IDB WORKING PAPER SERIES Nº 844

A Quantitative Assessment of Strategies to Achieve the Sustainable Development Goals

An Application to Guatemala

Onil Banerjee
Martin Cicowiez
Mark Horridge
Renato Vargas

Inter-American Development Bank
Environment, Rural Development and Disaster Risk Management Division

October 2017

Inter-American Development Bank

A Quantitative Assessment of Strategies to Achieve the Sustainable Development Goals

An Application to Guatemala

Onil Banerjee
Martin Cicowiez
Mark Horridge
Renato Vargas

October 2017

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
A quantitative assessment of strategies to achieve the sustainable development goals: an application to Guatemala / Onil Banerjee, Martín Cicowiez, Mark Horridge, Renato Vargas.
p. cm. — (IDB Working Paper ; 844)
Includes bibliographic references.
1. Sustainable development-Guatemala-Evaluation-Econometric models. 2. National income-Accounting-Guatemala. 3. Ecosystem services-Guatemala. I. Banerjee, Onil. II. Cicowiez, Martín. III. Horridge, Mark. IV. Vargas, Renato. V. Inter-American Development Bank. Environment, Rural Development and Risk Management Division. VI. Series.
IDB-WP-844

Corresponding author: Onil Banerjee, onilb@iadb.org

A Quantitative Assessment of Strategies to Achieve the Sustainable Development Goals: An Application to Guatemala

Onil Banerjee[1], Martin Cicowiez[2], Mark Horridge[3] and Renato Vargas[4]

[1] Corresponding author
Inter-American Development Bank
Environment, Rural Development, Environment and Disaster Risk Management Division
1300 New York Avenue N.W.
Washington, D.C., 20577, USA
+1 202 942 8128
onilb@iadb.org

[2] Universidad Nacional de la Plata
Facultad de Ciencias Económicas
Universidad Nacional de La Plata
Calle 6 entre 47 y 48, 3er piso, oficina 312
1900
La Plata, Argentina
mcicowiez@gmail.com

[3] Victoria University
PO Box 14428
Australia Melbourne,
Victoria 8001
mark.horridge@gmail.com

[4] CHW Research
18 calle 24-69 zona 10
Empresarial Zona Pradera, Torre 1, Nivel 18
Guatemala City, 01010
Guatemala
renovargas@gmail.com

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 make progress towards achieving them. In this paper, we apply the Integrated Economic-Environmental Modelling platform for Guatemala (IEEM-GUA) to evaluate the economic, environmental and wealth impacts of strategies for achieving the SDGs. We evaluate specific lines of action to achieve the second SDG to achieve food security and promote sustainable agriculture, and; the sixth SDG to achieve water and sanitation coverage for all. We find that significant new investment in these areas would be required to meeting these SDGs 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. It sheds light on the need for complementary policies to reconcile lines of action that can inadvertently move progress toward specific SDGs in opposite directions. Finally, an advantage of an integrated framework such as IEEM is its ability to highlight trade-offs, potential win-wins and inter-linkages between SDGs, where one line of action can make progress towards multiple SDGs simultaneously.

Keywords: ex-ante economic impact evaluation; system of environmental-economic accounting; computable general equilibrium model; sustainable development goals; system of national accounting; economic and environmental indicators; wealth; natural capital; ecosystem services.

JEL Codes: C6 Mathematical Methods - Programming Models - Mathematical and Simulation Modeling; E01 Measurement and Data on National Income and Product Accounts and Wealth - Environmental Accounts; Q Agricultural and Natural Resource Economics - Environmental and Ecological Economics; I3 Welfare, Well-Being, and Poverty; D61 Allocative Efficiency - Cost–Benefit Analysis.

1.0. Introduction

The post-2015 development goals are embodied in the 2030 Agenda for Sustainable Development[1]. In effect since January of 2016, the seventeen Sustainable Development Goals (SDGs) are a universal call to action to end poverty and protect the environment. To mainstream the SDGs in national processes, many countries are aligning their national development plans with the SDGs. In the case of Guatemala, the nation is now better positioned to make progress towards achieving the SDGs when compared with the previous Millennium Development Goals, where it achieved only 25% of the targets set. Analysis of the implementation experience showed that this limited progress was in part due to the absence of a national framework for development planning that could guide the investments of the Guatemalan Government and ensure policy consistency (CONADUR, 2014).

