Analysis

# Evaluating synergies and trade-offs in achieving the SDGs of zero hunger and clean water and sanitation: An application of the IEEM Platform to Guatemala

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ABSTRACT

The Sustainable Development Goals (SDGs) are a universal call to action to end poverty and protect the environment. The Government of Guatemala is prioritizing the SDGs it will focus on and defining lines of action to achieve them. In this paper, we apply the Integrated Economic-Environmental Modelling (IEEM) Platform for Guatemala to evaluate the economic, wealth and environmental impacts of strategies to achieve the second SDG of zero hunger and the sixth SDG of clean water and sanitation. The analytical power of the IEEM approach is driven by its integration of the first international standard for environmental statistics, the System of Environmental-Economic Accounting introduced in an earlier edition of this journal. This integration enables the evaluation of policy alternatives from economic, wealth and environmental perspectives which is essential given the integrated nature of the SDGs. We find that significant additional investment in agricultural productivity and water and sanitation would be required to meet these SDG targets and that the overall pace of economic growth is critical. IEEM applied to the SDGs lends transparency and structure to the prioritization and agenda setting process of the policy cycle and highlights the importance of allocating adequate resources in multi-year budgets if targets are to be met. IEEM can shed light on the need for complementary policies to reconcile lines of action that can make progress toward one SDG while inadvertently moving away from another SDG, as well as identify potential win-wins, where one line of action can make progress toward multiple SDGs simultaneously.

## 1. Introduction

The post-2015 development goals are embodied in the 2030 Agenda for Sustainable Development (UN, 2015). Since January of 2016, the Sustainable Development Goals (SDGs) are a universal call to action to end poverty, protect the environment and ensure prosperity for all.[1] The Agenda recognizes the eradication of poverty as the greatest global challenge and that it is intrinsic to sustainable development. The 17 SDGs and 169 targets build on progress made toward the Millennium Development Goals and address some of the gaps they were unable to address. The Sustainable Development Agenda is broad and inclusive, covering economic, social, and environmental dimensions with strong

interdependencies. Inherent in the implementation of the Agenda are trade-offs between meeting different SDG targets as well as potential synergies that can be capitalized on.

Lower-income countries have the widest gap to bridge in meeting SDG targets. These countries need to prioritize which SDGs to focus on in alignment with national development priorities. To enable effective targeting of scarce public resources, it is critical for policy makers to have information on the potential impacts, synergies and trade-offs of public policies and investments aimed at achieving the SDGs (Ruijs et al., 2018). In other words, what is required is evidence upon which public policy and investment decisions may be based which captures the multiple dimensions of the SDGs and their interdependencies. This

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paper presents the Integrated Economic-Environmental Modelling (IEEM) Platform, an integrated data and analytical platform that delivers these capabilities to policy makers for evidence-based policy design while enhancing transparency in the design of strategies to meet the SDGs.

In this paper, the IEEM Platform is applied to Guatemala, a country with 16.9 million people, 59.3% of which live in poverty and exhibiting some of the worst malnutrition and maternal child mortality rates in Latin America and the Caribbean. In Guatemala, the gap between today's level of wealth and prosperity, and that envisioned in the Agenda for Sustainable Development is vast and the need for effective targeting of public resources could not be more pressing. To demonstrate the application of the IEEM Platform to inform strategies to achieve the SDGs, we focus on the second SDG of ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture, and the sixth SDG of ensuring availability of water and sanitation for all.

The IEEM Platform is an economy-wide framework developed for evidence-based public policy and investment design. At the core of IEEM is a dynamic computable general equilibrium model which provides a full representation of the economy and how agents including households, producers and government interact. The two main data sources underpinning IEEM are the System of National Accounts and the first international standard for environmental statistics, the System of Environmental-Economic Accounting (SEEA) which was introduced in an earlier edition of this journal (Lange, 2007). The integration of these two data sources enables analysis of policy impacts on wealth whose three pillars- built capital, human capital and natural capital- are aligned with the three dimensions of sustainable development, namely economy, society and environment. This integration of SEEA data in IEEM elucidates economy-society-environment interactions which provides a powerful advantage over other decision-making frameworks.

The rest of this paper is structured as follows. Section 2 discusses the integration of the environmental dimension in economy-wide modelling. Section 3 provides a brief overview of the methodology, with an emphasis on the SEEA which underpins the IEEM Platform. Section 4 describes the specific lines of action the Government of Guatemala is pursuing to make progress toward the second SDG of zero hunger and the sixth SDG of clean water and sanitation, and operationalizes them for implementation in the IEEM Platform. Section 5 presents results and analysis and Section 6 presents the conclusions of the study. The final section discusses the importance of using an integrated framework such as IEEM for analysis of SDGs and other complex policy challenges.

## 2. Integrating the environmental dimension in economy-wide modelling

The SEEA Central Framework (UN et al., 2014a) is the first international statistical standard for accounting for the interactions between the economy and the environment, and is consistent and compatible with the System of National Accounts (SNA), the internationally agreed standard for accounting of economic activity. The SEEA tracks natural inputs into the economy, the flows of residuals such as waste and emissions back to the environment, and changes to stocks of environmental assets. A Special Issue of this Journal introduced an early version of the SEEA UN et al. (2003) to encourage its application in practitioners' work and to discuss some of the strengths and limitations of the 2003 version of the SEEA (Lange, 2007).

A motivation for the development of environmental-economic accounting was addressing one of the main critiques of the SNA. The critique was that while the SNA's balance sheet accounts allow for the recording of depletion and degradation of environmental assets as changes in wealth, these flows are not also recorded as deductions from measures of income. Thus, a key requirement of environmental-economic accounting is that the cost of natural capital should be integrated into national income accounts which in turn, drives adjustments to

measures of national income, Net Domestic Product, Gross Domestic Product (GDP) and investment accounts (Repetto, 2007). These considerations are fundamental for assessing the sustainability of economic growth.

This limitation in the definition of GDP has become more problematic with the increasing reliance on GDP as a measure of economic development. While GDP is an effective measure of gross income flow, by ignoring the cost of the depletion or degradation of environmental assets, it is a poor indicator of sustainable development and wealth (Lange et al., 2018). Indeed, using GDP as an indicator of development can have serious consequences for countries. For example, a high rate of GDP growth achieved through the over-exploitation of environmental assets could be taken as an indication that a country is on a strong sustainable development path. Unfortunately, in the extreme, this resource exploitation could result in the liquidation of a country's environmental assets and a sudden halt or decline in GDP growth. This situation is exacerbated when a country does not reinvest income from environmental assets in other forms of capital, such as human capital.

The SEEA complements the SNA in three important ways. First, the SEEA identifies environmental assets as the naturally occurring biotic and abiotic components of the environment. Seven environmental assets are considered in the SEEA, namely mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources, and water resources. These assets are quantified in physical units such as cubic meters and hectares. Monetary values are assigned to these assets according to market prices where they are observable; where market prices are unobservable, assets are valued using market price equivalent valuation approaches such as the net present value approach. While the SNA requires that for an environmental asset to be accounted for, it must have an owner and generate a future income stream, the SEEA extends the asset boundary. In physical terms in the SEEA, the asset boundary includes all environmental assets and land of an economic territory, including those without a market price. As we will see in the analysis presented in this paper, this is the case of irrigation water in Guatemala. Irrigation water is accounted for in Guatemala's SEEA, but it does not have an observable market price.

