analysis. Specifically, concerns were raised regarding missing components related to soil loss and biodiversity degradation.

Stakeholders also worried about capturing unforeseen events and temporal changes in the model. Ethiopia's ongoing political instability, they noted, can rapidly alter production, poverty, health, and undernourishment. They suggested mechanisms to handle these uncertainties. Climate extremes, like crop failures due to droughts, were also flagged as potential drivers of higher hidden costs, particularly undernourishment.

Incorporating national data sources can significantly strengthen the comparability and relevance of hidden cost estimates to national policies and strategies. Utilizing population data from the official national database can facilitate direct comparisons between hidden cost estimates and population-based targets outlined in national plans. Similarly, leveraging data from the national GHG inventory could provide a robust foundation for evaluating the hidden environmental costs. Moreover, integrating headcount data on poverty and undernourishment from national sources would enhance the policy relevance of the hidden cost estimates by explicitly linking them to key social vulnerabilities within the country.

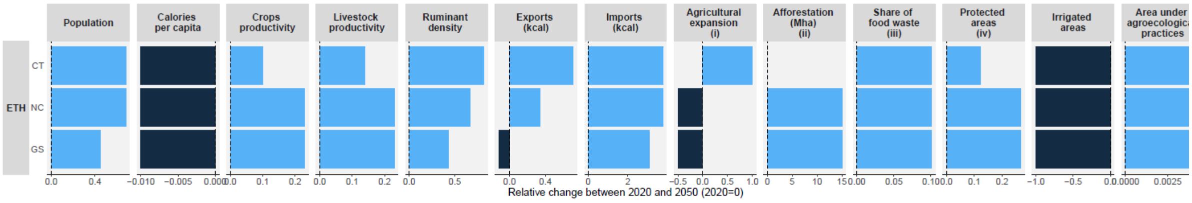
5.3 Evolution of hidden costs by 2030 and 2050

5.3.1 FABLE Calculator for Ethiopia

The FABLE Calculator (Mosnier et al., 2020) was used to analyze the temporal dynamics of the food-land-biodiversity nexus in Ethiopia. The FABLE team adapted the calculator to the Ethiopian context by incorporating country-specific data on items and commodities missing from the original database. This included adding teff, a staple crop in Ethiopia, to the FABLE Calculator's commodity list using data from the CSA. Teff was previously categorized as "other crops" in FAOSTAT data and was absent from the original FABLE Calculator commodity lists. Additionally, scenario parameters were refined based on stakeholder consultations and document reviews, including the development of a country-specific dietary scenario aligned with Ethiopian Public Health Institute (EPHI) dietary guidelines. Afforestation and reforestation scenarios were further adjusted to reflect national decadal and mid-century targets. Model outputs were evaluated against development targets outlined in national government policies and strategies. Additionally, stakeholder consultation workshops were conducted to validate both the modeling process and its outputs.

5.3.2 Scenathon 2023 pathways assumptions

Figure 5-4: *Overview of the assumptions under three different pathways by 2050*



Ethiopia's 2023 FABLE Scenathon pathways (FABLE, 2024) were developed through a comprehensive analysis of scientific literature, government policies, and international agreements aligned with global sustainability goals.

Current Trends pathway

The assumption for Current Trends (CT) was drawn based on the business-as-usual trajectory, which assumed the continuation of current development trends without significant changes. This scenario was informed by a review of scientific literature and data documenting temporal trends in key development goals. Historical data on major indicators for the past decade, primarily from secondary sources and scientific reports, were used to establish a baseline and projected future trajectory. This approach assumes that past trends will continue, resulting in similar magnitudes, directions, and dimensions of change in key development indicators compared to those observed between 2010 and 2020.

Projection of major development indicators under CT indicates population increase to 200 million by 2050. Dietary shifts are expected, with a slight decrease in cereal consumption and an increase in fruits, vegetables, pulses, oilseeds, milk, and poultry. Crop and livestock productivity are expected to increase by less than 10% and 50%, respectively. Food trade is anticipated to increase, with a higher import especially for wheat, milk, and corn. Regarding land, the CT scenario assumes free expansion of agricultural, with no establishment of new forest areas (no afforestation) beyond existing land. The no afforestation assumption is that the high deforestation rates will continue, and any natural and manmade forest gains will remain lower than forest loss.

