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Research Group on Integrated Assessment

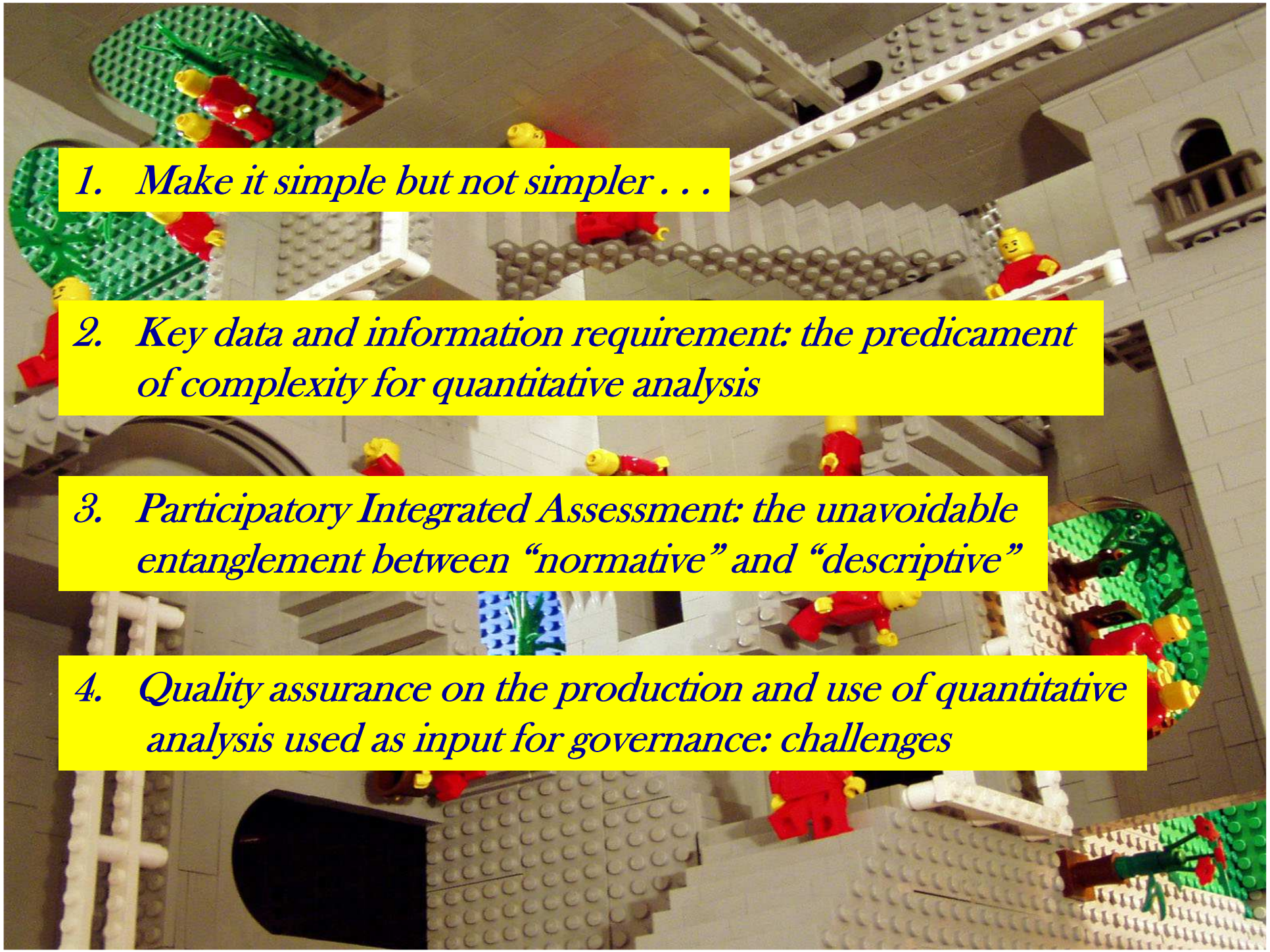
Sustainable Development Indicators: Dealing with complexity in governance

INTERNATIONAL CONFERENCE ON DATA, INFORMATION AND KNOWLEDGE FOR WATER GOVERNANCE IN THE NETWORKED SOCIETY

9-11th June 2014,
University of Seville, Seville

swan Sustainable Water ActioN

UNIVERSIDAD DE SEVILLA

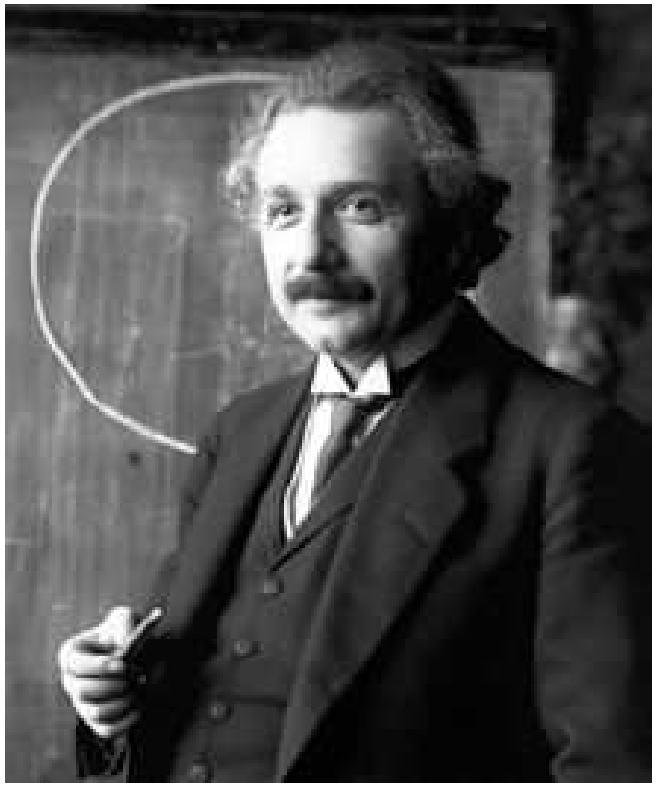

1. Make it simple but not simpler . . .
2. Key data and information requirement: the predicament of complexity for quantitative analysis
3. Participatory Integrated Assessment: the unavoidable entanglement between "normative" and "descriptive"
4. Quality assurance on the production and use of quantitative analysis used as input for governance: challenges

Key data and information requirement

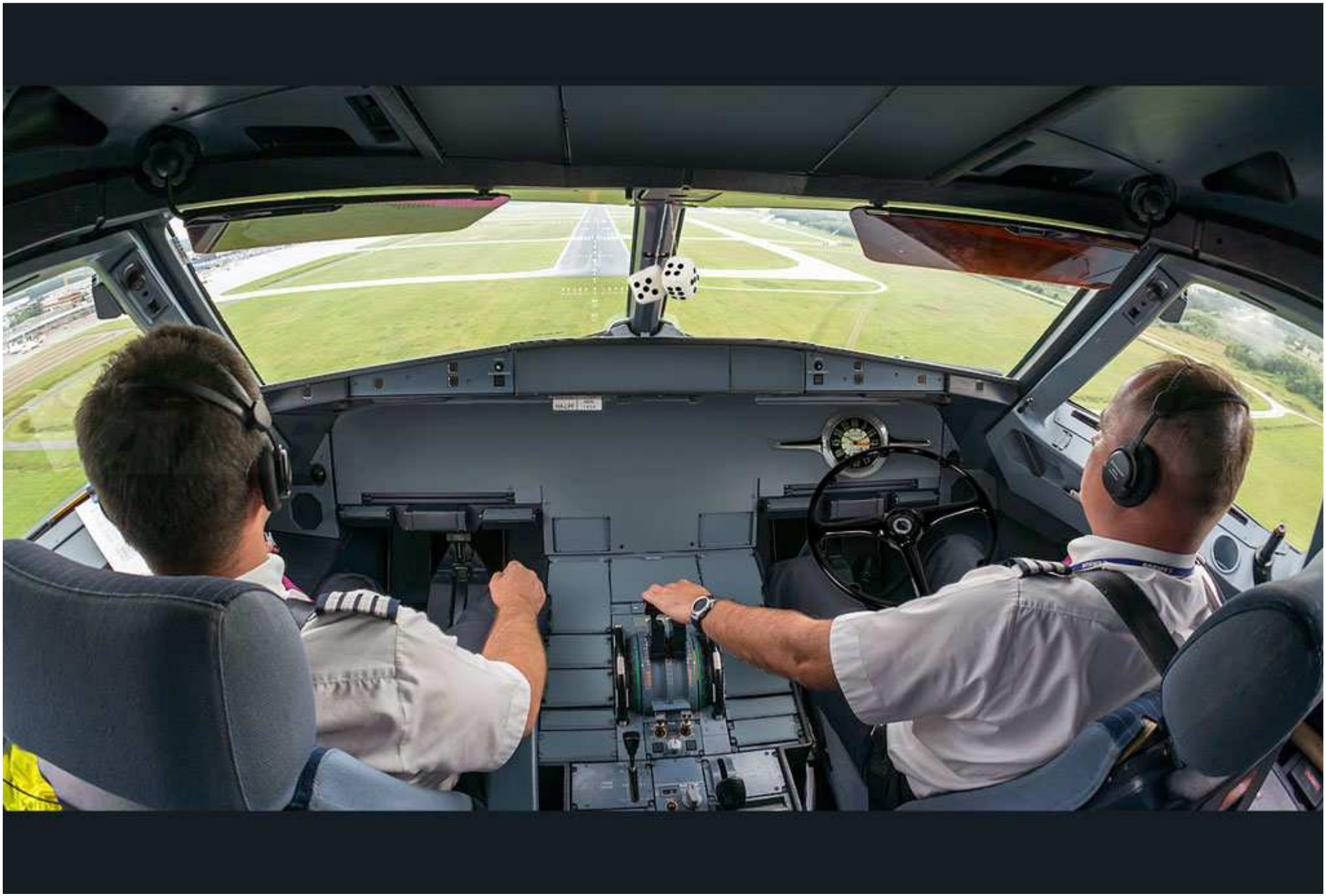
Media, politicians, and the general public like scientists that "keep it simple"

BUT . . .

"Make everything as simple as possible, but not simpler"

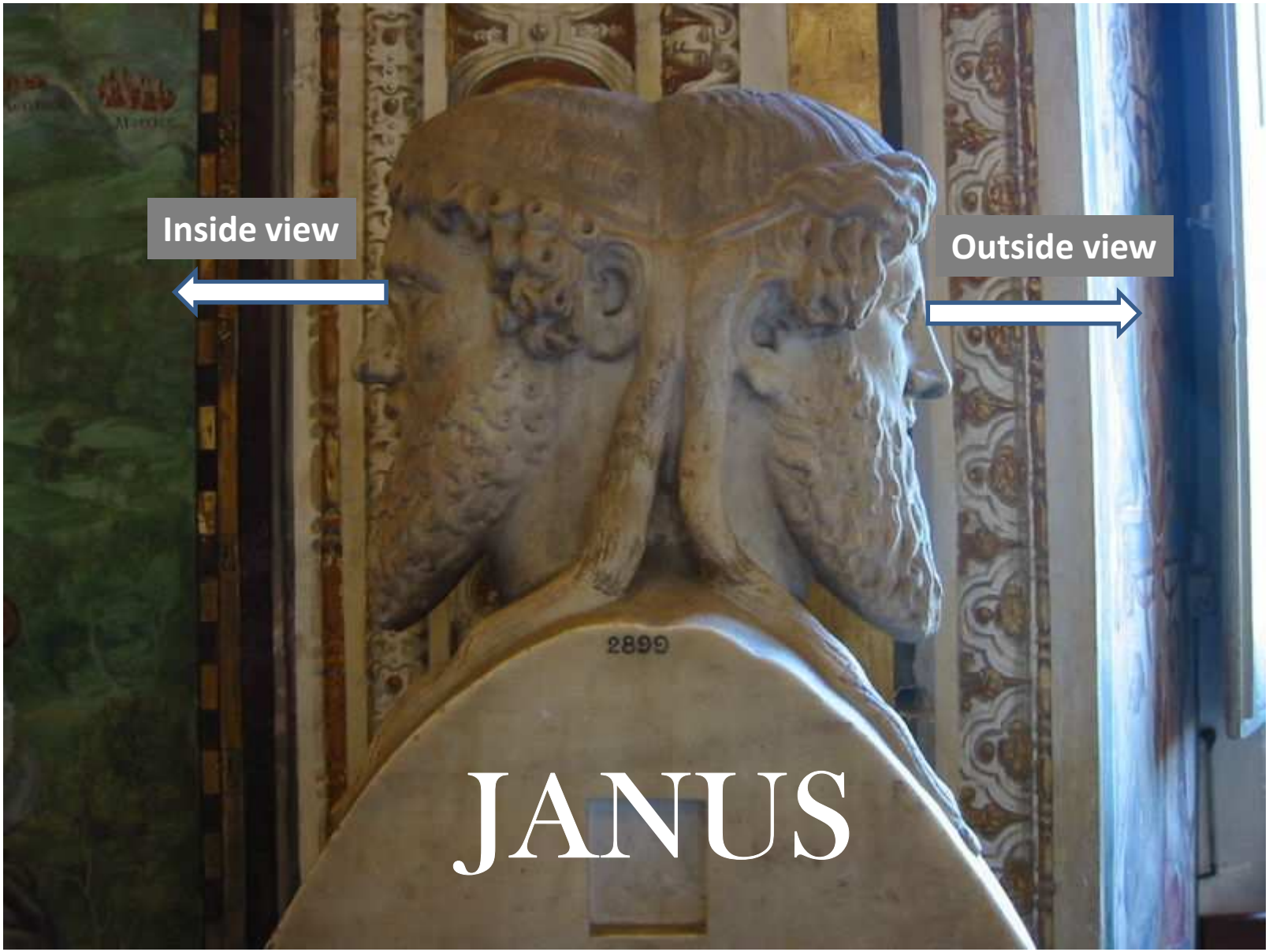


The amount of controls and commands needed by a pilot



Would you fly on this airplane?

This is where the concept of “HOLON” enters into play . . .