Guatemala has recently approved its *National Development Plan K'atun: Our Guatemala 2032* and efforts of the Council of Urban and Rural Development are underway to: prioritize specific SDGs; align them with strategic actions set out in Plan K'atun[2], and; create a statistical mechanism to monitor progress toward the SDGs (CONADUR, 2016, UNDG, 2016). With the United Nations supporting both the design of Plan K'atun and the socialization processes of the SDGs with Guatemalan society, 90% of the thematic areas addressed by the Plan K'atun and the SDGs are closely aligned (Moir, 2016).

---

[1] http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E

[2] The NDP is structured around 5 principle axes: (i) inclusive economic development; (ii) improved governance for ensuring human rights; (iii) sustainable urban and rural development; (iv) the environment, and; (v) human welfare. The NDP establishes 36 priorities, 122 results, 80 goals, and 730 directives that are to be monitored.

In this paper, we apply the Integrated Economic-Environmental Modelling platform for Guatemala (IEEM-GUA) to evaluate the economic, environmental and wealth impacts of implementing strategies to make progress toward achieving the SDGs in Guatemala. We focus on the second SDG of ending hunger, achieving food security and improved nutrition and promoting sustainable agriculture, and; SDG 6 of ensuring availability and sustainable management of water and sanitation for all. For SDG 2, we concentrate specifically on doubling agricultural productivity and incomes of rural producers (target 2.3), while for SDG 6, we focus on equitable access to drinking water and sanitation for all (targets 6.1 and 6.2). Scenarios are developed based on Plan K'atun, published Government policy directives, strategies, specific lines of action, and cost estimations.

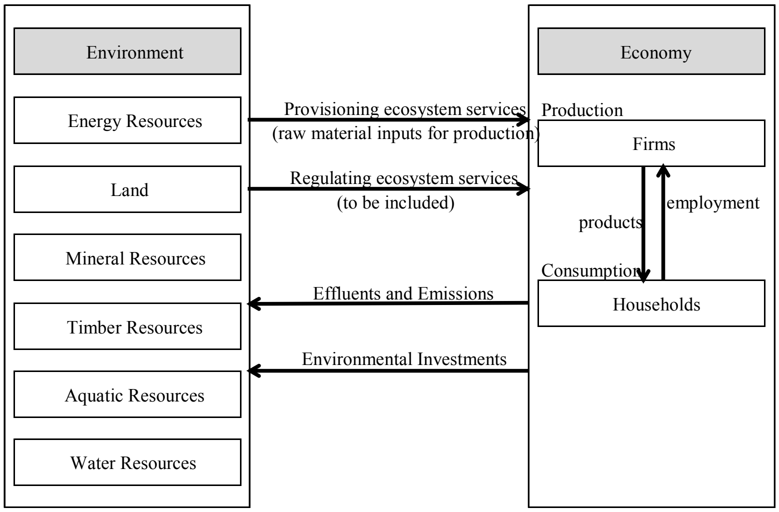
The rest of this paper is structured as follows. Section 2 provides a brief overview of the methodology. Section 3 describes the specific lines of action the Government of Guatemala is planning to pursue to make progress towards the second and sixth SDGs and details of the scenarios to be implemented with IEEM-GUA. Section 4 presents results and analysis. The Chapter concludes with a discussion of key findings and the advantages of using an integrated framework such as IEEM for analysis of SDGs and other complex policy challenges.

2.0. Methods

This analysis is undertaken using the IEEM platform developed in Banerjee et al. (2016 and 2017). IEEM is a decision-making platform that provides a quantitative, comprehensive and consistent framework for the analysis of public policy and investment impacts on the economy, the environment and wealth (Banerjee et al., 2017, Banerjee et al., 2016). At the core of IEEM is a dynamic computable general equilibrium model, calibrated with data based on the System of National Accounts and the System of Environmental-Economic Accounting (SEEA) (United Nations et al., 2014). What sets IEEM apart from other decision making frameworks is: its integration of rich environmental data based on the SEEA; customized environmental modelling modules that capture the particular dynamics of environmental resources and their use, and; the indicators IEEM generates capture policy and investment impacts not only on measures of income flows such as Gross Domestic Product (GDP), but also on wealth which is a more robust measure of welfare and the foundation of the economic growth and development prospects of a country.