National Commitments pathway

This pathway (NC) aligns with established government policies and strategies focusing on key development goals across food security, environmental sustainability, and economic growth. These policies aim to achieve sustainable development by the end of the decade and by the mid-century. Therefore, this scenario expects successful implementation of these development policies, leading to significant deviations from business-as-usual trends.

Global Sustainability pathway

This pathway (GS) adopts a green growth paradigm, assuming concerted efforts towards achieving the Sustainable Development Goals (SDGs). It postulates a trajectory in which economic growth becomes decoupled from environmental degradation, leading to sustainable development.

GS population is projected to be 14% lower than CT and NC by 2050. These projections align with the Ethiopian National Statistical Office's estimates, which forecast a reduced population growth rate due to increased contraceptive use (from 29% to 65% by 2050), delayed marriages, and higher school enrolment (CSA, 2013). These demographic shifts are consistent with national policies aimed at reducing fertility rates, including the National Reproductive Health Strategy (FMoH, 2016), National Adolescents and Youth Health Strategy (FMoH, 2021), and the National Guideline on Family Planning (FMoH, 2011).

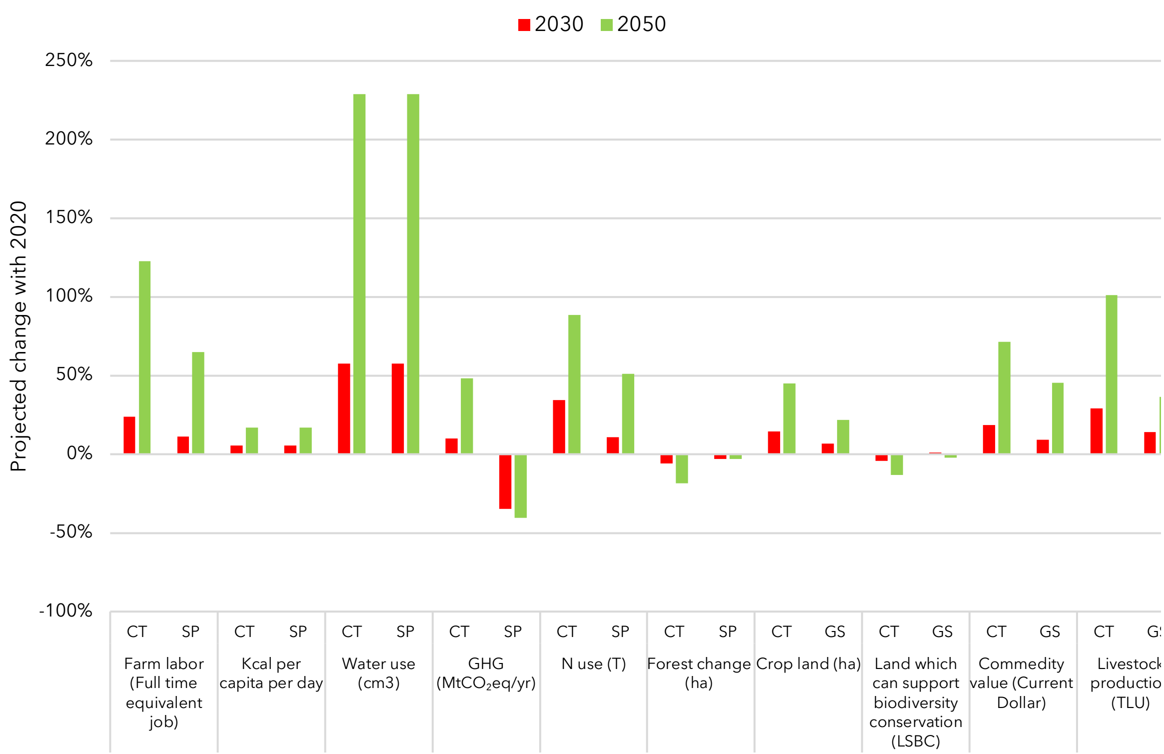
Crop and livestock productivity are expected to increase by over 20% and 100%, respectively, by 2050. Similar to CT, both NC and GS pathways project a slight rise in food import share, reaching 37% by 2050 from its historical level of 20%. However, the GS scenario diverges on exports, aiming to double coffee and sesame exports compared to the current trend.

