

Uncertainty associated for
selecting impact
indicators to measure a
green transformation in
the land use sector of
Costa Rica

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COMMUNICATING RISKS IN Decision
Support Systems: from basic research
to advance decision support tolos

June, 2018

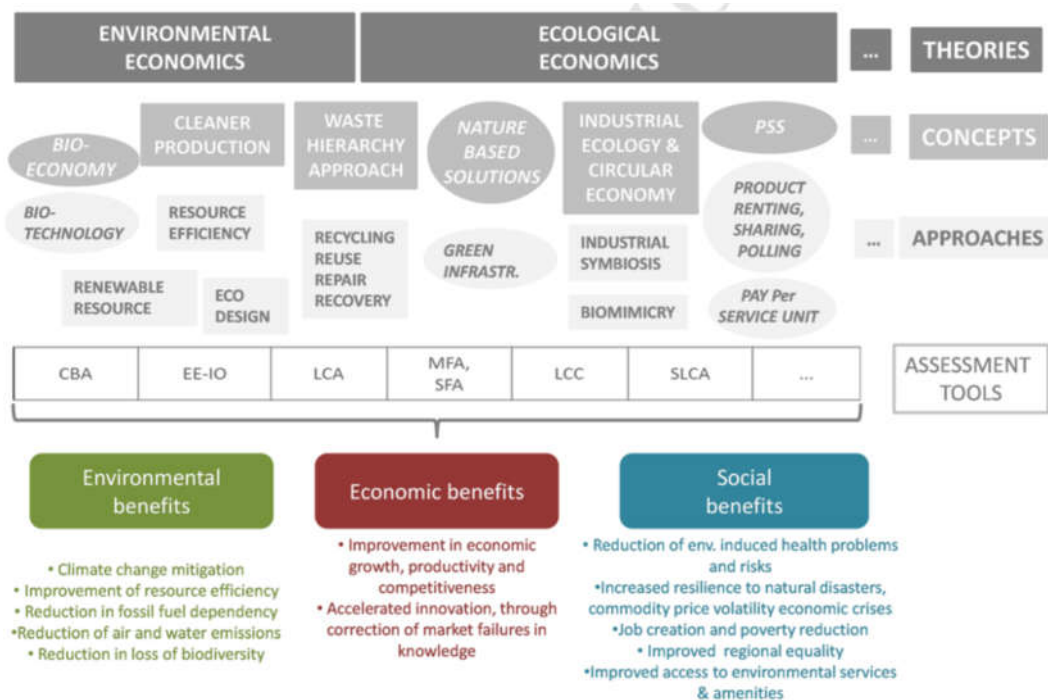


Green concepts

- **Sustainable development:** development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987)
- **Green economy:** one that results in improved well-being and social equity, while significantly reducing environmental risks and ecological scarcities (UNEP, 2011)
- From 1990 to 2016 “the literature research found 877 documents where the term “green economy” is mentioned in the title, the abstract or the keywords” (Loiseau et al., 2016)

Green concepts

- **Green growth:** fostering economic growth and development while ensuring that the natural assets continue to provide the resources and the environmental services on which our well-being relies (OECD, 2011)
- **Cleaner production:** the continuous application of an integrated environmental strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment (UNEP, 1990)
- **Circular economy:** an industrial economy that is restorative by design, and which mirrors nature in actively enhancing and optimizing the systems through which it operates (The Ellen MacArthur Foundation, 2012)
- **Nature based solutions:** actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits (Cohen-Shacham, 2016)
- **Bioeconomy:** an economy using biological resources from the land and sea as well as waste, including food wastes, as inputs to industry and energy production. It also covers the use of bio-based processes to green industries (The European Commission, 2012)



Loiseau et al., 2016

Green concepts

Green transformation: the pro-active restructuring of the economy in a way that respects planetary boundaries (Schmitz, 2015)



Technocentric transformation: meet rising demands in greener ways



Marketized transformation: recognize, and value economically, the natural capital on which growth depends



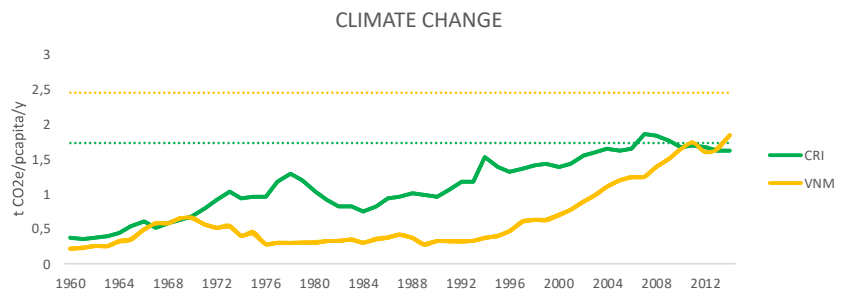
State-led transformation: re-embed markets in stronger frameworks of state control