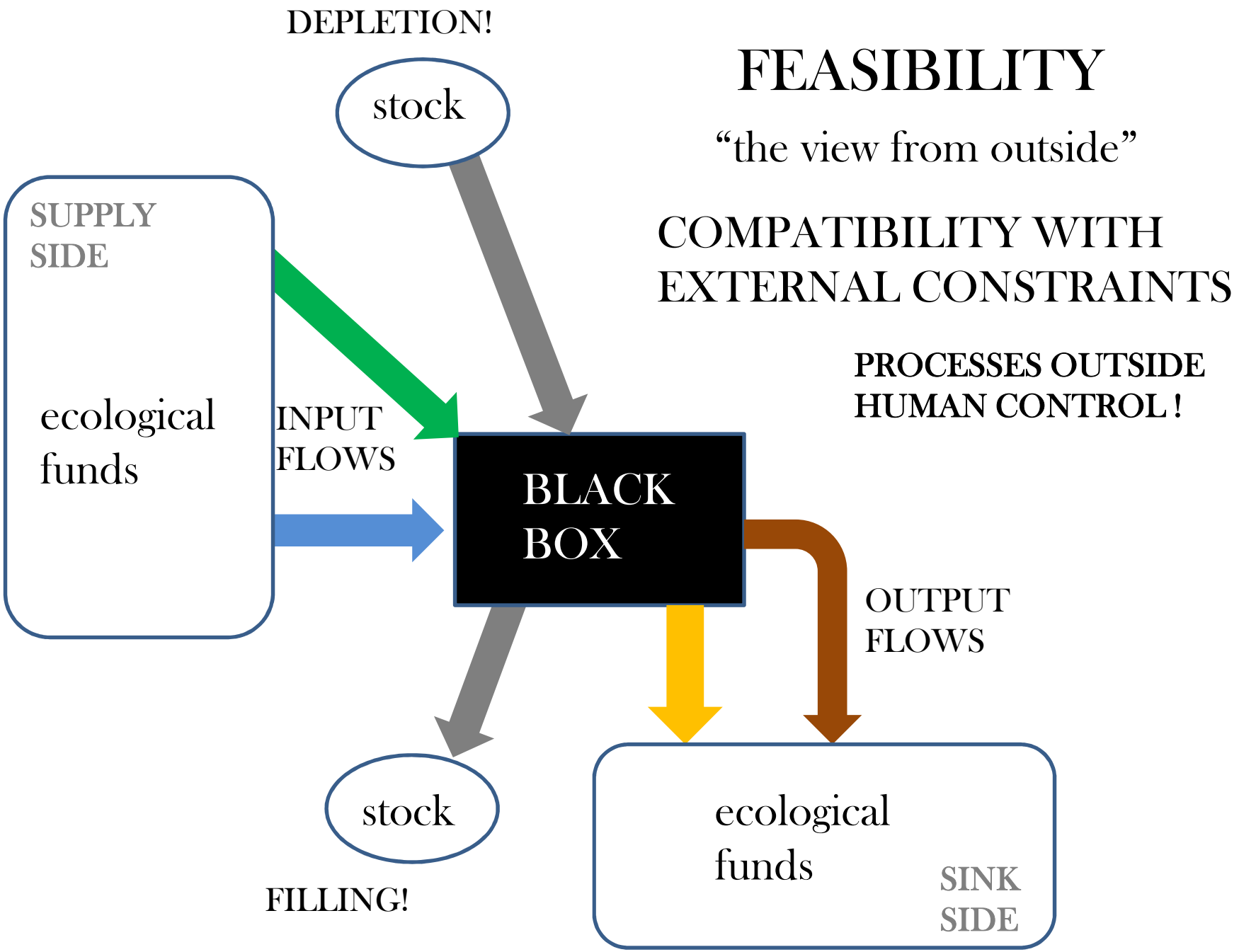
Sustainability indicators have to check “sustainability” in relation to three issues:

(i) FEASIBILITY – compatibility with external constraints

(ii) VIABILITY – compatibility with internal constraints

(iii) DESIRABILITY – compatiblity with normative values

Quantitative information useful to deal with one of these issues is not reducible to quantitative information useful for dealing with the others, so we have to learn how to hande multiple scales and multiple dimensions



FEASIBILITY

"the view from outside"

COMPATIBILITY WITH EXTERNAL CONSTRAINTS

PROCESSES OUTSIDE HUMAN CONTROL!

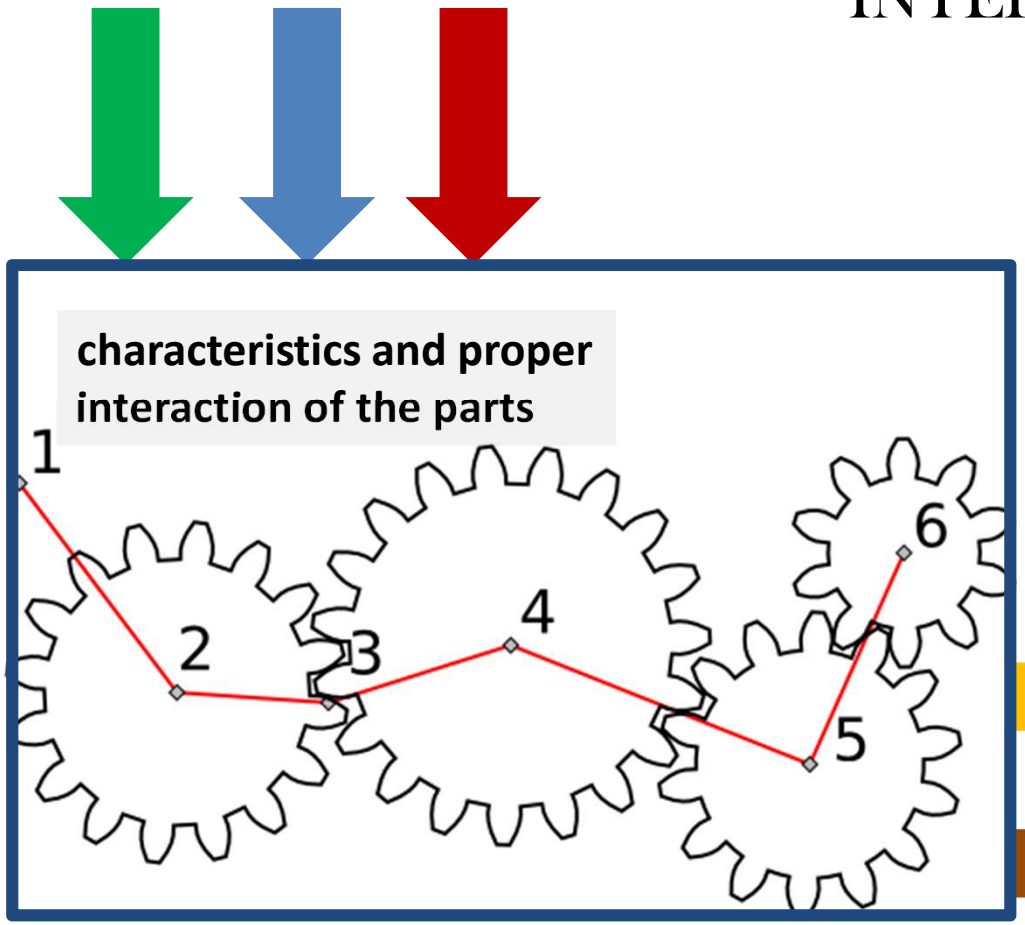
VIABILITY

"the view from inside"

SUPPLY OF NEEDED
INFLOWS AVAILABLE
"BY DEFAULT"

COMPATIBILITY WITH
INTERNAL CONSTRAINTS

PROCESSES UNDER
HUMAN CONTROL



NEEDED SINK CAPACITY
FOR OUTFLOWS AVAILABLE
"BY DEFAULT"

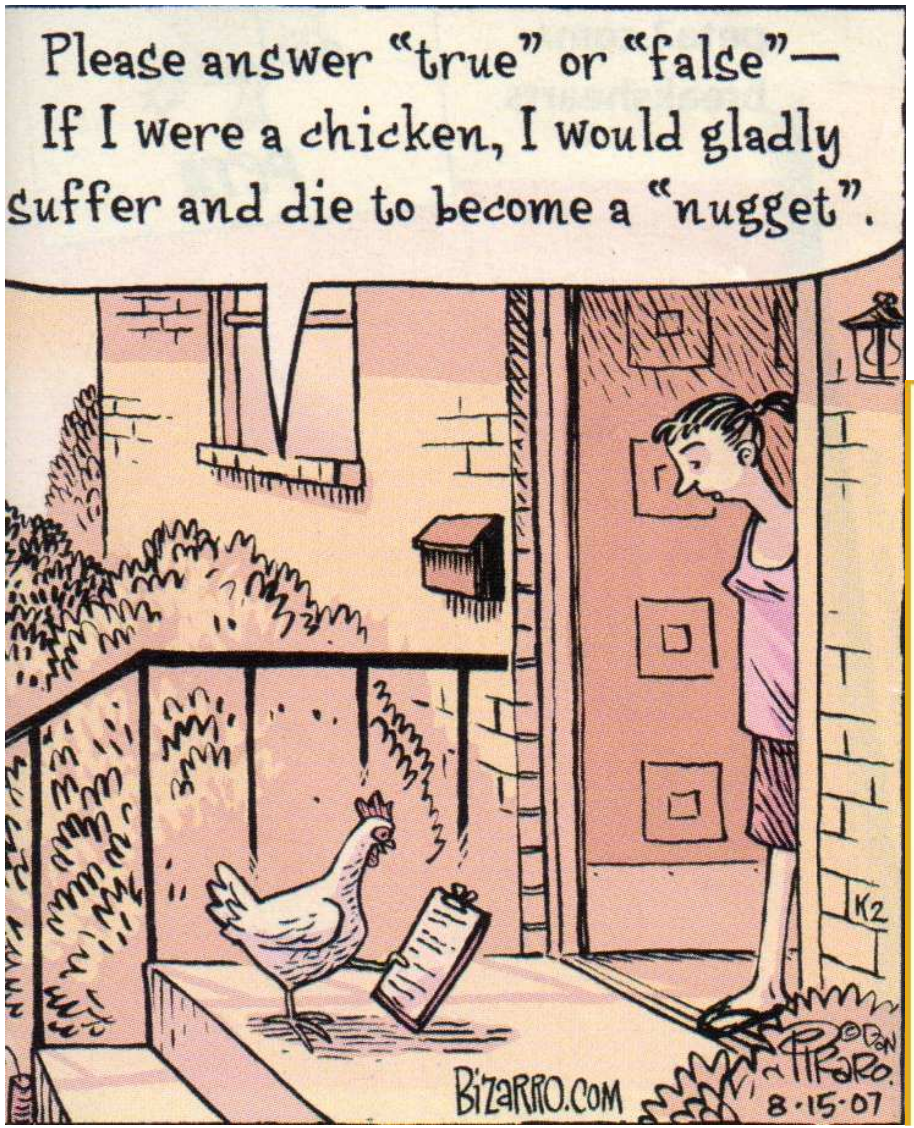
Values, Taboos, Cultural Identity
Path Dependence (history matters . . .)

DESIRABILITY

"whose view counts?"

COMPATIBILITY WITH SOCIAL INSTITUTIONS

PROCESSES UNDER HUMAN CONTROL



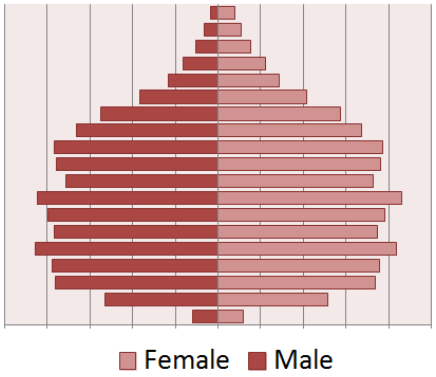
Lessons learned from the FAO-GIZ project

the nexus between food, energy, water and land use

http://nexus-assessment.info/

The epistemological predicament faced when accounting food flows

Population Structure



Dietary needs of the population

Inside view

FLOW elements

	Food (PJ)	Energy (PJ-G					
HH	5.9	15				4.5	
SG		21					
BM			23	250			
AG	1.3	0	110	50			
EM	negl	2	260	8	negl		0.2
exp		0					

0.8 losses

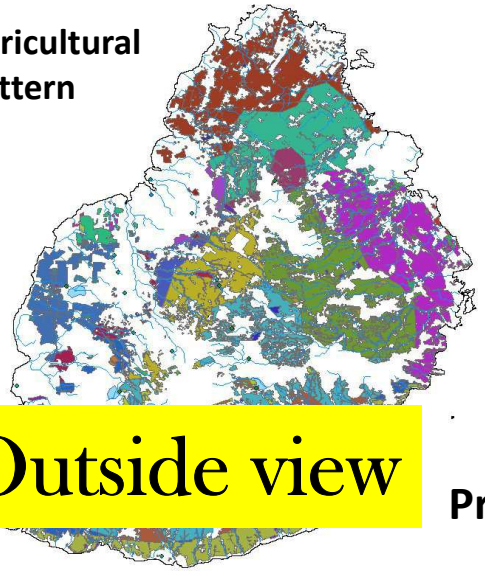
Diet Requirement

Unit: PJoule	CARB	PRO	FAT
Tourist	0.1	Negl	Negl
Rural	2.1	0.4	0.9
Urban	1.5	0.3	0.7

Diet composition

Unit: PJoules	CARB	PROT	FAT
	3.6	**0.7**	**1.6**
Cereals, roots	2.7	0.3	Negl
Animals products	0.1	0.3	0.3
Veg. and fruits	0.1	Negl	Negl
Oil	Negl	Negl	1.2
Others	0.7	Negl	Negl