Regarding agricultural expansion and afforestation, NC and GS scenarios envision policy interventions to forbid agricultural expansion in forested land. Agricultural land expansion would be primarily directed towards lowland areas with planned investments in mechanized irrigation systems. Furthermore, both pathways aim for significantly higher afforestation targets, aiming for 15 million hectares of new forest cover by 2050, aligning with the Bonn Challenge national plan and contributing to broader sustainability goals. While NG and GS scenarios envision a significant increase in protected areas exceeding 30% by 2050, the CT scenario maintains current levels. All scenarios assume irrigation area expansion, with GS and NC anticipating the most significant growth in lowlands due to planned government investments.

In summary, while NC and GS scenarios offer a more sustainable development path compared to the current trend, they both emphasize population control, agricultural advancements, strategic food trade, and responsible land management for long-term food security and environmental health. On the other hand, all three pathways share a similar dietary scenario due to the current cereal-dominated diet with limited intake of diverse food groups. Consumption trends suggest an increase in animal-source foods and fruits/vegetables, aligning with national guidelines and SDG 2: Zero Hunger (balanced diets). We posit ongoing food system shifts will converge with national and global targets, justifying the uniform dietary scenario.

5.3.3 Results across the three pathways

Figure 5-5 *- Projected changes in the major indicators based on the FABLE results*



Analysis of FABLE results based on the CT assumption indicates a projected increase in the production value of all commodities. By 2030 and 2050, total commodity value is expected to reach 66 billion 2020 PPP dollars and 91 billion 2020 PPP dollars, respectively. Corn, wheat, sorghum, teff, and barley will likely remain the most important food crops, with an average production volume increase of 18% and 45% by 2030 and 2050 compared to the baseline year (2020). Livestock production is also projected to rise substantially. Cattle herds are expected to reach 45.7 million TLU (tropical livestock unit) by 2020, with sheep and goats reaching 12.4 million TLU by 2030. These represent a 24.7% and 22.4% increase compared to the 2020 baseline.

Based on the assumption of free agricultural land expansion without afforestation, cropland is projected to expand from 20 million hectares in 2020 to 24 million hectares in 2030 and 31 million hectares in 2050. This expansion, along with the absence of afforestation efforts, is expected to lead to a projected decrease in forest area which is projected to decline from 14 million hectares in 2020 to 13 million and 11 million hectares by 2030 and 2050, respectively. Pastureland is expected to remain relatively stable throughout the projection period.

Consistent with the projected increase in livestock numbers and decrease in forest cover, a rise in greenhouse gas (GHG) emissions is anticipated. Net emissions of CO_2 equivalent (CO_2e) are projected to increase by 64% and 200% by 2030 and 2050, respectively, compared to the 2020 baseline of Mt 171 CO_2e emission.

Compared to the CT pathway, the NC scenario shows similar increasing trends for total commodity production value (reaching 66 billion 2020 PPP dollars and 91 2020 PPP dollars by 2030 and 2050, respectively). However, the GS pathway forecasts lower values (61 billion 2020 PPP dollars and 78 billion 2020 PPP dollars) due to its lower population assumption (169 million by 2050) compared to CT and NC (197 million). This difference in population growth also translates to lower projected increases in major cereal crops (corn, wheat, sorghum, teff, barley) for GS, with an average increase of 20% by 2050 compared to 41% for CT and NC. Livestock production shows a similar trend. NC forecasts a 20% increase in cattle and sheep/goat tropical livestock units (TLU by 2030, rising to 67% by 2050. GS exhibits lower growth (10% for both by 2030, rising to 45% for cattle by 2050) due to the assumption of increase in productivity, enabling similar production goals with fewer animals.

