IDB Infrastructure and Environment Sector

IEEM

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Session: Advancing Integrated Economic-Environmental Modelling for Evidence-Based Policy

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Outline

- Why IEEM and what is it good for?
- What is IEEM?
- What's new?
- Give me an example!
- What's next?

What is it good for?

Some limitations of economy-wide models

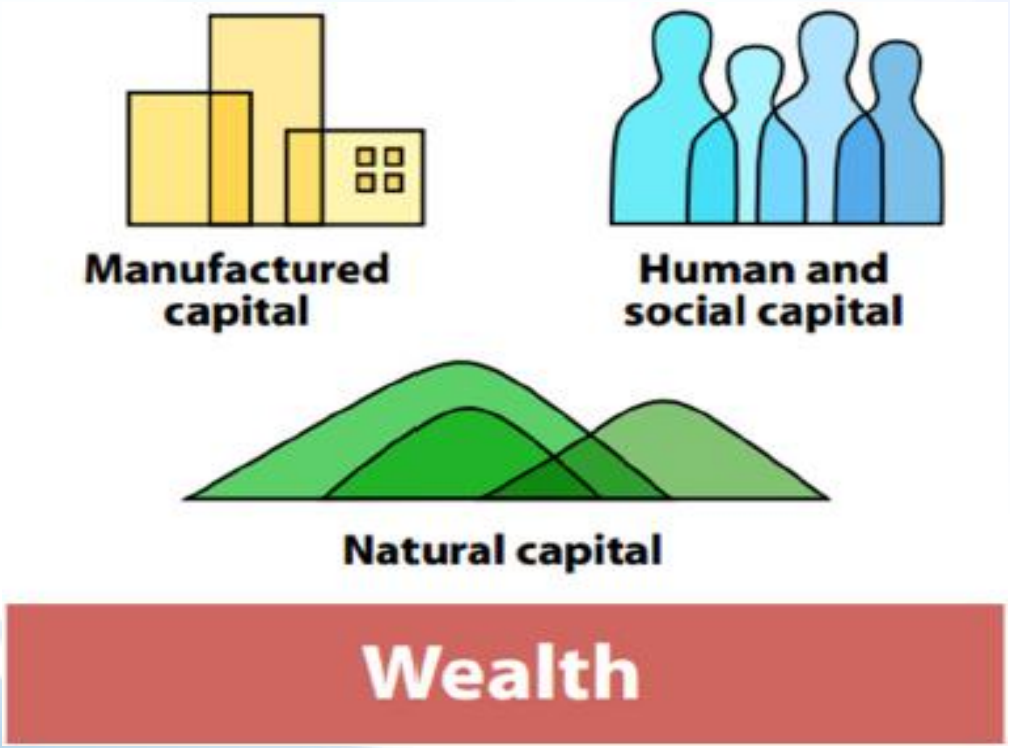
(i) Model development: one environmental resource/issue in isolation; data reconciliation/strong assumptions; cost/time;

(ii) Analytical: invisible role of ecosystem services, economy ↔ environment; "…the purpose of income calculations is to give people an indication of the amount which they can consume without impoverishing themselves in the future." (Hicks, 1939).

