Environmental Accounting and Ecosystem Services: an Introduction

Luis Rivera

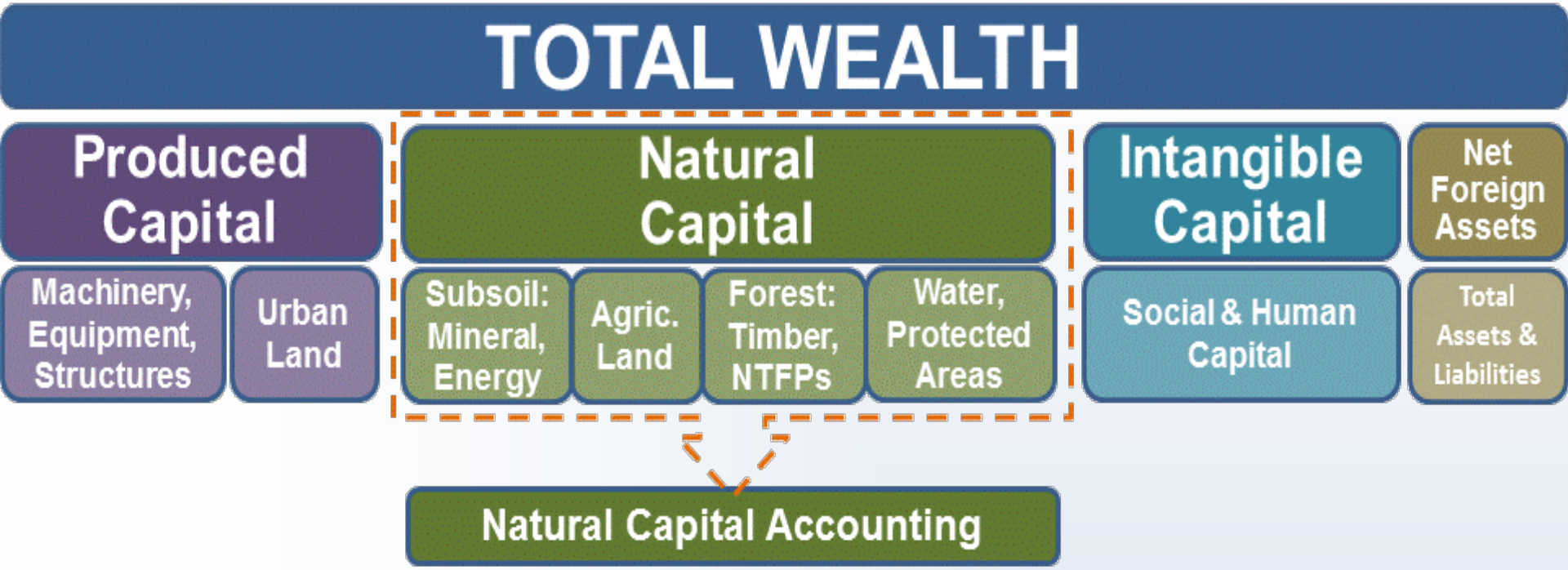
Professional Development Seminar on
Managing Ecosystems Services from
Tropical Forests
Liberia, Costa Rica: July 26, 2016

Outline

- Natural Capital Brief
- Environmental Accounting: Methods and Examples
- NCA in Costa Rica
- Relevance for Policy
- Discussion

NATURAL CAPITAL

Components of Wealth



Natural capital accounts for:

- 36% of total wealth in low income countries
- 21% in middle income countries
- and 3% in high income countries

Source: WAVES –The World Bank databases

Example: Australia´s Capital Base, current prices—as at 30 Jun

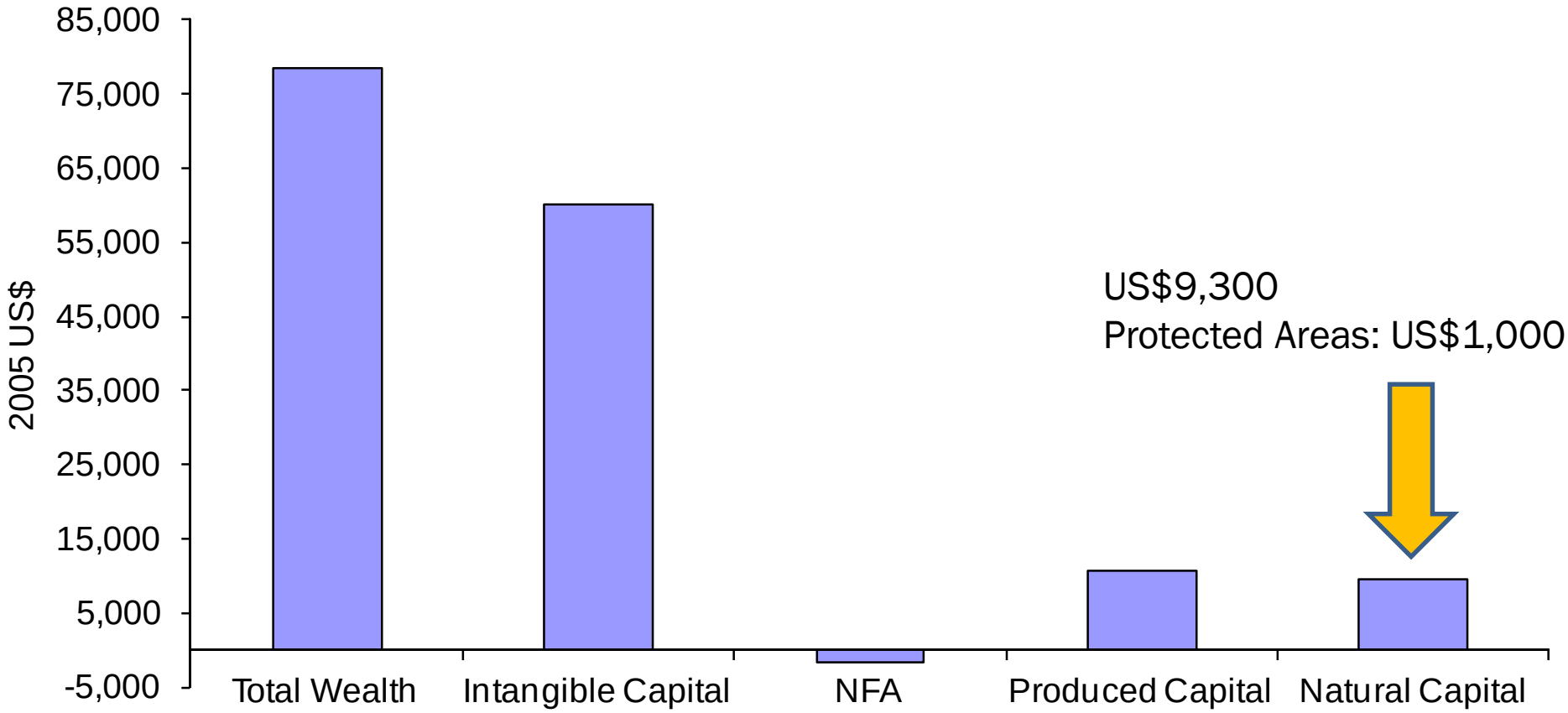
	2000-01	*2005-06*	*2006-07*	*2007-08*	*2008-09*	*2009-10*
Capital Estimate	$b	$b	$b	$b	$b	$b
Produced Capital(a)	2 251.2	3 271.5	3 554.0	3 843.4	4 048.0	4 227.9
Net Financial Assets with the rest of the world	–362.5	–528.7	–613.2	–658.5	–703.7	–776.9
Natural Capital(partial)	1 528.1	3 117.4	3 512.3	3 773.4	3 936.1	4 574.3
Human Capital	6 769.8	na	na	na	na	na
Social Capital	na	na	na	na	na	na

na not available

(a) Excludes plantation timber inventories, which are included under Natural Capital

Source: Australian System of National Accounts, 2010–11 (ABS cat. no. 5204.0)

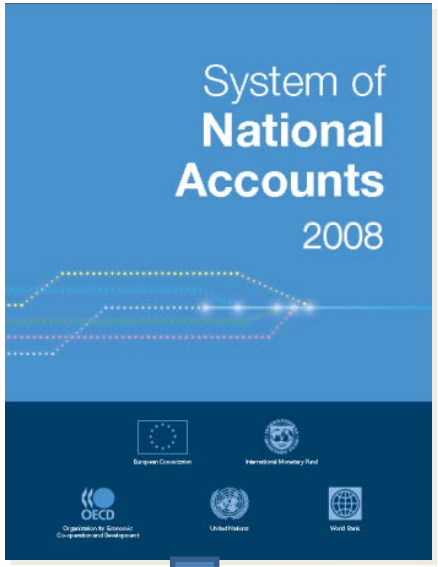
Example: Total Wealth of Costa Rica (2005 US$ per capita)



NOTE: Natural Capital estimation does not include Ecosystem Services
Source: own ellaboration with data from World Bank (2011)

ENVIRONMENTAL ACCOUNTING

Integrated Approach: Environmental-Economic Accounting



Part 1. SEEA-Central Framework

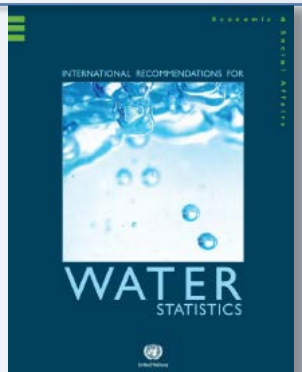
Adopted by UN Statistics Commission as International Statistical Standard in February 2012

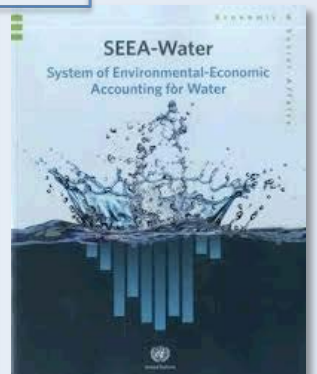
Part 2. SEEA Experimental Ecosystem 2013