Second, the SEEA Experimental Ecosystem Accounting Framework (UN et al., 2014a,b; UN, 2017) outlines basic concepts for ecosystem accounting. Experimental Ecosystem Accounting considers ecosystem services beyond *provisioning* ecosystem services which are those that are used as inputs into productive processes, most of which have an observable market price.[2] The Experimental Ecosystem Accounting Framework extends the production boundary of the SNA to include the whole biophysical environment and a broader set of ecosystem services which encompasses *regulating* and *cultural ecosystem services* (Banerjee et al., 2019a).[3]

Third, the SEEA and the Experimental Ecosystem Accounting Framework account for the depletion of environmental assets. The SEEA in fact defines a depletion adjusted measure of GDP. Depletion adjusted measures in the SEEA deduct not only the consumption of fixed capital, but also the cost of the depletion of environmental assets.[4] Changes to the condition of ecosystems and their capacity to generate ecosystem services are also accounted for in the Experimental

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[2] Ecosystem services may be classified as provisioning, regulating and cultural ecosystem services. Provisioning ecosystem services are material outputs from ecosystems (food and fibre); regulating services regulate ecosystem processes such as climate and hydrological regulation, and; cultural services are those related to recreation and health.

[3] For the classification of ecosystem services used in this paper, please see: European Environment Agency. 2018. The Common International Classification of Ecosystem Services (CICES): Towards A Common Classification of Ecosystem Services [Online] Copenhagen: European Environment Agency. Available: https://cices.eu/.

[4] For more details on depletion adjusted measures, see Sections 2.63, 6.25 and 6.94 of the SEEA Central Framework.

Ecosystem Accounting Framework (Obst and Vardon, 2014).

GDP growth is a good indicator of the rate at which income is growing. Wealth metrics on the other hand provide information on the sustainability of income growth in the long run (Lange et al., 2018). With the SNA and the SEEA underpinning the IEEM Platform, IEEM generates measures of wealth and well-being that complement the information provided by GDP thus directly addressing the concerns of relying on GDP as an indicator of sustainable development. IEEM generates three metrics that are worth noting. First, IEEM enables estimation of policy impacts on genuine savings. Genuine savings is calculated based on net national savings derived from the SNA and measures of: changes in environmental stocks which can include forest, mining and fisheries stocks; water availability, and; changes in environmental quality which can be measured through changes in greenhouse gas emissions and waste.

Second, IEEM tracks changes in the stocks and flows of environmental assets in physical as well as monetary units, which can provide important information to policy makers. For example, policy impacts on water availability can signal the need for mitigation measures, or; an increase in the $CO_2$ emissions intensity of GDP growth can indicate greater reliance on fossil fuels in driving growth, which can conflict with Paris Agreement commitments and the thirteenth SDG to take urgent action to combat climate change and its impacts.

Third, with the integration of the SEEA Land Accounts in the IEEM Platform, it is possible to track future changes in land use and land cover that may arise from policy implementation. This feature has proved particularly powerful as we link IEEM with ecosystem service modelling (IEEM + ESM). With projections of land use change generated by IEEM for different policy scenarios, we develop scenario-based land use land cover maps. We then use these maps to estimate policy impacts on future ecosystem service supply, including regulating and cultural ecosystem services and the biodiversity that underpins them (Banerjee et al., 2018a,b; Banerjee et al., in preparation).

Together, the SEEA and the SNA are a fundamental source of data for monitoring progress toward the SDGs (Alexander et al., 2018; Bann, 2016; Ruijs et al., 2018; UNSD, 2015a,b). When this data is incorporated in an integrated, prospective analytical framework such as IEEM, it becomes possible to assess ex-ante how alternative public policy and investment strategies make progress toward specific SDGs. The integrated nature of the IEEM Platform is particularly powerful in highlighting the synergies between multiple SDGs as well as potential trade-offs. Critical for Government budgetary planning, IEEM also provides insights into the cost effectiveness of different lines of action aimed at achieving specific SDGs.

Recently, SEEA's contribution to supporting the implementation and monitoring of the SDGs was debated among experts and policy makers at the Second Forum on Natural Capital Accounting for Better Policy in The Hague (Ruijs and Vardon, 2018; Ruijs et al., 2018; World Bank WAVES, 2018). Indeed, the SDGs, National Development Plans, the Paris Agreement and Green Growth Strategies all pose a set of highly interdependent and complex objectives where an integrated approach to policy design is critical (Ruijs and Vardon, 2018).

## 3. Methods

### 3.1. An economy-wide framework

At the core of the IEEM Platform is an economy-wide recursive dynamic[5] computable general equilibrium model (CGE).[6] In the

analysis of complex and interrelated policies such as those embodied by the SDGs, an economy-wide analytical approach is powerful. It effectively captures important inter-sectoral, backward and forward linkages with industries serving as consumers of intermediate inputs and producers of final goods and services, and the direct, indirect and induced impacts of policies and their spill-overs (Cattaneo, 2001; Dixon and Rimmer, 2002; Pearce et al., 2006; Banerjee et al., 2015). An economy-wide approach provides a systematic method for estimating both the direction and approximate magnitudes of policy impacts and external shocks on economic agents. As Nobel Economist Kenneth J. Arrow affirmed, "…in all cases where the repercussions of proposed policies are widespread, there is no real alternative to CGE" (Arrow, 2005, p. 13).

The IEEM Platform advances a standard economy-wide framework in three important ways. The first innovation is its integration of data from the SNA,[7] the main source of data for a CGE model, with the SEEA. With this data underpinning, IEEM enables quantitative analysis of how economies depend critically on the environment as a source of inputs and as a sink for emissions and waste. The consistency and compatibility of the SEEA and the SNA is a distinct advantage which reduces the assumptions required to reconcile environmental and economic data. The second innovation relates to the indicators IEEM generates, which include metrics of current and future wealth. In this context, wealth is understood as the aggregate value of manufactured, natural and human capital. Indicators of wealth such as genuine savings and the inclusive wealth index provide insights into the sustainability and equity of economic growth (Polasky et al., 2015; Stiglitz et al., 2010).

Another important feature related to indicators is that IEEM generates not only indicators of environmental impacts, but also all the standard economic indicators that include GDP, sectoral output, exports/imports, employment, income, poverty and inequality. IEEM thus provides decision makers in Ministries of Finance responsible for budgetary allocations with information on policy impacts on the indicators that they are most familiar with, as well as other metrics of impacts on wealth, natural capital stocks and environmental quality. This accessibility of IEEM results to government decision makers is critical for ensuring the uptake and institutionalization of IEEM as a decision-making platform and has reflected our experience in working with governments in countries including Guatemala, Costa Rica, Colombia and Rwanda. Furthermore, our linking of IEEM with ecosystem services impact assessments (IEEM + ESM) strongly enhances the communications potential of the analysis by enabling a visual display of the results in the form of maps.

The third innovation is IEEM's treatment of environmental assets. A number of economic activities that use environmental assets in their productive processes differ in their behavioral dynamics from conventional economic activities, such as automobile manufacturing or retail services. Thus, beyond the standard CGE configuration of cost minimizing firms, the IEEM Platform contains environmental modelling modules to capture environmental asset-specific dynamics for each of the environmental assets represented in the SEEA (forestry, land use, water, energy and emissions, mining, fisheries, and waste and residuals modules).[8] These modules deliver a more realistic representation of economic and environmental interactions and enable the application of the IEEM Platform to a broad range of economic and environmental issues. Before IEEM, typically a different model would be required for each environmental issue explored which is a resource intense and

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[5] Recursive dynamics implies that the CGE model is solved sequentially with behavior dependent on past and current conditions.

[6] Online supplementary material for Banerjee et al. (2019) offers a detailed mathematical model statement of IEEM and its environmental modelling modules.

[7] Some readers may be familiar with the Global Trade Analysis Project (GTAP) database which is based on individual countries' SNA and links all economies and regions through trade. The IEEM Platform presented here is a single country framework.