- Resource depletion, overstating GDP; *Adjusted Net Savings.*

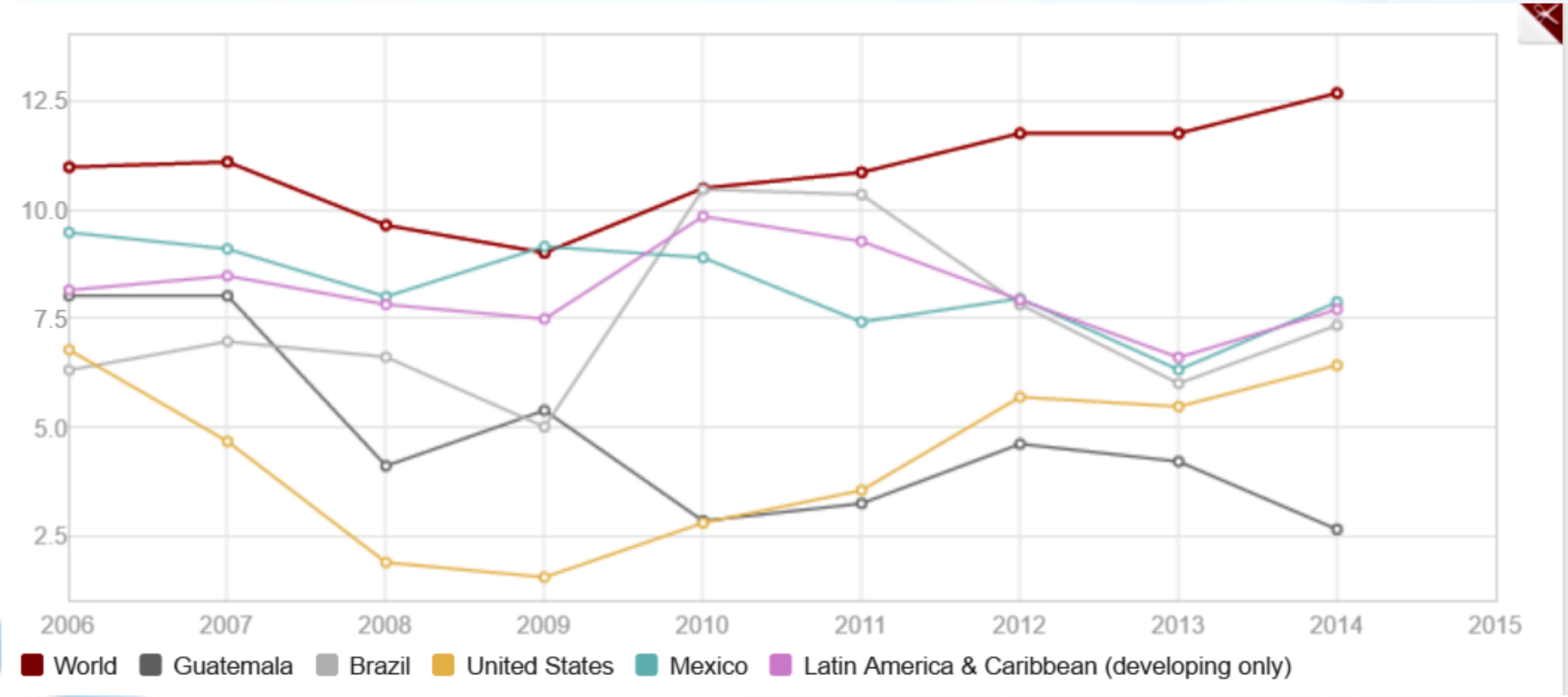
Some limitations of economy-wide models

Development organization: wealth enhancing investments.



Source: Castañeda, 2014.

Adjusted net savings as % GNI



Source: WB World Development Indicators.

Net national savings plus education expenditure, minus energy/mineral/forest depletion, plus cost of CO_2 and particulate emissions damage.

Advancing the agenda: DATA.

- Agenda 21, 1992: “A first step towards the integration of sustainability into economic management is the establishment of better **measurement of the crucial role of the environment as a source of natural capital and as a sink for by-products**… A common framework needs to be developed whereby the contributions made by all sectors and activities of society, that are not included in the conventional national accounts, are included…**A programme to develop national systems of integrated environmental and economic accounting in all countries is proposed.**”

Enter the SEEA CF.

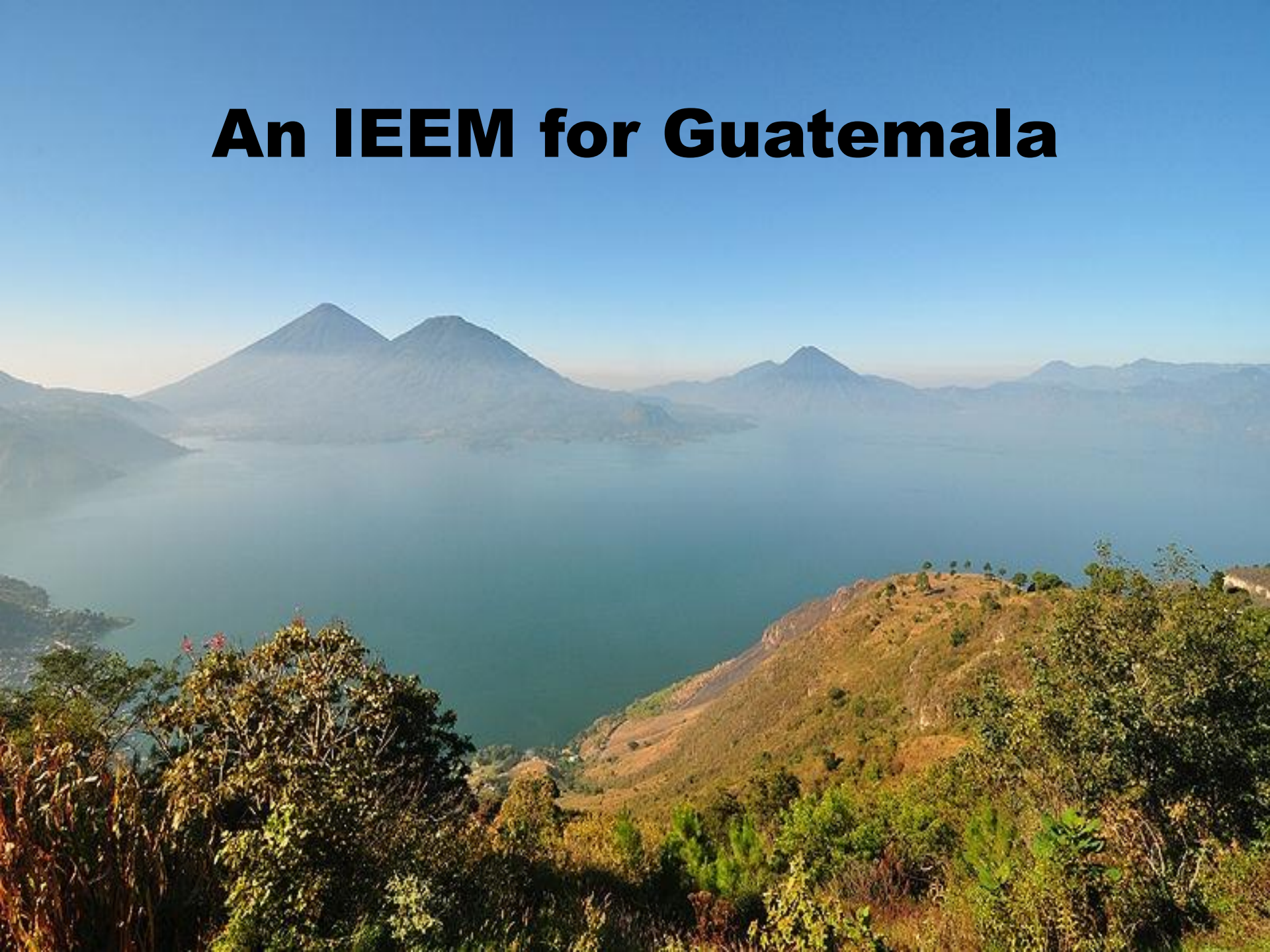
System of Environmental-Economic Accounting 2012