Citizen-led transformation: de-growth and bottom-up transitions

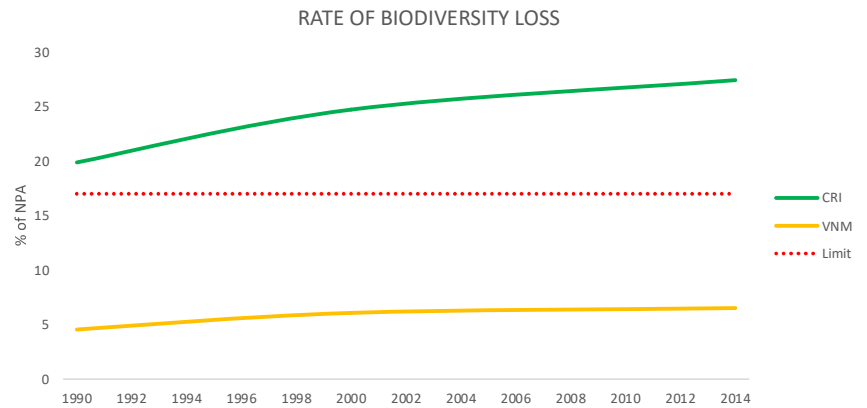
Planet Boundary	Definition	Indicators		Limit	
		Rockström et al (2009)	National	Global	National
Climate change	The climate-change boundary proposed here aims at minimizing the risk of highly non-linear, possibly abrupt and irreversible, Earth System responses (National Research Council (NRC) 2002, IPCC 2007b) related to one or more thresholds, the crossing of which could lead to the disruption of regional climates (Lenton et al. 2008), trigger the collapse of major climate dynamics patterns such as the thermohaline circulation (Clark et al. 2002), and drive other impacts difficult for society to cope with, such as rapid sea-level rise. The risk of crossing such thresholds will rise sharply with further anthropogenically driven deviation from the natural variability of the Holocene climate.	Atmospheric CO2 concentration (parts per million by volume) Gt CO2-eq./yr	CO2 Emissions per Capita (WB) CO2 Emissions in the agriculture and livestock sector (WB) CO2 Emissions in the environmental and forestry sector (WB) Nitrous oxide emissions (WB)	350–550 ppm (Rockström et al 2009) 393,81 ppm (NOAA 2013) 46–55 Gt CO2-eq./yr for 2011 (Hoekstra and Wiedmann 2014)	Costa Rica: 10.9 MtCO2e for 2021 (INDC 2015) 9.37 MtCO2e for 2030 (INDC 2015) 5.96 MtCO2e for 2050 (INDC 2015) 170,500 t of GHG per year (INDC 2015) Vietnam: 474.1 MtCO2e for 2020 (INDC 2015) 787,4 MtCO2e for 2030 (INDC 2015)

Downscaling of the limit (t CO2e/pcapita/y)	
Global	National
2 t CO2 / capita / y (UNDP 2007)	Costa Rica (25% of 2012): 1.73 tCO2e for 2030 (INDC 2015)
9,7 t CO2 / capita / y (Rockström et al 2009)	1.19 tCO2e for 2050 (INDC 2015) -0,27 tCO2e for 2100 (INDC 2015) Vietnam (8% of 2010): 2,45 tCO2e for 2030 (INDC 2015)



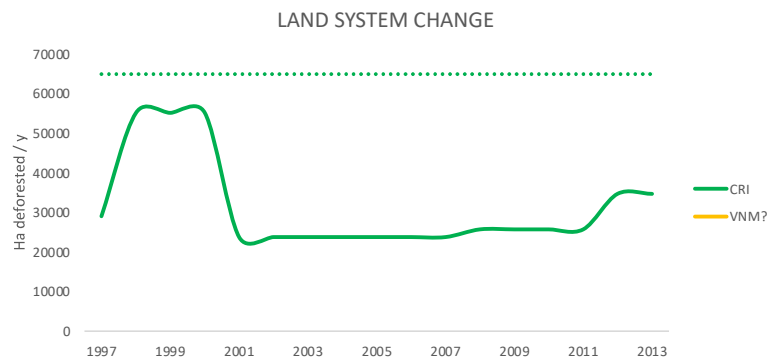
Planet Boundary	Definition	Indicators		Limit	
		Rockström et al (2009)	National	Global	National
Rate of Biodiversity Loss	Accelerated biodiversity loss during the Anthropocene (Mace et al. 2005) is particularly serious, given growing evidence of the importance of biodiversity for sustaining ecosystem functioning and services and for preventing ecosystems from tipping into undesired states (Folke et al. 2004).	Extinction rate, extinctions per million species per year (E/MSY)	Percentage of protected areas (WB) Threatened and endangered species (IUCN, CITES) Tree species (NFI)	<10 E/MSY (10–100 E/MSY) (Rockström et al 2009)	NA