[8] The version of the IEEM Platform applied in this study only considers flows of emissions. The 2019 version of IEEM is designed to enable tracking of carbon stocks considering emissions from economic activities, above and below carbon stocks in forests and changes in land use and land cover.
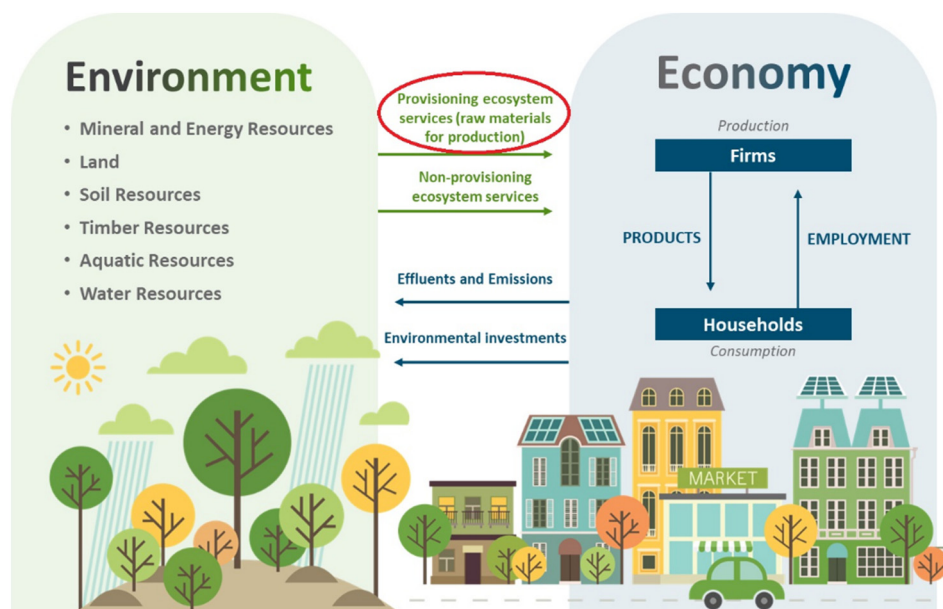
**Fig. 1.** Environment-economy interactions embodied in IEEM.
Source: Authors' own elaboration.

costly process (Banerjee et al., 2016).

Fig. 1 shows the environment-economy interactions captured in the IEEM Platform. On the left side of the figure, the environment is represented by the environmental asset accounts contained in the SEEA, namely mineral and energy resources, land, soil resources, timber resources, aquatic resources and water resources. On the right side of the figure is the economy, represented by firms that use labor, capital and other factors of production, and intermediate inputs to produce goods and services that are consumed by households, the government and exports markets. IEEM captures the two-way interactions between the economy and the environment, with the environment providing inputs to productive processes in the form of raw materials or provisioning ecosystem services. Through the production and the consumption of goods and services, emissions and waste are generated and returned to the environment. To mitigate environmental damage and improve environmental quality, investments are made in the environment for controlling pollution or administering protected areas, for example. The data structure that underpins IEEM and its system of equations captures all of these interactions quantitatively. Online Supplementary material for Banerjee et al. (2019a) offers a detailed mathematical model statement of the IEEM Platform and its environmental modelling modules.

### 3.2. The IEEM database

Underpinning any CGE model including IEEM is a social accounting matrix (SAM). A SAM is constructed based on data from the SNA, particularly from the supply and use tables, integrated economic accounts, balance of payments accounts, government accounts data and other ancillary data sources. Detailed descriptions of a SAM are found elsewhere, for example: Breisinger et al., (2009), King (1981), and Pyatt and Round (1985). For the development of the IEEM database, some modifications to a standard SAM may be appropriate depending on the particular policy application. One example is the disaggregation of irrigation water as a factor of production where there is no observable market price. This adjustment may be useful should a decision maker be interested in evaluating increasing water scarcity and the evolution of a water market. Certain basic information beyond that contained in the SEEA, however, would be required, such as: the cost of irrigation, the productivity differential between irrigated and rainfed cropping, and

any difference in value that an irrigated crop may have due to differences in seasonality or quality of the good produced.

Based on the SEEA and the SNA, environmentally extended supply and use tables are developed to calibrate IEEM's environmental modelling modules. These tables extend the standard supply and use tables in the SNA by including additional columns for environmental data, and rows for environmental inputs and residuals. This extended framework is created in three steps: (i) different levels of data disaggregation are mapped to account for any differences that may exist between how international and local standards are applied; (ii) information on environmental interactions between sectors, households and government are added to this supply and use table, and; (iii) some rearrangement of the environmentally extended supply and use table is undertaken, usually along thematic lines such that, for example, data rows describing resource use are arranged next to rows describing the return flows to the environment. Based on the environmentally extended supply and use tables, satellite environmental accounts are developed and used to calibrate IEEM. Table 1 presents the satellite environmental accounts used to calibrate the IEEM Platform for Guatemala.

### 3.3. Capturing distributional impacts of public policy

With our focus on SDGs two (zero hunger) and SDG six (water and sanitation) in this paper, the household level poverty and inequality impact of strategies to achieve these SDGs is important. The IEEM Platform's design includes a microsimulation module to consider the impacts on the percentage of the population living below the poverty line, as well as other Foster-Greer-Thorbecke poverty metrics which place a greater weight on poverty of the poorest individuals, and on economy-wide measures of income inequality expressed as the Gini coefficient. Most standard economy-wide models use a representative household formulation where all households in an economy are aggregated into one or a few households. The main limitation of this formulation is that the intra-household income distribution does not respond in scenario analysis and thus important insights may be missed. IEEM overcomes this limitation with its microsimulation module. Specifically, in a policy simulation, changes in prices, wages, aggregate labor market variables (i.e., the unemployment rate and the sectoral structure of employment) and non-labor incomes are used as inputs into

**Table 1**
Environmental accounts in the IEEM Platform for Guatemala.

| Category - # | Item | Category - # | Item |
| --- | --- | --- | --- |
| Water (11) | Registered, supply | Energy (10) (*) | Supply, Fuelwood |
| | Registered, use | | Supply, Mining |
| | Non-registered, rainfed | | Supply, Refined petroleum prod |
| | Non-registered, sprinkler irrigation | | Supply, Recycling |
| | Non-registered, drip irrigation | | Supply, Electricity |
| | Non-registered, gravity use | | Use, Fuelwood |
| | Non-registered, other use | | Use, Mining |
| | Return, sprinkler irrigation | | Use, Refined petroleum prod |
| | Return, drip irrigation | | Use, Recycling |
| | Return, gravity use | | Use, Electricity |
| | Return, other use | Emissions (12) | Carbon Dioxide (CO2), by comm, 4 |
| Forestry (14) | Supply by commodity, 7 | | Nitrous Oxide (N2O), by comm, 4 |
| | Use by commodity, 7 | | Methane (CH4), by comm, 4 |
| Fishing (4) (*) | Supply, Fishing | Waste (2) (*) | Total supply |
| | Supply, Food prod | | Total use |
| | Use, Fishing | Land use (8) | Agriculture, 4 |
| | Use, Food prod | | Bushes |
| Mining (4) (*) | Total supply | | Pastures |
| | Total use | | Forest |
| | Initial stock | | Other |
| | Final stock | | |

For those categories marked with (*), more disaggregated information is available from Guatemala's SEEA should it be required for a particular application. SEEA data source: Instituto Nacional de Estadística et al. (2013).

the microsimulation module. The module in turn, and through a household income generation model, generates simulated household (per capita) incomes which are then used to estimate changes in poverty and inequality (Banerjee et al., 2015).