Figure 1 shows how environment-economy interactions are modelled in the IEEM Platform. On the left side of the figure, the environment is represented by the environmental accounts contained in the SEEA, namely energy, land, minerals, timber, aquatic resources, and water. 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 serving as an input for productive processes in the form of provisioning ecosystem services. Through productive processes and through household consumption of goods and services, emissions and waste are produced and returned to the environment. To mitigate environmental damage and improve environmental quality, investments are also made in the environment. The data structure that underpins IEEM captures all of these interactions quantitatively.

Figure 1. Environment-economy interactions embodied in IEEM.



Source: Authors' own elaboration.

With our focus on the SDGs, household level poverty and inequality impacts of public policy and investment are particularly important. The IEEM platform has a built-in microsimulation module which enables the consideration of impacts on the percentage of the population living below the poverty line and on economy-wide measures of income concentration (i.e. the Gini coefficient). While it is possible to use the internationally established poverty line (US$1.90 per day using 2010 prices), we use Guatemala's nationally determined poverty line which is Q8,282.9 Quetzales per person per year or US$2.83 per person per day (INE, 2013). The extreme poverty line is Q4,380 per person per year and represents the cost of acquiring a minimum of 2,362 Kilocalories per day in rural areas (2,246 in urban areas) while the overall poverty line is the income required to purchase the minimum amount of calories and basic non-food consumption (INE, 2013).

Most standard economy-wide models use a representative household formulation where all households in an economy are aggregated into one or a few households to represent household behavior. The main limitation of this formulation is that the intra-household income distribution does not respond in scenario analysis. IEEM overcomes this limitation by linkages with a microsimulation module. In a policy simulation, IEEM produces changes in prices that are fed as inputs into the microsimulation module. This module in turn generates results in terms of real wages, aggregate employment variables, and non-labor income (Banerjee et al., 2015). The microsimulation module in IEEM-GUA is calibrated based on Guatemala's 2011 Household Survey on Quality of Life (INE, 2011).

The first step in the analysis of SDGs with IEEM 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 as well as 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, consumption, emissions/waste, natural capital use and wealth), meso (sector output, employment, household income/consumption, sectoral natural capital use/emissions/waste, household emissions/waste), and micro impacts (poverty and inequality) impacts. IEEM reports 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 IEEM-GUA.

3.0. Lines of Action for Achieving the Sustainable Development Goals and Scenario Design

Considering the 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 the income earned from irrigated crops is even greater 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 crops irrigated. The current irrigated area is just 29% of the 850,120 hectares that have been identified as having a good potential for irrigation. Current irrigation schemes focus on export crops such as sugarcane and banana. Potential productivity gains and gains in economic value, however, are the highest with higher value crops such as tomato, peppers, onion and carrots among others (MAGA, 2013).

The new government's Great National Agriculture and Livestock Plan 2016-2020 sets out general lines of action for enhancing agricultural productivity and competitiveness of the agricultural sector, including expanding irrigated agriculture (MAGA, 2016). The previous government's Irrigation Development Policy (2013 to 2023) and National Irrigation Diagnostic provide additional detail on lines of action and costs for expanding irrigated agriculture (MAGA, 2013, MAGA, 2012). We draw from these national policies and the diagnostic and undertake two simulations aimed at making progress toward SDG target 2.3.

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 6,399 hectares. 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 investment. In the absence of information confirming new government budget allocations to fund this investment, it is assumed that 50% of the investment will be 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, international development agencies invested US$17.3 million in enhancing food security in drought prone areas of the country alone.

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. Currently there are 236,243 hectares with a high need as well as aptitude for irrigation to improve food security and contribute to livelihood opportunities for the rural poor. Over 58 thousand hectares in the Dry Corridor alone require irrigation that could be supplied from above ground water sources. Guatemala's Great National Agriculture and Livestock Plan has the goal of increasing irrigation on an additional 100,000 hectares at a cost of

US$1.95 million over a 5-year period (US$19.50/hectare). In this second scenario, this policy is implemented along with the first scenario for a total investment of US$7,995,780 and a total increase in irrigated areas of 106,399 hectares.