Central Framework

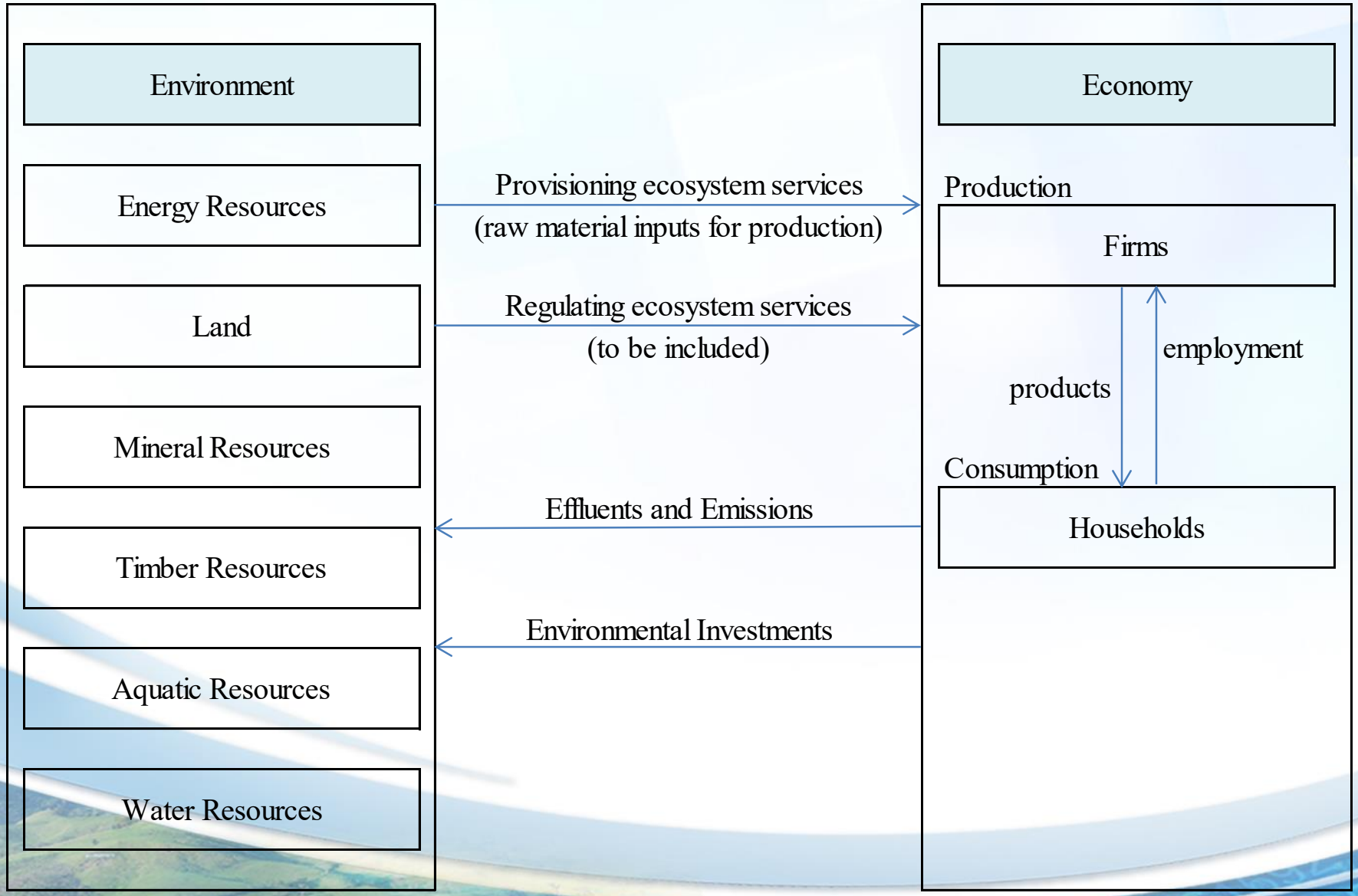
Importance of SEEA for IEEM:

1. First international standard consistent with the SNA.
2. Stocks and flows for/fish/min; flows of water/energy/emissions/residuals ($/m^3); enviro. expenditures; combined accounts.
3. Extends production boundary of SNA in physical units (no owner/payment/market price; e.g. water). **Includes all resources/land of an economic territory.**
4. Generate indicators to reflect economic ↔ environment interaction; adjusted net savings et al.