5.3.4 What are the most influential factors to reduce the hidden costs by 2030 and 2050?

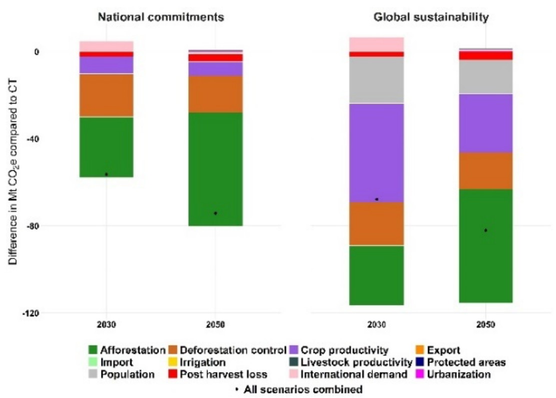
Compared to the CT scenario, both NC and GS pathways exhibit relatively lower rates of cropland expansion. By 2030 and 2050, the cropland area in the NC scenario is projected to reach 23 million and 29 million hectares, respectively, while the GS scenario projects 22.2 million and 26 million hectares, respectively. Decomposition analysis suggests that the primary driver for the lower expansion rates in both NC and GS pathways, compared to CT, is a combined effect of increased crop productivity and reduced post-harvest losses (Figure 5-6). These improvements enable the achievement of production targets without resorting to significant land use change, thus mitigating the need for cropland expansion. While both scenarios share the assumption of improved productivity and reduced losses, the GS pathway projects a lower cropland area requirement due to its lower population growth assumption compared to NC.

In contrast to the CT scenario, both NC and GS pathways project a decline in pastureland. By 2030 and 2050, pastureland is projected to decrease from 20 million hectares in 2020 to 18 million and 17 million hectares, respectively. This trend coincides with a relatively higher net forest cover compared to the CT pathway, reaching 13 million hectares by 2030 (compared to 11 million hectares in CT). Decomposition analysis suggests that afforestation is the primary driver of this land use shift, with projections indicating a conversion of approximately 500,000 hectares of pastureland to forest every five years in both NC and GS scenarios. Furthermore, decomposition analysis reveals that the combined assumption of non-deforestation agricultural expansion and increased crop productivity is a key factor contributing to the rise in the forest area in NC and GS pathways compared to CT. Additionally, the lower population assumption in the GS pathway contributes to a higher projected forest area compared to the NC pathway.

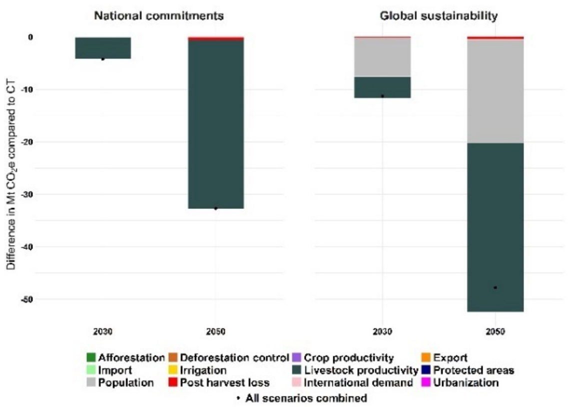
The most prominent distinction between the scenarios lies in greenhouse gas (GHG) emissions. NC projects a 21% decline by 2050, while the GS achieves a significantly steeper reduction (39%). Both pathways share common factors contributing to lower emissions compared to the CT scenario, including increased afforestation, enhanced crop productivity, reduced agricultural expansion (mitigating CO_2-equivalent emissions), and improved livestock productivity (leading to reduced methane emissions). Notably, the GS pathway is projected to achieve a higher rate of CO_2e and methane reduction than NC due to its lower population growth assumption.

Figure 5-6: *Isolation of the impact of single scenarios on major model's outputs*