Agricultural pattern

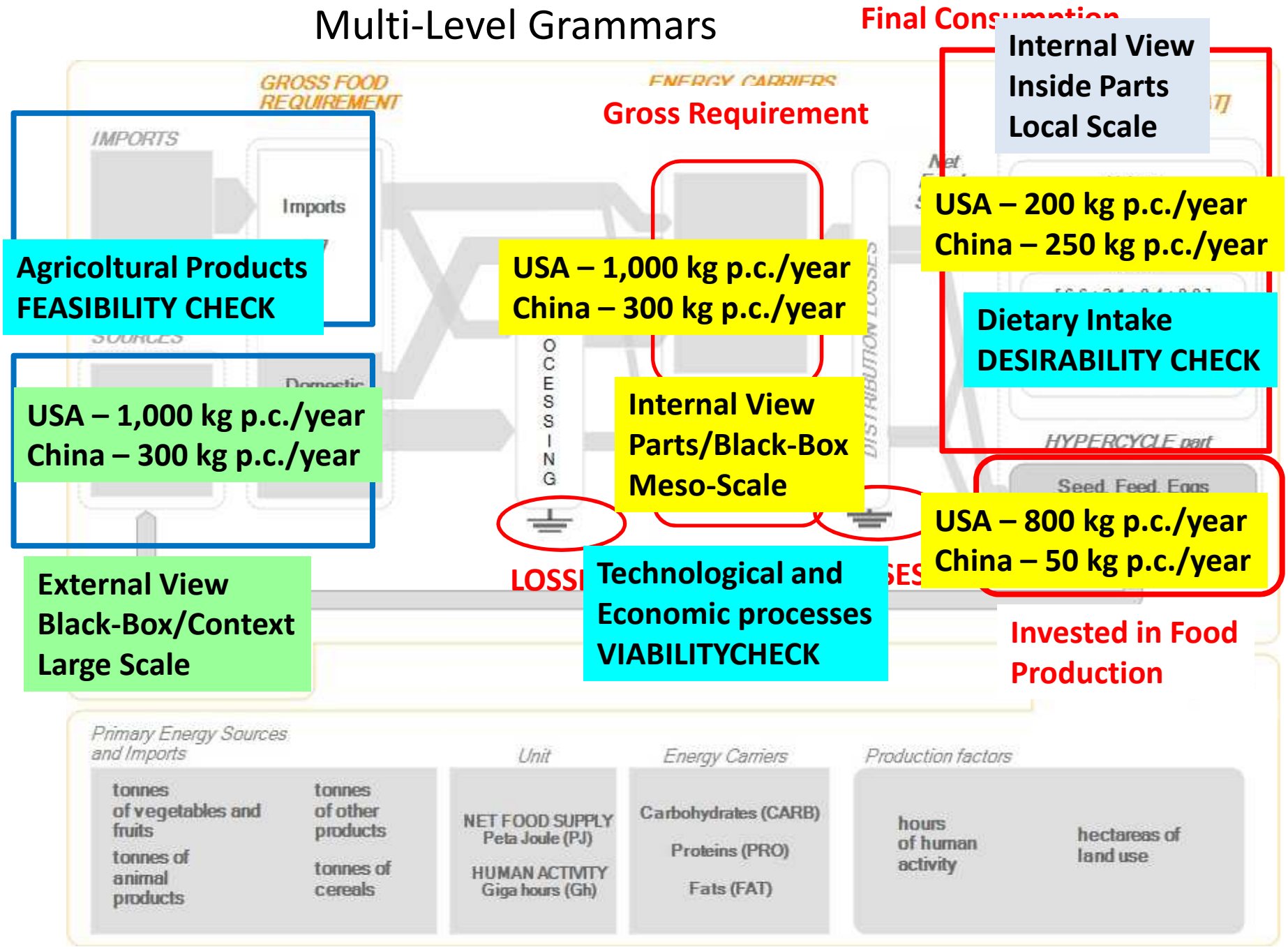


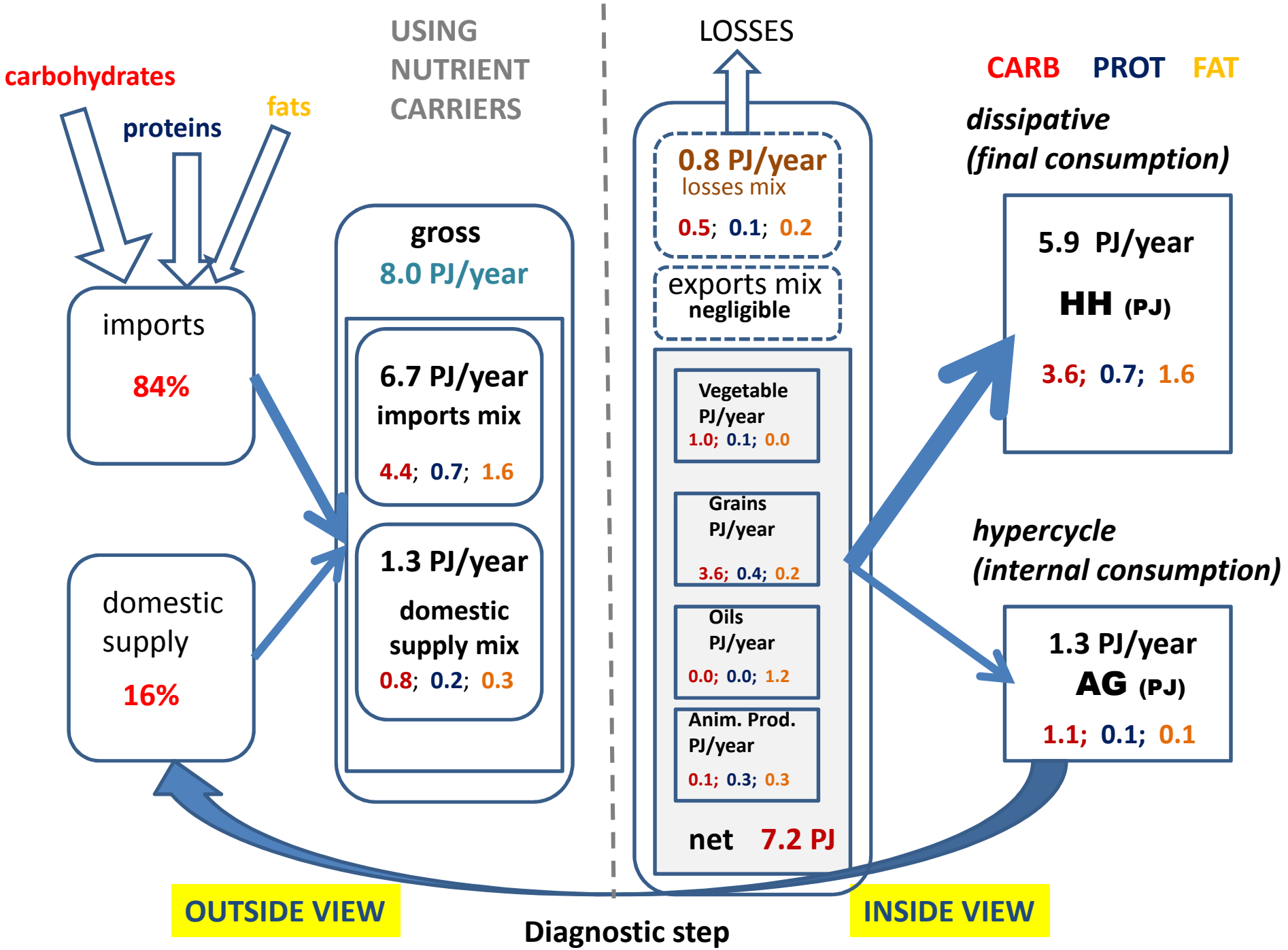
Outside view

Primary Agricultural Products

Nutrients supply by agriculture or imports

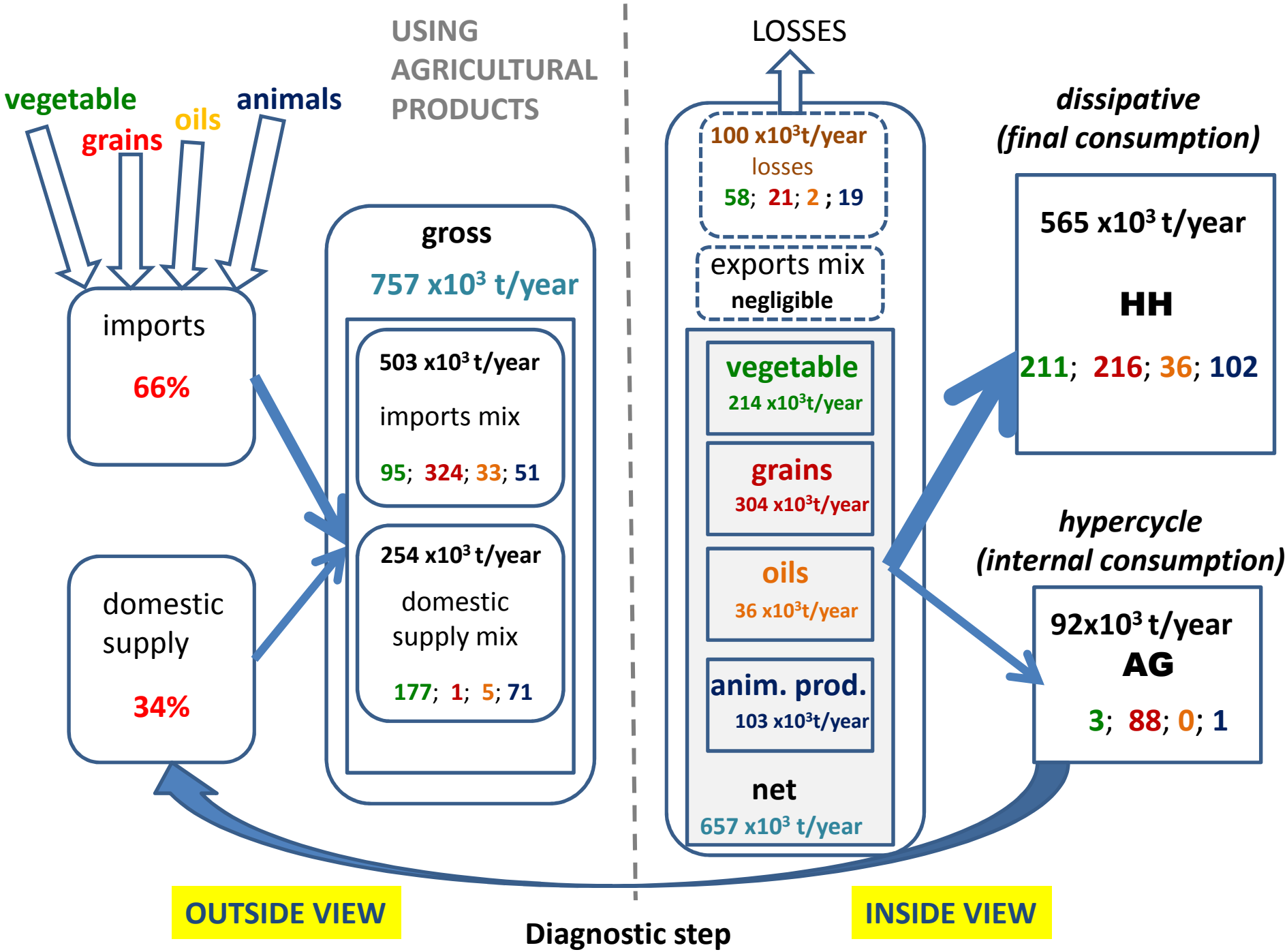
Multi-Level Grammars




carbohydrates
proteins
fats
imports
84%
domestic supply
16%
USING NUTRIENT CARRIERS
gross
8.0 PJ/year
6.7 PJ/year
imports mix
4.4; 0.7; 1.6
1.3 PJ/year
domestic supply mix
0.8; 0.2; 0.3
LOSSES
0.8 PJ/year
losses mix
0.5; 0.1; 0.2
exports mix
negligible
Vegetable PJ/year
1.0; 0.1; 0.0
Grains PJ/year
3.6; 0.4; 0.2
Oils PJ/year
0.0; 0.0; 1.2
Anim. Prod. PJ/year
0.1; 0.3; 0.3
net 7.2 PJ
CARB PROT FAT
dissipative
(final consumption)
5.9 PJ/year
HH (PJ)
3.6; 0.7; 1.6
hypercycle
(internal consumption)
1.3 PJ/year
AG (PJ)
1.1; 0.1; 0.1
OUTSIDE VIEW
Diagnostic step
INSIDE VIEW

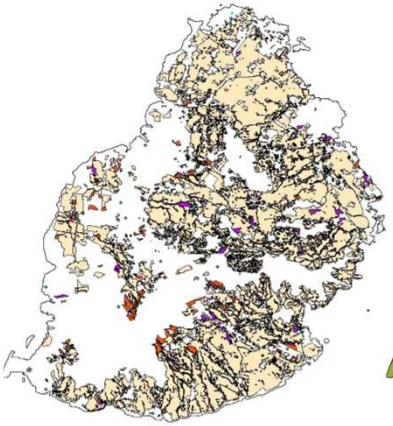
What if we want to implement this food grammar to check the requirement of land and water availability?

Then we have to use categories of accounting relevant for the “external view”


USING AGRICULTURAL PRODUCTS
LOSSES
vegetable
grains
oils
animals
imports
66%
domestic supply
34%
gross
757 x10³ t/year
503 x10³ t/year
imports mix
95; 324; 33; 51
254 x10³ t/year
domestic supply mix
177; 1; 5; 71
100 x10³t/year
losses
58; 21; 2 ; 19
exports mix
negligible
vegetable
214 x10³t/year
grains
304 x10³t/year
oils
36 x10³t/year
anim. prod.
103 x10³t/year
net
657 x10³ t/year
dissipative
(final consumption)
565 x10³ t/year
HH
211; 216; 36; 102
hypercycle
(internal consumption)
92x10³ t/year
AG
3; 88; 0; 1
OUTSIDE VIEW
Diagnostic step
INSIDE VIEW