Downscaling of the limit (% of NPA)	
Global	National
Aichi Target 11: By 2020, at least 17 per cent of terrestrial and inland water, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes	NA



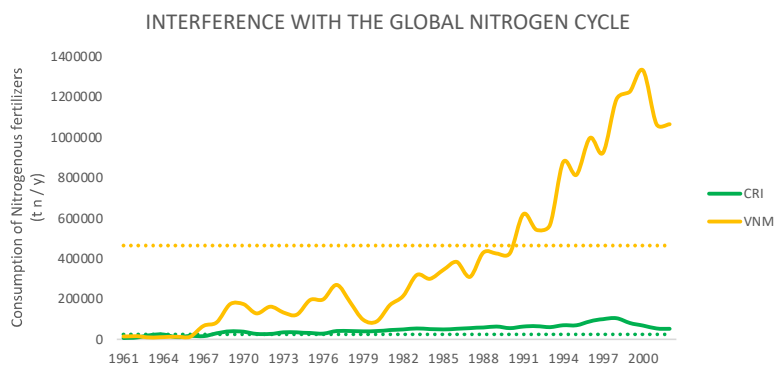
Planet Boundary	Definition	Indicators		Limit	
		Rockström et al (2009)	National	Global	National
Land-System Change	Land-system change, driven primarily by agricultural expansion and intensification, contributes to global environmental change, with the risk of undermining human well-being and long-term sustainability (Foley et al. 2005, MEA 2005a).	Percentage of global land cover converted to cropland	Deforestation (CD)	≤15% of global ice-free land surface converted to cropland (Rockström et al 2009)	NA

Downscaling of the limit (ha deforested yr-1)	
Global	National
0.3 ha / capita (Rockström et al. 2009 divided by world population)	Costa Rica: 1 457 182,2 ha Vietnam: 27 810 330 ha
15% national available land (Rockström et al 2009)	Costa Rica: 580 034,37 ha Vietnam:
Maximum recorded deforestation	Costa Rica: 65 000,00 ha (Hartshorn 1993) Vietnam: ??



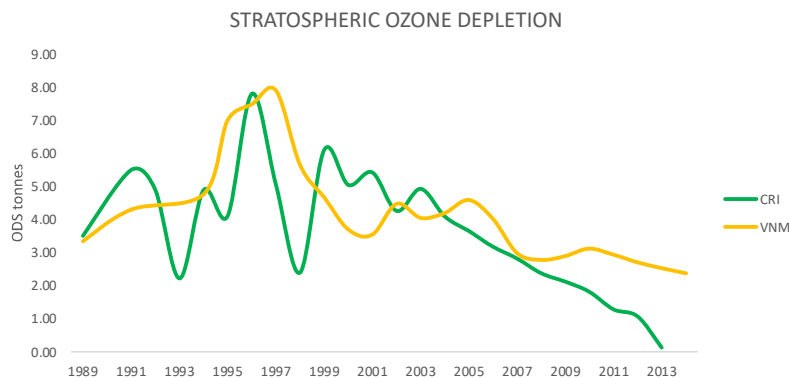
Planet Boundary	Definition	Indicators		Limit	
		Rockström et al (2009)	National	Global	National
Interference with the Global Phosphorus and Nitrogen Cycles	Human-induced degradation of ecosystem states (e. g., overfishing, land degradation) and increase in N and P flows at regional to global scales may cause undesired non-linear change in terrestrial, aquatic, and marine systems, while simultaneously functioning as a slow driver influencing anthropogenic climate change at the planetary level.	Amount of N ₂ removed from atmosphere for human use (millions of tonnes per year)	Consumption of Nitrogenous Fertilizers (tonnes) (FAO)	35 Mt (Rockström et al 2009) 121 Mt (Nykvist 2013)	NA