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 in their implementation. 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 with the magnitude of this effect 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).

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 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 on a national level was 75.3% and 55.96%, respectively. This level of coverage indicates that 3 million people lack access to water and in fact represents a decline in coverage of 3.4% when compared with 2006. 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 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 25% and 31% for water availability and water quality, respectively, demonstrating the 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, 2011). Estimates show that an increase of one point of percentage in access to drinking water in rural areas leads to increased productivity of the agricultural workforce of 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. In this simulation, water coverage is increased from 75.3% to 81.5% and sanitation coverage from 56% to 66%. The cost for increasing water coverage is equal to US$1.602 billion and the cost of increasing sanitation coverage is equal to US$70.2 million for a total investment of US$1.6722 billion or US$128,630,769 per year from 2017 to 2030 (SEGEPLAN, 2013).

In addition to the endogenous mechanisms in IEEM, we also impose a rural agricultural labor productivity shock to simulate 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 introduced in the simulation. It should be noted that various other benefits could be considered both inside and outside of the modelling framework. For example, in this simulation, 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 will benefit and therefore higher economy-wide labor productivity would result. Also not considered in this analysis are costs associated with illness, nor are notions of the cost of lives lost as a result of 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 assigns only US$1.3 million to water quality.

COMBI: In the fourth and final simulation we simulate the joint impact of IRRIG2 and WTSN. In this simulation, the IRRIG2 investment of US$7,995,780 and increase in irrigated areas of

106,399 hectares are simulated. At the same time, the WTSN investment of US$1.6722 billion is implemented along with the agricultural labor productivity shock of 0.44%. COMBI results demonstrate the combined impact of the three underlying lines of action to achieve SDGs 2 and 6 which are the rehabilitation of current irrigation infrastructure and establishment of new irrigated areas, and investments in water and sanitation to increase water coverage from 75.3% to 81.5% and sanitation coverage from 56% to 66%.

4.0 Results and Analysis

Table 1 shows the scenario impacts on macroeconomic indicators in terms of difference from baseline values in 2030. As the table shows, IRRIG2 would tend to drive positive impacts on all macro indicators. Private consumption would increase by US$797.9 million in IRRIG2; in the WTSN scenario, the impact would be less, 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 flow on to the COMBI scenario. The COMBI scenario shows the overall GDP impact would be US$1.185 billion. Driven by the expansion in irrigated agriculture, the unemployment rate declines slightly from 7.4% to 7.3% in the COMBI scenario.

Table 1. Macroeconomic indicators; difference from baseline by 2030 in millions of USD.

	IRRIG1	IRRIG2	WTSN	COMBI
Absorption	69.2	1,078.0	108.1	1,184.7
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
GDP	79.9	1,243.3	129.8	1,371.4
Genuine Savings	36.5	563.1	33.7	595.4

Source: Authors' own elaboration.

With regard to sectoral output, by 2030 the increased output of non-export crops would be equal to US$2.2 million and overall agriculture sector output would be equal to US$10.4 million in IRRG1. In IRRIG2, non-export crop output would increase by US$37.3 million above baseline and overall agriculture sector output would increase by US$162.4 million. The overall agriculture output increase in the WTSN scenario would be US$18.9 million, while the combined impact on overall agricultural output in the COMBI scenario would be US$181.1 million. In the baseline in 2030, cumulative non-export crop output would be equal to US$776 million. Output of non-export agricultural crops in the baseline in 2030 is 52% greater than in 2017; in COMBI, output is 59% greater than in the baseline in 2017. This result indicates that when business-as-usual non-export crop growth and the increased output generated by the expansion in irrigated agriculture are considered, additional investment and productivity enhancements would still be required to meet the second SDG and close the gap of 41% to double agricultural output by 2030.