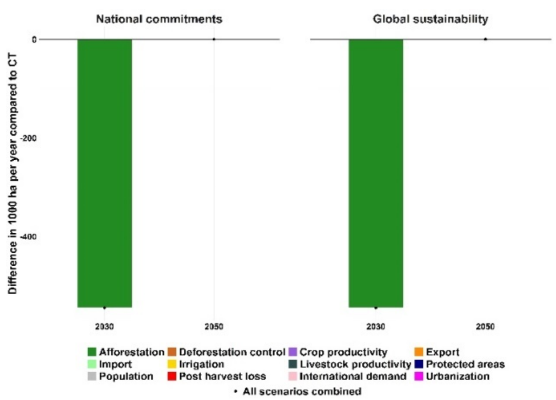
CO_2 emissions



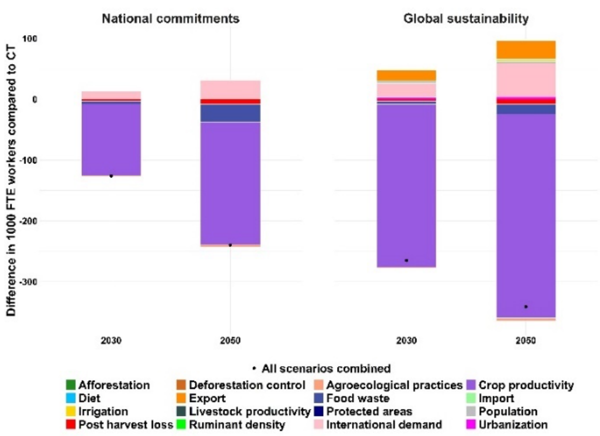
CH_4 emissions

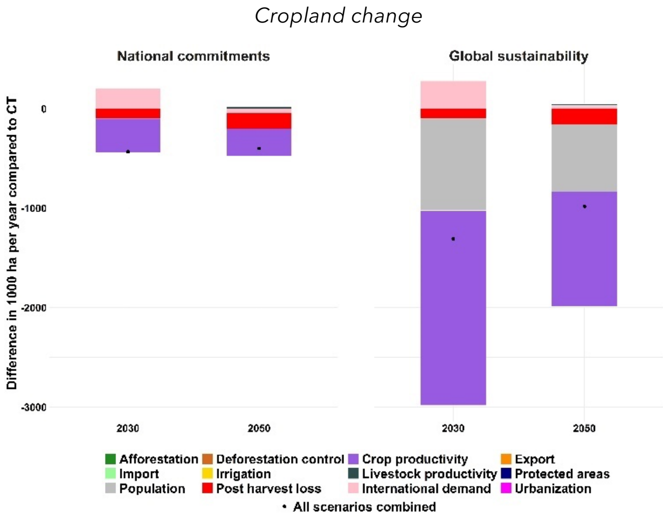


Pasture change



Farm labor FTE



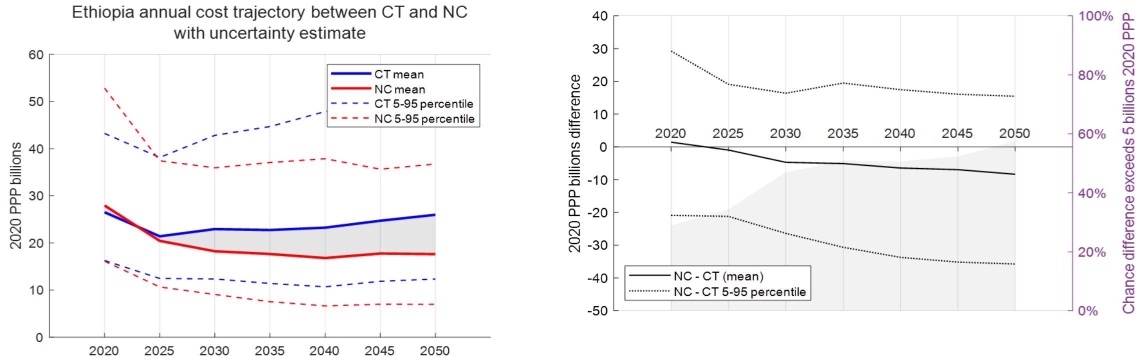


5.3.5 Impacts on the agrifood system's hidden costs

Projections show agrifood system hidden costs steadily rising under the CT scenario until 2050. This highlights the contradiction of economic growth alongside continued land use changes and high GHG emissions. Excluding poverty externalities (estimated at 24 billion 2020 PPP dollars by 2020), total hidden costs are projected to reach 25 billion 2020 PPP dollars by 2050, adjusted for social discounting based on anticipated economic growth (Figure 5-7).

Environmental externalities, primarily driven by high emissions and land use expansion, are expected to remain the most significant contributor to hidden costs, reaching 24 billion 2020 PPP dollars by 2024. However, under the NC and GS scenario, hidden costs are projected to decrease by 25% compared to the CT scenario. This translates to total hidden costs of 16 billion 2020 PPP dollars by 2050, representing an average annual avoidance of 6 billion 2020 PPP dollars. These reductions stem from the assumption of lower population growth rates, decreased livestock numbers, and increased crop and livestock productivity, all of which can significantly reduce emissions, pollution, and land use change impacts, thereby lowering hidden costs.