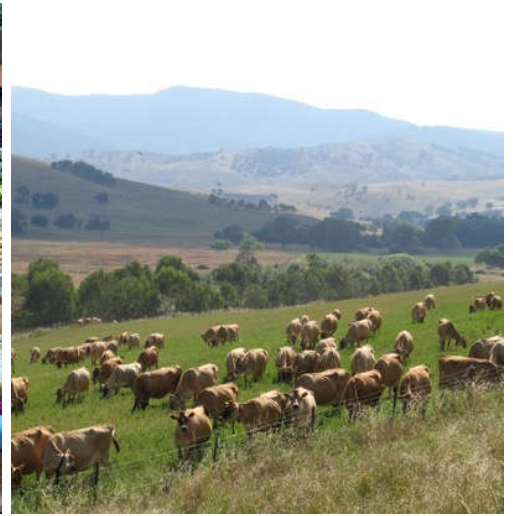
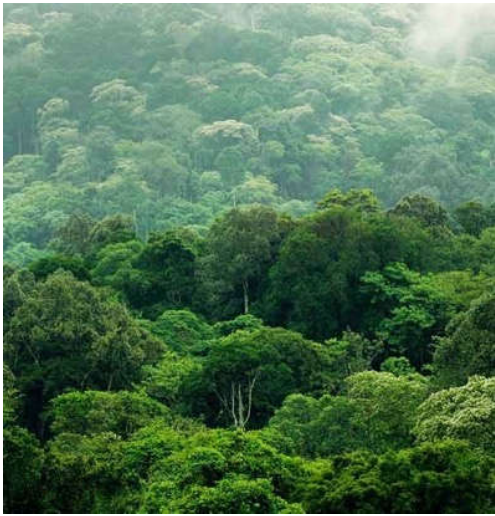
Downscaling of the limit (t n / y)	
Global	National
5 kg n / capita / y (Rockström et al. 2009 divided by world population)	<u>Costa Rica</u> : 24 286,37 <u>Vietnam</u> : 463 505,50



Planet Boundary	Definition	Indicators		Limit	
		Rockström et al (2009)	National	Global	National
Stratospheric ozone depletion	The ozone hole “tipping point” depends on anthropogenic ozone-depleting substances, but also on sufficiently cold temperatures and a sufficient amount of water vapor and, in some cases, nitric acid. Humans contribute directly to the first (and to some extent the last) of these, and indirectly to the others. Although polar ozone holes have local impacts, a thinning of the extra-polar ozone layer would have a much larger impact on humans and ecosystems.	Stratospheric O ₃ concentration (Dobson units - DU)	Consumption of Ozone-Depleting Substances - ODS (tonnes) (UNEP) PM2.5 air pollution (micrograms per cubic meter) (WB)	<5% reduction from pre-industrial level of 290 DU (5%–10%) (Rockström et al 2009) 283 DU (WMO 2010)	NA

Downscaling of the limit (ODS tonnes)	
Global	National
Due to the longevity of ODS and the fact that much of the use of ODS has already been phased out, essentially removing the driver behind ozone depletion, the global PB of a 5% reduction in the thickness of the global ozone layer (state) cannot easily be translated into national variables on emissions. However, a relevant indicator for measuring national territorial performance is the use of ODS (Nykvist 2013)	NA





Costa Rica: why the land use sector matters?

ENVIRONMENTAL AND FORESTRY SECTOR

- Mitigate 57% of total CO2 emissions (7.4M tons/CO2/yr)

Mitigation capacity



- 52.4% of the national territory
- 26.94% is under public domain

Area



- 95,157 known species
- 5% of the world's known biodiversity

Biodiversity



- Forest production is 2% of GDP
- Tourism is 4% of GDP

Economic value



- 1million ha of private forests
- USD 25M /yr

PES System



- Annual gross deforestation is 30,000 ha/yr

Deforestation



- Exports in 2016: \$73.03 M
- Imports in 2016: \$116 M

Commercial trade



- 19,236 people in 2006
- 14,806 people in 2015

Employment



- 3,500 ha/yr, 1/3 of the area in 1997
- PES program covered only 2,330 ha in 2015

Reforestation



- 0.03% of PES funds, 3.7% of the national wood consumption
- 248,362 m3 in 1998; 14,448 m3 in 2015

Forest management activities

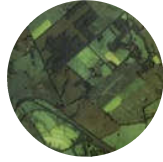


AGRICULTURAL AND LIVESTOCK SECTOR



Economic/Social impacts

- 11% of total employment
- Aprox. 230k persons employed
- 72% of rural employment
- 40% of total exports
- USD 3.5 billion / yr



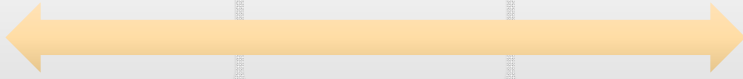
Contribution in area of Costa Rica

- 47% of the national territory
- 43% pastures (1.4 M ha is cattle); 31% forests (mostly mature forests); 16% permanent crops (mostly coffee)



Contribution in emissions of Costa Rica

- 37% of total CO2 (pastures) (1x)
- 50% of total CH4 (1.3 M cattle heads) (25x)
- 79% of total N2O (fertilizers) (298x)



WATER

Electricity production

- 75.3% of electricity supply
- Less than 1% of the energy matrix-fossil fuels
- 75% of hydropower generation potential has not yet been exploited

Economic value

- US\$280 M in drinking water and sanitation activities
- 0.5% of GDP

Agricultural production

- 75% of the water extracted
- 765 million cubic meters of water extracted in 2012
- Water delivered by irrigation districts to users is billed at \$0.01/m3