Part 3. SEEA Applications and Policy Uses

2013

- Energy
- Land and Ecosystems
- Forest
- Fisheries
- Water



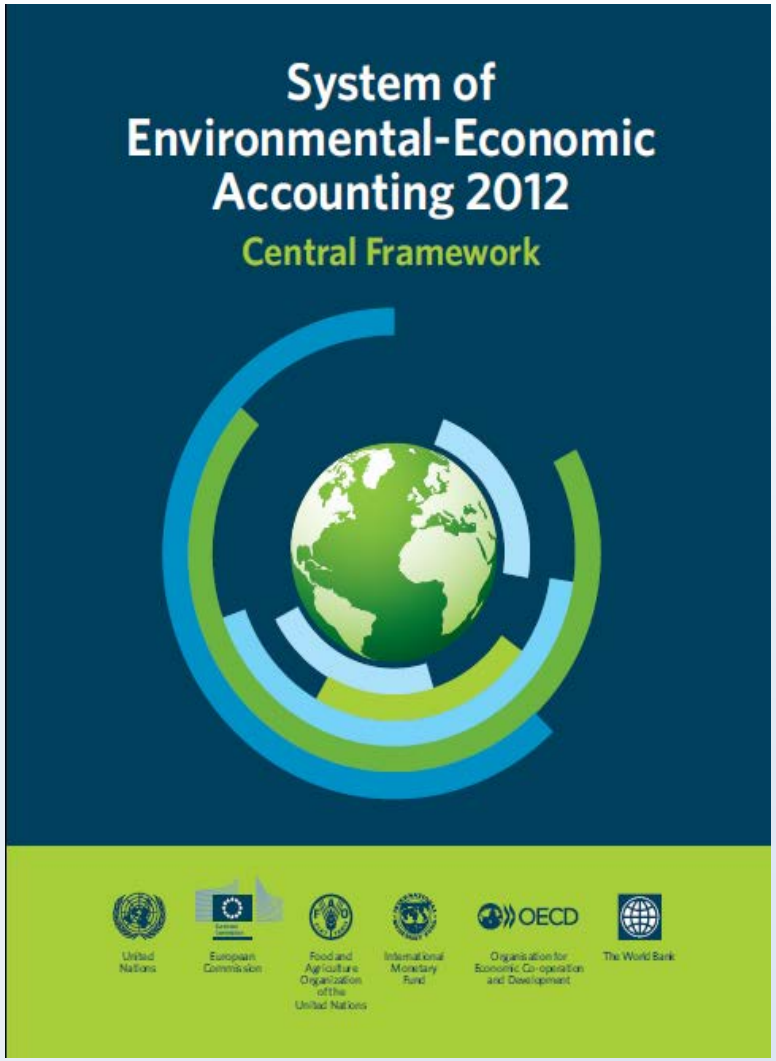


SEEA Central Framework

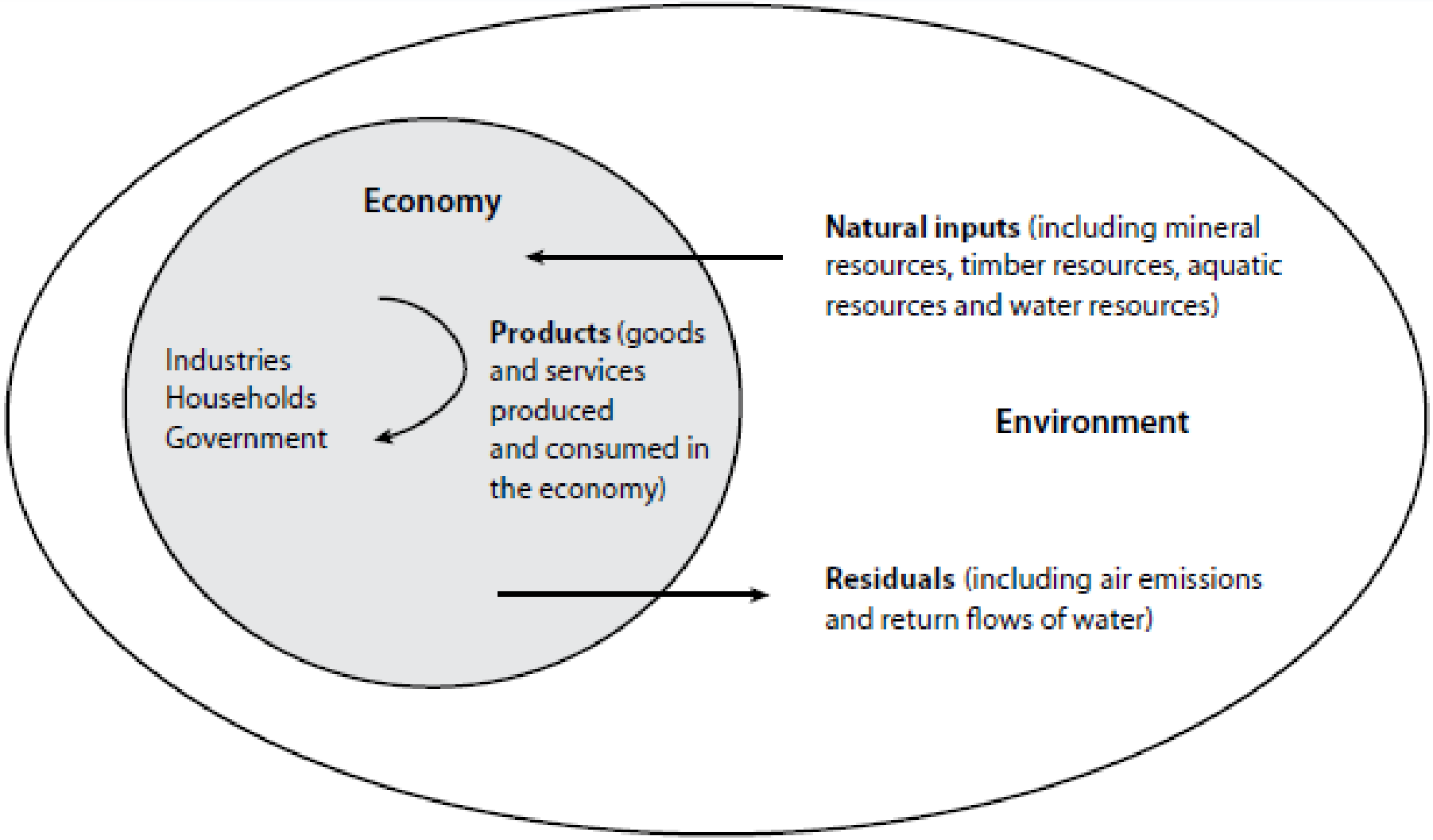
- Adopted as an international standard by the United Nations Statistical Commission in 2012.

- Interactions between the economy and the environment:
  - physical flows between the environment and the economy
  - the stocks of environmental assets and changes in those stocks
  - economic activity and transactions related to the environment

- It puts statistics on the environment and its relationship to the economy at the core of official statistics.



Physical flows of natural inputs, products and residuals



Source: United Nations et al (2014a)

Supply-Use Table

	Industries	Households	Accumulation	Rest of the world	Environment	Total
Supply table						
Natural inputs					Flows from the environment	Total supply of natural inputs
Products	Output			Imports		Total supply of products
Residuals	Residuals generated by industry	Residuals generated by final household consumption	Residuals from scrapping and demolition of produced assets			Total supply of residuals
Use table						
Natural inputs	Extraction of natural inputs					Total use of natural inputs
Products	Intermediate consumption	Household final consumption	Gross capital formation	Exports		Total use of products
Residuals	Collection and treatment of waste and other residuals		Accumulation of waste in controlled landfill sites		Residual flows direct to environment	Total use of residuals

Source: United Nations et al (2014a)

Asset Account

Opening stock of environmental assets
Additions to stock
Growth in stock
Discoveries of new stock
Upward reappraisals
Reclassifications
Total additions of stock
Reductions of stock
Extractions
Normal loss of stock
Catastrophic losses
Downward reappraisals
Reclassifications
Total reductions in stock
Revaluation of the stock[a]
Closing stock of environmental assets

Source: United Nations et al (2014a)

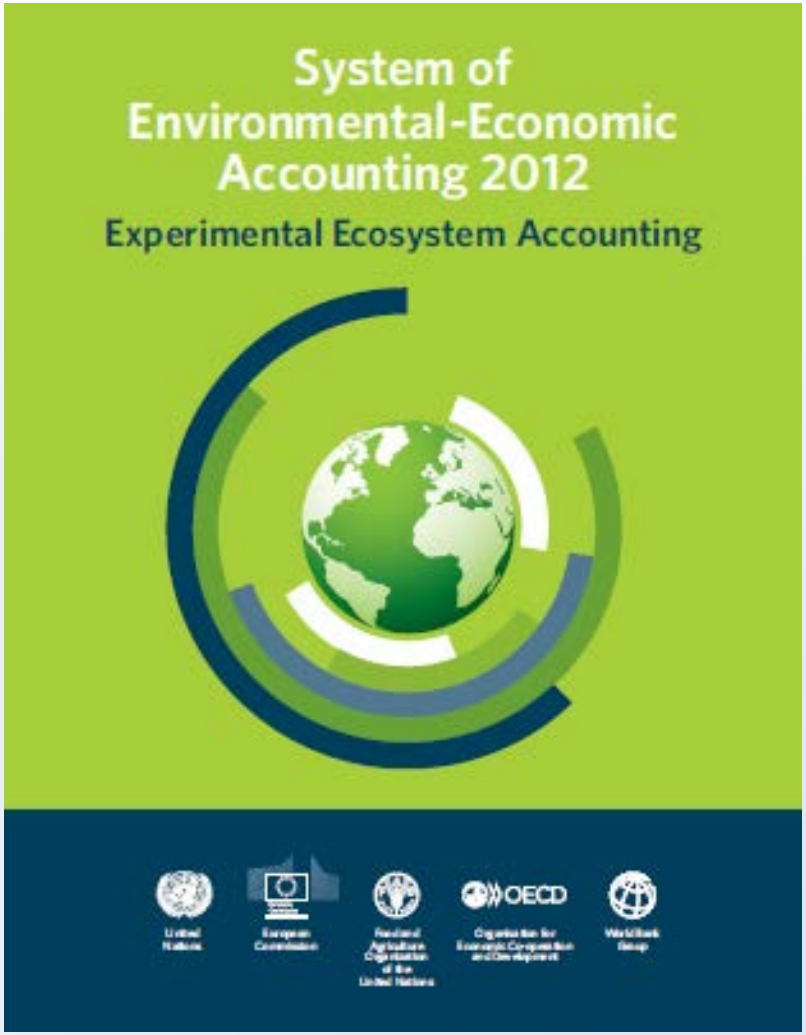
Example: Physical asset account for water resources of Costa Rica, 2012 (million of m3)