An IEEM for Guatemala



IEEM interactions



IEEM for Guatemala

Category - #		Item	Category - #	Item
Activities, commodities (25)	**Primary (5)**	Agriculture	**Factors (8)**	Labor, salaried unskilled
		Livestock		Labor, salaried skilled
		Other forestry		Labor, non-salaried unskilled
		Fuelwood		Labor, non-salaried skilled
		Fishing		Capital
		Mining		Land
	Manufacturing (12)	Food production		Natural resources, fishing
		Beverages and tobacco		Natural resources, mining
		Textiles and apparel	**Trade and transport margins (3)**	Distribution margins, domestic
		Wood products		Distribution margins, imports
		Pulp and paper		Distribution margins, exports
		Refined petroleum	**Taxes and subsidies (8)**	Social contributions, unskilled
		Chemicals		Social contributions, skilled
		Rubber and plastics		Tax, activities
		Non-metallic mineral		Subsidy, activities
		Basic metals		Tax, value added (VAT)
		Machinery and equiment		Tax, imports (tariffs)
	Services (7)	Electricity		Tax, commodities,
		Water		Subsidy, commodities
		Construction		Tax, income
		Trade	**Institutions**	Households, rural, quintiles
		Hotels and restaurants		Households, urban, quintiles
		Transport		Enterprises
		Other services		Government
				Rest of World
			Savings-Investment (4)	Savings
				Investment, private
				Investment, government
				Stock change

Note: disaggregated version has 122 activities, 219 commodities.

Environmentally extended SUT

	Account	Units	Output/ IC	Enviro	Import	Export	Cons
1	Supply	$					
2	Use	$					
3	Value added	$					
4	Employment	individuals					
5	Water supply registered/unregistered	m^3					
6	Water use registered/unregistered	m^3					
7	Cultivated area	Ha					
8	Rainfed, sprinkler, drip, gravity, other use	m^3					
9	All irrigation	m^3					
10	Sprinkler, drip, gravity, other return	m^3					
11	Energy supply	terajoule					
12	Energy use	terajoule					
13	Carbon dioxide supply	CO_2 t. eq.					
14	Nitrous oxide supply	CO_2 t. eq.					
15	Methane supply	CO_2 t. eq.					
16	Timber products supply	m^3					
17	Timber products use	m^3					
18	Animal species supply	individuals					
19	Animal species use	individuals					
20	Residual supply	tonnes					
21	Residual use	tonnes					
22	Extractive resource supply	tonnes					
23	Extractive resource use	tonnes					
24	Aquatic resources supply	tonnes					
25	Aquatic resources use	tonnes					

Environmentally extended SUT, ESAM and satellite/stock matrices.

IEEM Modules

- **Forest resource module:** capital, labor, land; imperfect land mobility; track forest stock.

- **Land module:** used until marginal product of land = marginal revenue; enabled to set lower bound, endogenous subsidy, tax financed. Land supply vertical or upward sloping (deforestation/rezoning).

- **Water module:** use proportional to sector output and population. Price zero in baseline; non-base positive price if demand > supply, income distributed according to land ownership.

IEEM Modules

- **Energy/emissions:** Guatemala SEEA considers carbon dioxide, nitrous oxide and methane; track ACT/HH emissions; improved efficiencies; caps and taxes.

- **Extractive resources:** nonrenewable with costs related to stocks; stocks updated; mining productivity falls as stocks decline.

- **Aquatic resources:** biological model relates quantity of harvest/stock/growth/carrying capacity. Can fix level of stock or upper bound to attain MSY.

Applying IEEM: fuelwood/forestry

National Strategy for Sustainable Production/Efficient Use of Fuelwood (2013-2024).

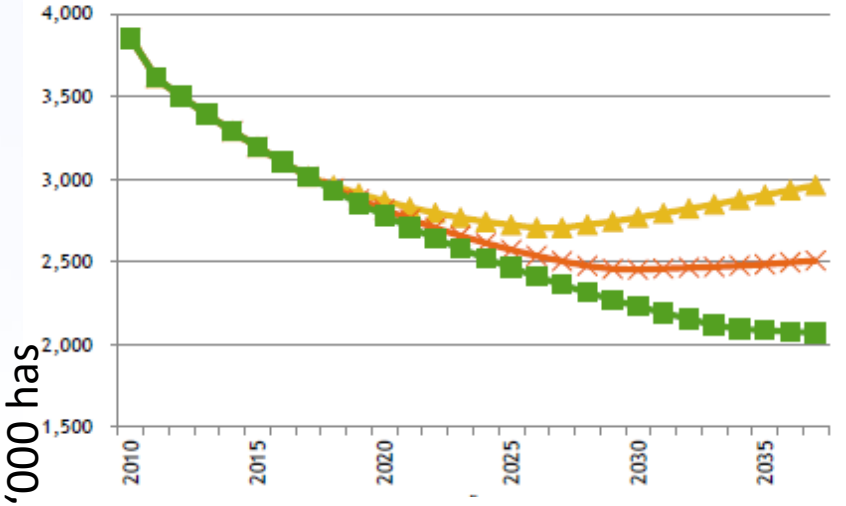
- 67% (2.1 million) households use fuelwood; 57% total energy; cooking/heating/cultural.
- Fuelwood scarcity, time of women/children.
- Health impacts: 31% > chance of RI; premature death of over 5,000; 1% GDP loss; 10 M m^3 deficit, degradation.
- Strategy will plant forests, promote efficient cookstoves, reduce fuelwood deficit by 25%.