Management

- Half of the water extracted for irrigation is lost
- Only 20% of the population is connected to sewage networks
- 5% of the country's wastewater is treated before being deposited in rivers
- 57% of rivers and estuaries of the country have high levels of pollution



CO₂e emissions in Costa Rica

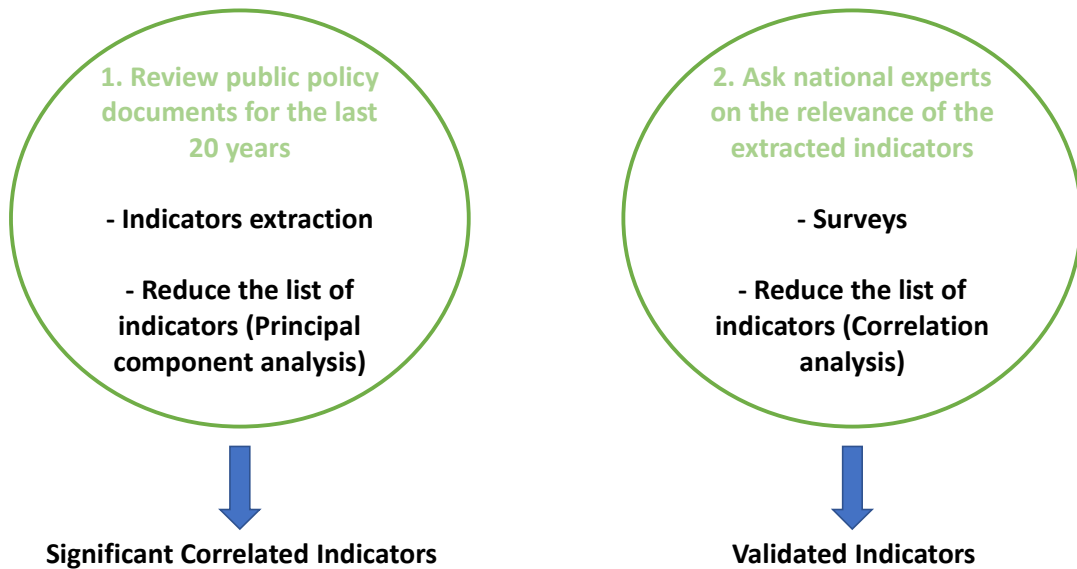
Data for 2012. IMN 2015. 2006 IPCC Guidelines



Two big questions

1. How to design a monitoring framework for public policies to measure a green transformation in the land use sector in Costa Rica? (Phase 1)
2. What is the best approach to measure the selected indicators? (Phase 2)

Two methods



Steps for each method

1

Significant correlated indicators

- Detect redundant indicators
- Collect data for each indicator
- Normalize data
- Simulations of PCA
- Extraction of components

2

Validated indicators

- Collect responses from the surveys
- Correlation analysis from the responses
- Calculation of statistical variables for each correlation
- Selection of best indicators

Indicator	Code	Component 1	Component 2
Public forests	VAR00002	0.937	-0.082
CO2 Emissions in the agriculture and livestock sector	VAR00003	0.350	-0.818
CO2 Emissions per Capita	VAR00005	0.708	0.577
Agriculture and livestock value added	VAR00013	0.958	-0.165
International tourism receipts	VAR00015	0.972	0.029
Wood consumption	VAR00017	0.043	0.660
Gross domestic product per capita	VAR00027	0.988	-0.095
Growth rate of real GDP per employed person	VAR00028	0.986	-0.095
Gini Index	VAR00031	0.106	0.813
Human Development Index	VAR00032	0.991	0.050
Access to Drinking Water	VAR00034	0.986	0.115