	Type of water resource			
	Surface water	Groundwater	Soil water	Total
Opening stock of water resources	2 001			2 001
Additions to stock (+)				
Returns (H.1)	26 465	881		27 346
Precipitation (B.1)			170 036	170 036
Inflows from other territories (B.2)				
Inflows from other inland water	94 893	23 723		118 617
Total additions to stock	121 358	24 604	170 036	315 998
Reductions in stock (-)				
Abstraction (E.1)	27 581	380		27 961
for hydro power generation	25 584			25 584
for irrigation of crops	1 746	42		1 788
for other uses	250	338		589
Evaporation & actual evapotranspiration (C.1)			51 419	51 419
Outflows to other territories (C.2	39 500			39 500
Outflows to the sea (C.2.2)	54 515	24 224		78 739
Outflows to other inland water resources			118 617	118 617
Total reductions in stock	121 596	24 604	170 036	316 235
Closing stock of water resources	1 764			1 764
Change in assets	- 237	0	0	- 237

Source: BCCR (2016)

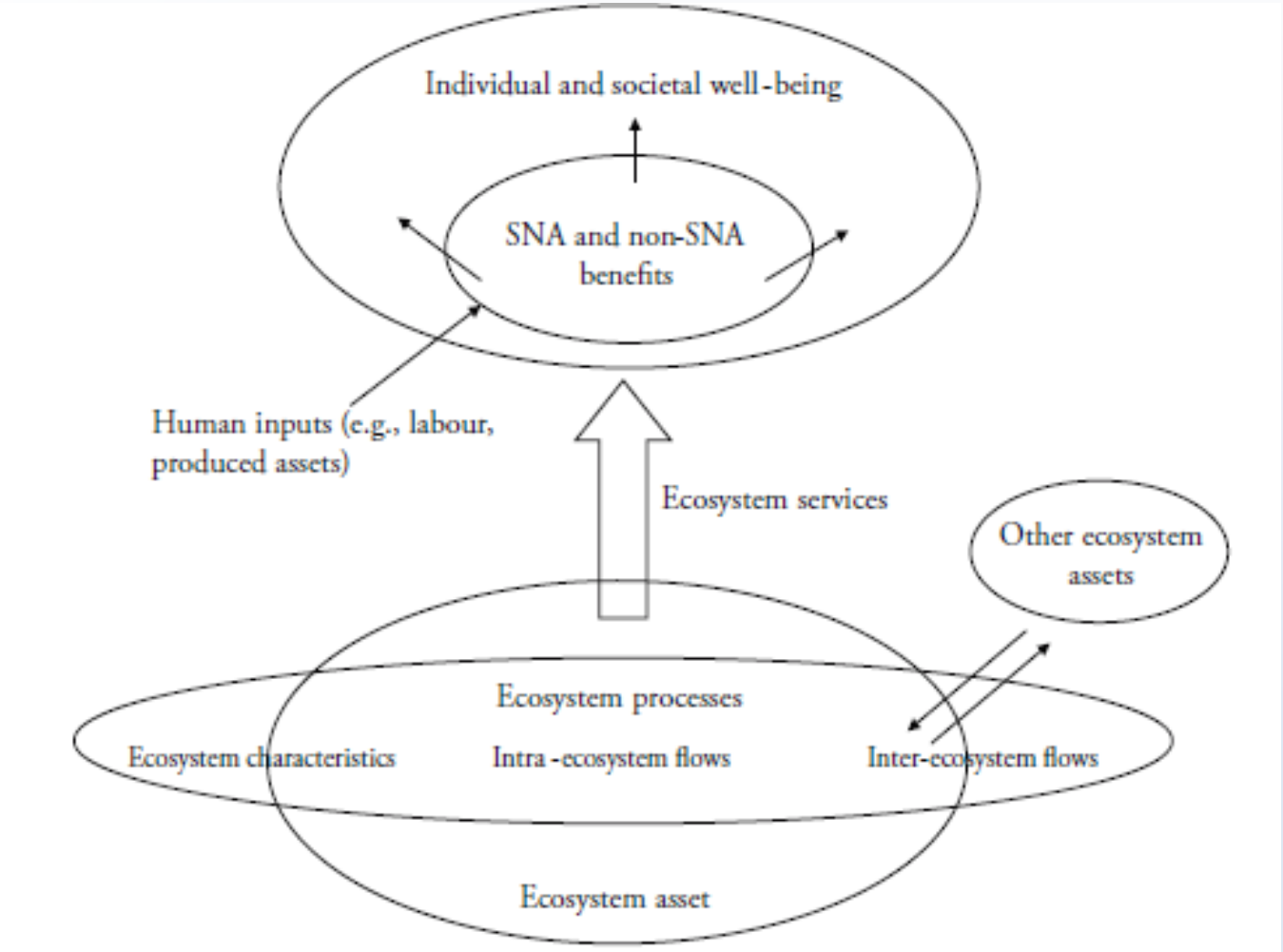
SEEA Experimental Ecosystem Accounting

- Integrated accounting structure of ecosystem services and ecosystem condition (physical and monetary).
- Basic focus for measurement: spatial areas (*ecosystem asset*).
- Measurement of ecosystem services generated from ongoing ecosystem processes (i.e. regulation of climate, air filtration and flood protection) and human engagement with the environment (such as through recreation activity).



Ecosystem Services in SEEA

"Contributions of ecosystems to benefits used in economic and other human activity"



Source: United Nations et al (2014b)

Selected Ecosystem Services

Type of ecosystem services	Description	Corresponding benefit
Provisioning services		
Services for crop production	Abstraction of soil water, nutrient uptake, pollination for the growing of crops, etc.	Crops can be consumed directly or further processed
Fodder for livestock	Rangelands provide fodder (grass, herbs, leaves from trees) for livestock	Livestock products (including animals, meat, leather, milk)
Raw materials, including wood and non-timber forest products	Ecosystems, in particular forests, generate stocks of wood and non-timber forest products which may be harvested. Non-timber forest products include, for instance, rattan, various food products, genetic materials, ornamentals and pharmaceuticals	Firewood, logged timber, non-timber forest products
Fish and other aquatic and marine species from marine and inland waters	Marine and other aquatic ecosystems provide stocks of fish and other species which can be harvested	Fish and other species can be consumed or further processed
Water	Water that is filtered and stored by ecosystems can be used as raw material for the production of drinking water or in other economic activities (e.g., irrigation)	Drinking water
Regulating services		
Carbon sequestration	Ecosystems sequester and store carbon	Climate regulation
Air filtration	Vegetation can filter particulate matter from ambient air	Cleaner air
Flood protection	Ecosystems regulate river flows and can provide a barrier against floods	Protection of properties and lives
Cultural services		
Providing opportunities for tourism and recreation	Ecosystems provide physical space and landscape features, enabling people to enjoy landscape views or undertake activities such as hiking and cycling	Recreational benefits

Source: United Nations et al (2014b)

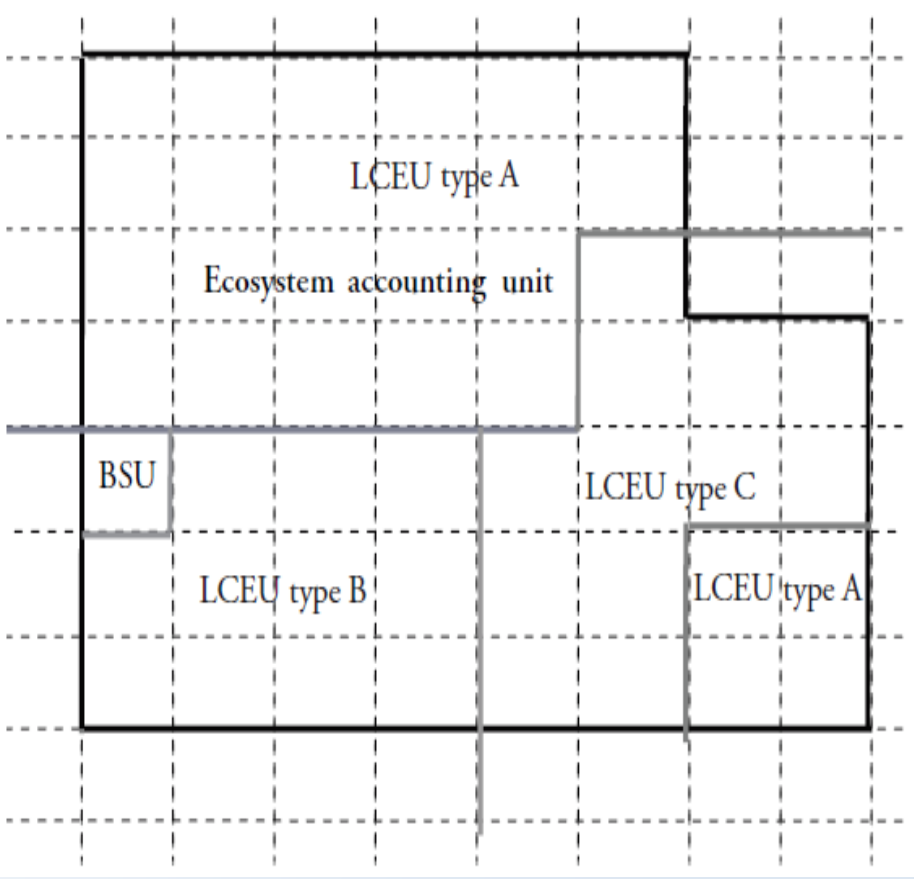
UNITS: BSUs, LCEUs and EAUs

The statistical units of ecosystem accounting are spatial areas about which information is collected and statistics are compiled

- **Basic spatial units (BSUs):** tessellations (e.g., of 1 km2), land parcels cadaster, remote-sensing pixels; grid squares: available information, landscape diversity and analytical requirements.