Applying IEEM: fuelwood/forestry

PROBOSQUE (2015): Program for establishment, recuperation, restoration, management, production and protection of Guatemala's forests. Goals:

1. Increase forest cover for regulating ecosystem services.
2. Create rural jobs.
3. Enhance energy and food security.
4. Reduce vulnerability to climate variability/change.

G: Undesirable; R: probable; Y: desirable



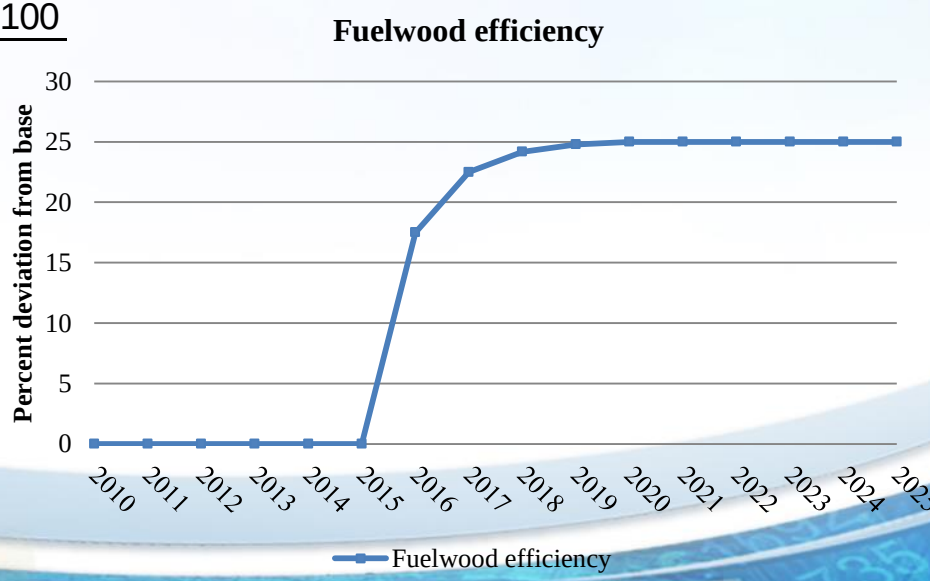
Source: Inab/pfn-Url/Iarna, 2012.

Scenario design

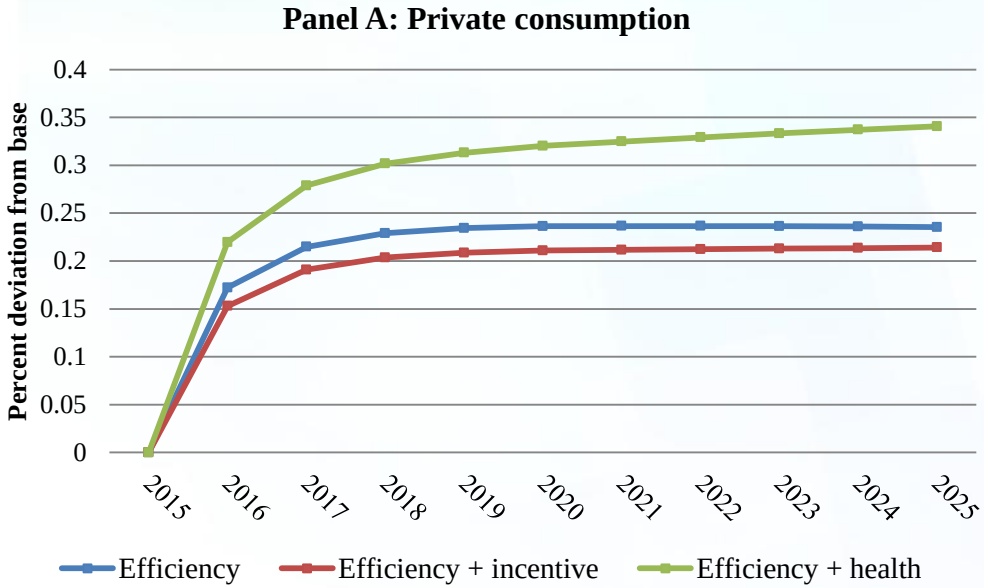
- **Baseline:** Past trends will continue from 2016 to 2025.
- **Efficiency:** 25% increase in fuelwood household consumption efficiency.
- **Efficiency + incentive:** Efficiency shock and forest incentive; lower bound on forest land use.
- **Efficiency + health:** Increased household fuelwood efficiency and health impacts; 1.25% improvement rural labor productivity.