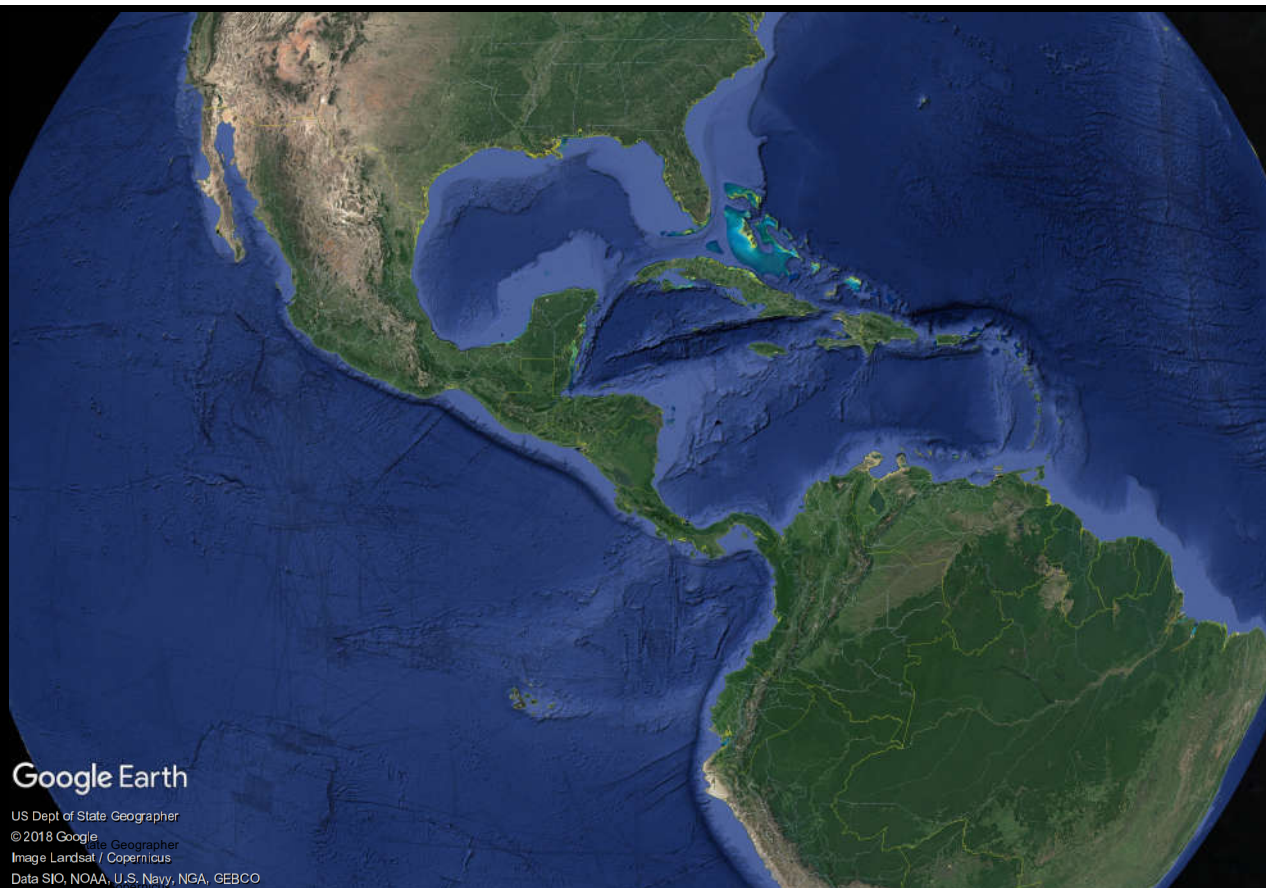
Significant correlated indicators

Indicator	Best correlation	V1	V3	V5	V6	Best evaluated indicator	Cum.%
Gross domestic product per capita	Growth rate of real GDP per employed person	0,912	0,514	10	2	Gross domestic product per capita	78,90
Growth rate of real GDP per employed person	Gross domestic product per capita	0,912	0,536	11	4	Gross domestic product per capita	78,90
Livestock area	Agriculture area	0,881	0,482	10	2	Livestock area	91,20
Agriculture area	Livestock area	0,881	0,515	11	2	Livestock area	91,20
Agriculture and livestock value added	Forestry and environmental value added	0,858	0,483	8	3	Forestry and environmental value added	91,20
Forestry and environmental value added	Agriculture and livestock value added	0,858	0,489	8	3	Forestry and environmental value added	91,20
Head of State's advocacy for green issues	National and International Climate Policy	0,801	0,466	7	4	National and International Climate Policy	94,70
National and International Climate Policy	Head of State's advocacy for green issues	0,801	0,471	8	2	National and International Climate Policy	94,70
Poverty gap at national poverty lines	Rural poverty gap at national poverty lines	0,788	0,518	10	5	Rural poverty gap at national poverty lines	85,90
Rural poverty gap at national poverty lines	Poverty gap at national poverty lines	0,788	0,497	10	3	Rural poverty gap at national poverty lines	85,90
Private forests	Public forests	0,779	0,466	7	3	Private forests	94,70
Balance of trade in forest products	Wood consumption	0,739	0,511	12	2	Wood consumption	84,20
Good farming practices	Government Effectiveness	0,713	0,525	12	4	Government Effectiveness	94,70
Government Effectiveness	Good farming practices	0,713	0,484	9	2	Government Effectiveness	94,70
Area under forest management	Illegal logging	0,663	0,458	8	2	Illegal logging	91,30
Illegal logging	Area under forest management	0,663	0,459	8	2	Illegal logging	91,30
Reforestation	Private forests	0,661	0,478	10	2	Reforestation	91,20
Area purchased by the state for conservation	Good farming practices	0,634	0,503	11	3	Good farming practices	92,90
Valuation of environmental damage	Area under forest management	0,625	0,523	12	5	Area under forest management	87,70