In practice, the household income generation model moves individuals across segments of the labor market and assigns them counterfactual labor incomes based on their simulated labor market status. For instance, selected individuals might move from being unemployed to being employed in manufacturing. Then, based on their observable characteristics, a new labor income is assigned to them. Finally, simulated household incomes are computed using the simulated labor incomes. The microsimulation module in the IEEM Platform for Guatemala is calibrated based on Guatemala's 2011 Household Survey on Quality of Life (INE, 2011).

While it is possible to use the internationally established poverty line (US$1.90 per day, 2010 prices), in this application we use Guatemala's nationally determined poverty line which is Q8282.9 Quetzales per person per year or US$2.83 per person per day (INE, 2013). The extreme poverty line is Q4380 per person per year and represents the cost of acquiring a minimum of 2362 Kilocalories per day in rural areas (2246 in urban areas). The overall poverty line is the income required to purchase the minimum number of calories and basic non-food consumption (INE, 2013).

### 3.4. Implementing scenarios in the IEEM Platform

The IEEM Platform can contribute to informing different phases of the public policy cycle (Fig. 2). For example, IEEM can be applied to target seeking scenarios where quantitative targets exist, though many alternative pathways are possible as is the case with the SDGs. Where different policies can generate similar outcomes in meeting targets, policy screening with IEEM can illustrate multidimensional impacts where a policy affects not only the outcome indicator of interest, but various other non-target indicators. These impacts can create positive synergies but can also create negative synergies and move progress away from other targets. The application of IEEM in policy screening can elucidate these complex interactions, prior to policy implementation.

The first step in the analysis of SDGs with the IEEM Platform is to outline the scenarios to be implemented in a quantitative way. Specifically, it requires knowledge of the costs of implementing a policy

and in some cases, potential benefits, as well as their temporal distribution. Some simulations may rely entirely on the endogenous mechanisms in IEEM, such as the transformation of Government investment into new public capital stock. Other simulations may rely on both the endogenous mechanisms of the model and expectations on policy impacts estimated outside the model. For example, an investment in agricultural research and development is expected to generate higher agricultural factor productivity growth over time. Estimates from regression analysis of the factors driving productivity growth can be used to inform these expectations in IEEM.

Once the scenario is designed and quantitatively described, it is implemented in IEEM which generates detailed reports on macro (GDP, trade, investment, aggregate consumption, emissions/waste, environmental resource use, changes to environmental stocks, and wealth), meso (sector output, employment, household income/consumption, sectoral environmental resource use, and sectoral/household emissions and waste), and micro impacts at the household level in terms of poverty and inequality. IEEM reports scenario results in a variety of ways including average annual growth rates, average growth over the period of analysis, annual change in levels or quantities of an indicator, and annual change in levels above baseline levels. The section that follows outlines the four SDG scenarios implemented in the IEEM Platform.

## 4. Scenario design: lines of action for achieving the Sustainable Development Goals

In this analysis we focus on SDG two which is that of ending hunger, achieving food security and improving nutrition, and promoting sustainable agriculture, and; SDG six, for ensuring access to water and sanitation for all. Specifically, we examine SDG 2.3 which by 2030 aims to double agricultural productivity and income of small-scale producers; SDG target 6.1 which aims to achieve universal and equitable access to safe and affordable drinking water, and; SDG target 6.2 which aims to ensure access to adequate and equitable sanitation and hygiene for all.

Considering SDG target 2.3, a key strategy for improving agricultural productivity and incomes of the rural poor in Guatemala is expanding irrigated agriculture, with an emphasis on the country's dry corridor. Irrigated agriculture has the potential to increase crop yields by 150% and income by a greater degree when irrigated crops obtain a
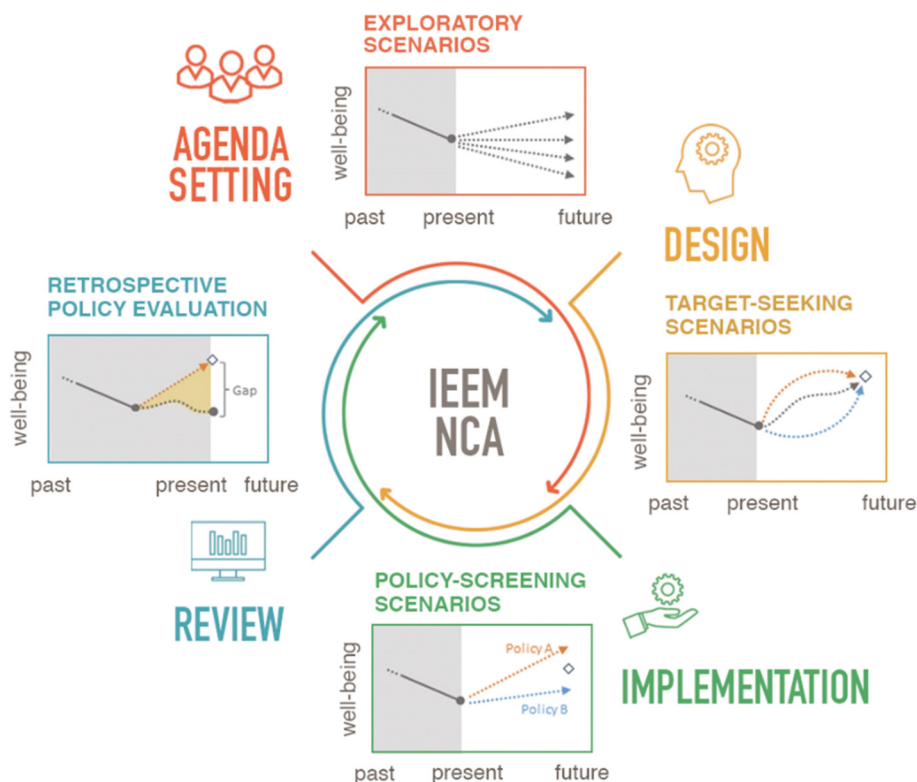
**Fig. 2.** IEEM and the policy cycle.
Source: Authors' own elaboration based on IPBES (2018).

price premium due to improved quality and seasonal availability (Amezquita, 2012). There is significant potential for expanding irrigated agriculture in Guatemala, both in terms of the area and the types of crops irrigated. The current irrigated area is just 29% of the 850,120 ha that have been identified with good potential for irrigation. Current irrigation schemes focus on export crops such as sugarcane and banana. Potential productivity and economic gains are the highest, however, for higher value crops such as tomatoes, peppers, onions and carrots, among others (MAGA, 2013).

The Guatemalan Government's Great National Agriculture and Livestock Plan 2016–2020 sets out general lines of action for enhancing agricultural sector productivity and competitiveness, including expanding irrigated agriculture (MAGA, 2016). The Government's Irrigation Development Policy (2013 to 2023) and National Irrigation Diagnostic provide details on lines of action and costs for expanding irrigated agriculture (MAGA, 2012, 2013). We draw from these national policies and diagnostics to define two scenarios aimed at making progress toward SDG target 2.3.

### 4.1. IRRIG1

In the first scenario (IRRIG1), we simulate a key component of the country's plans for irrigated agricultural expansion which focuses on investments in rehabilitating and modernizing existing irrigated water supply systems and infrastructure. These modernization and rehabilitation efforts are expected to increase the total irrigated area by 6399 ha. The estimated cost of the investment is US$6,045,780 which is distributed over a 5-year period (MAGA, 2013). This amount represents 0.07% of the government's total annual outlays. In the absence of information confirming new government budget allocations to fund this investment, it is assumed that 50% of the investment is financed through an international development grant and the other half through an increase in Guatemala's external debt. This is a reasonable assumption since in 2016 alone, international development agencies invested

US$17.3 million in enhancing food security in drought prone areas of the country. This investment in irrigation infrastructure is required to create some of the enabling conditions for the next irrigation investment scenario, IRRIG2.