Fuelwood expenditure share

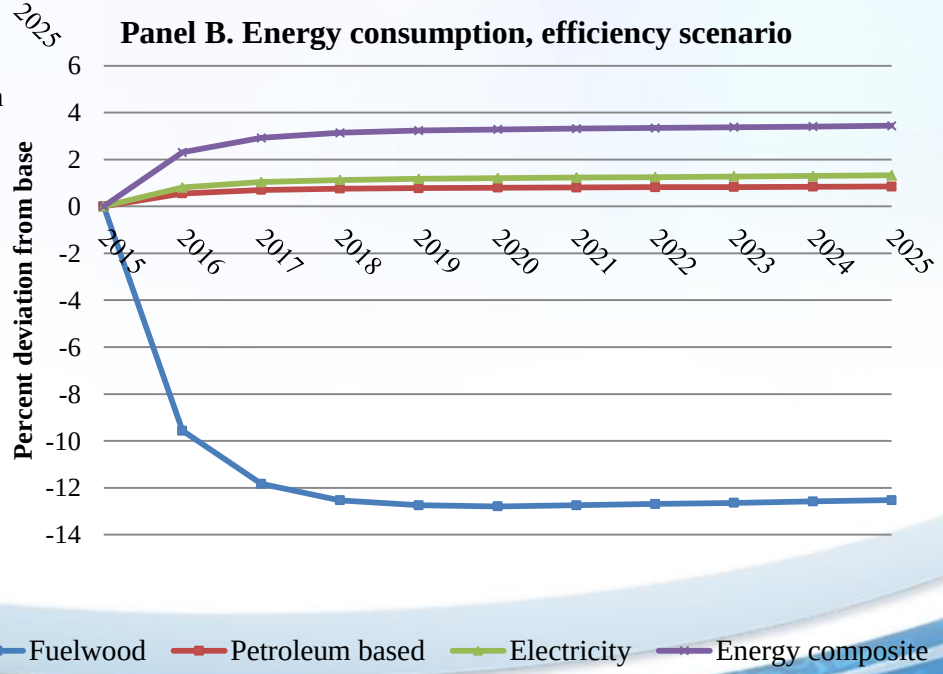
	Household quintile	Fuelwood expenditure share	Share of total income
Rural	HH q1	13.1	3.3
	HH q2	15.2	4.6
	HH q3	14.1	5.5
	HH q4	13.9	6.8
	HH q5	11.3	10.0
Urban	HH q1	12.4	6.3
	HH q2	9.0	8.8
	HH q3	5.4	11.9
	HH q4	4.0	15.2
	HH q5	1.6	27.7
	Total	100	100



Consumption impacts



Panel A: GDP, employment and wage impacts follow same trends.