In terms of household income, the expansion of irrigation would have a greater impact on incomes than that of improved water and sanitation. Figure 2 shows the percent deviation in per capita income between 2030 and 2017, distinguishing between urban and rural households and income quintile, with the first quintile representing the lower income households and the fifth quintile representing the higher income households. Urban wealthier households experience the greatest increase in income, equal to 1.31% for the wealthiest households in the COMBI scenario. The increase in per capita income of the poorest rural households is not far behind, experiencing a 1.05% increase over the period. Income increases are similar across income classes when the IRRIG1 and IRRIG2 scenarios are considered. When baseline growth is taken into account, per capita income increases between 9% and 18% across rural and urban households and income quintiles.

In terms of absolute values, in the COMBI scenario, the higher income and urban households experience the greatest per capita increase in income. The poorest households by 2030 experience a cumulative US$130 increase in income while the wealthiest urban households experience a US$2,200 cumulative impact by 2030. These results show that the investments in irrigation and water and sanitation improve incomes only marginally. When overall economic growth is taken into account, there is still a gap of around 83% in the case of the poorest households in the COMBI scenario to reach SDG target 2.3 of doubling the incomes of the poorest.

One key mechanism at work to describe the greater returns to labor in the IRRIG scenarios compared with the WTSN scenario is that total factor productivity in the agricultural sector producing irrigated crops increases as a result of the investment. Thus, returns are greater for all factors including capital and land, while in the case of the WTSN scenario it is only the productivity of labor employed in the agricultural sector whose productivity is enhanced. In terms of how the increased income is distributed, since wealthier households own a greater share of land and capital, their incomes tend to increase significantly more than those poorer households who contribute mostly only their labor to agricultural production.

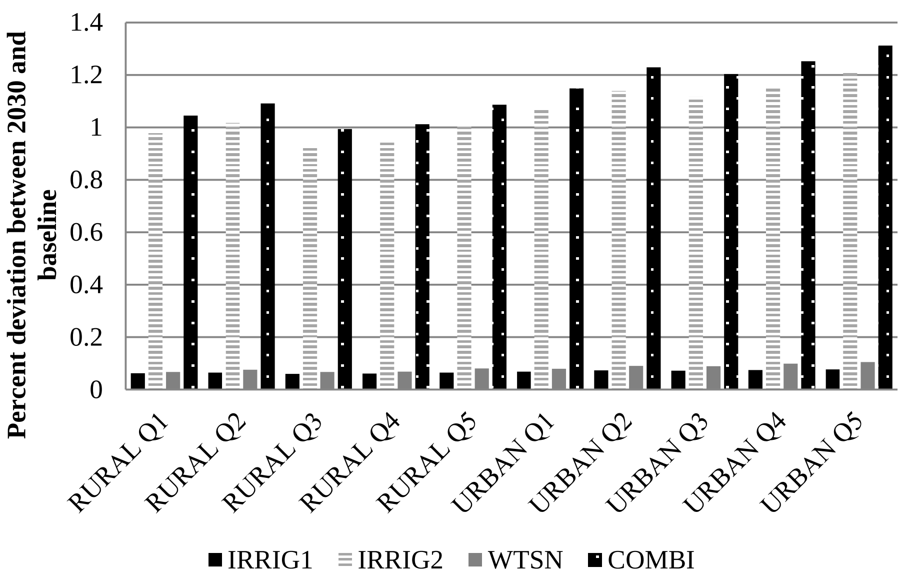


Figure 2. Percent deviation in per capita income between 2030 and baseline; rural/urban household income quintile. Source: Authors' own elaboration.

Equivalent variation is a measure of welfare and is defined as the change in household income at current prices that a change in prices would have on household welfare if income were held constant. In other words, where an investment does not occur, EV is the amount of income an individual would have to be given to make them as well off if the intervention did take place. Overall, by 2030, Guatemalan households would be better off by US$43.5 million in the IRRIG1 scenario, US$678.2 million in the IRRIG2 scenario, US$69.5 million in the WTSN scenario, and US$747 million in the COMBI scenario.