### 4.2. IRRIG2

In the second scenario (IRRIG2), we consider additional investments proposed under Guatemala's Great National Agriculture and Livestock Plan for increasing irrigated agriculture focusing on Guatemala's Dry Corridor. This Plan has a goal of increasing irrigation on an additional 100,000 ha at a cost of US$1.95 million over a 5-year period (US $19.50/ha). In this scenario, this policy is implemented along with IRRIG1 for a total investment of US$7,995,780 and increase in irrigated area of 106,399 ha.

In IRRIG1 and IRRIG2, we rely entirely on the endogenous mechanisms in IEEM to generate the expected economic impact of the investments. In the context of irrigated agricultural expansion and food security, there are complementary shocks that could be justified. Though not implemented in this study, one example is the labor productivity enhancing impacts of improved food security and nutrition. Findings of the Food and Agriculture Organization of the United Nations demonstrate that better nutrition is associated with faster economic growth in the long run, estimated at around 0.5 percentage points of GDP for a 500-kcal/day increase in the Dietary Energy Supply of a country (Taniguchi and Wang, 2003). Implementing the productivity-enhancing effect of better nutrition and food security would have a positive impact on most economic indicators including GDP and household income.

### 4.3. WTSN

In the third scenario (WTSN), we simulate lines of action for making progress toward SDG targets 6.1 and 6.2. Guatemala's Water and

**Table 2**
Macroeconomic indicators; difference from baseline by 2030 in millions of USD.
Source: IEEM Platform results.

|  | IRRIG1 | IRRIG2 | WTSN | COMBI |
|---|---|---|---|---|
| Absorption | $ 69.2 | $ 1078.0 | $ 108.1 | $ 1184.7 |
| GDP | $ 79.9 | $ 1243.3 | $ 129.8 | $ 1371.4 |
| Private consumption | $ 51.1 | $ 797.9 | $ 74.5 | $ 871.4 |
| Fixed investment | $ 18.1 | $ 280.1 | $ 33.6 | $ 313.3 |
| Exports | $ 34.2 | $ 533.6 | $ 60.2 | $ 593.2 |
| Imports | $ 23.5 | $ 368.3 | $ 38.5 | $ 406.5 |
| Genuine savings | $ 36.5 | $ 563.1 | $ 33.7 | $ 595.4 |

Guatemala's SNA, SEEA and the IEEM database use Guatemala's currency, the Quetzal. We present results in US Dollars applying the average exchange rate for the year 2016 which is 7.29494 Quetzals to the USD.

Sanitation National Policy is a framework that outlines priorities, strategies and objectives for water and sanitation. Household survey data from 2011 shows that water and sanitation coverage at the national level was 75.3% and 55.96%, respectively. This level of coverage indicates that 3 million people lack access to water. A key goal of Guatemala's Water and Sanitation National Policy is to increase water and sanitation coverage to 95% and 90%, respectively, by 2025 (SEGEPLAN, 2013).

The consequences of limited access to quality water and sanitation are grave. The availability and quality of water and sanitation impact infant mortality, maternal mortality and general mortality at a rate of 30, 140 and 3 persons per 100,000, respectively. The main cause of death for children under 5 years of age in Guatemala are infectious and parasitic diseases which are related to limited access to water and sanitation. These diseases result in a mortality rate of 66 individuals per 100,000. Improved access and quality of water and sanitation reduces the frequency of gastrointestinal sickness by 32% in the case of sanitation and by 25% and 31% for water availability and water quality, respectively. Clearly, there are potentially large gains from investing in enhanced coverage (SEGEPLAN, 2013; UNICEF and WHO, 2008).

Access to improved water and sanitation has been linked to higher productivity and economic growth. Kiendrebeogo (2012) showed that better access to water improves agricultural productivity due to better health and less downtime resulting from sickness. This result is reinforced when accompanied by improved sanitation systems (Kiendrebeogo, 2012). Estimates show that an increase of one percentage point in access to drinking water in rural areas leads to increased productivity of the agricultural workforce by between 0.025% and 0.116%.

In this scenario, we simulate investment in increasing water and sanitation coverage. While the scenario is less ambitious than the SDG target of full water and sanitation coverage for 100% of the population, it is more realistic given current budget allocations and economic growth prospects. In this scenario, water coverage is increased from 75.3% to 81.5% of the Guatemalan population and sanitation coverage is increased from 56% to 66% of the population. The cost for increasing water and sanitation coverage is $1.607 billion or US$123,630,769 per year from 2018 to 2030 (SEGEPLAN, 2013).

In addition to the endogenous mechanisms in IEEM, we also impose a rural agricultural labor productivity shock to capture the labor productivity gains from healthier household members who get sick less frequently (Kiendrebeogo, 2012). With the increase in water coverage of 6.2 percentage points, a total labor productivity enhancement of 0.44% is implemented. Various other benefits could be considered both inside and outside of IEEM. For example, in this scenario, the labor productivity enhancement is only assessed for rural agricultural sector workers, while it is reasonable to expect that with increased access and quality of coverage, both rural and urban households would benefit and therefore higher economy-wide labor productivity would result. Also, not considered in this analysis are costs associated with illness

(medicines and doctor/hospital visits, for example), nor are estimated costs of lives lost (Value of a Statistical Life) due to inadequate access to water and sanitation.

As in the previous scenarios, in the absence of information confirming new government budget allocations to fund improved water and sanitation, it is assumed that 50% of the investment is financed through an international development grant and the other half through an increase in Guatemala's external debt. This is a reasonable assumption since in the Government's results-oriented budget for 2017, the Ministry of Health assigned only US$1.3 million to water quality.

### 4.4. COMBI

In the fourth and final simulation (COMBI), we simulate the joint impact of IRRIG2 and WTSN. In this simulation, the IRRIG2 investment of US$7,995,780 and increase in irrigated area of 106,399 ha are simulated. At the same time, the WTSN investment of US$1.607 billion is implemented along with the agricultural labor productivity shock of 0.44%. COMBI results demonstrate the combined impact of the three lines of action to achieve SDGs 2 and 6.

### 5. Results and analysis

Table 2 shows the scenario impacts on macroeconomic indicators as the difference from baseline values in 2030. IRRIG2 would drive positive impacts on all macro indicators with private consumption increasing by US$797.9 million; in the WTSN scenario, the impact would be less than one-tenth of the impact of IRRIG2, equal to US$74.5 million. Imports would increase across scenarios as the real exchange rate appreciates, strengthening Guatemala's purchasing power in international markets. Foreign exchange earnings would be considerably greater in the IRRIG2 scenario which is led by agricultural export growth. The COMBI scenario shows the overall GDP impact would be US$1371 million. Driven by the expansion in irrigated agriculture, the unemployment rate declines slightly from 7.4% to 7.3% in the COMBI scenario.