- **Land-cover/ecosystem functional units (LCEUs):** characteristics of an ecosystem (land-cover type, water resources, climate, altitude, soil type); FAO´s Land Cover Classification System, version 3 (LCCS 3).

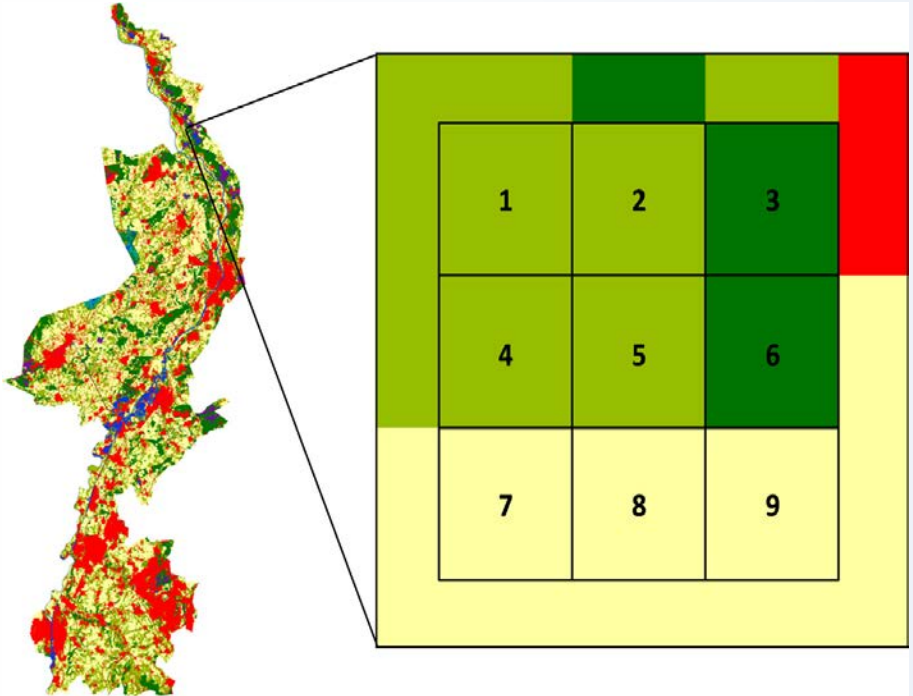
- **Ecosystem accounting units (EAUs):** administrative boundaries, environmental management areas, large-scale natural features (e.g., river basins), areas for reporting purposes (e.g., national parks and other protected areas).

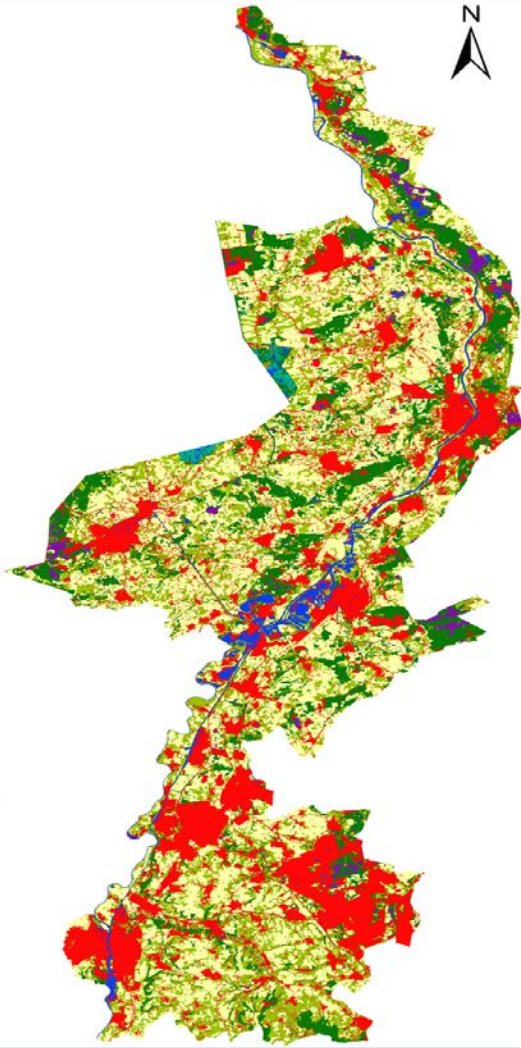


Source: United Nations et al (2014b)

Example: Limburg (Netherlands)

- **Ecosystem accounting units (EAUs):** Limburg (administrative area)
- **Land-cover/ecosystem functional units (LCEUs):** Landelijk Grondgebruiksbestand Nederland ver. 6
- **Basic spatial units (BSUs):** 25m2 grid cells





Pasture
Agricultural cropland
Forest
Water
Urban and infrastructure
Heathland
Peatland
Other nature

0 5 10 15 20
Kilometers

Source: Remme et al (2014)

TABLES: flows of ecosystem services and stocks of ecosystem assets

Type of ecosystem services (by CICES)	Type of LCEU: Forest tree cover	Agricultural land[a]	Urban and associated developed areas	Open wetlands	...
Provisioning services	For example, tonnes of timber	For example, tonnes of wheat			
Regulating services	For example, tonnes of CO_2 stored/ released	For example, tonnes of CO_2 stored/ released	For example, tonnes of CO_2 stored/ released	For example, tonnes of phosphorus absorbed	
Cultural services	For example, number of visitors and hikers		For example, hectares of parkland	For example, hectares of habitat for ducks	

a Medium to large fields of rain-fed herbaceous cropland.

Type of LCEU	Ecosystem extent	Characteristics of ecosystem condition				
		Vegetation	Biodiversity	Soil	Water	Carbon
		Examples of indicators				
	Area	Leaf area index, biomass, mean annual increment	Species richness, relative abundance	Soil organic matter content, soil carbon, groundwater table	River flow, water quality, fish species	Net carbon balance, primary productivity
Forest tree cover						
Agricultural land[a]						
Urban and associated developed areas						
Open wetlands						

a Medium to large fields of rain-fed herbaceous cropland.

Source: United Nations et al (2014b)

Example: ecosystem services in the Central Highlands of Victoria (Australia), 2010-2015

2010-15		Land cover						
Ecosystem service	Units	built[a]/ bare	open water	crops / pasture/ horticulture	plantations	native open vegetation	native forest	total
Area	Ha	32,803	4,361	58,213	36,335	29,624	575,737	737,072
	%	4.5	0.6	7.9	4.9	4.0	78.1	
Provisioning services								
Food[b]	t							
Water	GL yr^{-1}	0.99	0.14	0.14	0.12	0.22	3.39	3.97
Timber - sawlogs	m^3 yr^{-1}				257,793		304,920	
Timber - residual logs	m^3 yr^{-1}				247,294		524,045	
Regulating services								
Carbon sequestion[c]	MtC yr^{-1}	0.00	0.00	0.00	0.10	0.01	1.58	1.69
Cultural and recreational services								
Tourism[d]								

[a] built includes low-density and semi-rural residential, parks and gardens

[b] the physical volumes of production of different crops, fruit, vegetables and livestock and livestock products are available for ABS statistical areas and can be estimated for the study region, but they have not been presented because the utility of adding these to a single measure in tonnes is doubtful. Monetary estimates of this service were generated

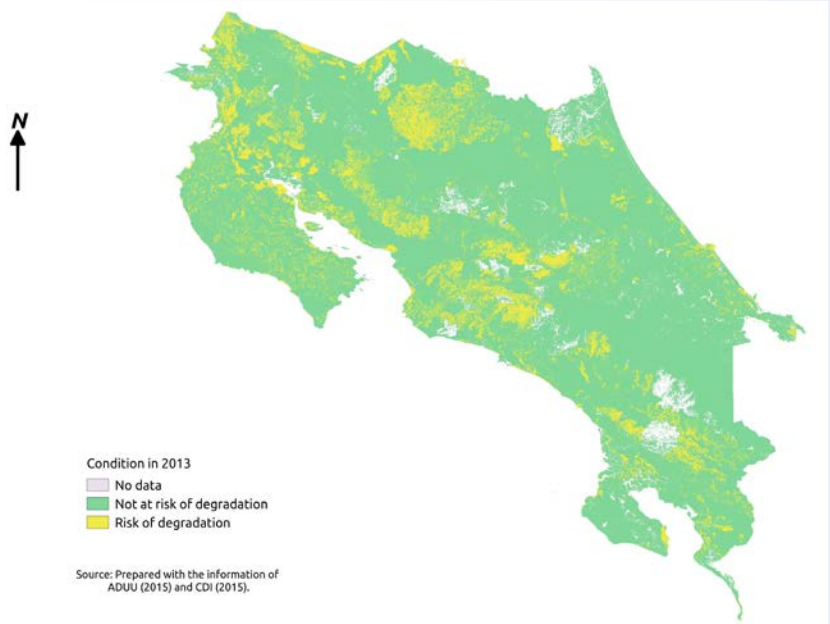
[c] carbon sequestration is equated with net carbon stock change because this is the metric that is valued in the Australian Government abatement scheme

[d] physical estimates of the tourism services were not made but monetary estimates were made

Source: Keith et al (2016)