Validated Indicators

Category	Indicator	SCI	VI	AD	Unit	References
Carbon emissions and sequestration	CO2 Emissions in the agriculture and livestock sector	✓		✓	gG CO2e	Himics et al., 2018
	CO2 Emissions per Capita	✓		✓	m-tons PC	UN, 2007; Mehdi and Slim, 2017; EU 2017; Simas et al., 2017
Area	Livestock area		✓		ha	Pubule et al., 2017; Simas et al., 2017
	Public forests	✓		✓	ha	UN, 2007; Witheman et al., 2015; Sardain et al., 2016; Brambila and Flombaum, 2017
	Private forests		✓		ha	Witheman et al., 2015
	Reforestation		✓		ha	Dinh Le et al., 2012; Agol et al., 2014
Climate change commitment	National and International Climate Policy		✓			Tamanini, 2016
Environmental damage	Illegal logging		✓		m3	Tegegne et al., 2014
Productivity	Agriculture and livestock value added	✓		✓	USD	Alamdarlo, 2016; Zafeiriou and Azam, 2017
	Forestry and environmental value added		✓	✓	USD	Tegegne et al., 2014
	International tourism receipts	✓		✓	USD	UN, 2007
	Area under forest management		✓		ha	UN, 2007; Tegegne et al., 2014
	Wood consumption	✓	✓	✓	m3	Blettert et al., 2017
	Good farming practices		✓		# proj.	Maxim, 2012; Pubule et al., 2017; Kelly et al., 2018; EU, 2017
State effectiveness	Government Effectiveness		✓	✓	NA	Kaufmann et al., 2010
	Gross domestic product per capita	✓	✓	✓	NA	UN, 2007; Mozumder et al., 2006; Sardain et al., 2016; EU, 2017
	Growth rate of real GDP per employed person	✓		✓	NA	ILO, 2013
	Rural poverty gap at national poverty lines		✓	✓	%	UN, 2007
	Gini Index	✓		✓	NA	Otoi et al., 2014; Sardain et al., 2016; EU, 2017
	Human Development Index	✓		✓	NA	Jha and Murthy, 2003; Otoi et al., 2014
Water	Access to Drinking Water	✓		✓	% of pop.	UN, 2007; Cook et al., 2017; OECD, 2017

Merged Indicators



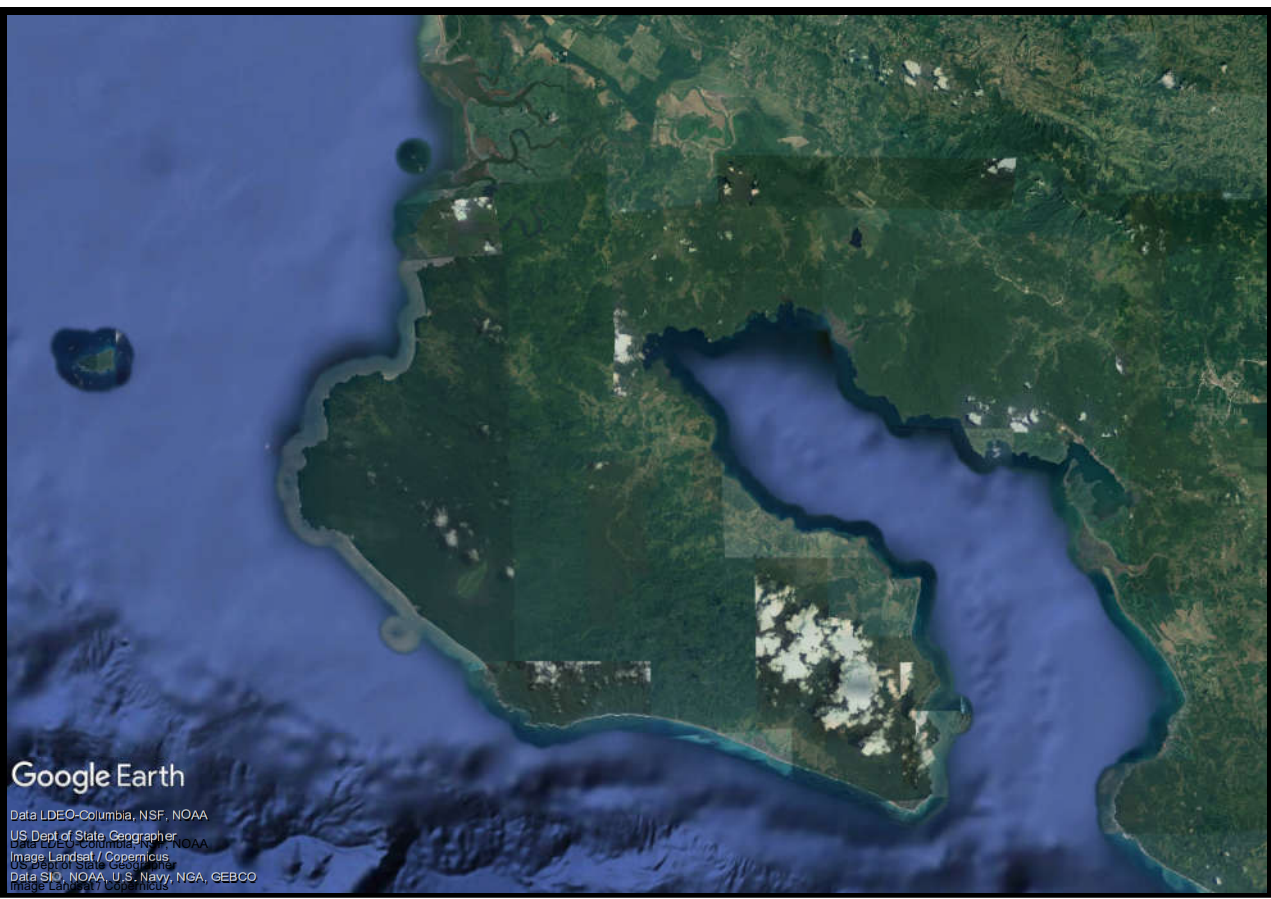
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Google Earth