External constraints: checking suitable lands

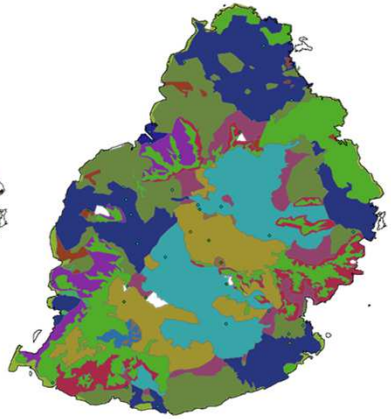
Sugar Cane



Check of Previous Locations

+

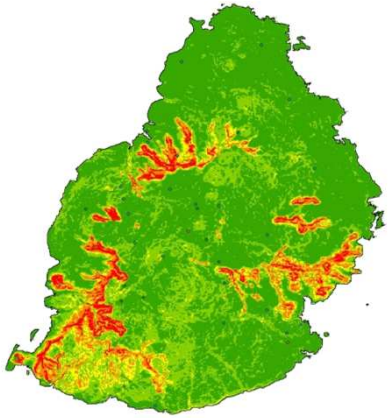
Types of Soil



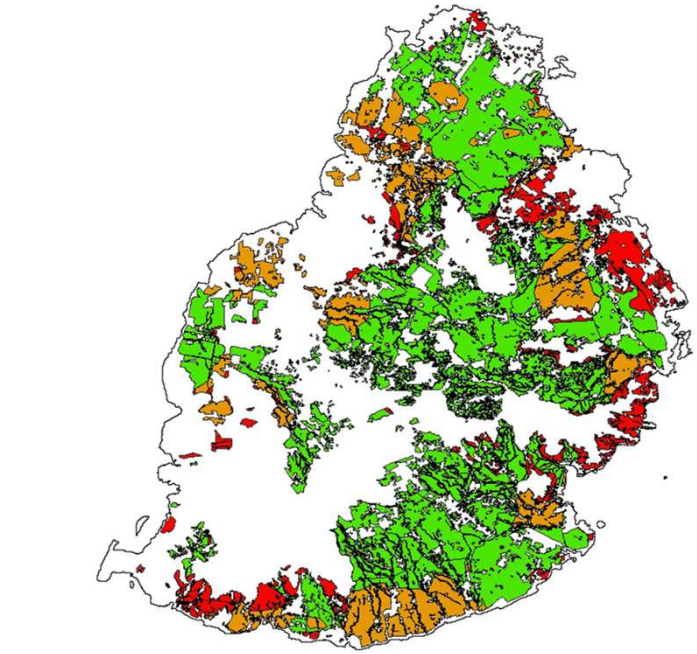
Compatibility with soils

+

Slope



Slope compatibility

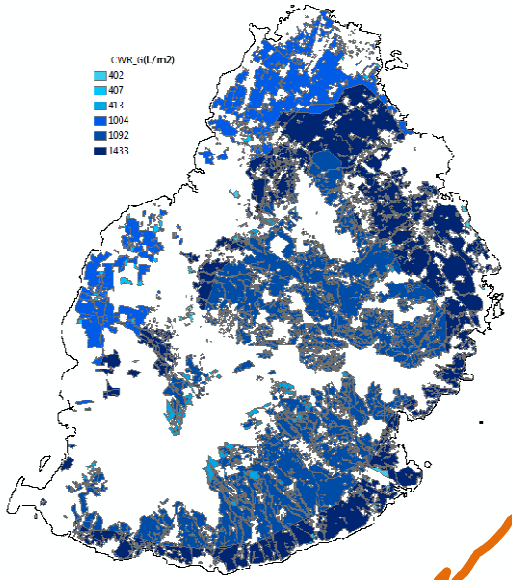


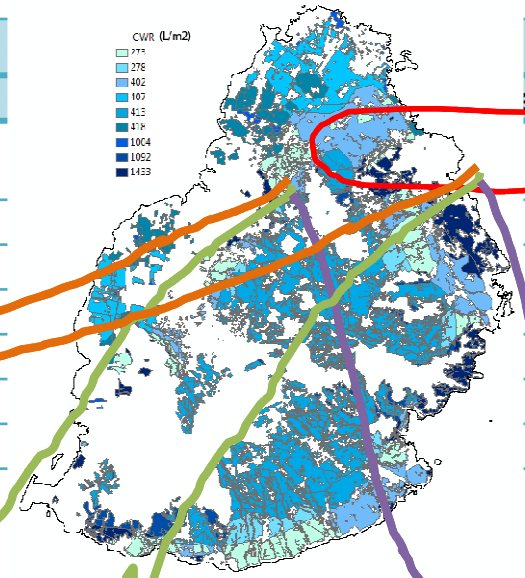
suitable land for a different location of crops mix

Suitable for new crop mix

Suitable for maize

Only suitable for sugarcane





Unit		hm3	hm3		hm3
Crop/	ɔ-2	USE g-2	USE b -3	een	USE total
Grou	0	1		6	6
Maize	0	0		1	1
Potat	0			4	4
Swee	0			0	0
Cassa	0	0		0	0
Taro	0	0		0	0
Beans	0	0		1	1

Unit	ha	mm (l/m2)	mm (l/m2)	ha	mm (l/m2)	mm (l/m2)	ha	mm (l/m2)	mm (l/m2)	ha
Crop/Indicator	Area Harvested	BCWR 1	GCWR 1	AREA 1	BCWR 2	GCWR 2	AREA 2	BCWR 3	GCWR 3	AREA 3
Group 1	**1,880**	**0**	**300**	**1,122**	**0**	**289**	**445**	**0**	**386**	**312**
Maize	335	0	278	200	0	273	79	0	418	56
Potatoes	1,072	0	320	640	0	316	254	0	478	178
Sweet potatoes	74	0	310	44	0	306	17	0	374	12
Cassava	38	0	290	23	0	286	9	0	---	6
Taro	36	0	329	21	0	324	9	0	---	6
Beans and Peas	326	0	269	194	0	227	77	0	275	

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The epistemological predicament faced when accounting energy flows

ENERGY GRAMMAR

Physical gradients

Supply

GROSS ENERGY REQUIREMENT (Convention)

Imports as EC

Imports as GER

ENERGY & MINING

ENERGY CARRIERS

Thermal energy

Mechanical energy

Gross Supply of EC

DISTRIBUTION LOSSES

Net Supply of EC

Production Factors used by Hypercycle Part

Net End Uses

AG
[HA, ETt, PCt, ETm, PCm]

HYPERCYCLE part

EM
[HA, ETt, PCt, ETm, PCm]

Primary Energy Sources

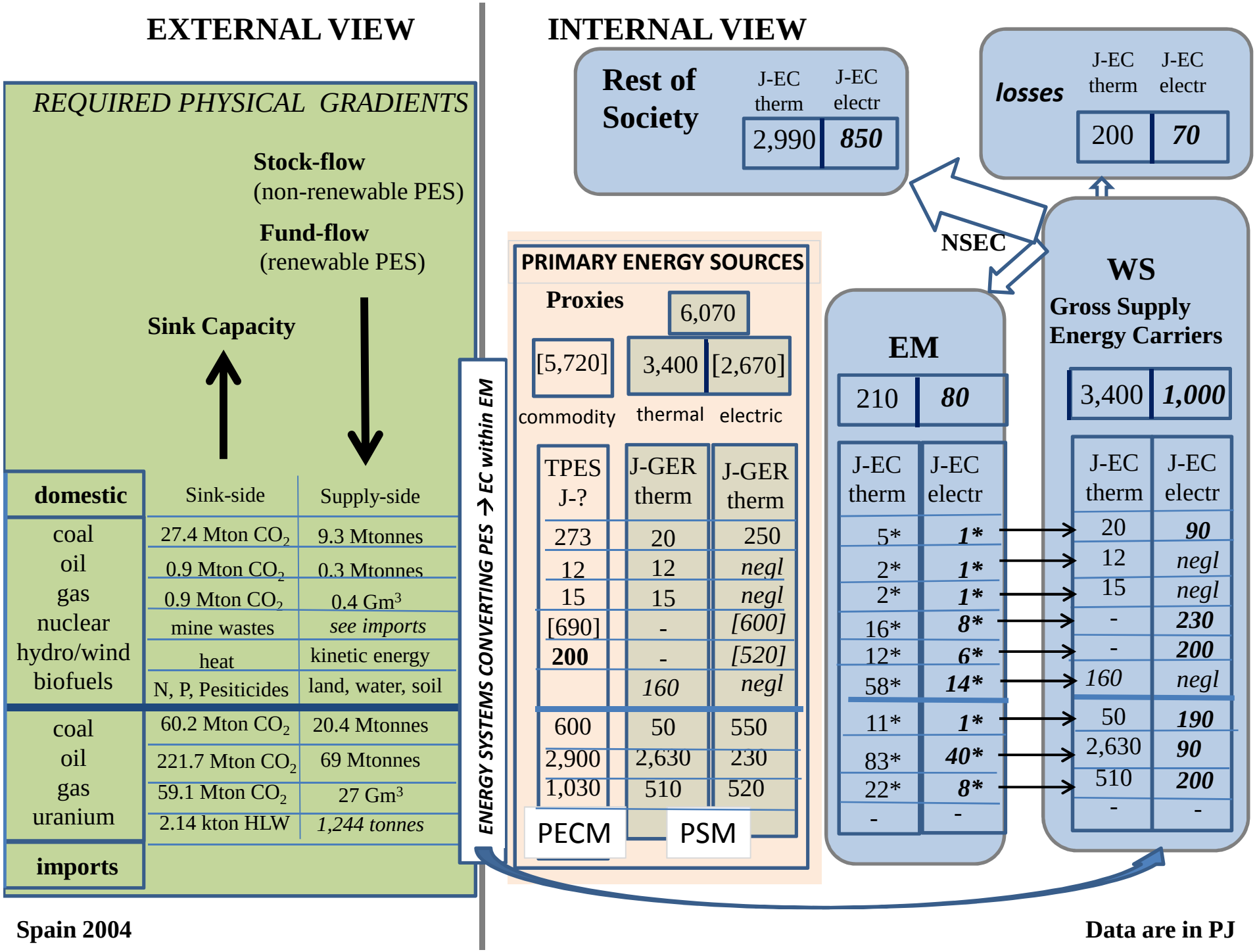
physical quantities

Gross Energy Carriers

non-equivalent quantities!!!!

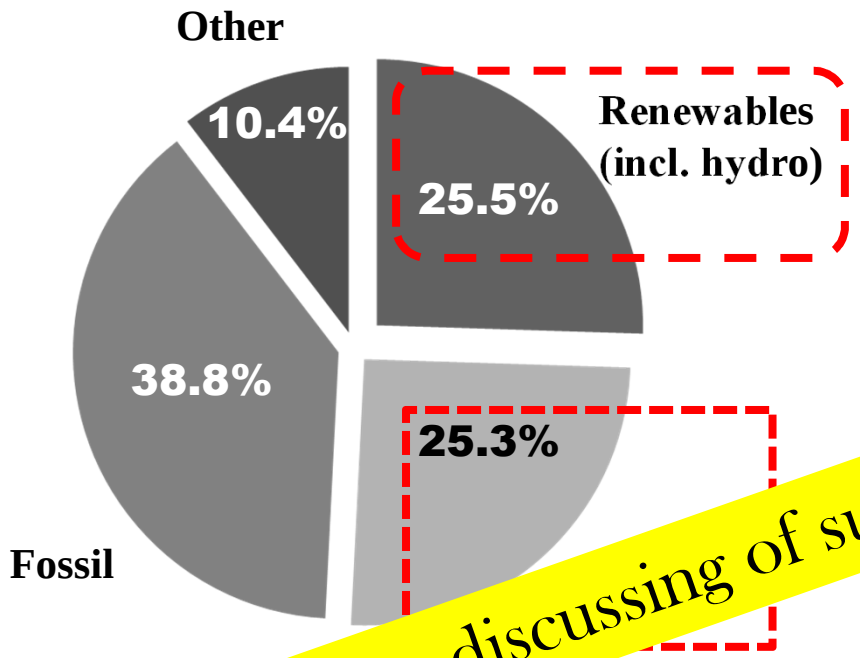
Net EC

End Uses for making EC


EXTERNAL VIEW
INTERNAL VIEW
REQUIRED PHYSICAL GRADIENTS
Stock-flow
(non-renewable PES)
Fund-flow
(renewable PES)
Sink Capacity
domestic
Sink-side
Supply-side
coal
oil
gas
nuclear
hydro/wind
biofuels
27.4 Mton CO2
9.3 Mtonnes
0.9 Mton CO2
0.3 Mtonnes
0.9 Mton CO2
0.4 Gm3
mine wastes
see imports
heat
kinetic energy
N, P, Pesiticides
land, water, soil
coal
oil
gas
uranium
60.2 Mton CO2
20.4 Mtonnes
221.7 Mton CO2
69 Mtonnes
59.1 Mton CO2
27 Gm3
2.14 kton HLW
1,244 tonnes
imports
ENERGY SYSTEMS CONVERTING PES → EC within EM
Rest of Society
J-EC therm
J-EC electr
2,990
850
losses
J-EC therm
J-EC electr
200
70
NSEC
PRIMARY ENERGY SOURCES
Proxies
6,070
[5,720]
3,400
[2,670]
commodity
thermal
electric
TPES J-?
J-GER therm
J-GER therm
273
20
250
12
12
negl
15
15
negl
[690]
-
[600]
200
-
[520]
160
negl
600
50
550
2,900
2,630
230
1,030
510
520
PECM
PSM
EM
210
80
J-EC therm
J-EC electr
5*
1*
2*
1*
2*
1*
16*
8*
12*
6*
58*
14*
11*
1*
83*
40*
22*
8*
-
-
WS
Gross Supply Energy Carriers
3,400
1,000
J-EC therm
J-EC electr
20
90
12
negl
15
negl
-
230
-
200
160
negl
50
190
2,630
90
510
200
-
-
Spain 2004
Data are in PJ

BP statistics
US statistics

Partial
Subtitution
Method

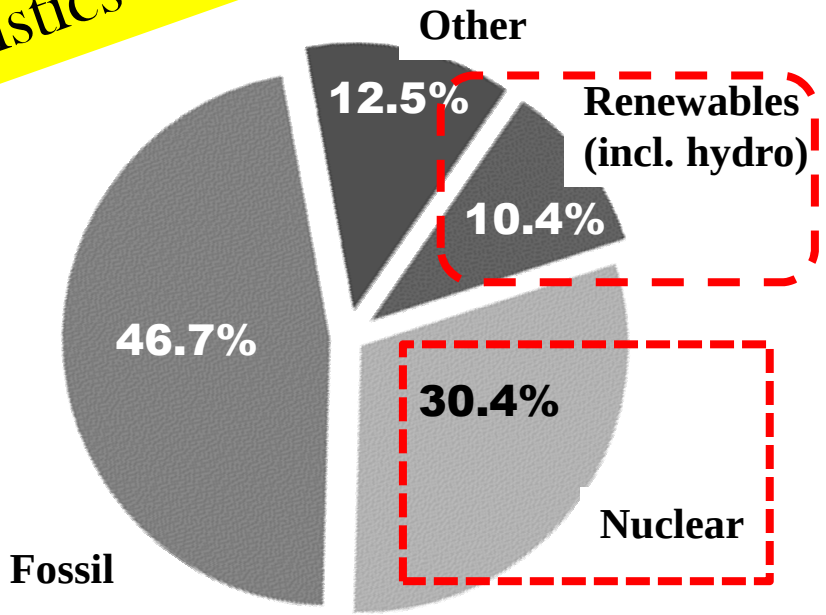


Are energy statistics useful for discussing of sustainability?

SWEDEN

Eurostat stati
IEA

Physical
Energy
Content
Method



The PES "hydro" produces more kWh of electricity than the PES "nuclear" . . .