Example: Area at risk of Soil degradation in Costa Rica, 2013

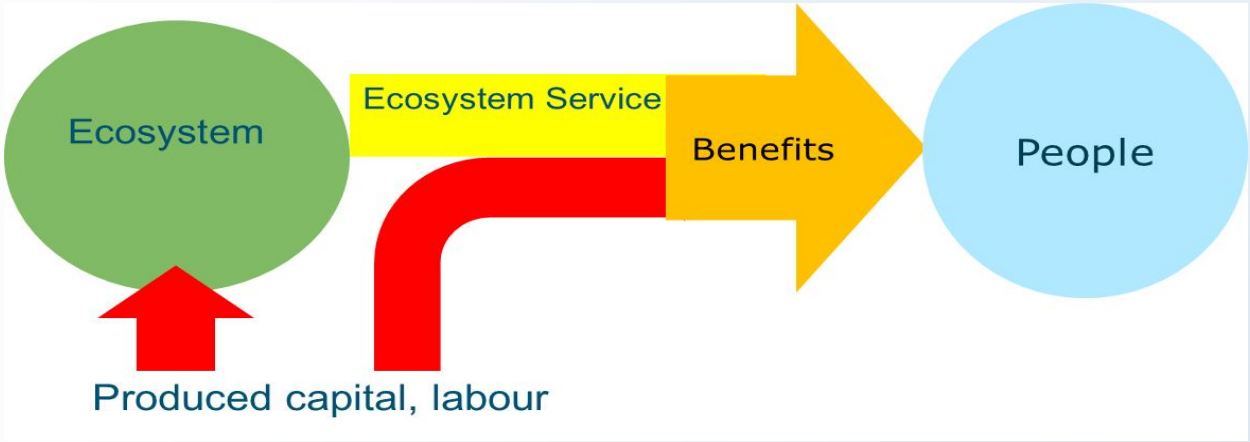
Year	Nation	Brunca	Central	Chorotega	Huetar Atlantica	Huetar Norte	Pacifico Central
1997	12.7%	10.3%	16.3%	17.4%	3.7%	15.0%	14.9%
2008	13.0%	10.8%	16.6%	17.5%	4.5%	15.9%	13.0%
2013	12.9%	10.7%	16.3%	16.9%	4.9%	15.2%	14.5%
Change (ha), 1997-2008	0.3%	0.5%	0.3%	0.1%	0.8%	0.9%	-1.9%
Change (ha), 2008-2013	-0.1%	-0.1%	-0.3%	-0.6%	0.4%	-0.7%	1.5%
Change (ha), 1997-2013	0.2%	0.4%	0.0%	-0.5%	1.2%	0.2%	-0.4%



Source: Vega-Araya and Rivera, work in progress

Valuation of Ecosystem Services

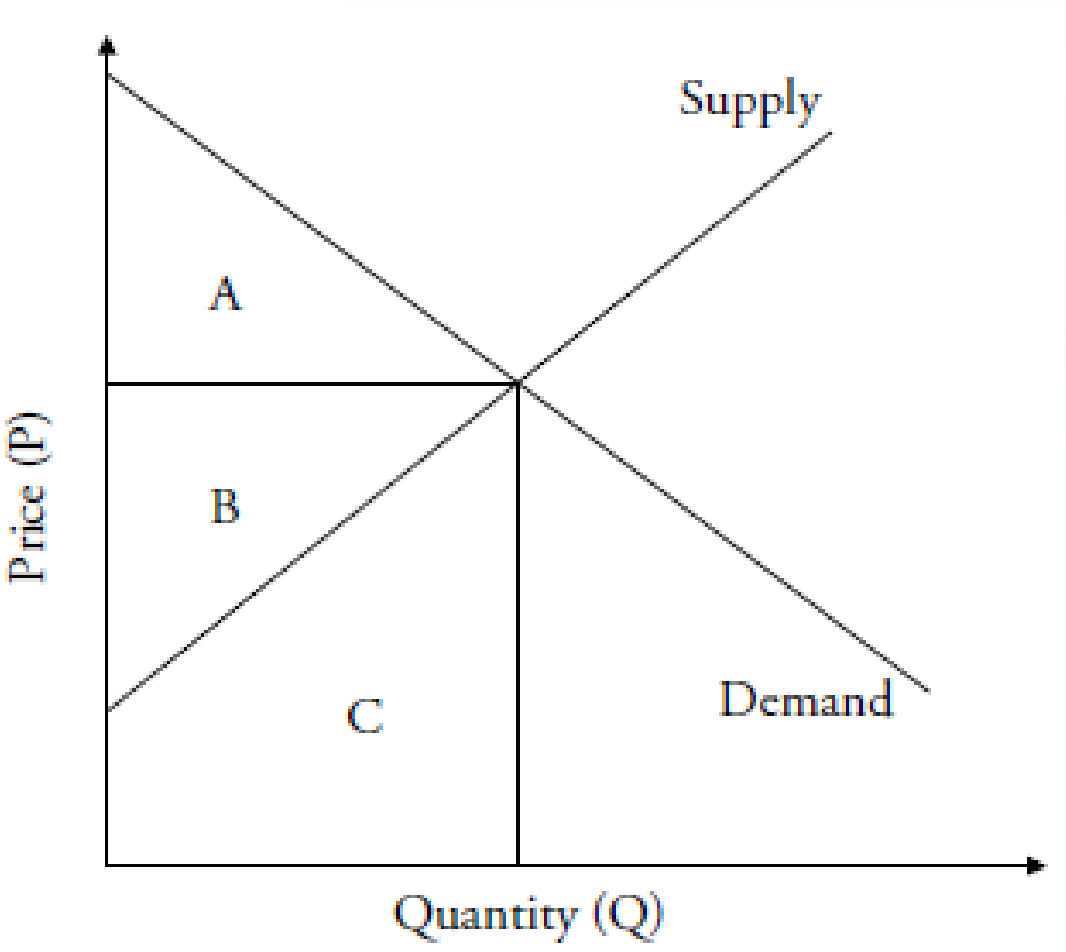
- Different ecosystem services contribute to economic and other human activity and link to benefits and well-being in different ways (Provisioning, Regulating, Cultural):
  - how the service leads to the generation of benefits
  - the relation between those benefits and the recording of the related economic activity in the SNA



Source: United Nations et al (2014b)

Exchange Value Approach

- Non-market transactions: proxy for “prices”



- Shadow prices

- Total Economic Value (TEV):
  - Direct Use Value
  - Indirect Use Value
  - Option Value
  - Non-use Value

Pricing of Ecosystem Services

- **Unit Resource Rent**: associated with provisioning services (outputs of the agriculture, forestry and fishing industries)
- **Replacement Cost Method:** particular relevance in the case of regulating services (water purification, flood control)
- **Payments for ecosystem services and trading schemes**: markets for regulating services
- **Revealed and stated preference methods**:
  - Production function methods (contribution of ecosystem services to production processes)
  - Hedonic pricing methods (environmental qualities affect the prices that people pay for market products or assets)
  - Travel cost methods (ecosystem services associated with recreational sites)
  - Stated preference methods (people's willingness to pay for ecosystem services without observing an actual payment or transaction): Contingent Valuation, Choice Experiments.

Resource Rent

Economic rent is best considered to be the surplus value accruing to the extractor or user of an asset calculated after all costs and normal returns have been taken into account

Output (sales of extracted environmental assets at basic prices, includes all subsidies on products, excludes taxes on products)
Less Operating costs
Intermediate consumption (input costs of goods and services at purchasers' prices, including taxes on products)
Compensation of employees (input costs for labour)
Other taxes on production plus other subsidies on production
Equals **Gross operating surplus—SNA basis**[a]
Less Specific subsidies on extraction
Plus Specific taxes on extraction
Equals **Gross operating surplus—for the derivation of resource rent**
Less **User costs of produced assets**
Consumption of fixed capital (depreciation) + return to produced assets
Equals **Resource rent**
Depletion + net return to environmental assets[b]

Source: United Nations et al (2014a)

Example: Resource Rent of Rice, Corn, Coconut, Oil Palm, 2014 (Southern Palawan, Philippines)

Ecosystem Units	Area	Production Costs per hectare				Yield	Farm-Gate Price	Resource Rent / ha	Resource Rent, Pulot Watershed
		Intermediate Consumption	Compensation to Employees	Taxes and Subsidies	User Costs of Produced Assets				
	(ha)	(Php)	(Php)	(Php)	(Php)	(ton / ha)	(Php / kg)	(Php)	(million Php)
Annual Crop Ecosystem, Rice and Corn	**608**								**35.45**
Rainfed Rice	150	8,531	16,150	-	0	3.2	15	22,696	3.4
Irrigated Rice (paddy-paddy)	398							65,447	26.0
1st Cropping		8,995	16,150	-	0	4.0	15	34,447	13.7
2nd Cropping		8,233	15,904	-	0	3.3	17	30,882	12.3
Irrigated Rice (paddy-corn-paddy)								99,682	6.02
Yellow Corn	40	9,183	16,519	141	4,269	3.0	13	12,421	0.5
White Corn	20	9,183	16,519	141	5,209	3.0	16	21,815	0.4
Coconut	**1,455**	1,271	9,421	-	2,424	1.3	18	13,547	**19.7**
Oil Palm	**1,316**	36,424	14,350	-	5,168	9.7	5	(6,709)	**(8.83)**

Source: Southern Palawan Technical Working Group (TWG), WAVES (2016)

Discounting for Future Value

$$V_t = \sum_{\tau=1}^{N_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}}$$

- Vt = value of the asset of time t
- N = asset life
- RR = resource rent
- r = nominal discount rate

Source: United Nations et al (2014a)

Example: Costa Rica, value of carbon sequestration (2007 USD)

	Social cost of carbon $36 (2007 USD/T), @3%	Social cost of carbon $11 (2007 USD/T), @5%
1997	$400,954,884	$122,513,992
2008	$410,843,664	$125,535,564
2013	$446,120,136	$136,314,486

Source: Vega-Araya and Rivera, work in progress

Summary: The Ecosystem Accounts

Accounts for ecosystem assets	Ecosystem extent account
	Ecosystem condition account
	Ecosystem monetary asset account
Accounts for ecosystem services	Ecosystem services supply and use table – physical terms
	Ecosystem services supply and use table – monetary terms
Integrated accounts*	Combined presentations
	Extended supply and use table
	Sequence of accounts for institutional sectors
	National and sector balance sheets