Sectoral impacts by 2030 show that agricultural output in IRRIG1 would be US$29 million greater than in the baseline (Fig. 3). The impact on industrial sectors and services would be US$38 million and US$57 million, respectively. IRRIG2 would increase agricultural, industrial and services output by US$473 million, US$571 million and US$884 million, respectively, for an overall increase of US$1929 million in economic output. WTSN makes a smaller contribution to sectoral output, slightly greater than the contribution of IRRIG1 and equal to US$39 million, US$79 million and US$92 million for agriculture, industry
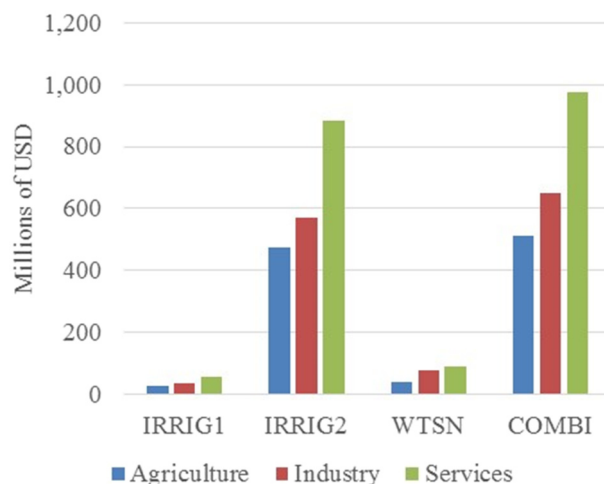


**Fig. 3.** Scenario impacts on sectoral output; millions of USD.
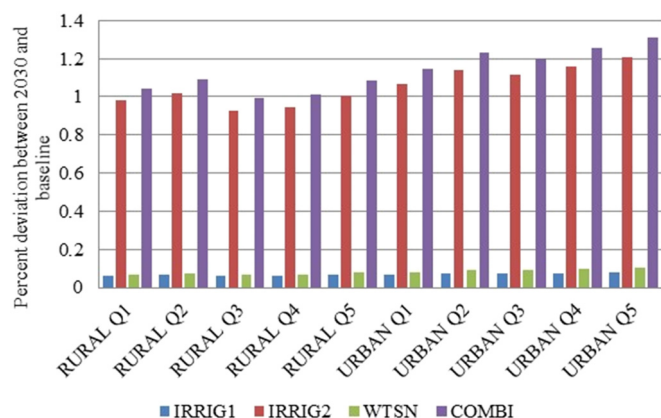Source: IEEM Platform results.

**Fig. 4.** Percent deviation in per capita income between 2030 and baseline; rural/urban household income quintile.
Source: IEEM Platform results.

and services, respectively. The joint impact on all scenarios reflected in COMBI is US$514 million, US$648 million and US$975 million, for an overall impact of US$2136 million. This is equivalent to a 3%, 0.9% and 1% increase over the baseline for the agricultural, industrial and services sectors, and a 1.1% increase overall in sectoral output.

In the baseline, non-export agricultural output in 2030 would be 52% greater than in 2017. In COMBI, output would be 59% greater than in the baseline in 2017. This result indicates that when IRRIG2 and WTSN impacts along with baseline growth are considered together, a gap of 41% still remains if SDG Target 2.3 is to be met and agricultural output is to be doubled by 2030.

In terms of household income, the expansion of irrigation would have a greater impact on incomes compared to improved water and sanitation. Fig. 4 shows the percent deviation in per capita income between 2030 and 2017, distinguishing between urban and rural households and income quintile. The first quintile represents lower-income households and the fifth quintile represents higher-income households. Wealthier urban households experience the greatest increase in per capita income, equal to 1.31% while per capita income of the poorest rural households would increase by 1.05%. Per capita income would increase similarly across income classes in the IRRIG1 and IRRIG2 scenarios; the impact of WTSN exhibits the greatest variation across income classes. When baseline growth is accounted for in COMBI, per capita income increases by between 10% and 19% across rural and urban households and income quintiles. For the poorest households, a gap of around 83% still remains to reach SDG target 2.3 of doubling the incomes of the poorest. This income gap, in the absence of the interventions in irrigation and water and sanitation, is 84% in the baseline which shows that the investments in irrigation and water and sanitation improve incomes by very little in fact.

The larger impact of IRRIG2 on income when compared to WTSN may be explained by the fact that in IRRIG2, total factor productivity in the irrigated agricultural sector increases as a result of the investment. Thus, returns are greater for all factors of production, while in the case of the WTSN scenario, only agricultural sector labor productivity increases. In terms of how income gains are distributed, since wealthier households own a greater share of land and capital, their incomes increase proportionally more than poorer households who contribute mostly only labor to agricultural production.

In terms of the national poverty gap, the poverty headcount ratio is reduced by 0.67 percentage points in 2030 in the COMBI scenario which is equivalent to approximately 117 thousand individuals being lifted out of poverty (2017 population level). Considering the baseline pace of economic growth alone, the poverty gap falls from 56.4% in 2017 to 44.7% by 2030. This change of 11.7 percentage points indicates that projected economic growth in Guatemala would reduce the

poverty headcount by over 2.31 million people. The impact of the COMBI scenario coupled with baseline economic growth would reduce the number of individuals living in poverty by 2.42 million. Income inequality across household income quintiles would be reduced slightly across all scenarios as indicated by the Gini coefficient, though inequality increases slightly between rural and urban households.

Governments routinely undertake cost benefit analysis to evaluate the viability and returns to public investments. There are a number of approaches that may be taken to calculate the Net Present Value of the scenarios implemented here. In this analysis, the investment is not considered as a direct cost within IEEM. Instead, the investment cost and economic benefits are assessed outside of the simulations to calculate Net Present Value. A discount rate of 12% is used, which is a standard rate used by some multi-lateral development banks. Results show a Net Present Value of US$126.7 million, US$2.1 billion, negative US$718.5 million, and US$1.3 billion for IRRIG1, IRRIG2, WTSN and COMBI, respectively. The negative Net Present Value of the WTSN scenario indicates that the agricultural sector labor productivity improvements from greater access to water and sanitation are insufficient to compensate for the cost of the investment.

In terms of environmental impacts, all investment scenarios affect the level of deforestation (Fig. 5). In 2017, the total forested area in Guatemala was 3.0286 million hectares. The IRRIG1 scenario would result in the deforestation of 37,177 ha which is a 649 ha increase above the baseline (Fig. 5). The IRRIG2 scenario would result in an increase of 45,737 ha of deforestation, 9209 ha of which is attributable to the investment in irrigation. The COMBI impact would be 9820 ha of additional deforestation above the baseline level for a total of 46,348 ha.

The expansion of irrigated agriculture has consequences for overall water consumption. Considering all water uses including irrigation, water consumption above the baseline would increase by 105 megaliters (ML) per capita in IRRIG1, 1700 ML per capita in IRRIG2, 141 ML per capita in WTSN, and 1860 ML per capita in the COMBI scenario.

With the agricultural sector's use of fossil fuels and accelerated economic growth across all scenarios, the investments in irrigation and water and sanitation result in increased greenhouse gas emissions. By 2030, overall emissions would increase above 2030 baseline levels by 37,653 tons of $CO_2$ equivalent in IRRIG1 and by 576,901 tons of $CO_2$ equivalent in IRRIG2. The WTSN scenario has a relatively smaller impact on overall emissions, increasing emissions by 66,771 tons of $CO_2$ equivalent, while the COMBI scenario would increase emissions over baseline levels in 2030 by 642,346 tons of $CO_2$ equivalent. Fig. 6 shows total and disaggregated $CO_2$, $CH_4$ and $N_2O$ emissions for each scenario.