Lessons learned from the FAO-GIZ project

the nexus between food, energy, water and land use

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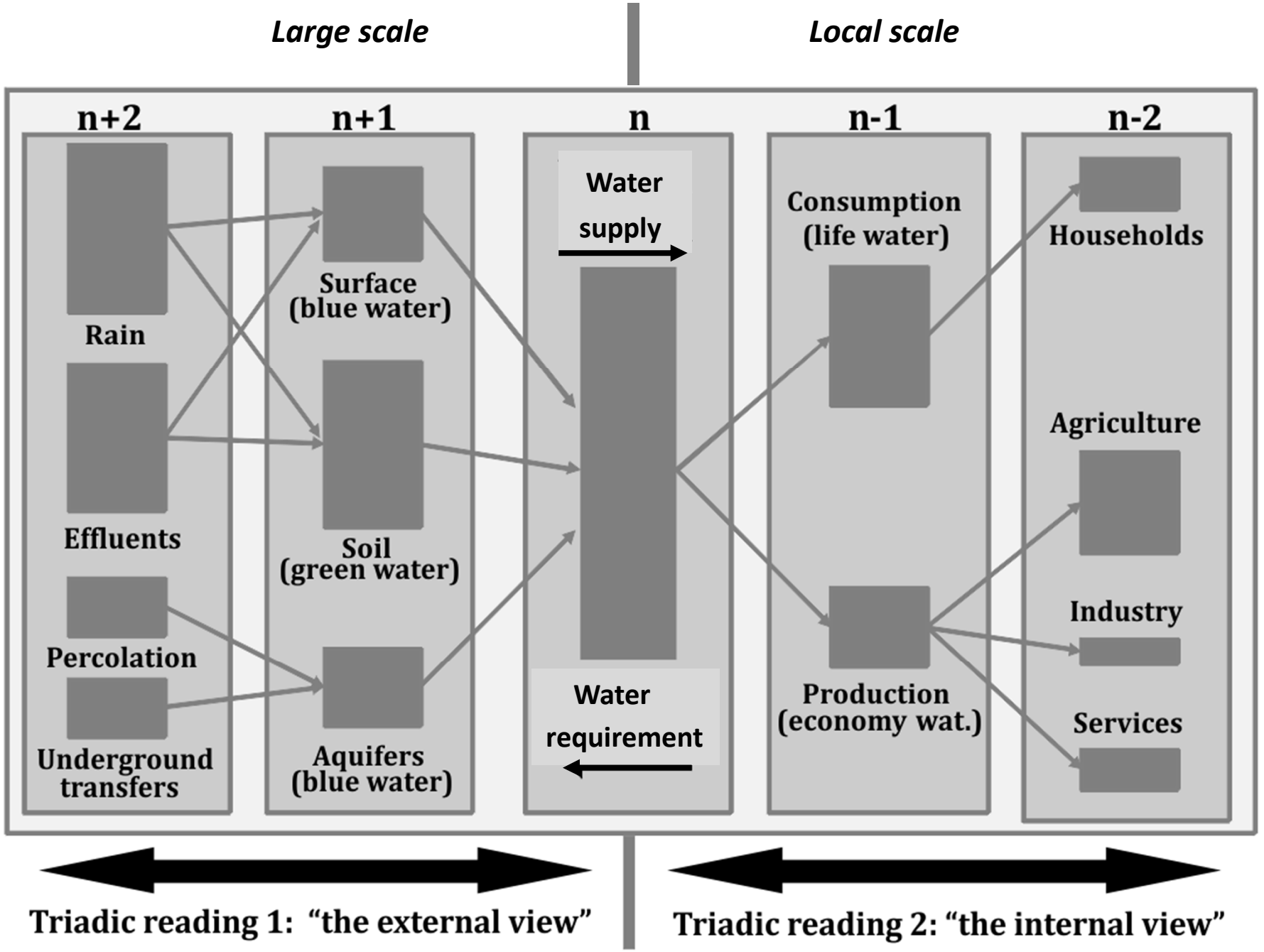
The epistemological predicament faced when accounting water flows


Large scale
Local scale
n+2
n+1
n
n-1
n-2
Rain
Effluents
Percolation
Underground transfers
Surface (blue water)
Soil (green water)
Aquifers (blue water)
Water supply
Water requirement
Consumption (life water)
Production (economy wat.)
Households
Agriculture
Industry
Services
Triadic reading 1: "the external view"
Triadic reading 2: "the internal view"

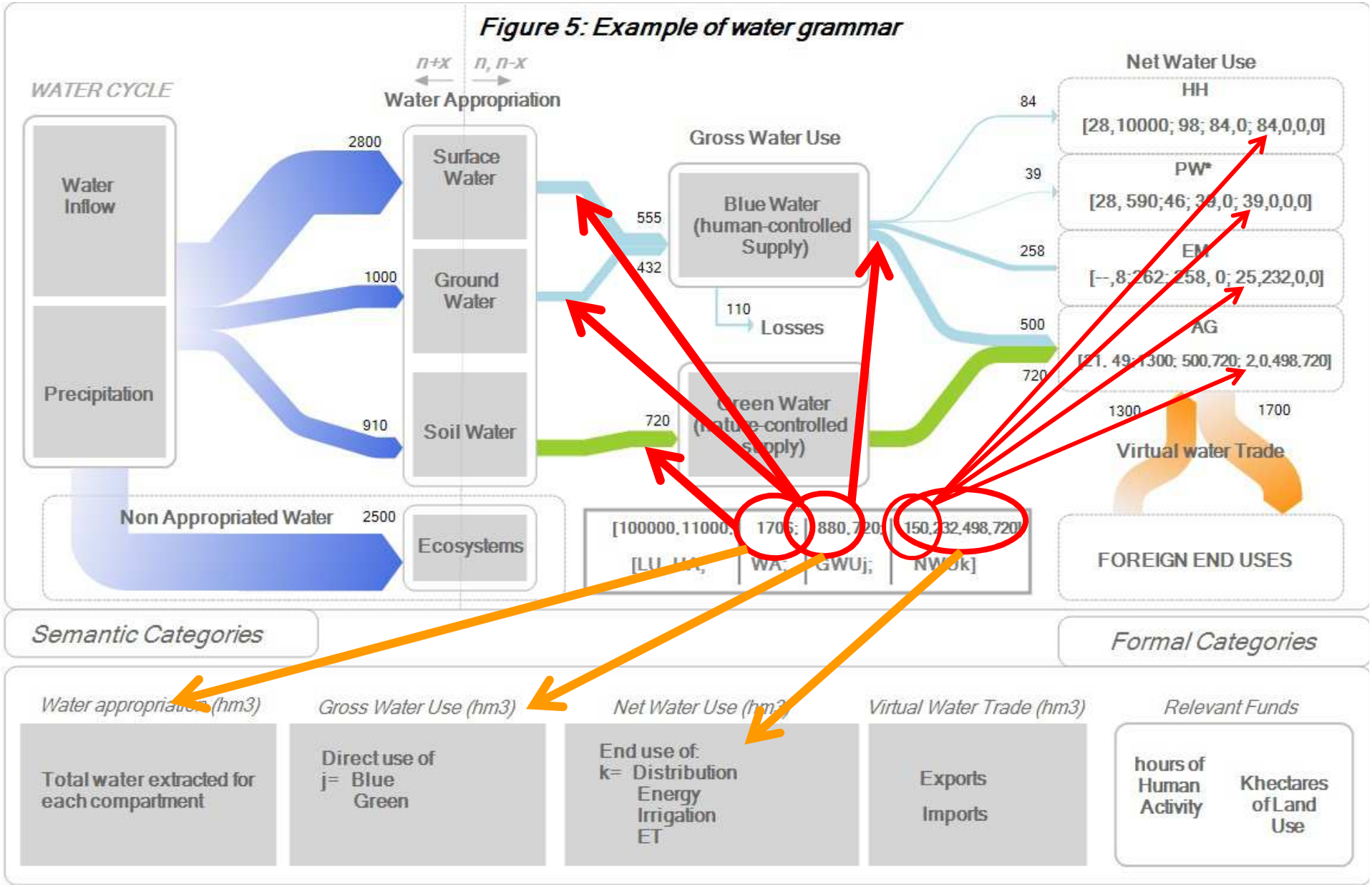
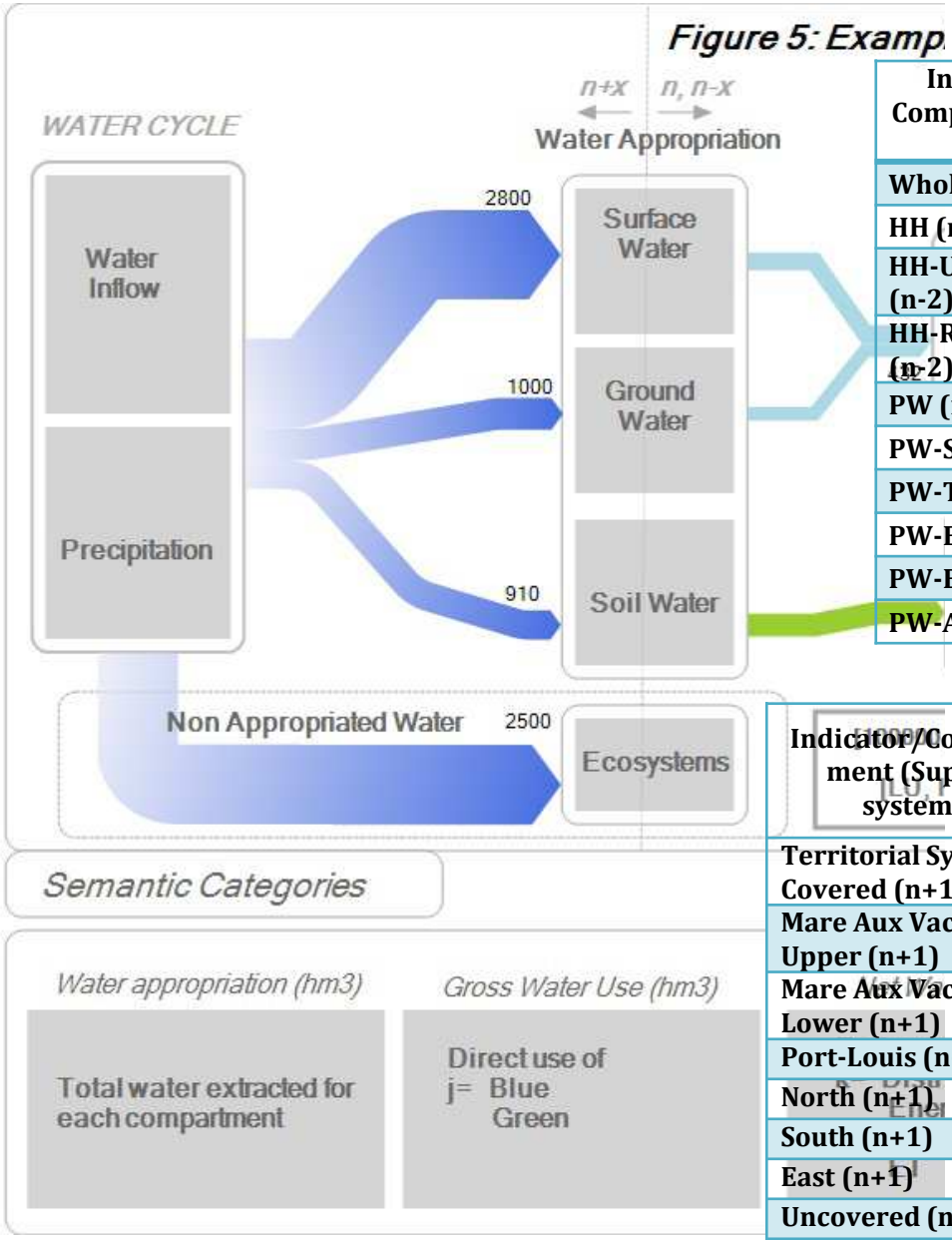
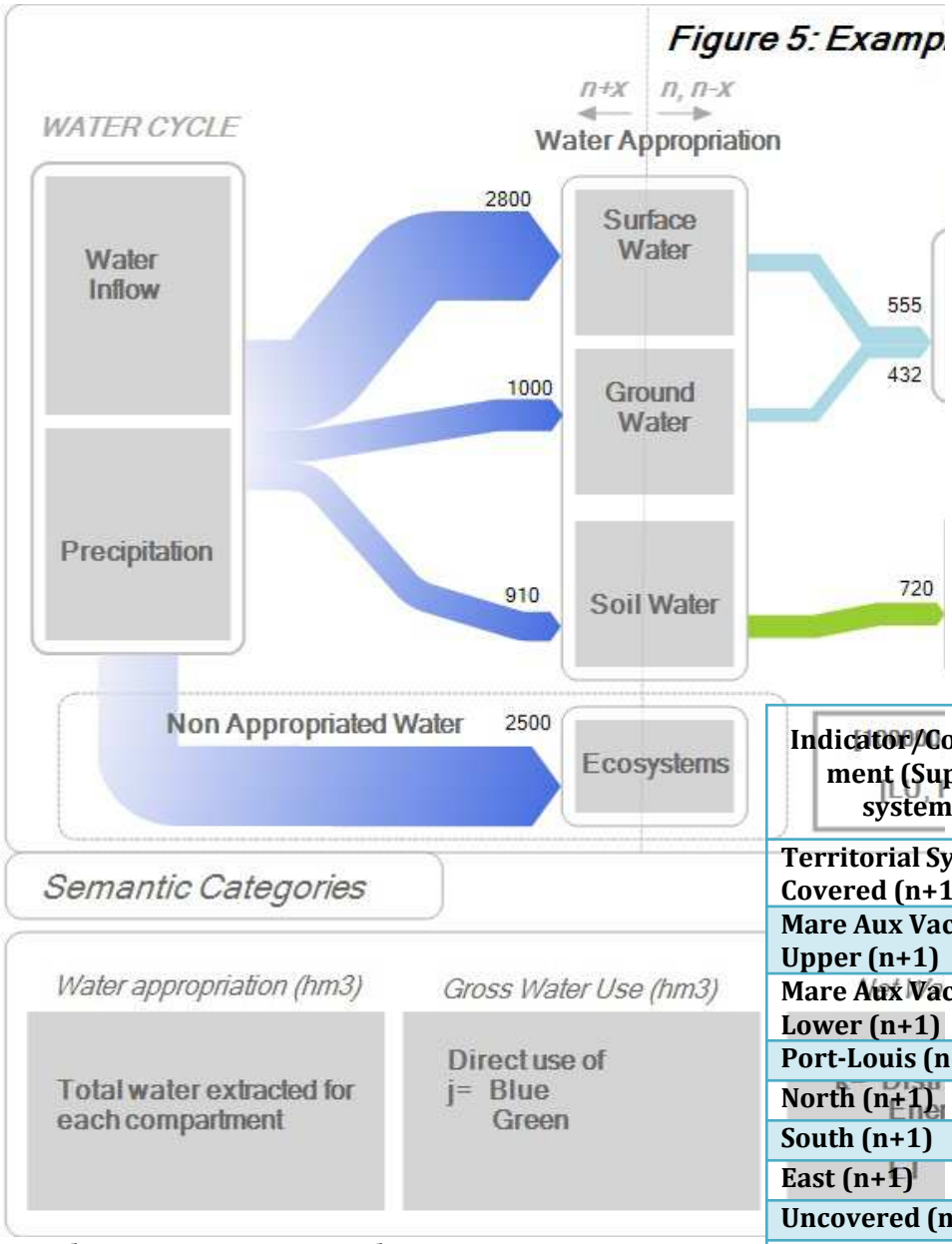