* These accounts reflect the integration of ecosystem accounting based information with information from the standard set of national accounts

Source: UNSD (2015)

Example: San Martín (Peru), Water Supply, 2011 (m3/year)

2011	SAN MARTÍN	USO-SUMINISTRO DE AGUA (M^3/AÑO)							
ACTIVO DEL ECOSISTEMA		TOTAL	DE CONSUMO				DE NO CONSUMO		
			AGRICULTURA*	INDUSTRIA	SECTOR PÚBLICO	MINERÍA	ENERGÍA	ACUICULTURA	RECREACIÓN
Bosque	Aguajal	1,704,823	1,695,034	0	3,959	0	0	5,829	0
	Bosque Húmedo de Colina Alta	18,104,332	16,002,411	28,697	1,676,616	0	0	394,779	1,829
	Bosque Húmedo de Colina Baja y Lomada	3,550,916	1,602,673	0	5,447	0	0	1,942,796	0
	Bosque Húmedo de Montaña	299,823,912	198,965,784	510,654	16,908,263	0	82,728,707	677,808	32,696
	Bosque Húmedo de Terraza Alta	2,162,144	2,132,276	0	15,730	0	0	14,138	0
	Bosque Húmedo de Terraza Baja y Media	17,542,976	14,499,315	43,731	440,253	0	2,505,043	54,409	225
Herbazal	Matorral Arbustivo	25,869	25,215	0	654	0	0	0	0
	Herbazal Hidrofítico	266,913	265,435	0	618	0	0	860	0
Pastizal	Pajonal Altoandino y Páramo	13,425,392	7,367,694	0	227,788	0	5,826,228	3,049	633
Humedal	Bofedal	15,932	15,529	0	403	0	0	0	0
Total		**356,623,208**	**242,571,366**	**583,082**	**19,279,731**	**0**	**91,059,978**	**3,093,668**	**35,383**

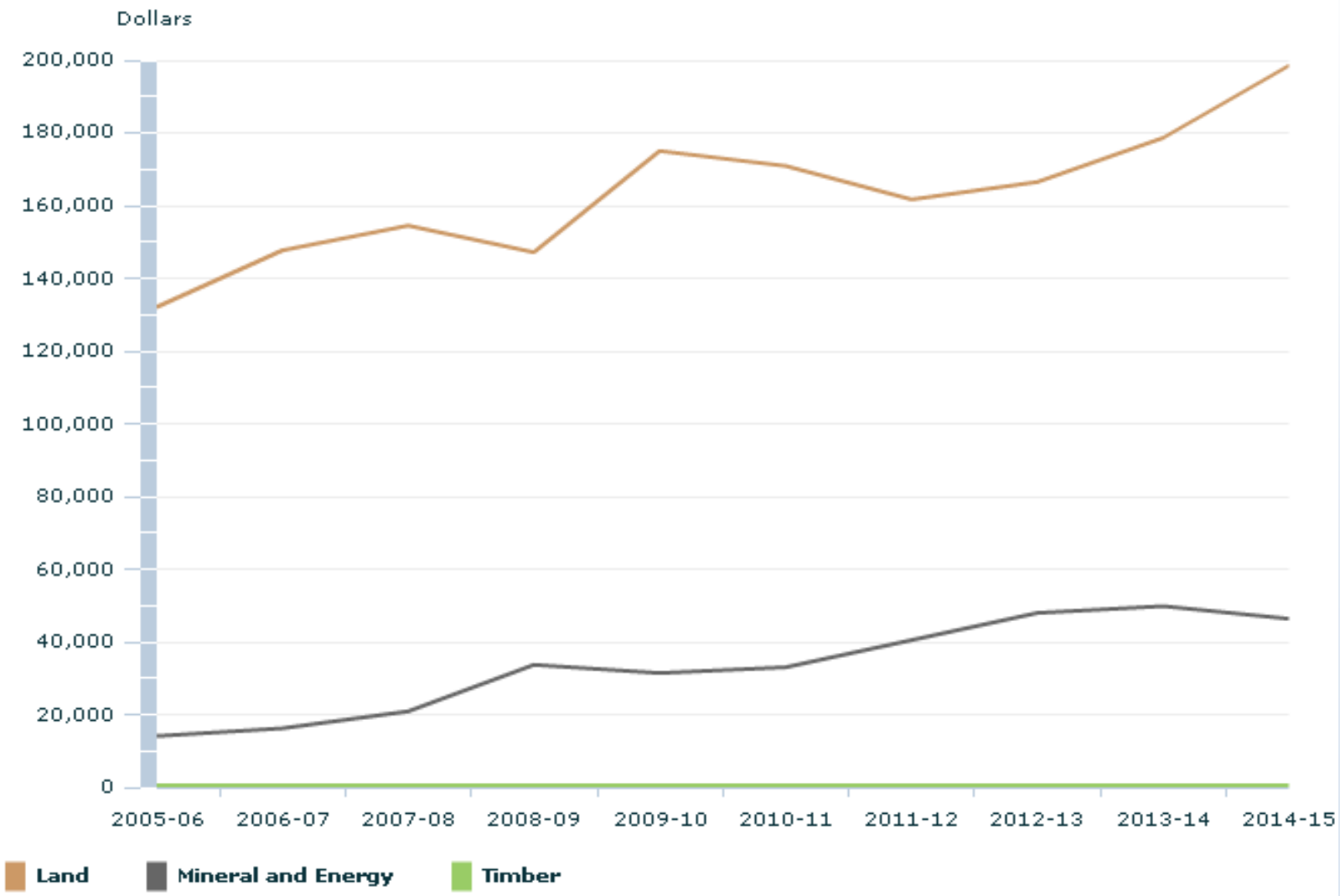
Source: Fundación Conservación Internacional (2016)

Example: UK, Pollination of Crops, 2010

Crop	Dependence on Pollinators (%)	Production Value (£ millions) 2010	Pollination Value (£ millions) 2010
Oilseed Rape	25	674	169
Strawberries	45	261	118
Dessert Apples	85	63	54
Raspberries	45	103	46
Cucumbers	65	53	35
Culinary Apples	85	40	34
Tomatoes	25	115	29
Runner Beans	85	17	14
Pears	65	16	10
Plums	65	13	8
Other	5-85	285	88
Total			Approx. 603

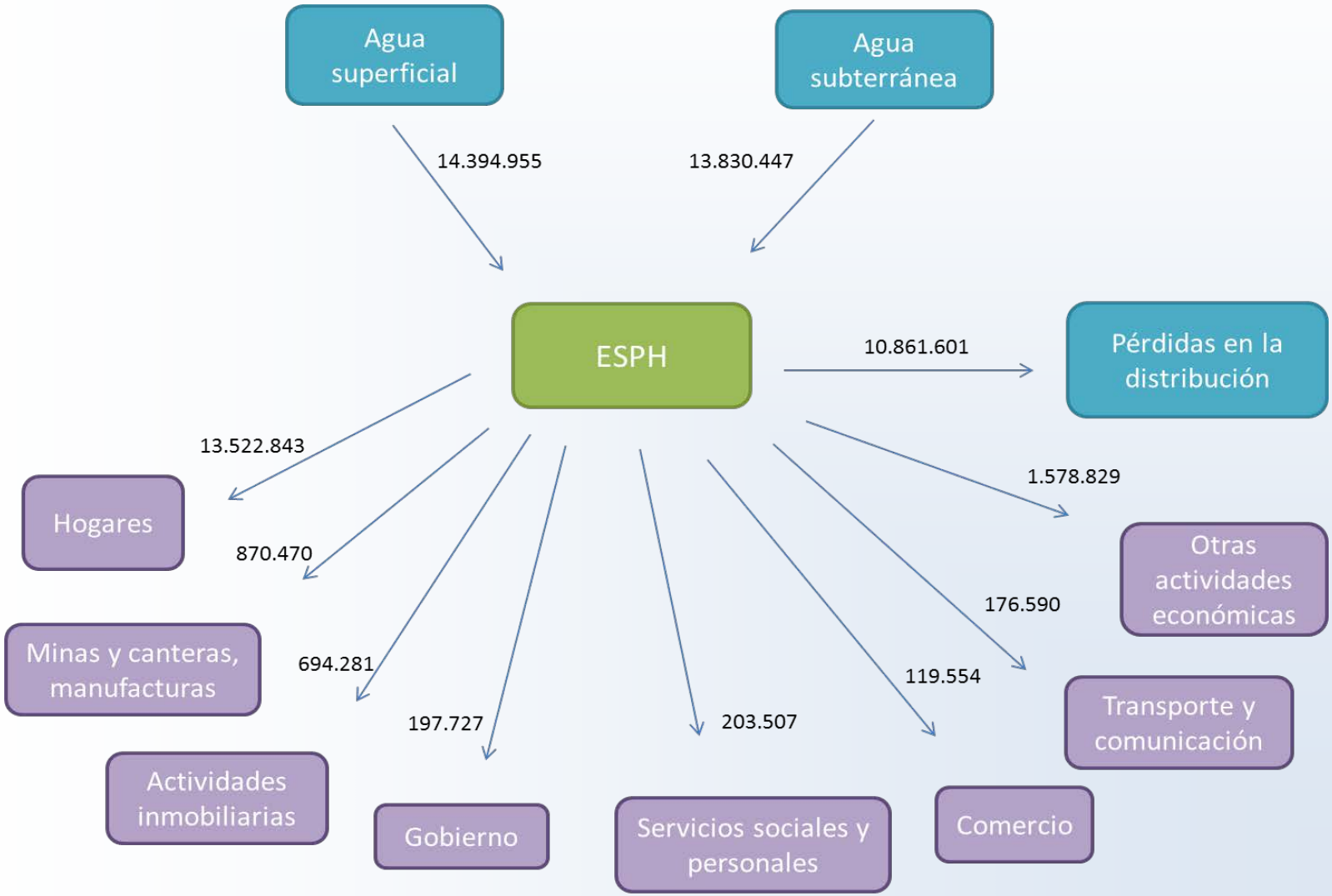
Source: Office for National Satistics (2016)