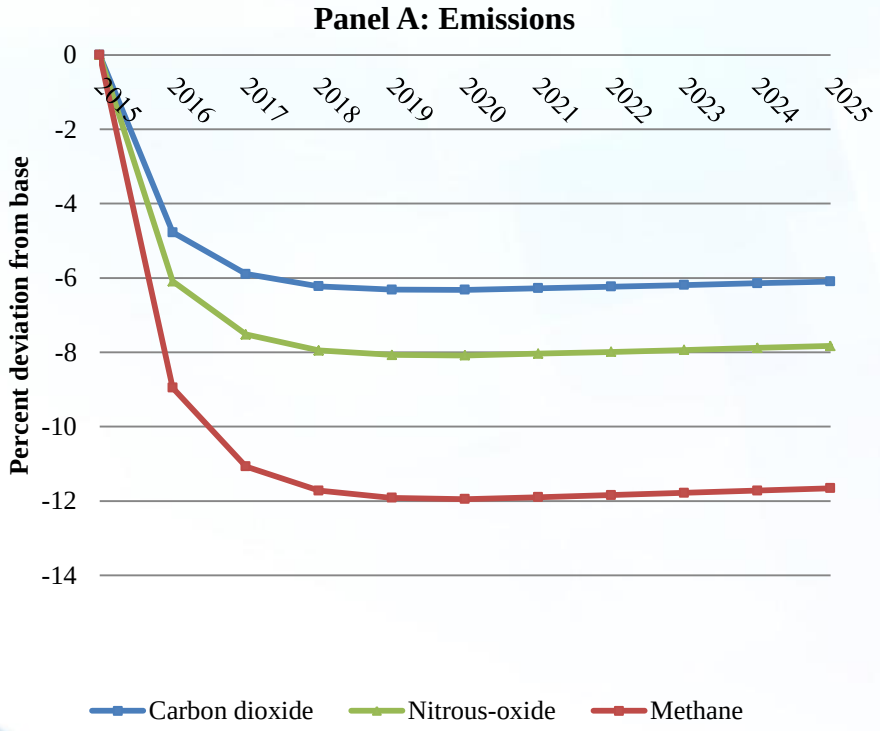


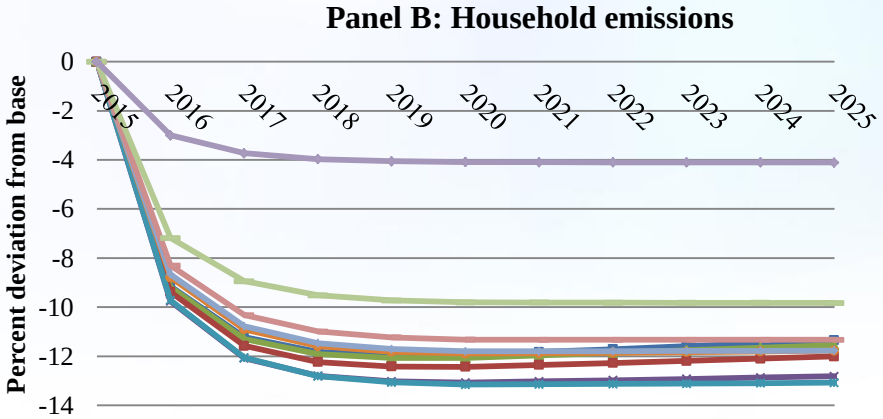
Sectoral impacts

	Efficiency	Efficiency + incentive	Efficiency + health
Agriculture	**0.734**	**0.117**	**0.825**
Livestock	**0.078**	**0.131**	**0.186**
Other forestry	**-0.312**	**0.996**	**-0.118**
Fuelwood	**-10.735**	**-10.656**	**-10.668**
Fishing	-0.020	0.042	0.041
Mining	-0.036	0.020	0.034
Food prod	0.074	0.133	0.192
Beverages and tobacco prod	0.050	0.100	0.152
Textiles and wearing apparel	-0.186	0.155	0.031
Wood and wood prod	-0.059	0.199	0.124
Paper and paper prod	-0.058	0.077	0.102
Refined petroleum prod	-0.043	0.025	0.057
Chemicals	-0.054	0.074	0.106
Rubber and plastics	-0.012	0.060	0.131
Non-metallic mineral prod	0.000	0.063	0.192
Basic metals and metal prod	-0.165	-0.006	0.029
Machinery and equipment	-0.282	0.089	-0.035
Other manufactures	-0.003	0.134	0.151
Electricity	0.248	0.250	0.369
Water	0.033	0.061	0.151
Construction	0.023	0.055	0.235
Trade	0.006	-0.088	0.127
Hotels and restaurants	-0.074	0.108	0.146
Transport	-0.158	-0.083	-0.019
Other services	0.028	0.053	0.145

Percent deviation from baseline in 2025.