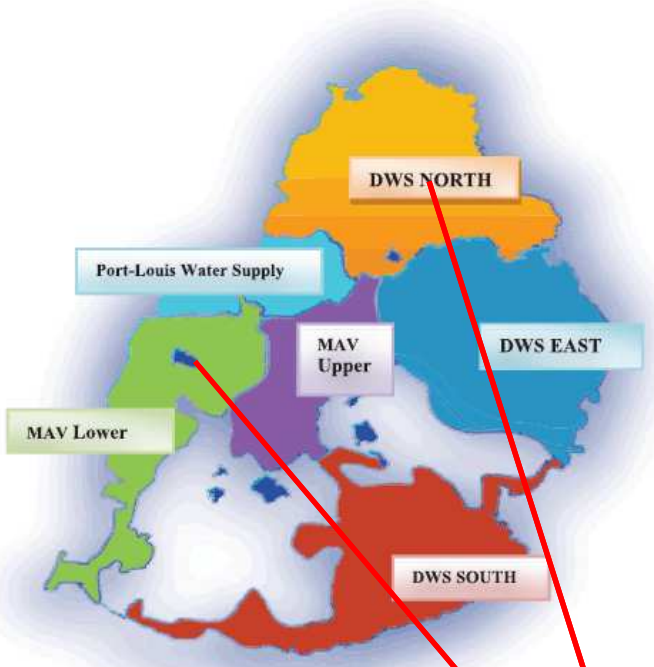
Figure 5: Example of water grammar
WATER CYCLE
n+x
n, n-x
Water Appropriation
Water Inflow
Precipitation
2800
1000
910
Surface Water
Ground Water
Soil Water
Non Appropriated Water
2500
Ecosystems
Gross Water Use
555
432
Blue Water (human-controlled Supply)
110
Losses
720
Green Water (nature-controlled supply)
[100000,11000; 1705; 880,720; 150,232,498,720]
[LU, U-L; WA; GWUj; NWUk]
Net Water Use
84
39
258
500
720
HH
[28,10000; 98; 84,0; 84,0,0,0]
PW*
[28, 590;46; 39,0; 39,0,0,0]
EM
[--,8,262; 258, 0; 25,232,0,0]
AG
[21, 49;1300; 500,720; 2,0,498,720]
1300
1700
Virtual water Trade
FOREIGN END USES
Semantic Categories
Formal Categories
Water appropriation (hm3)
Total water extracted for each compartment
Gross Water Use (hm3)
Direct use of
j= Blue
Green
Net Water Use (hm3)
End use of:
k= Distribution
Energy
Irrigation
ET
Virtual Water Trade (hm3)
Exports
Imports
Relevant Funds
hours of Human Activity
Khectares of Land Use



Indicator/ Compartment	Extraction Total	EXT Blue-Surface	EXT Blue-Ground	EXT Green	USE Losses	USE Total
Whole (n)	**1,706**	**555**	**432**	**718**	**108**	**1,599**
HH (n-1)	**98**	74	24	0	14	**84**
HH-Urban (n-2)	**41**	31	10	0	0	**35**
HH-Rural (n-2)	**57**	43	14	0	0	**49**
PW (n-1)	**1,608**	481	408	718	94	**1,515**
PW-SG (n-2)	**17**	13	4	0	2	**15**
PW-TR (n-2)	**1.72**	1.30	0.42	0	0	**1**
PW-BM (n-2)	**27**	20	7	0	4	**23**
PW-EM (n-2)	**262**	255	7	0	4	**258**
PW-AG (n-2)	**1,300**	192	390	718	84	**1,218**

Indicator/Compartment (Supply system)	Extraction-TOTAL	Water Renewable Res ources (WRR)			Extraction as (%) WRR
		Surface Inflow	Ground Inflow	Total	
Territorial System Covered (n+1)	**1,492**	2,055	778	**2,834**	53
Mare Aux Vacoas-Upper (n+1)	**252**	344	130	**474**	53
Mare Aux Vacoas-Lower (n+1)	**193**	88	34	**122**	**158**
Port-Louis (n+1)	**291**	562	213	**775**	38
North (n+1)	**291**	259	98	**358**	**81**
South (n+1)	**247**	383	145	**528**	47
East (n+1)	**229**	464	176	**640**	36
Uncovered (n+1)	**214**	820	311	**1,130**	19
TOTAL (n)	**1,706**	2,875	1,089	**3,964**	**43**





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MuSIASEM as a simulator tool: scenario 2 in Mauritius

Transition from a cropping pattern based on sugar cane to another cropping pattern

Facing internal constraints: new crop mix is incompatible with the profile of HA

DEMAND		FOOD (PJ-NFS)	ENERGY (PJ-GER)	WATER (hm3-GWR)	VALUE ADDED (million US$)	HUMAN ACTIVITY (million hr)	LAND USE (ha)	POWER CAPACITY (GW)
	HH (n-1)	5.9	15	84	N/A	10197 (!)	28,070	11
	PW (n-1)	N/A	39	540	8266 (!)	1273 (!)	127,092	3
	SG					680 (!)	N/A	1
	TR					92 (!)	N/A	1
	BM					409 (!)	N/A	1
	AG (n-2)	N/A	0	240	1,256	280	99,022	0
	EM (n-2)	N/A	2	260	212 (!)	8 (!)	negligible	0
	LOSSES	2.1	1	110	N/A	N/A	N/A	N/A
WHOLE (n)		8	56	730	N/A	11,469	127,092	14
EXPORTS		negligible	0	200	5,197	N/A		N/A
SUPPLY	**IMPORTS**	5.3	48	480	5,648	N/A	211,466	N/A
	EM	N/A	7	N/A	N/A	N/A	N/A	N/A
	AG	2.7	N/A	N/A	N/A	N/A	20,516	N/A

THIS SCENARIO IS IMPOSSIBLE BECAUSE OF AN INTERNAL CONSTRAINT – IT WOULD REQUIRE TOO MUCH WORK IN AGRICULTURE . . .

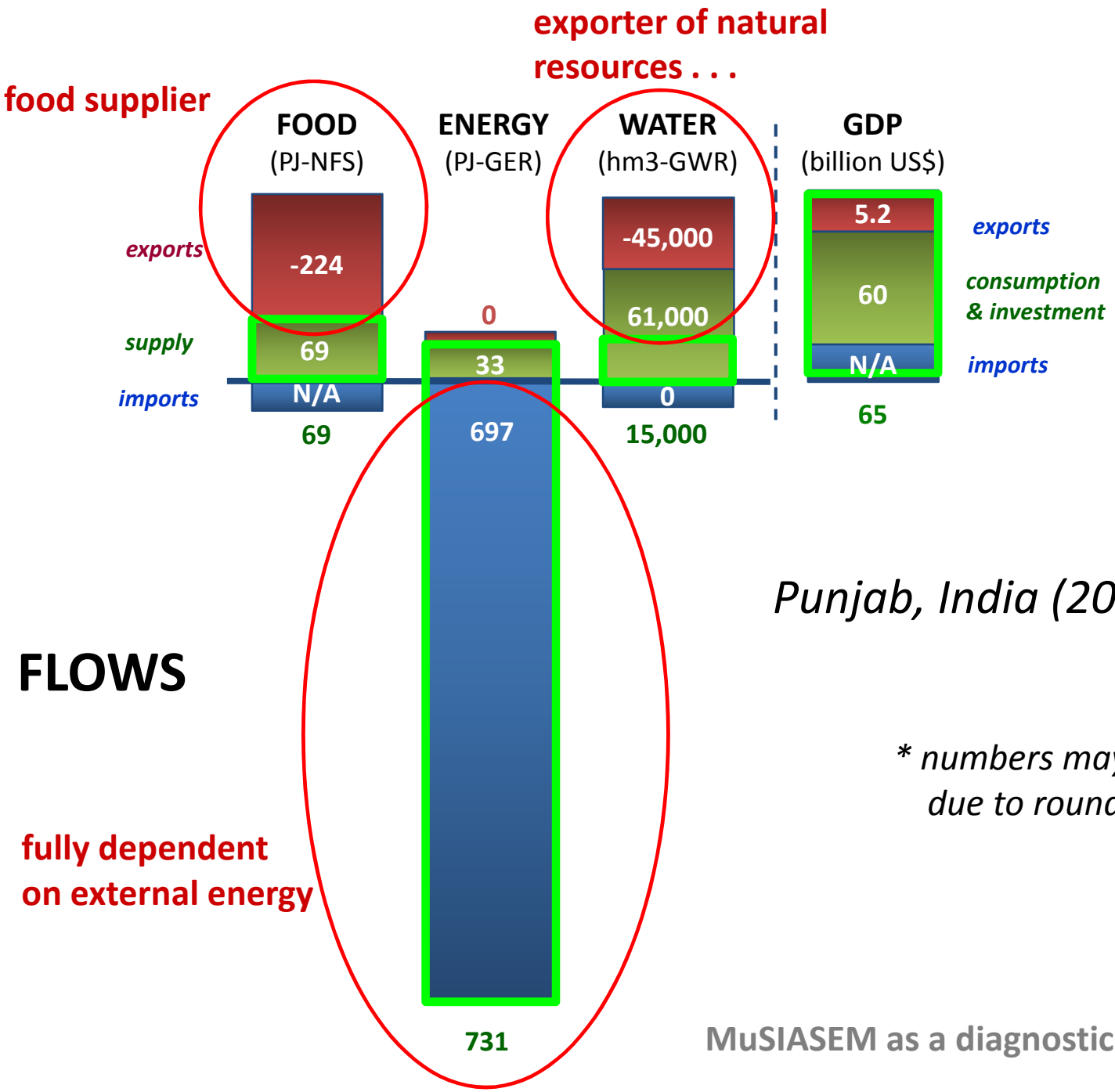
MuSIASEM as a simulator tool: scenarios in Mauritius

Transition from a cropping pattern based on sugar cane to another cropping pattern

Keeping the actual supply of AG-labor the new cropping mix would reduce Land Use

DEMAND		FOOD (PJ-NFS)	ENERGY (PJ-GER)	WATER (hm3-GWR)	VALUE ADDED (million US$)	HUMAN ACTIVITY (million hr)	LAND USE (ha)	POWER CAPACITY (GW)
	HH (n-1)	5.9	15	84	N/A	10,197	28,070	11
	PW (n-1)	N/A	39	540	8,714	1,273	120,211	3
	SG (n-2)	N/A	8	15	5,178	680	N/A	1
	TR (n-2)	N/A	13	1	826	92	N/A	1
	BM (n-2)	N/A	16	23	2,158	409	N/A	1
	AG (n-2)	N/A	0	240	372	83	21,815	0
	EM (n-2)	N/A	2	260	180	8	negligible	0
	LOSSES	2.1	1	110	N/A	N/A	N/A	N/A
WHOLE (n)		8	56	730	N/A	11,469	120,211	14
EXPORTS		negligible	0	200	4,822	N/A	70,326	N/A

SUPPLY	**IMPORTS**	5.3	48	480	6,235	N/A	192,656	N/A
	EM	N/A	7	N/A	N/A	N/A	N/A	N/A
	AG	2.7	N/A	N/A	N/A	N/A	21,815	N/A



*Punjab, India (2010)**

FLOWS

fully dependent on external energy

** numbers may not add up due to rounding*

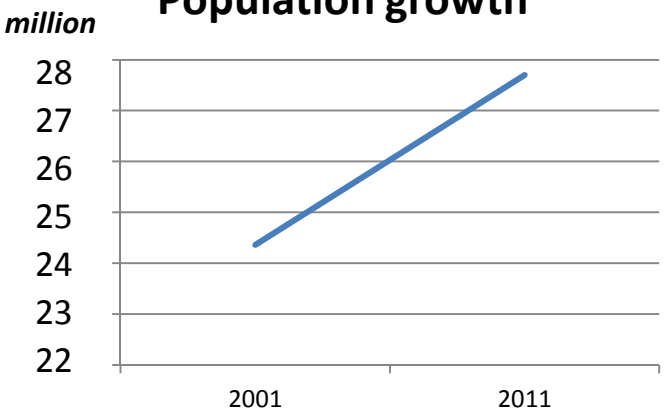
MuSIASEM as a diagnostic tool: Punjab

GDP p.c. and Share of Agriculture in GDP

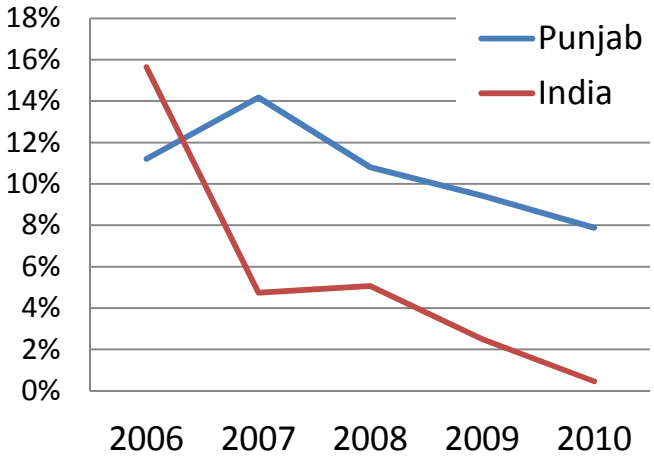
State	GDP p.c. (US$ ppp) (2005-06)	Share of Agriculture as % of Total GDP
Puducherry	6,600	5
Haryana	5,300	20
Maharashtra	4,700	10
Punjab	4,300	31
Gujarat	4,100	16
Kerala	4,000	17