As discussed in Section 2 of this paper, the SEEA was not developed to revise measures of GDP. Integration of the SEEA in the IEEM Platform, however, enables the estimation of metrics that capture the
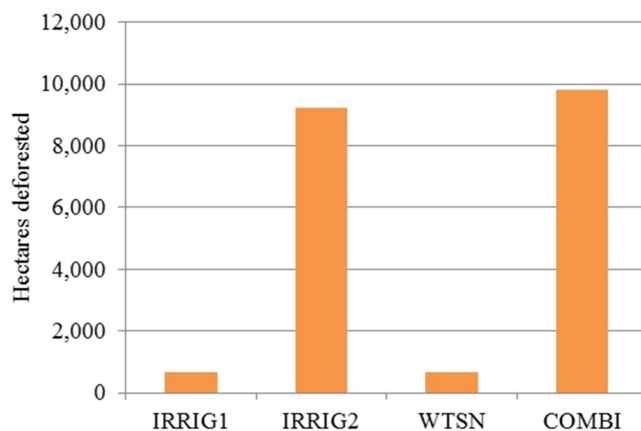


**Fig. 5.** Scenario impacts on cumulative deforestation in hectares between 2030 and 2017.
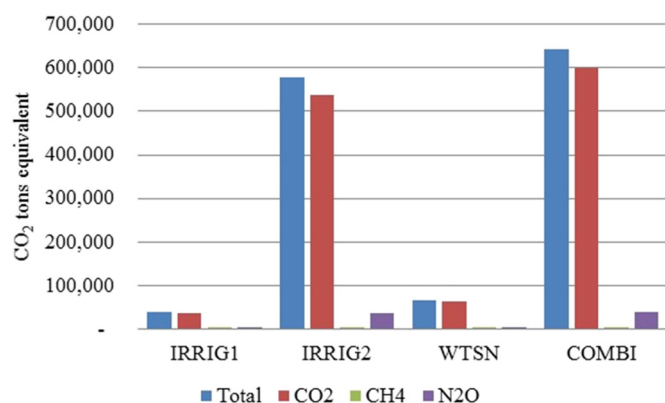Source: IEEM Platform results.

**Fig. 6.** Difference between 2030 and 2017 cumulative emissions, $CO_2$ tons equivalent.
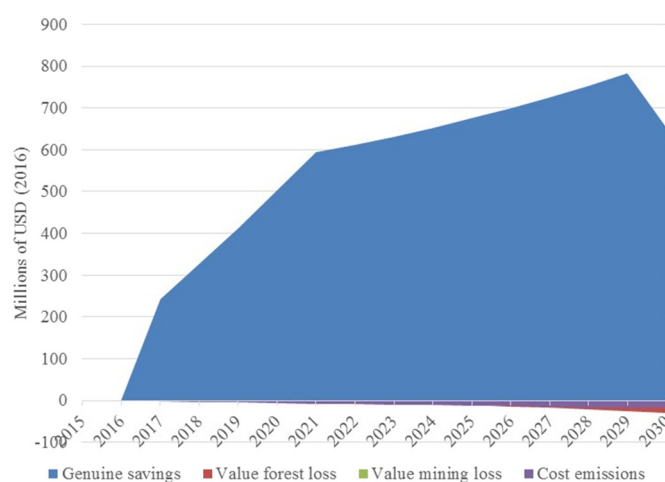Source: IEEM Platform results.



**Fig. 7.** Decomposition of Genuine Savings, COMBI scenario; millions of USD (2016).
Source: Authors' own elaboration.

impact of an investment on wealth and trajectories of sustainable development. The indicator estimated here is an adjusted form of genuine savings which considers investment impacts on stocks of environmental assets (forest, fisheries and mining assets) and environmental quality measured by changes in greenhouse gas emissions (Fig. 7). The IRRIG1 scenario results in a US$36.5 million increase above the baseline in 2030 in genuine savings and an increase of US$33.7 million in the WTSN scenario. IRRIG2 increases genuine savings by US$563.1 million while the COMBI scenario would raise genuine savings by US$595.4 million above baseline levels in 2030.

It may seem counterintuitive that genuine savings increases across all scenarios, while at the same time, deforestation and greenhouse gas emissions also increase. While it is true that the increase in deforestation and emissions push genuine savings downward, the positive investment impacts in irrigation and water and sanitation result in a large increase in net national savings which outweighs the negative impacts of forest loss and reduced environmental quality. For this reason, the impacts on genuine savings are positive across all scenarios.

Fig. 8 presents some of the advantages of applying an integrated framework such as the IEEM Platform to complex and inter-related policy issues such as the SDGs. The figure demonstrates three interesting relationships. First, only an integrated framework such as IEEM, underpinned by SEEA data, can generate indicators in both physical and economic value terms that are entirely consistent with a country's System of National Accounts. Agricultural land use, livestock land use,

forest land use, water use, energy use and emissions in Fig. 8 are all reported as percent deviation from the baseline in physical quantity terms (hectares of agricultural/livestock/forest land use, gigaliters, terajoules and tons of $CO_2$ equivalent, respectively). At the same time, genuine savings, GDP, wages, forestry value-added and fuelwood value added in the figure are reported in percent deviation from the baseline in economic value terms.

Second, while lines of action to meet SDG targets 2.3, 6.1 and 6.2 were evaluated in this study, the integrated nature of the IEEM Platform shows not only the effectiveness of these strategies in making progress toward these targets, but also on the impacts of the strategies on other SDGs. As shown in this example, IEEM provides insights in how these strategies impact multiple other SDGs such as SDG 1 (poverty), SDG 7 (affordable and clean energy), SDG 8 (decent work and economic growth), SDG 10 (inequality), SDG 12 (responsible consumption and production), SDG 13 (climate action), and SDG 15 (life on land).

Third, IEEM clearly identifies trade-offs where one line of action may move a country toward achieving a specific SDG, Target 2.3 for example, which aims to double rural productivity, while simultaneously moving a country away from another SDG, Target 15.2 for example, which aims to stop deforestation. Finally, while not shown here, integrated analysis with the IEEM Platform can be used to evaluate and compare the cost effectiveness of different strategies to achieve multiple SDGs according to the criteria represented by each one of the 14 axes in Fig. 8. This information is critical for Governments to effectively prioritize actions when faced with increasingly scarce public resources.

## 6. Conclusions

In this paper, the IEEM Platform for Guatemala was used to investigate the impacts of specific lines of action oriented to making progress toward the second SDG of ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture, and; the sixth SDG of ensuring water and sanitation for all. In the case of SDG 2, our focus was on the doubling of agricultural incomes and productivity, while in the case of the sixth SDG, it was on increasing water and sanitation coverage. The scenarios implemented were informed by Guatemala's National Development Plan K'atun, published Government policy directives and strategies, and Government estimates of investment costs.

Results showed that reaching these goals would require substantially larger investments, specifically to double agricultural output and incomes. Where investment in agriculture and water and sanitation are considered together along with baseline economic growth, over 2.4 million individuals would be lifted out of poverty. Considering baseline economic growth and the investment scenarios, agricultural output would increase by 59%; to double agricultural output by 2030, additional and potentially different investments would be required to effectively increase agricultural output by the remaining 41%. The investments in irrigated agricultural development were also insufficient to reach the goal of doubling income, with an income gap of 83% remaining.

The relatively small impact on incomes arising from irrigated agricultural expansion is worth probing. Our scenarios expand irrigated cropping of higher value crops. Stimulating this sector resulted in lower prices and in fact lower employment and wages for unskilled labor. With poor households deriving much of their income from providing unskilled labor, increases in income for these poor households was below average compared to other households. Indeed, while rural households were better off as a result of the policy, income inequality between rural and urban households increased slightly with urban households earning greater returns through providing capital and land to the agricultural sector. Furthermore, the aggregate sector that includes higher value crops exports less than 18% of current output. Our results show that if more export-oriented agricultural sectors were targeted for irrigated agricultural expansion, there would be little, to no

**Fig. 8.** IEEM Platform results; COMBI scenario, percent deviation from baseline.
Source: IEEM Platform results.

decline in prices and rural poor households would have been better off. Thus, in light of SDG Target 2.3 and its emphasis on doubling rural incomes, a complementary strategy of promoting exports of higher value agricultural crops would boost incomes to a greater extent. Alternatively, expanding irrigated agriculture of traditional export-oriented agricultural sectors would also have a greater positive impact on incomes of the rural poor.