Figure 5-7: *Trajectory of Ethiopia total annual hidden costs and cost reduction for CT and NC with uncertainty estimate*



Note: The top graph in each panel shows the expected hidden costs under CT (blue) and alternative pathway (red). The shaded area between the trajectories indicates the mean value of the total reduction under the alternative pathway over the period 2020–2050 in 2020 PPP dollars.

5.4 Entry points for action by type of actor of the agrifood system and foreseen implementation challenges

Ethiopia's widespread poverty in agriculture is a major issue that leads to hidden costs. Stakeholders focus on reducing poverty and ensuring everyone has enough to eat as starting points. The stakeholders suggested that the upcoming FAO-SOFA report can inform policy decisions to address rural poverty and increase access to safe, nutritious food. This can be achieved by:

Limited population growth: Decomposition analysis and projections of hidden costs reveal that a lower population growth rate in the GS (14% less than NC and CT assumptions) significantly reduces hidden costs of the agrifood system. By curbing population growth, GHG emissions and farmland expansion decrease, leading to lower environmental and social externalities. Consequently, controlling population growth emerges as a primary strategy for mitigating the hidden costs associated with agrifood systems.

Increasing crop production and productivity: The high poverty rates among agrifood workers highlight the issue of income inequality and the need to break the cycle of poverty. A key strategy to achieve this is by increasing crop land productivity from its current very low average levels. This will empower farmers to raise their income and improve their livelihoods, while also reducing the negative externalities associated with low production. Boosting crop productivity aligns perfectly with the strategic development goals outlined by the government and relevant stakeholders.

Diversifying livelihood options: The high poverty rates among agrifood workers are partly due to their continued reliance on low-productivity farming system. To address this, a key solution is to encourage a significant shift in the labor force, enabling workers to transition from agriculture to higher-paying sectors like industry and services. This shift can offer a crucial pathway out of poverty.

Dietary diversification and enhanced nutrition interventions: High malnutrition costs highlight Ethiopia's economic burden so shifting the focus beyond solely quantity to nutrition is crucial. This means promoting nutrient-rich crops, food fortification, and dietary education. Ethiopia has begun improvements to promote nutritious food production with the development of national food fortification standards. Examples include mandatory iodine fortification (2011) and voluntary fortification of edible oil with vitamin A and wheat flour with iron, zinc, and B vitamins (2018) (Rudolph and Aydos, 2021). These efforts, along with existing strategies to increase production of nutritious foods like potatoes and sweet potatoes (MoE, 2024), demonstrate a commitment to improving national food security and reducing malnutrition. Furthermore, encouraging farmers to cultivate a wider variety of crops aligns with the National Nutrition Sensitive Agriculture Strategy (MoANR and MoLF, 2017), as well as promoting food diversity, access, and consumption for better family nutrition and reduced reliance on purchased staples.

Indigenous dietary practices: Ethiopia's low rates of diet-related health externalities compared to the world suggest its traditional dietary practices, rich in cereals and plant-based foods, may offer valuable insights. Building upon this existing wisdom, rather than imposing complete dietary changes, could be a more effective approach to improving national food habits. This aligns with the country's national food policy, which prioritizes promoting indigenous food and dietary practices (FDRE, 1986).

Improved market access and value optimization: High social costs reflect underlying income inequality in Ethiopia. Promoting direct sales to consumers through improved infrastructure, farmer cooperatives, and market data access can empower farmers and reduce costs by streamlining marketing processes. This aligns with the Ethiopia Rural Connectivity to Support Food Security Project (RCSFSP) (MoA and ATI, 2024), which aims to create physical and digital access for rural communities, enhancing market linkages.

Enhancing food security through low-emission agriculture: Decomposition analysis shows possible ways of reducing environmental externalities in agrifood systems through enhancing crop and livestock productivity without compromising yields. This strategy fosters lower greenhouse gas emissions by minimizing the need for farmland expansion and reducing livestock populations. Aligning with this principle, the Ethiopian Environmental Protection Agency's Climate-Resilient Green Economy strategy (FDRE, 2011) prioritizes low-emission crop and livestock production systems, coupled with afforestation efforts.