Example: Australia, Environmental Assets (Value per capita, 2005–2014)



Source: ABS (2016)

Example: ESPH (Costa Rica), Water Supply by Industry, 2013 (m3)



Source: BCCR (2016)

NCA IN COSTA RICA

Good Measurement for Good Policy

- Costa Rica is a country with an abundant natural wealth: five percent of the world´s biodiversity
- The production of ecosystem services sustain (and determine) the country´s development potential
- Agriculture, renewable energy, and leading industries like tourism, are all valuable returns from its natural capital
- However, most of this wealth has not been accounted for and reflected in national indicators

First Environmental Accounts

- With World Bank and WAVES support, Costa Rica compiled three Accounts: Water, Forests, Energy

- The Central Bank of Costa Rica (BCCR) created a new Unit to continue the work on environmental accounting: updates to be published every June

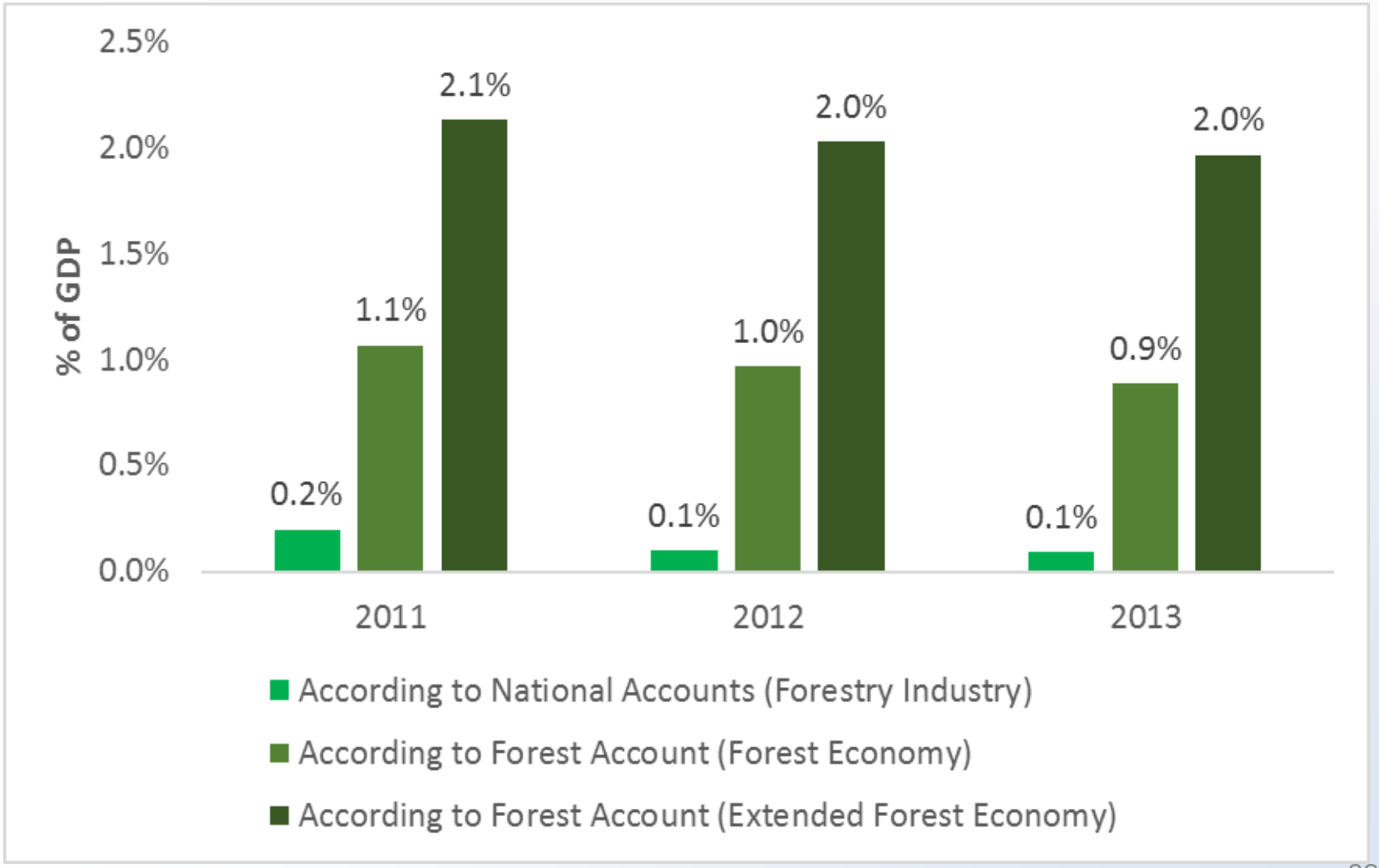
- The implementation of SEEA will contribute a better integration with Sustainable Development Goals (SDGs), Green Growth and other international statistical frameworks

Some Policy Questions

- **Forest Account**: Contribution of Forests to national wealth
  - Investments on Payments for Environmental Services (PES)
  - REDD+ Strategy
  - National Forests Policy and National Climate Change Strategy (2021 carbon neutrality goal)

- **Water Account:** Water Resources integrated management
  - Water supply in the long term (quantity and quality)
  - Water productivity (decoupling of economic growth from unsustainable use)
  - Water as a “human right” and the need to “value it”

Forest Accounts show Forests contribution to GDP



Source: BCCR (2016)

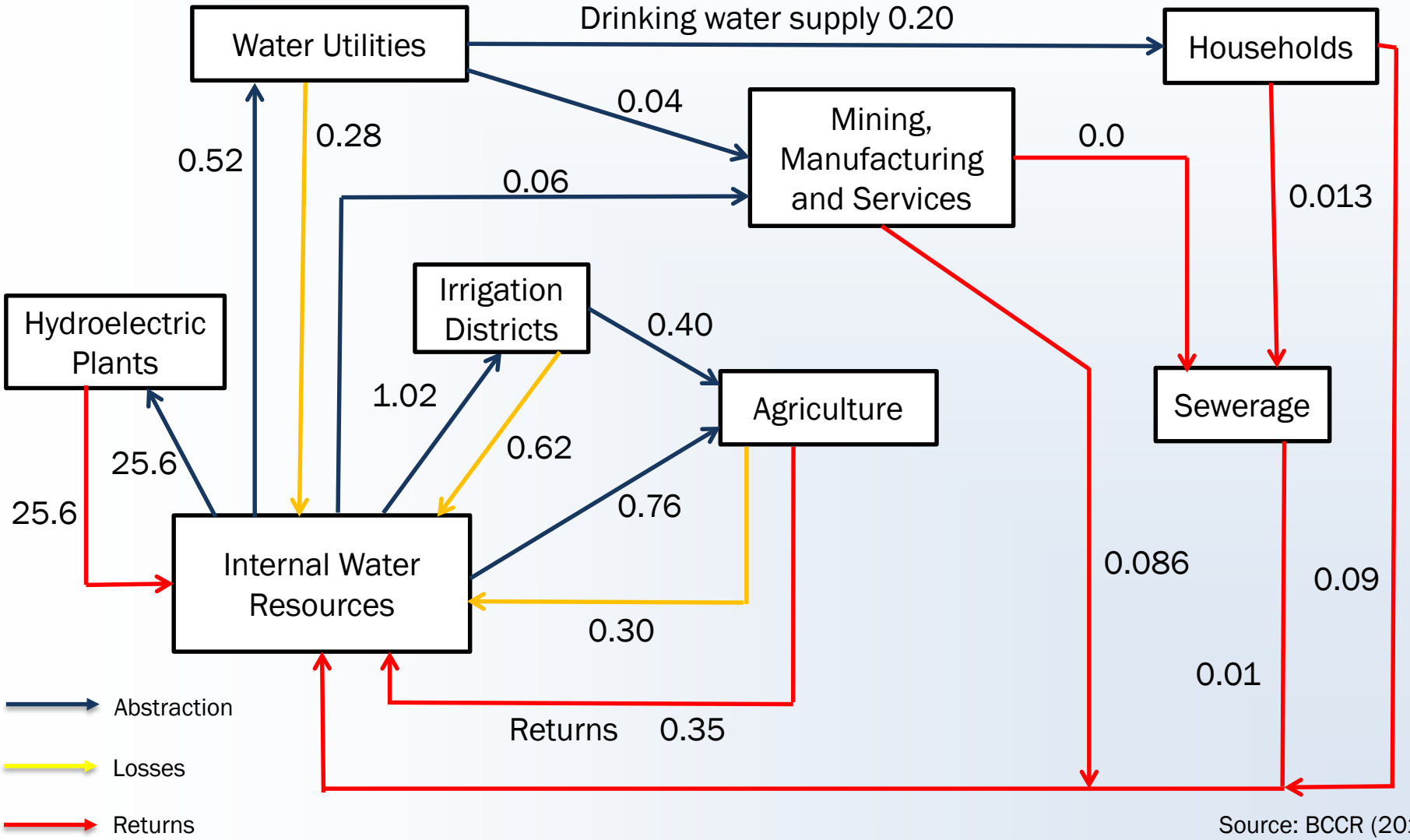
Indicators from Forest Accounts (example)

- Forest cover: 52,4% of total land area

- Forest cover change (2011-2013): increase of 96,140 hectares (3.8%), resulting mainly from reductions in Crops (-48,036 ha) and Grassland (-46,171 ha)

  - Conservation of forests as a key policy in last decades
  - Possible trade-offs with alternative productive activities
  - Relevance of **ecosystem services** and the need to account them

Water Flows in the Costa Rican Economy, 2012 (km^3/year)