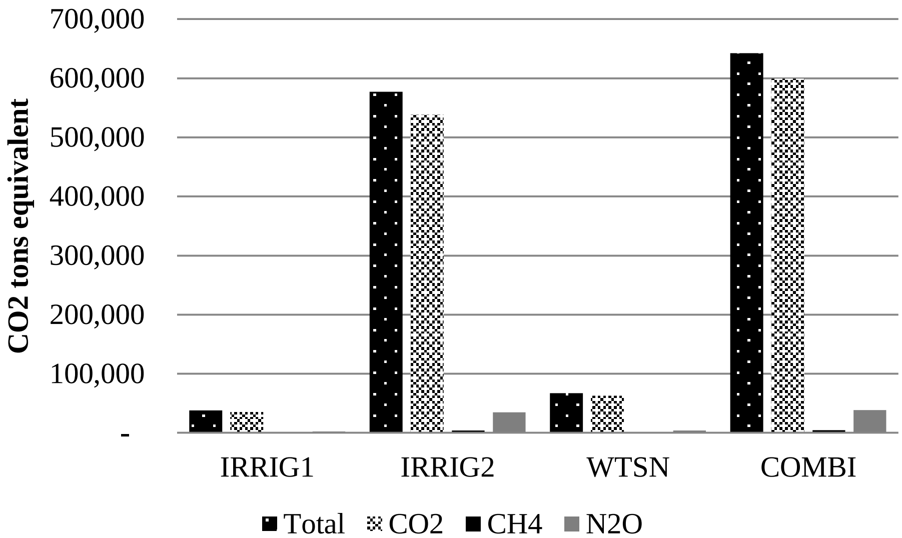
In terms of the poverty gap, in the baseline at the national level, the poverty headcount ratio is 44.77% in the base year. The investment scenarios would appear to have small impacts on the poverty headcount, equivalent to 0.67 percentage points in 2030 in the COMBI scenario. This small percent change, however, indicates that over 100 thousand individuals would be lifted out of poverty in this scenario (2017 population level). While it may not be obvious, it is the business-as-usual overall economic growth that underpins the baseline and all scenarios that would have the greatest impact on reducing poverty. The poverty gap in the base year is 56.5%; by 2030, it would fall to 44.7%. This change of 11.8 percentage points indicates that economic growth in Guatemala would reduce the poverty headcount by over 2.31 million people. The impact of the COMBI scenario coupled with the poverty reducing impact of economic growth would reduce the number of individuals living in poverty by 2.42 million. Income inequality as measured by the Gini coefficient would decline indicating more equal income distribution across households, though scenario impacts are small.

There are a number of approaches that may be taken to calculate the Net Present Value (NPV) based on the scenarios implemented. The approach taken here does not consider the investment as a direct cost within the model. Instead, the economic benefits measured by equivalent variation are assessed alongside investment costs outside of the simulations to calculate NPV. A discount rate of 12% is used, which is a standard rate used by some multi-lateral institutions. Certainly, one can predict how the NPV may vary should a different discount rate be applied.

Results show an NPV of US$126.7 million, US$2.1 billion, negative US$718.5 million, and US$1.3 billion would result for IRRIG1, IRRIG2, WTSN and COMBI, respectively. In the case of the WTSN scenario, the negative NPV shows that the labor productivity improvements from greater access to water and sanitation are insufficient to compensate for the cost of the investment.

The level of deforestation would be impacted as result of the investment scenarios. In the baseline, the total forested area in Guatemala is a little over 3 million hectares. The IRRIG1 scenario would result in the deforestation of 37,177 hectares, which is a 649 hectare increase above baseline levels. The IRRIG2 scenario would result in 9,209 hectares of deforestation above the baseline, and WTSN would cause an additional 657 hectares of deforestation. The COMBI impact would be 9,820 hectares of additional deforestation. In terms of overall water consumption per capita, considering all water uses including irrigation, there would be an increase above baseline in all scenarios of 105 megaliters (ML)/capita in the IRRIG1 scenario, 1.7 billion liters/capita in the IRRIG2 scenario, 141 ML/capita in the WTSN scenario, and 1,860 ML/capita in the COMBI scenario. Overall, greenhouse gas emissions would increase by 37,653 and 576,901 tons of CO_2 equivalent by 2030 in the IRRIG1 and IRRIG2 scenarios, respectively. The WTSN scenario would impact overall emissions by 66,771 tons while the COMBI scenario would increase emissions over the baseline by 642,346 tons of CO_2 equivalent, respectively. Figure 3 shows total and disaggregated CO_2, CH_4 and N_2O emissions for each scenario.