All investments considered in this study would be wealth enhancing, increasing genuine savings by US$595 million. This result is driven by the large positive impact on household savings which outweighs the negative impacts of forest loss and increased greenhouse gas emissions. The US$1.607 billion investment in water and sanitation would generate a US$69.5 million welfare gain, though the net present value of the investment would be negative. From an economic perspective, this analysis shows that such investment is unlikely to occur without strong political will. There are of course important reasons for the Government to undertake this investment, including one of basic human rights as reflected in the 2010 United Nations Resolution 64/292.

IEEM generates results that can be used to substantiate compelling cases to government institutions, particularly Ministries of Finance who are responsible for budget allocations to achieve the SDGs. Impacts expressed in terms of GDP, income and employment continue to rank high on the agenda of policy makers and Ministries of Finance. The estimated economic return of US$1.37 billion from investing in irrigated agricultural development and enhancing water and sanitation coverage communicates a powerful and saleable message that policy makers can take to their constituents and is information that Ministries of Finance can use in preparing multi-year budgets to achieve the SDGs. A clear advantage of an integrated framework such as IEEM is its ability to generate results in terms of wealth, stocks of natural capital and

environmental quality. These indicators are increasing in relevance and provide policy makers and Ministries of Finance with a broader evidence base upon which to formulate policy and engage with the relevant line ministries and the public in considering all economic and environmental impacts of policies. As highlighted in this application, investment in agriculture has important consequences for deforestation, water consumption and greenhouse gas emissions which may require complementary or mitigating policies for ensuring sustainable economic development and a well-balanced approach to meeting the SDGs.

## 7. Discussion

This study has demonstrated the SEEA's potential for supporting integrated environmental and economic analysis of public policy and investment, which was the impetus for efforts to advance environmental accounting in the 1980s and 1990s. While the SEEA was not developed to revise estimates of GDP, its use in underpinning an integrated framework such as the IEEM Platform to derive indicators that speak to impacts on environmental stocks and national wealth is powerful. Genuine savings is one such indicator that the SEEA enables us to derive from our analysis, while reporting impacts of policies on other indicators in physical terms provides additional useful information to policy makers. Data organized under the SEEA reduces the resources required to reconcile data from multiple sources to render it compatible with SNA data, and for use in economy-wide analytical frameworks.

Results of this exercise with the IEEM Platform demonstrate the importance of considering specific lines of action both individually and in an integrated way. Analysis of individual lines of action is important for transparency and can contribute to prioritization exercises and the agenda setting phase of the policy cycle. Through individual analysis,

some investments may reveal a business case that could be appealing to the private sector as in the case of the investment in irrigated agriculture explored here. In these instances, it may be appropriate for the Government to concentrate efforts on creating an enabling environment for private sector investment. These types of findings are fundamental inputs into the policy formulation stage of the policy cycle. In the case of Guatemala, an application of this finding would be the creation of a legal framework for water management which would set the stage for private investment in irrigated agriculture.

On the other hand, an integrated analytical approach sheds light on how individual SDGs can be mutually supportive to achieving the overall Agenda for Sustainable Development. We have shown that improvements in water and sanitation (SDG 6) that increase agricultural labor productivity would in turn increase agricultural output and contribute to SDG Target 2.3. While the specific lines of action considered here targeted the second and sixth SDGs, both positive and negative spill-overs on other SDGs were revealed. All investment scenarios would contribute to achieving the first SDG of ending poverty in all its forms as well as the eighth SDG of promoting inclusive and sustainable economic growth, and employment. The investments evaluated would boost GDP by US$1.37 billion, diversify the agricultural sector, and create jobs. A portfolio approach to the SDGs can be appropriate to capitalize on these types of win-wins, and in cases where some lines of action generate greater returns to investment, these higher yielding investments can compensate for those that yield less. Aristotle's quote "the whole is greater than the sum of its parts" holds true where the SDGs are concerned.

Yet, investments in agricultural expansion and in water and sanitation also lead to trade-offs. The expansion of irrigated agriculture is not without its consequences for the environment, with a 9820 ha increase in deforestation above the baseline deforestation of 36,528 ha. This increase in deforestation moves Guatemala away from SDG fifteen and the sustainable use of forests, and specifically Target 15.2 which aims to halt deforestation. SDG thirteen calls for action on climate change, though the expansion of agriculture gives rise to 642,346 tons of additional greenhouse gas emissions by 2030 which should be summed with those emissions generated by deforestation and the burning of forests. All scenarios generate faster economic growth which in the absence of mitigating measures, also increases emissions across all economic sectors. How increased emissions affect Guatemala's commitments to the Paris Agreement and the thirteenth SDG will require careful consideration of potential trade-offs and in the design of mitigation strategies. Irrigated agricultural expansion also has consequences for overall water consumption, increasing by 1860 ML per capita.

In this study, the impact of forest loss and the calculation of genuine savings accounts for the foregone value of future timber harvests (timber provisioning ecosystem services). Forests of course provide a range of other provisioning ecosystem services, as well as regulating and cultural ecosystem services which are directly impacted by forest loss. Indeed, to shed light on policy impacts on ecosystem services without an observable market price, we have linked IEEM with ecosystem service modelling (IEEM + ESM). Policy scenario-based projections of land use change estimated with the IEEM Platform are used to generate scenario-based land use land cover maps. With these maps and parameterized ecosystem service models, we estimate impacts on future ecosystem service supply, including regulating and cultural services and the biodiversity that underpins them. This work is well advanced in the context of our SDG analysis for Guatemala, in our assessment of a government proposal for a Payment for Ecosystem Services Program in Colombia, and in evaluating Green Growth Strategies in Rwanda (Banerjee et al., 2018a,b; Banerjee et al., in preparation).

As discussed, the investments to achieve SDG 2 and 6 led to an increase in genuine savings despite the increase in deforestation and greenhouse gas emissions which initially seemed counter-intuitive. This

was explained, however, through the large increase in net national savings arising from the investments. Another important consideration in the interpretation of this result is that in our calculation of genuine savings, we use the *discounted value of future returns* approach which is consistent with recommendations in the SNA (UN et al., 2009, p. 262). This forgone value includes the timber provisioning ecosystem service value of the forests but not the value of the other important ecosystem services that forests generate. Thus, it may be useful in some cases to supplement the estimates presented here, with measures of changes in ecosystem service supply.

There are a range of welfare-based and exchange-based approaches to measuring and valuing a broader array of ecosystem services, that take into account the many direct/indirect use, non-use and option values forests provide. Presenting to policy makers the value of this broader set of ecosystem services can further guide decision making, particularly when high biodiversity and conservation value ecosystems may be at stake.

SDG Target 6.5 calls for the implementation of integrated water resources management and Target 6.6 aims to protect and restore water-related ecosystems, both of which are closely related to water consumption which would increase in all scenarios. Certainly, to ensure policy consistency among SDG lines of action, it will be important to monitor how increased water usage affects water availability and quality and potential negative externalities such as salinization in drought prone areas. Integrated landscape management for the production and targeting of a variety of ecosystem services such as water provisioning and climate regulating ecosystem services can make progress toward the eighth, sixth and thirteenth SDGs discussed here. Furthermore, these natural systems are critical for sustaining rural livelihoods and thus also critical to the first and second SDGs.

The IEEM Platform enables consideration of public policy and investment impacts on multiple sectors and complex integrated economic-environmental objectives. Without such an integrated framework, some of the synergies and trade-offs between different SDGs may have been missed. IEEM sheds light on these interactions and generates evidence that can inform and elevate the discourse on the most effective strategies for achieving the SDGs and identify low hanging fruits and potential win-win situations. As we have seen in this application, IEEM's language is grounded in economics, generating results that resonate with policy makers and Ministries of Finance with clear points of entry into the policy cycle, while quantifying and recognizing natural capital's contribution to economic development and the challenges posed by the SDGs.

## Acknowledgments

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