The special situation of Punjab I

Population growth



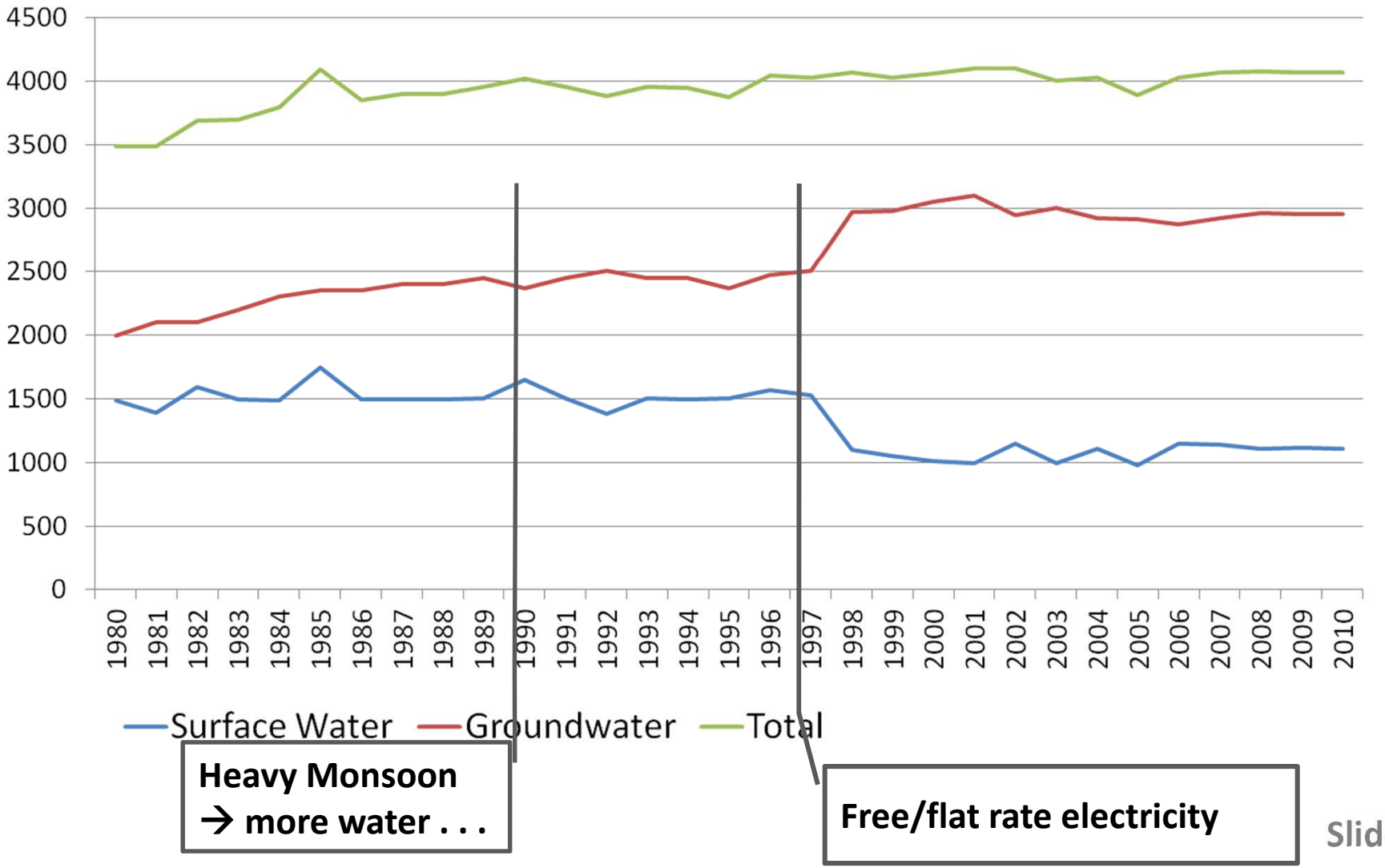
Remittances as % of GDP



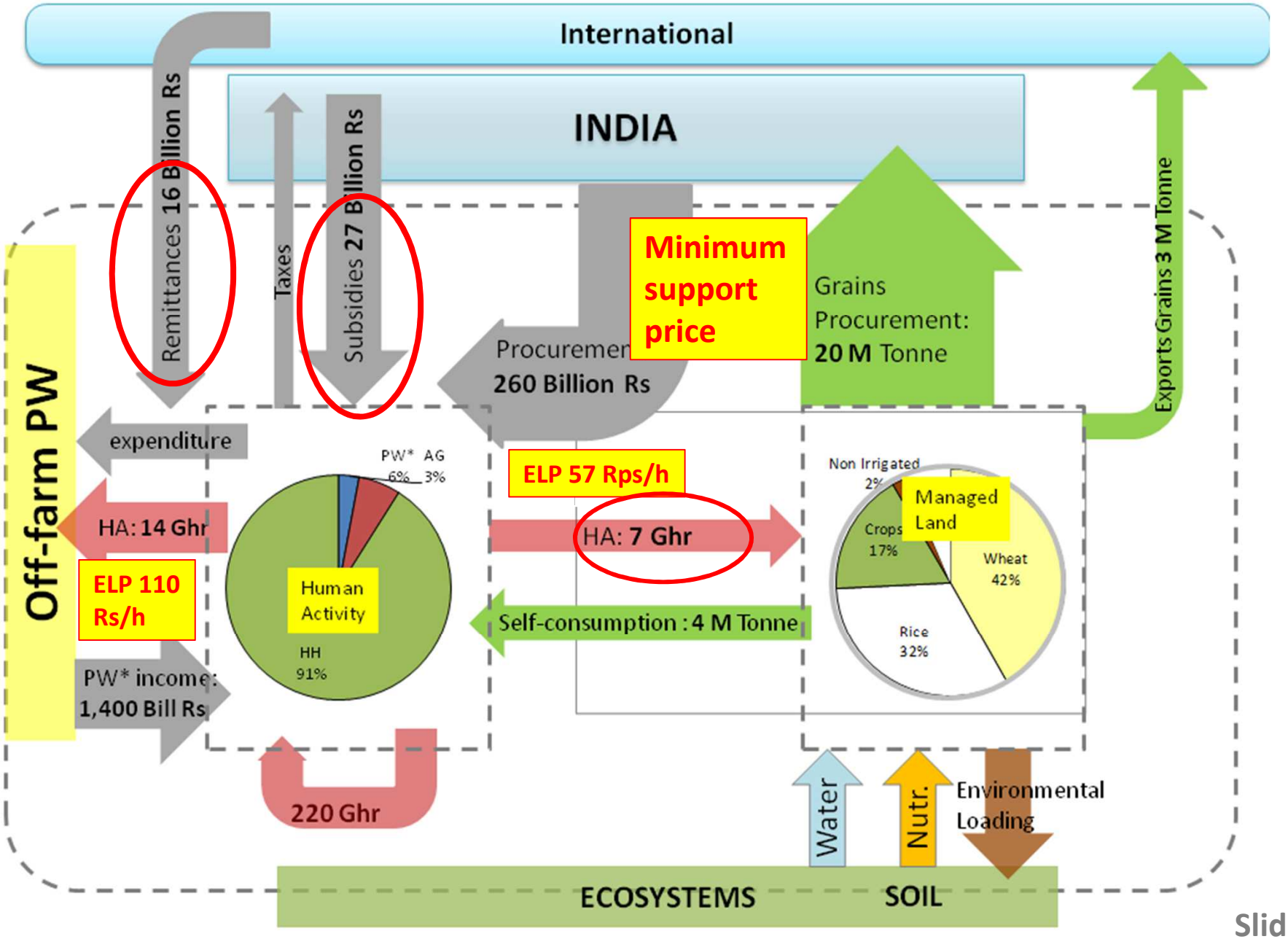
Economic Labour Productivity

Economic Sector	Economic Labour Productivity ($/hour)
Agriculture, forestry and fishing	1.6
Manufacturing	3.6
Construction	1.2
Wholesale, retail trade	3.1
Transport, storage	4.2
Financing, insurance	3.1

Subsidies: addressing an internal constraint . . .

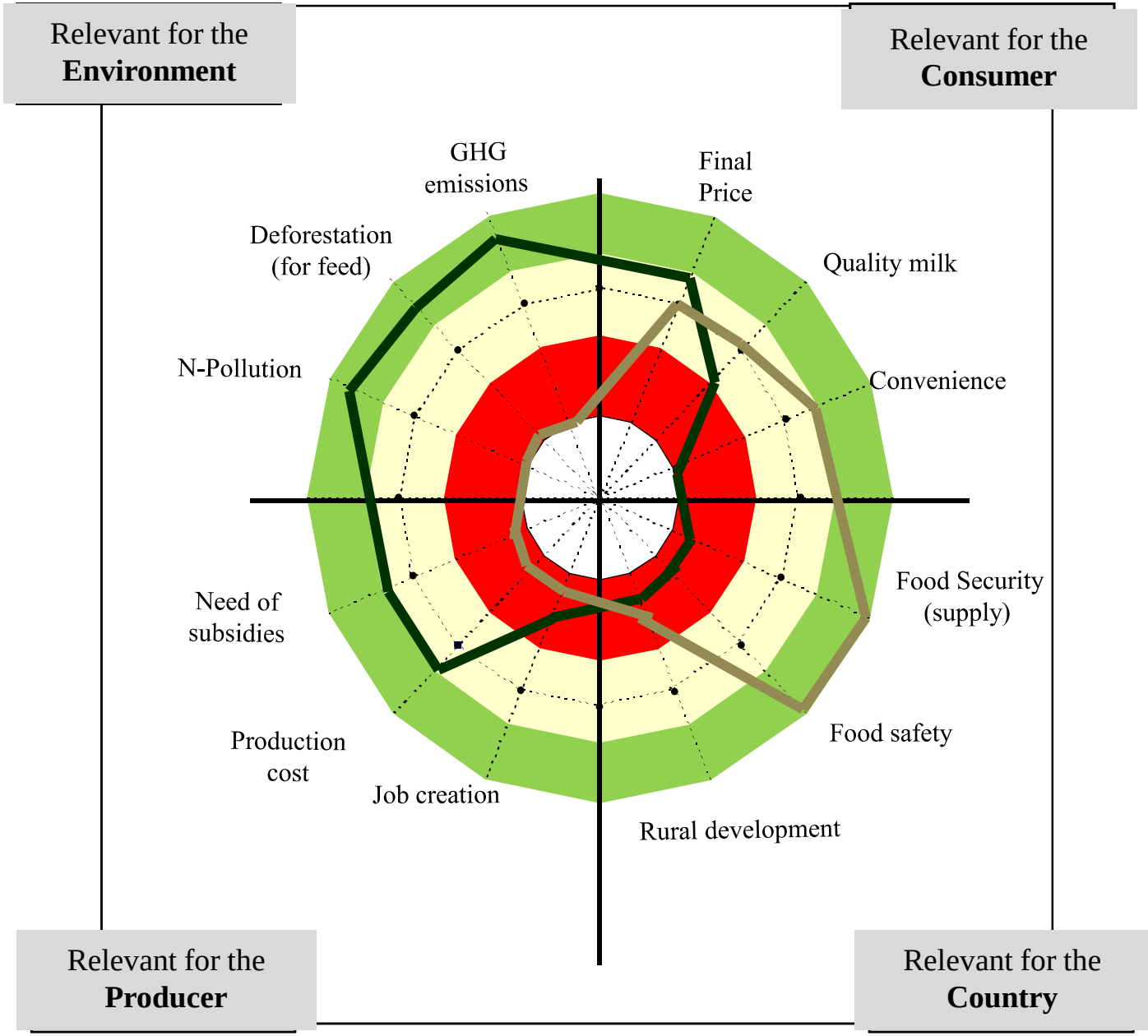


5. MuSIASEM as a simulator tool: scenarios in Punjab

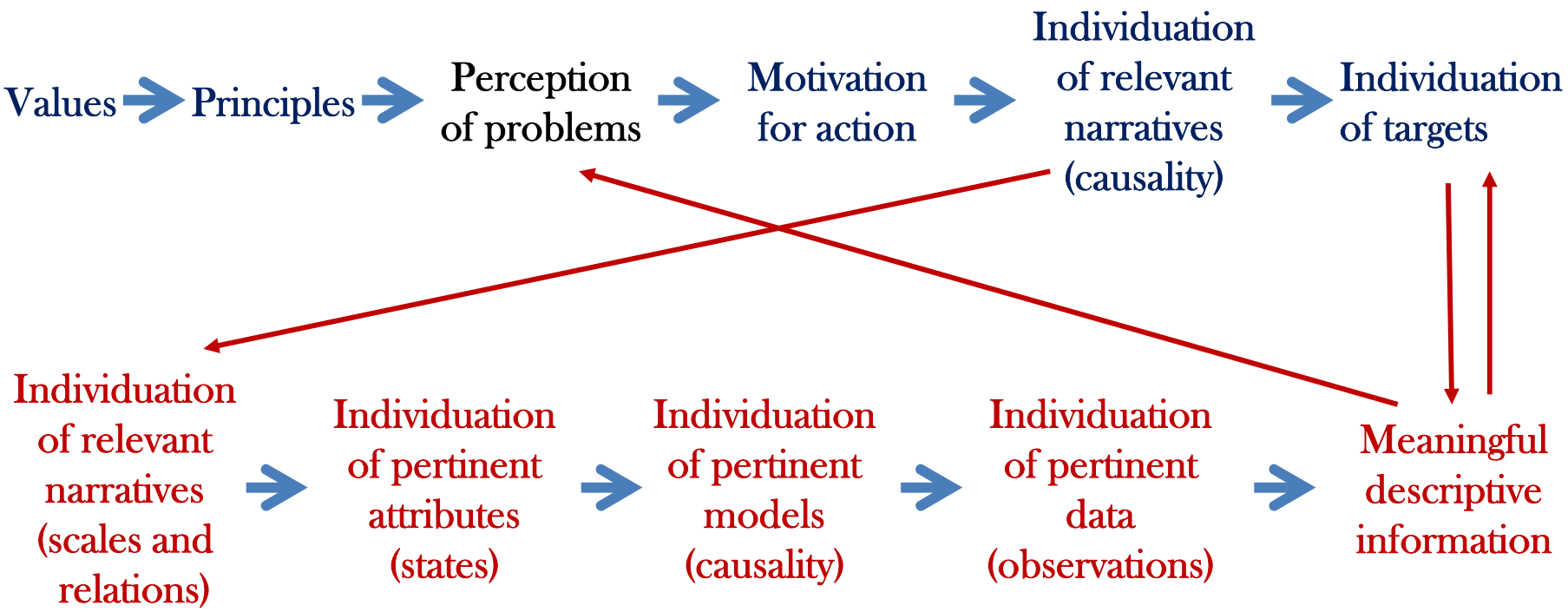


Participatory Integrated Assessment: the unavoidable entanglement between "normative" and "descriptive"