Emissions impacts

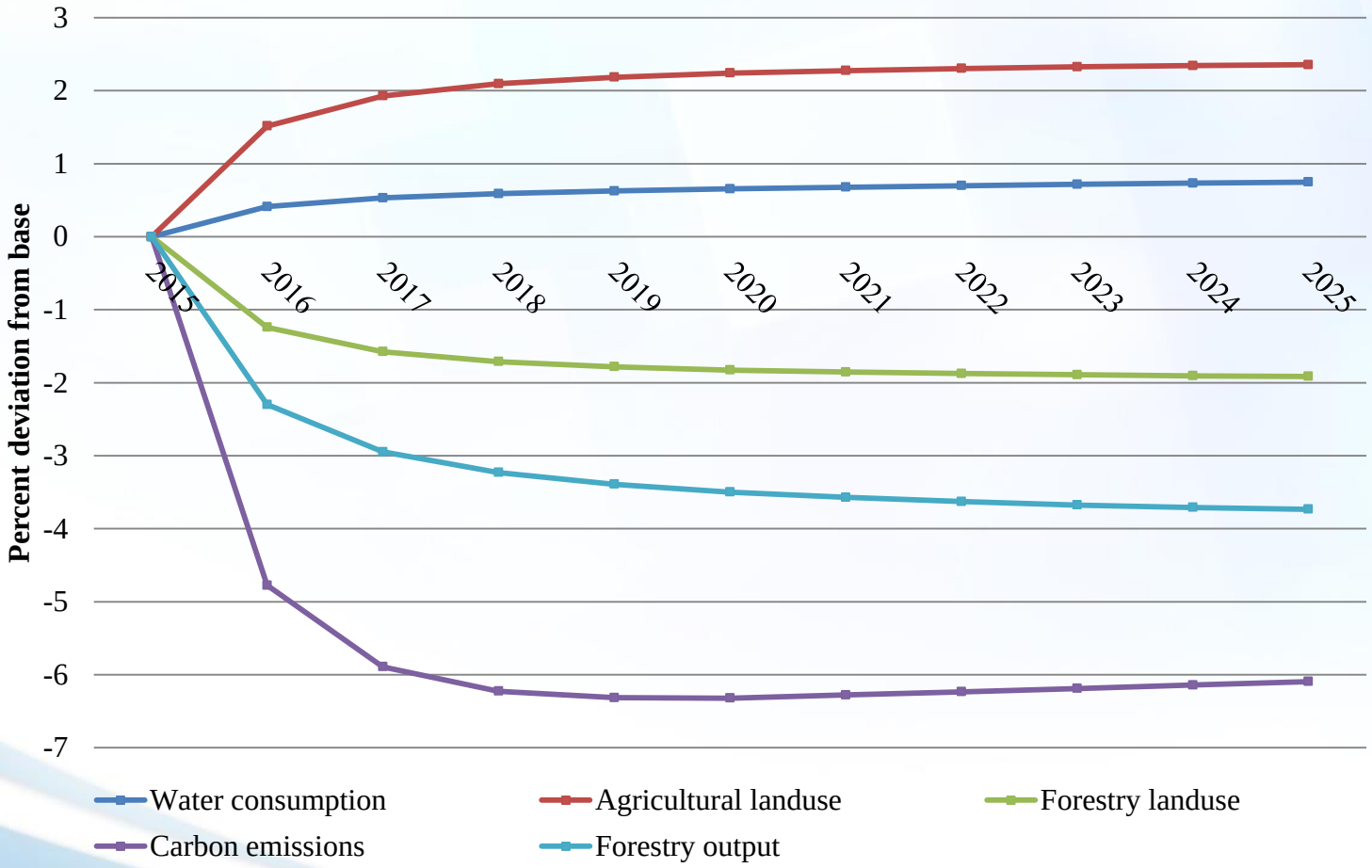




Household differentiated impacts on income, health and productivity.

Rural HH q1 Rural HH q2 Rural HH q3 Rural HH q4
Rural HH q5 Urban HH q1 Urban HH q2 Urban HH q3
Urban HH q4 Urban HH q5

Multidimensional impacts



Summary

1. Guatemala's fuelwood strategy reduces fuelwood consumption, but increases overall energy consumption.

2. The strategy enhances household well being; positive health impacts amplify this result (poor benefit more).

3. The strategy results in agricultural expansion and increased water consumption (+emissions/waste); forests are lost in the expansion process

4. Forest incentives improve well being, but less than efficiency scenario alone. **Adjusted income/savings indicators?**

Key messages

1. IEEM captures environment ↔ economy interactions; enabling adjustment of standard indicators of economic development/prospects in our projections.

2. IEEM is based on comprehensive/consistent data (SEEA) reducing data reconciliation/strong assumptions; reduces costs/timeliness of policy advice.

3. IEEM implements sectoral modeling approaches capitalizing on richness of SEEA data.

Where to next?

- Reporting to include adjusted indicators.
- Improve sectoral specification.
- Multi-regional model (bottom-up).
- Incorporate regulating and cultural and aesthetic ecosystem services (tourism as a function of standing forest/fisheries stocks, emissions/capita).

IEEM

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For more details:

1. Banerjee, O., Cicowiez, M., Horridge, M. and Vargas, R. Forthcoming September 2016. A Conceptual Framework for Integrated Economic-Environmental Modelling. *Journal of Environment and Development.*

2. Banerjee, O., Cicowiez, M., Vargas, R. and Horridge, M. 2016. The SEEA-Based Integrated Economic-Environmental Modelling Framework: An Illustration with Guatemala's Fuelwood/Forest Sector. GTAP Conference Paper, Washington DC, June 15-17, 2016.

NOTES

System of Environmental-Economic Accounting 2012

Central Framework

1. **Flow accounts**: flows of materials and energy within the economy and between the economy and the environment; in physical and/or monetary values.

2. **Stock accounts**: forest/fish/extractives/land.

3. **Activity accounts** Environmental Protection Expenditure accounts, environmental tax and subsidies

4. **Combined accounts** consolidate physical/monetary info to derive indicators: depletion adjusted aggregates.

System of Environmental-Economic Accounting 2012

Central Framework

The production boundary: The System of National Accounts (SNA) states that:

- "Economic production may be defined as an activity carried out under the control and responsibility of an institutional unit that uses inputs of labour, capital, and goods and services to produce outputs of goods or services…..institutional unit entitled to compensation…." and "A purely natural process without any human involvement or direction is not production in an economic sense" (UN et al, 2009).

- In monetary terms, the asset boundaries of SEEA and SNA are the same. In physical terms, SEEA includes all natural resources and areas of land of an economic territory with/without market value.

An integrated accounting system

A Stylized ESAM

	act	com	fact	hhd	gov	RoW	sav-inv	tot mon	enviro	water-reg	water-unreg	other resrsc	resid	emiss
act		dom prod						inc firm		supply		supply	by-prod	by-prod
com	IC			C	G	E	I	demand						
fact	VA							inc fac						
hhd			VA					inc hhd						by-prod
gov	T	T						inc gov						
RoW		M	INC-F	TR				out forex				imp	imp	
sav-inv				SH	SG	SF		sav						
tot mon	cost firm	supply	spend fac	spend hhd	spend gov	in forex	inv							
enviro							enviro invest				source	source		
water reg	int-dem			fin-dem										
water unreg	int-dem													
other resrcs	int-dem			fin-dem		exp	fin-dem							
resid	int-dem						fin-dem		sink					
emiss									sink					

Source: Authors' own elaboration