5.5 References

Bank, W., 2018. Ethiopia Economic Update: The Inescapable Manufacturing-Services Nexus. World Bank.

Bizikova, L., De Brauw, A., Rose, M.E., et al., 2022. IISD.org ii Achieving Sustainable Food Systems in a Global Crisis: Ethiopia International Institute for Sustainable Development Achieving Sustainable Food Systems in a Global Crisis: Ethiopia Ceres2030 Deep Dives into the Nexus of Food Systems, Climate Ch.

CSA, 2013. Population projections for Ethiopia 2007–2037. Fed. Democr. Repub. Ethiop. Popul. Census Comm. Addis.

Diao, X., Pauw, K., Thurlow, J., Ellis, M., 2023. Ethiopia's agrifood system structure and drivers of transformation.

Fanzo, J., Haddad, L., McLaren, R., et al., 2020. The Food Systems Dashboard is a new tool to inform better food policy. Nat. Food 1, 243–246. https://doi.org/10.1038/s43016-020-0077-y

FABLE (2024) Transforming food and land systems to achieve the SDGs. In Sachs et al. (2024) The Sustainable Development Report 2024. SDSN, New York and Paris

FAO, 2024. The State of Food and Agriculture 2024: Value driven transformation of agrifood systems. Rome.

FAO, 2023. The State of Food and Agriculture 2023: Revealing the true cost of food to transform agrifood systems. Rome.

FDRE, 2022. Ethiopia's Third National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) 1–349.

FDRE, 2021. Vision 2030: Transforming Ethiopian Food Systems.

FDRE, 2017. Federal Democratic Republic of Ethiopia Ethiopia ' s Progress Towards Eradicating Poverty :

FDRE, 1986. Food and Nutrition Policy. Food Nutr. Bull. 8, 1–6. https://doi.org/10.1177/156482658600800310

FDRE, F.D.R. of E., 2011. Ethiopia's Climate Resilient Green Economy (CRGE) Strategy. Fed. Democr. Repub. Ethiop. 200.

FMoH, 2021. National Adolescents and Youth Health Strategy.

FMoH, 2016. National Reproductive Health Strategy. FMoH 1–49.

FMoH, 2011. National Guideline for Family Planning Services In Ethiopia.

Guendehou, G.H.S., 2006. IPCC NGGIP Technical Support Unit Inventory Internship Land-Use Changes and Greenhouse Gas Fluxes : Scientific Understanding and Contribution to Improving Methodologies for Greenhouse Gas Inventory in BENIN. Strategies 2005–2006.

Mekuriaw, Z., Harris-Coble, L., 2021. Ethiopia's livestock systems: Overview and areas of inquiry.

Minten, B., Dereje, M., Bachewe, F., Tamru, S., 2018. Evolving food systems in Ethiopia : Past , present and future.

MoA, ATI, 2024. Rural Connectivity to Support Food Security Project (P176303) Appraisal Federal Democratic Republic of Ethiopia Ministry of Agriculture (MoA) and Agricultural Transformation Institute (ATI) 1–11.

MoANR and MoLF, 2017. Federal Democratic Republic of Ethiopia National Nutrition Sensitive Agriculture Strategy 1–35.

MoE, 2024. The National Potato and Sweetpotato Development Strategy (NSPSDS) 2024-2030.

Mosnier, A., Penescu, L., Perez-Guzman, K., Steinhauser, J., Thomson, M., Douzal, C., Poncet, J., 2020. FABLE Calculator documentation- 2020 update. IIASA (Laxenburg) and SDSN (Paris).

Reardon, T., Echeverria, R., Berdegué, J., et al., 2019. Rapid transformation of food systems in developing regions: Highlighting the role of agricultural research & innovations. Agric. Syst. 172, 47–59. https://doi.org/10.1016/j.agsy.2018.01.022

Rudolph, S., Aydos, E., 2021. Lessons learned from the implementation of ETS. Carbon Mark. Around Globe 1–7. https://doi.org/10.4337/9781839109096.00013

WB, 2020. Ethiopia poverty assessment: Harnessing continued growth for accelerated poverty reduction.