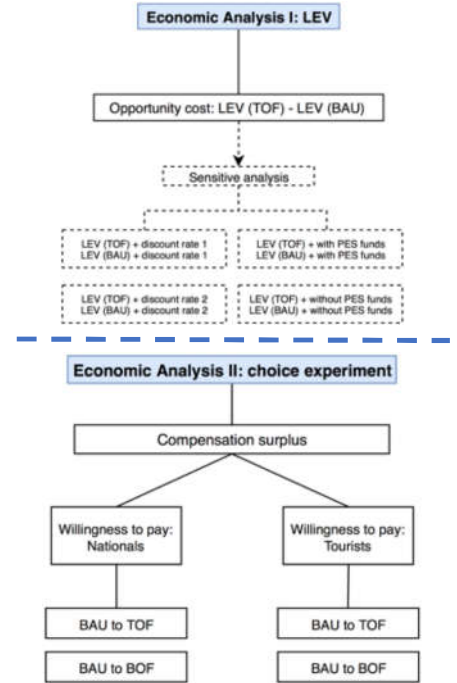
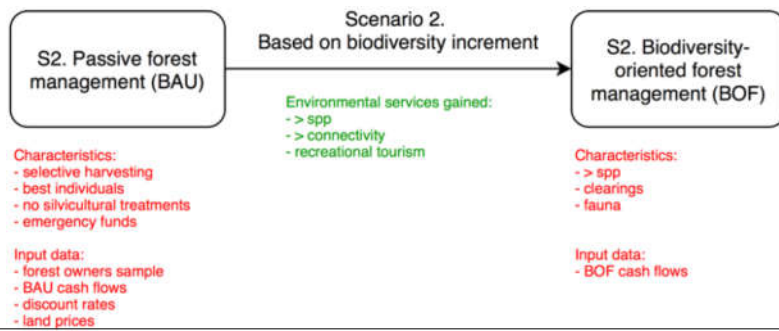
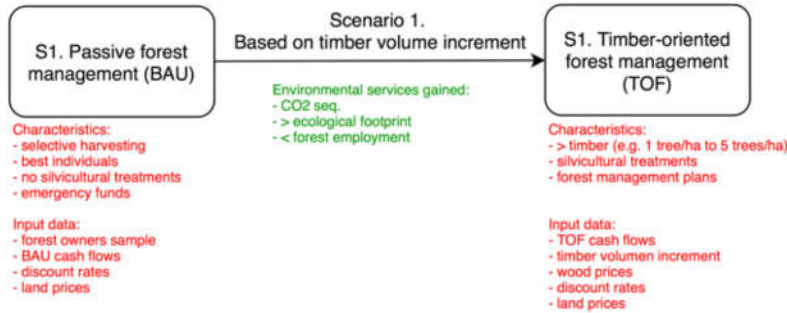
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Next Steps (Aug-Dec, 2018): testing indicators



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Thanks!

We would like to acknowledge the funding of this study by the research project "GreeTS: Green Transformations in the Global South" (www.greetts-project.org) that is funded by the Volkswagen Foundation, Riksbankens Jubileumsfond and Wellcome Trust. The study also benefited from the research ex-change platform provided by the SuFoRun project (Marie Skłodowska-Curie Grant Agreement No. 691149).