Figure 3. Difference between 2030 and 2017 cumulative emissions, CO_2 tons equivalent.



Source: Authors' own elaboration.

All investments would be wealth enhancing when we consider impacts on genuine savings which is a measure of well-being that considers policy and investment impacts on natural capital stocks (forest, fisheries and mining resources) and environmental quality as it is negatively impacted by greenhouse gas emissions. There would be large gains in genuine savings in the IRRIG2 scenario which carry over to the COMBI scenario, equivalent to US$595.4 million. The IRRIG1 scenario (US$36.5 million) would be slightly more wealth enhancing than the WTSN scenario (US$33.7 million). While deforestation and emissions would increase in all scenarios, it is the increase in household savings that would drive the resulting increase in genuine savings.

5.0 Conclusions

In this paper, IEEM-GUA was used to simulate 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 specific focus was on the doubling of agricultural incomes and productivity, while in the case of the sixth SDG, our focus was on increasing water coverage. The simulations undertaken were informed by Guatemala's National Development Plan K'atun, published Government policy directives, strategies, and specific lines of action and cost estimations.

Results showed that reaching these goals would require substantial investments. Where investment in agriculture and water and sanitation are considered together in the COMBI-scenario, along with business-as-usual economic growth, over 2.4 million individuals would be lifted out of poverty. Yet, the baseline developments plus the investments as proposed in the COMBI-scenario increase agricultural output by 59%. To reach the objective of doubling agricultural output by 2030, additional investments would be required to increase agricultural output by the remaining 41%. Also, the goal of doubling incomes cannot be reached with the COMBI-scenario alone. An income gap of 83% remains.

All investments analyzed in this analysis would be wealth enhancing, increasing genuine savings by US$595 million, despite the increase in deforestation and emissions. This result is driven by the investment impacts on household savings, while increases in the value of standing forest and the costs of emissions damage would reduce this value. The US$1.67 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. This analysis shows that such investment is unlikely to occur without a strong Government commitment. 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[3].

IEEM generates results that can be used to substantiate compelling cases to government institutions, particularly Ministries of Finance, whose support is critical for budget allocations to achieve the SDGs. Impacts expressed in terms of GDP, income and employment continue to rank high on policy makers' agendas. The estimated economic return of US$1.37 billion from investing in agriculture and water and sanitation for example, communicates a powerful message. IEEM also generates results in terms of wealth and natural capital impacts; these indicators are increasing in relevance and provide policy makers a broader evidence base upon which to formulate policy and engage with their constituents. As highlighted in this application, investment in agriculture has important impacts on water consumption and emissions which may require complementary or mitigating policies for ensuring sustainable economic development as well as delivering on international agreements.

6.0. Discussion

Results of this modelling exercise with IEEM-GUA 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

[3] http://www.un.org/es/comun/docs/?symbol=A/RES/64/292&lang=E

business case that could be appealing to the private sector as illustrated with the investment in irrigated agriculture. 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 would increase agricultural labor productivity which in turn would increase agricultural output and contribute to 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 found to arise. 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 grow GDP by US$1.37 billion, diversify the agricultural sector, and create jobs. A portfolio approach to the SDGs is appropriate to capitalize on these types of win-wins, and in cases where some lines of action generate greater returns to investment, compensating for those that do not. Aristotle's quote that "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 agriculture is not without its consequences for the environment, with an increase in deforestation of 9,820 hectares, in addition to the business-as-usual deforestation of 36,528 hectares. This increase in deforestation disfavors making progress toward SDG fifteen which aims to promote the sustainable use of forests and indicator 15.1.1 which is the forest area as a proportion of total land area. SDG thirteen calls for action on climate change, though the expansion of agriculture and increased deforestation gives rise to greater emissions, particularly when forests are burned and replaced with agriculture. All scenarios generate faster economic growth which 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.