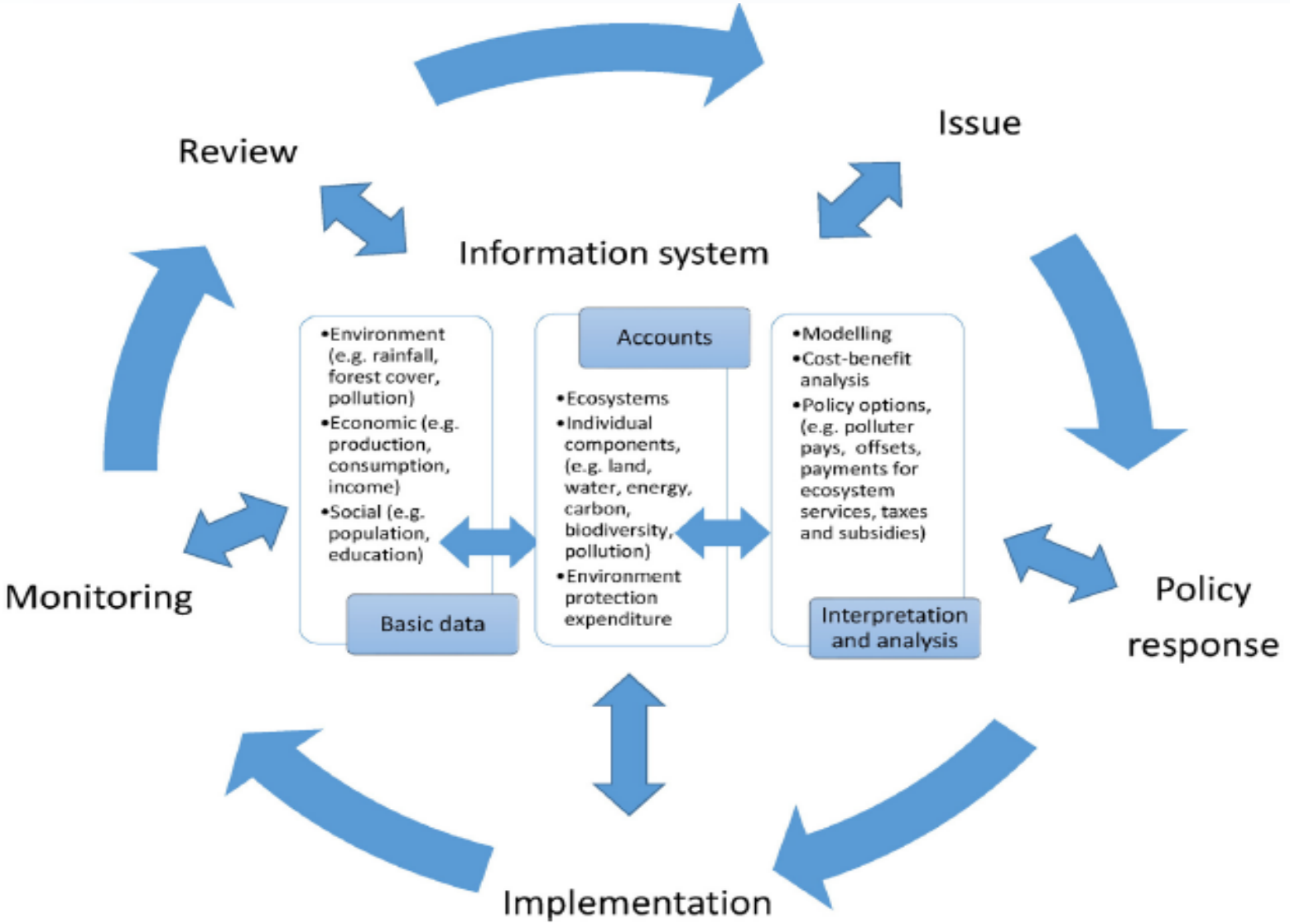
Source: BCCR (2016)

Indicators from Water Accounts (example)

- 99% of population using improved water sources
- Physical loss in water utilities: 57%
- Average Tariff: 576 colones/m3
  - Use of water and production (added value)
  - Management and sustainability of water sources

USE FOR POLICY

Environmental accounts in the information system and policy cycle

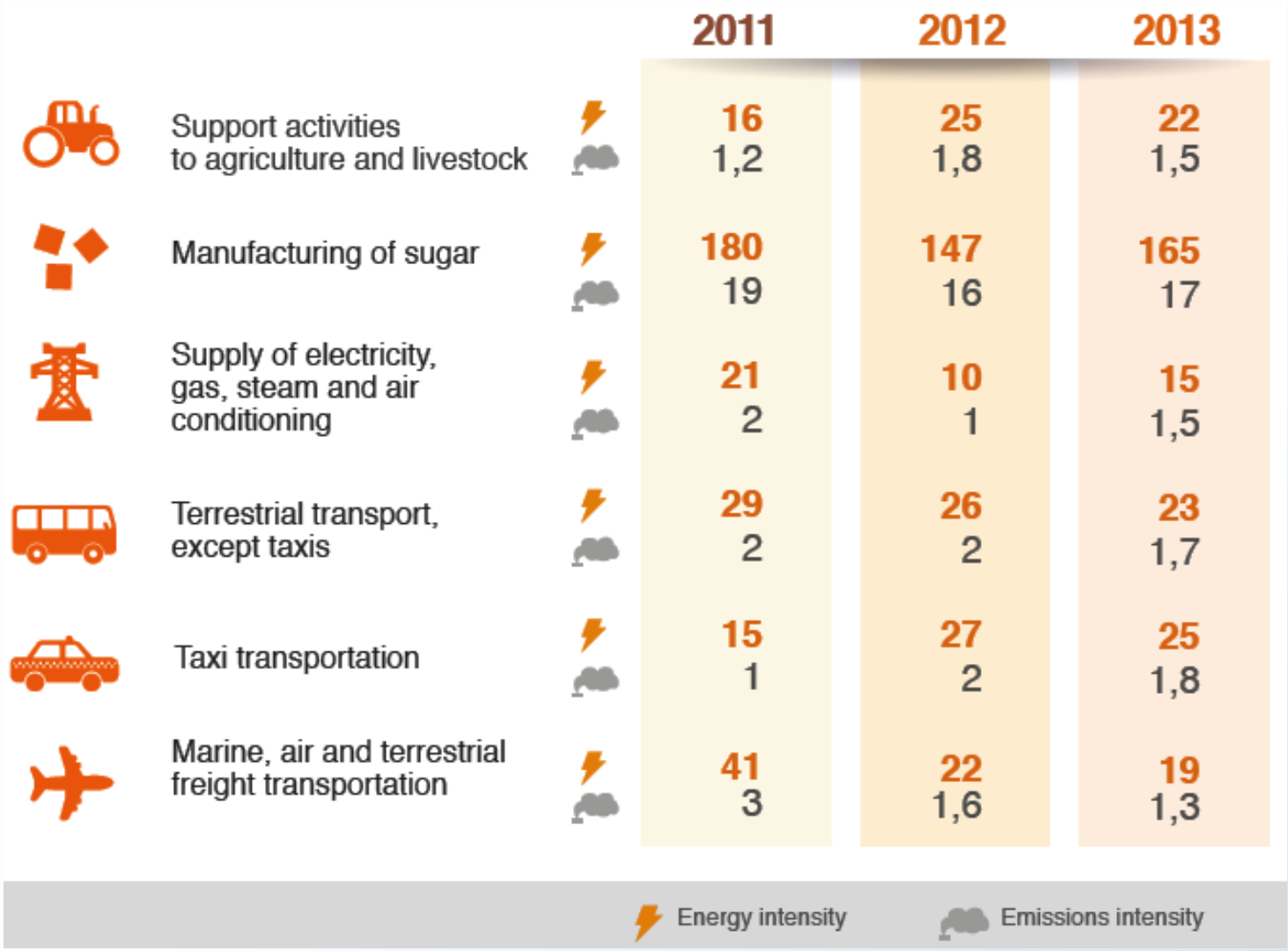


Source: Vardon et al (2016)

Indicators for Decision Makers

Source: BCCR (2016)

Example: Energy and Emissions intensity in Costa Rica (GJ and tCO2, per million colones)



	2011	2012	2013
Support activities to agriculture and livestock	16	25	22
	1,2	1,8	1,5
Manufacturing of sugar	180	147	165
	19	16	17
Supply of electricity, gas, steam and air conditioning	21	10	15
	2	1	1,5
Terrestrial transport, except taxis	29	26	23
	2	2	1,7
Taxi transportation	15	27	25
	1	2	1,8
Marine, air and terrestrial freight transportation	41	22	19
	3	1,6	1,3

Energy intensity

Emissions intensity

Source: BCCR (2016)

Example: birds, pest control and coffee yield in Río Negro, Costa Rica

Coffee's most damaging insect pest is the coffee berry borer (Hypothenemus hampeii), a ~ 2 mm beetle native to Africa

	2010 Harvest	2011 Harvest
Area (ha)	30	30
Coffee production (kg)	29 900	38 410
% Infested (control)	4.60 (1.7)	6.4 (1.2)
% Infested (no birds)	8.50 (2.5)	11.6 (2.2)*
% Diff (excluded-control)	3.9 (2.4)	5.1 (1.0)
Total ratio (excluded per control)	1.8	1.8
Production saved (kg)	1200 (700)	2000 (400)
Coffee price (US$ kg^{-1})	3.03	4.75
Value saved (US$)	3500 (2200)	9400 (1800)
Production saved per ha (kg)	40 (20)	70 (10)
Value saved per ha	120 (70)	310 (60)

Source: Carp et al (2013)

Integration of (scattered) Data with a Policy-information perspective

- PES
- REDD+
- Productive Sustainable Landscapes
- Climate Smart Agriculture
- Adaptation Fund
- Biodiversity Fund
- LEDS
- Water Smart Economy

DISCUSSION

Some Points

- Environmental Accounting as an integration tool
- Interaction of NCA with key environmental issues
- Relevance of Natural Capital Accounting (NCA) for policy design, implementation and monitoring
- Perspectives to consolidate Ecosystem Accounting in the near future

THANK YOU

LUIS.RIVERA@UCR.AC.CR

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