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 of a variety of ecosystem services such as water provisioning and climate regulation can aid in making 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 speak to policy makers 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

This work was funded by the BIO Program of the Inter-American Development Bank. The authors thank Dr. Arjan Ruijs (PBL Netherlands Environmental Assessment Agency) for constructive feedback.

References

AMEZQUITA, M. A. 2012. Diagnostico Regional. Agricultura Bajo Riego del Altiplano Occidental: Quetzaltenango, San Marcos, Totonicapan, Huehuetenango, El Quiche, Solola. Guatemala City: USAID.

BANERJEE, O., CICOWIEZ, M. & GACHOT, S. 2015. A quantitative framework for assessing public investment in tourism – An application to Haiti. *Tourism Management,* 51**,** 157-173.

BANERJEE, O., CICOWIEZ, M., HORRIDGE, M. & VARGAS, R. 2016. A Conceptual Framework for Integrated Economic–Environmental Modeling. *The Journal of Environment & Development,* 25**,** 276-305.

BANERJEE, O., CICOWIEZ, M., VARGAS, R. & HORRIDGE, J.M. 2017. The Integrated Economic-Environmental Modelling Framework: An Illustration with Guatemala's Forest and Fuelwood Sectors. In IDB Working Paper Series No. 757. Washington DC: Inter-American Development Bank.

CONADUR (Consejo Nacional de Desarrollo Urbano y Rural). 2014. Plan Nacional de Desarrollo K'atun: Nuestra Guatemala 2032. Guatemala City: Consejo Nacional de Desarrollo Urbano y Rural and Secretaria de Planificación y Programación.

CONADUR———. 2016. Punto Resolutivo Número 15-2016 [Approval of Prioritization of SDGs]. Guatemala City: Consejo Nacional de Desarrollo Urbano y Rural & Secretaría de Planificación y Programación de la Presidencia.

INE (Instituto Nacional de Estadística). 2011. ENCOVI: Encusta Nacional de Condiciones de Vida 2011. Guatemala City: Instituto Nacional de Estadistica.

INE 2013. Mapas de Pobreza Rural en Guatemala 2011. Guatemala City: Instituo Nacional de Estadistica.

KIENDREBEOGO, Y. 2011. Access to Improved Water Sources and Rural Productivity: Analytical Framework and Cross-Country Evidence. *Working Paper Groupe d'economie Lare-Efi du developpement, Universite Montesquieu-Bordeaux IV.* Clermont-Ferrand: CERDI, Université d'Auvergne.

MAGA (Ministerio de Agricultura Ganadería y Alimentación). 2012. Politica de Promocion del Riego 2013-2023. Guatemala City: Ministerio de Agricultura, Ganaderia y Alimentacion.

MAGA 2013. Diagnostico Nacional de Riego de Guatemala. Guatemala City: Ministerio de Agricultura, Ganaderia y Alimentacion.

MAGA 2016. Gran Plan Nacional Agropecuario. Guatemala City: Ministerio de Agricultura, Ganaderia y Alimentacion.

MOIR, M. A. 2016. Presentacion de la Politica General de Gobierno y su Vinculacion en el Plan Nacional de Desarrollo. Guatemala City: Secretaría de Planificación y Programación de la Presidencia.

SEGEPLAN (Secretaría de Planificación y Programación de la Presidencia). 2013. Politica Nacional del Sector de Agua Potable y Saneamiento. Guatemala City: Secretaría de Planificación y Programación de la Presidencia.

TANIGUCHI, K. & WANG, X. 2003. Nutrition Intake and Economic Growth: Studies on the Cost of Hunger. Rome: Food and Agriculture Organization of the United Nations.

UNDG (United Nations Development Group). 2016. The Sustainable Development Goals are Coming to Life: Stories of Country Implementation and UN Support. New York: United Nations Development Group.

UNICEF (United Nations Children's Fund) and WHO (World Health Organization). 2008. Joint Monitoring Report. Geneva: United Nations International Children's Fund and the United Nations World Health Organization.

UN (United Nations), EC (European Commission), FAO (Food and Agriculture Organization), IMF (Inernational Monetary Fund), OECD (Organisation for Economic Co-operation and Development) and World Bank. 2014. System of Environmental Economic Accounting 2012-Central Framework. New York: UN.