Lessons learned from the PARTICIPIA Project:
Participatory Integrated Assessment of Energy Systems to Promote Energy Access and Efficiency
http://www.participia.net/


Relevant for the **Environment**
Relevant for the **Consumer**
GHG emissions
Final Price
Deforestation (for feed)
Quality milk
N-Pollution
Convenience
Need of subsidies
Food Security (supply)
Production cost
Food safety
Job creation
Rural development
Relevant for the **Producer**
Relevant for the **Country**

Chain of choices leading to the selection of an indicator on the NORMATIVE SIDE



Chain of choices leading to the selection of an indicator on the DESCRIPTIVE SIDE

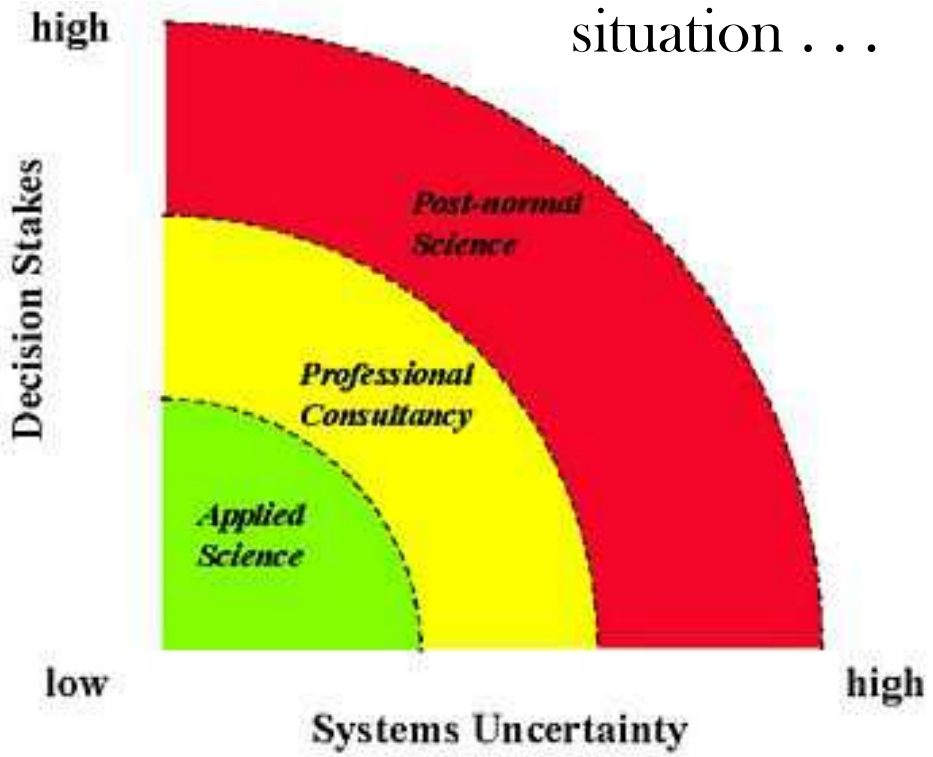
NORMATIVE SIDE

Values Principles

Perception of problems Motivation for action

Individuation of relevant narratives (causality) Individuation of targets

When operating in a Post-Normal Science situation . . .



Individuation of relevant narratives (scales and relations)

Individuation of pertinent attributes (states)

Individuation of pertinent models (causality)

Individuation of pertinent data (observations)

Meaningful descriptive information

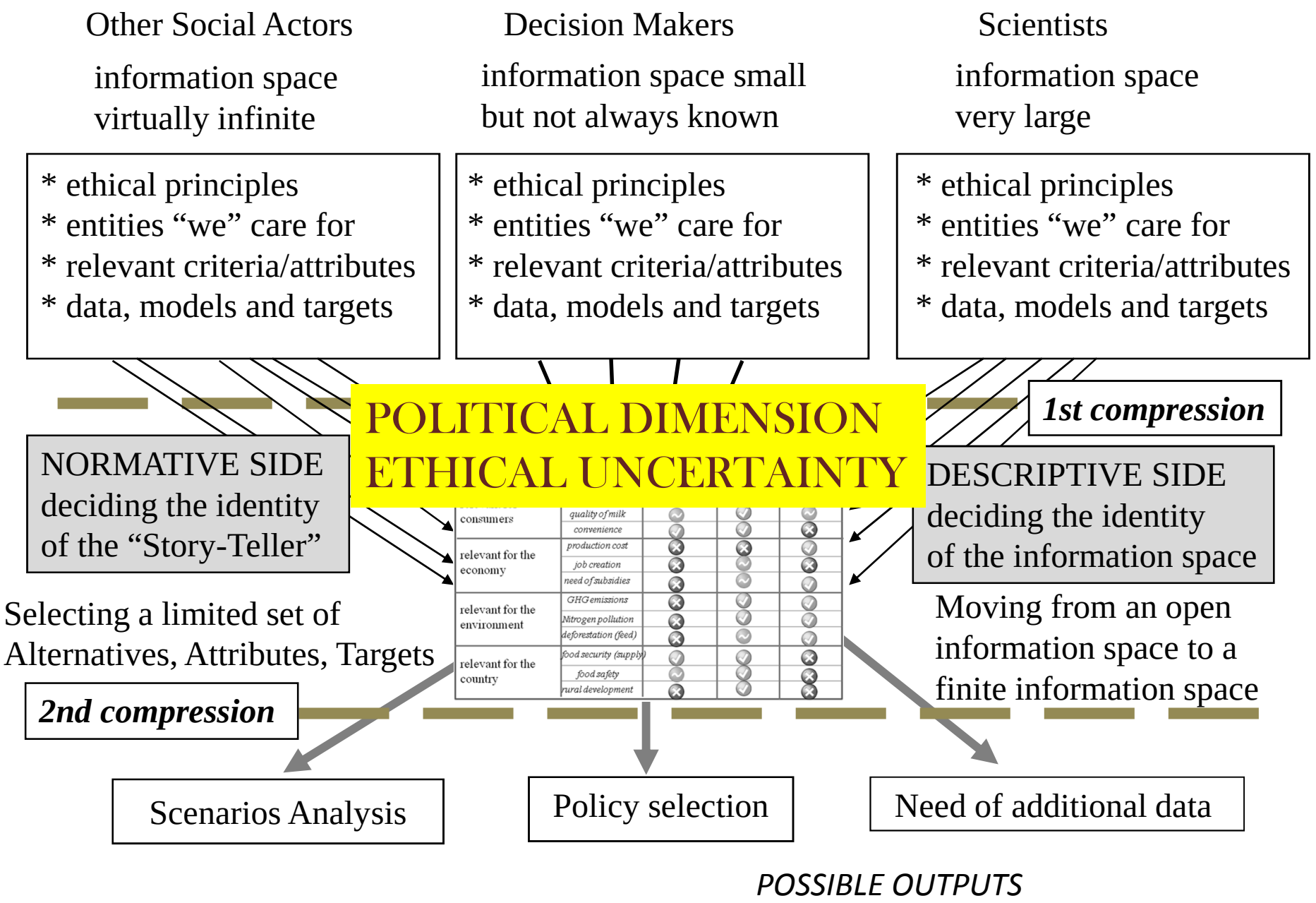
DESCRIPTIVE SIDE

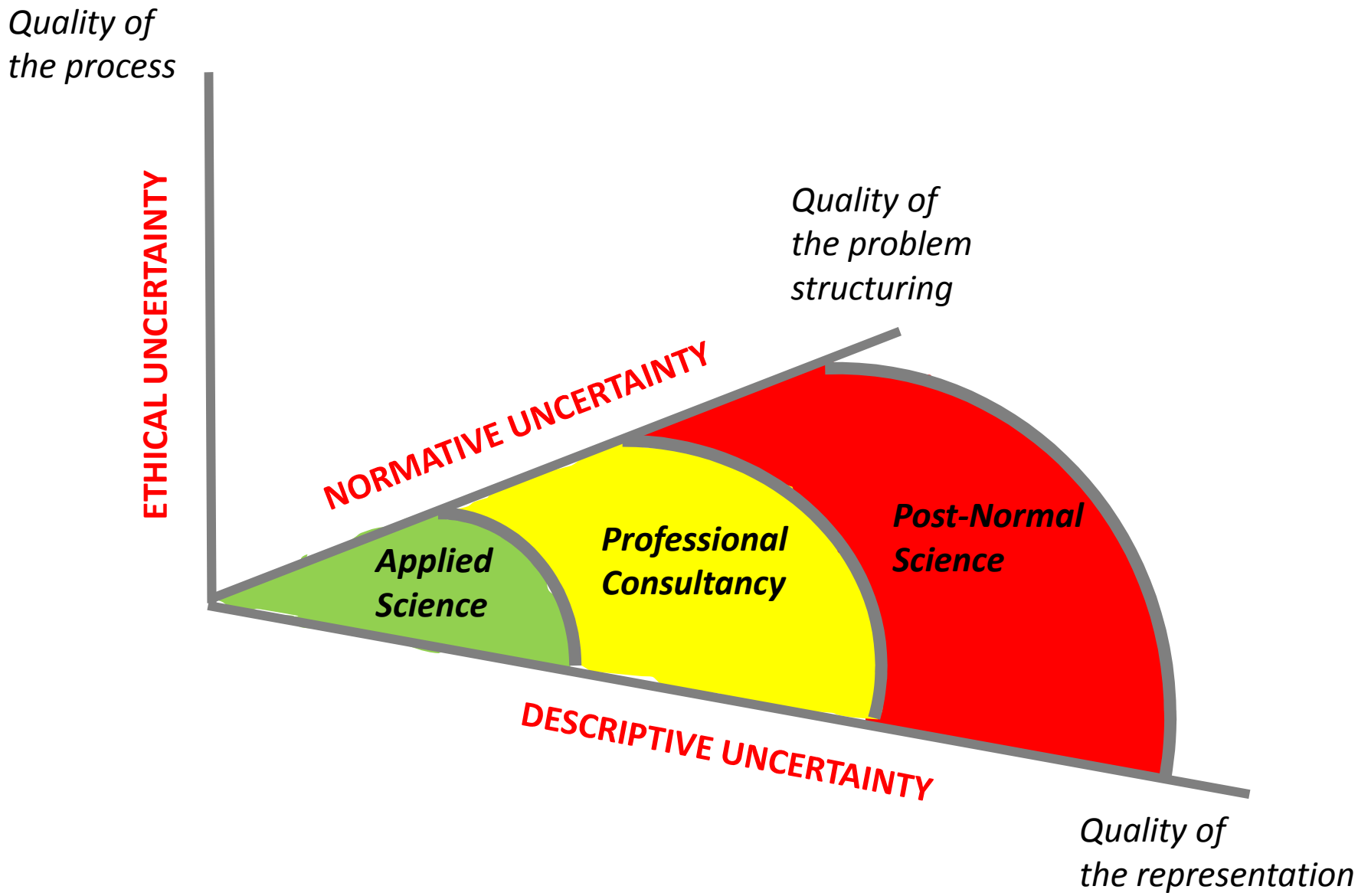
NORMATIVE UNCERTAINTY

ENTITIES CONSIDERED AS RELEVANT	RELEVANT ATTRIBUTES	CONSIDERED ALTERNATIVES		
		"High Tech" commodity for the market	"Organic" quality product for the market	"household" subsistence
the consumer	*final price*	**GOOD**	**MORE OR LESS**	**GOOD**
	quality of milk	**MORE OR LESS**	**GOOD**	**MORE OR LESS**
	convenience	**GOOD**	**BAD**	**BAD**
the producer	*production cost*	**MORE OR LESS**	**MORE OR LESS**	**GOOD**
	available subsidies	**GOOD**	**MORE OR LESS**	**BAD**
	risk protection	**MORE OR LESS**	**MORE OR LESS**	**BAD**
the country	*reliable supply*	**GOOD**	**MORE OR LESS**	**MORE OR LESS**
	food safety	**GOOD (?)**	**GOOD**	**BAD**
	rural development	**BAD**	**GOOD**	**BAD**
the environment	*GHG emission*	**BAD**	**GOOD**	**GOOD**
	N leakages	**BAD**	**GOOD**	**GOOD**
	deforestation (feed)	**BAD**	**MORE OR LESS**	**GOOD**

DESCRIPTIVE UNCERTAINTY

Problem Structuring: a brutal simplification of the information space




Quality of
the process
ETHICAL UNCERTAINTY
Quality of
the problem
structuring
NORMATIVE UNCERTAINTY
Applied
Science
Professional
Consultancy
Post-Normal
Science
DESCRIPTIVE UNCERTAINTY
Quality of
the representation

EQUITY MATRIX APPLIED TO THREE ALTERNATIVES OF MILK PRODUCTION

ENTITIES CONSIDERED AS RELEVANT	High tech commodity for the market	Organic quality product for the market	Traditional subsistence production
the consumer	low price; concerns about health and taste	higher price; better milk quality	Very low convenience
the produ			ve; nic y
the country (government)	robust supply	reducing tensions in the food chain	lack of rural development
the environment	externalization on supply side; bad on sink side	better on both sides (depending on density)	OK if population density low

Discusing the quality of the option space:
Are these the more useful alternatives?

‘red’–bad ‘yellow’–so-so ‘green’–good

IMPACT MATRIX APPLIED TO ALTERNATIVES OF MILK PRODUCTION

ENTITIES CONSIDERED AS RELEVANT	RELEVANT ATTRIBUTES	CONSIDERED ALTERNATIVES		
		High tech commodity for the market	Organic quality product for the market	Household subsistence
the consumer	*final price*	GOOD	MORE OR LESS	GOOD
	quality of milk	MORE OR LESS	GOOD	MORE OR LESS
				AD
the produ				OOD
				AD
	risk protection	MORE OR LESS	MORE OR LESS	BAD
the country	*reliable supply*	GOOD	MORE OR LESS	MORE OR LESS
	food safety	GOOD (?)	GOOD	BAD
	rural development	BAD	GOOD	BAD
the environment	*GHG emission*	BAD	GOOD	GOOD
	N leakages	BAD	GOOD	GOOD
	deforestation (feed)	BAD	MORE OR LESS	GOOD

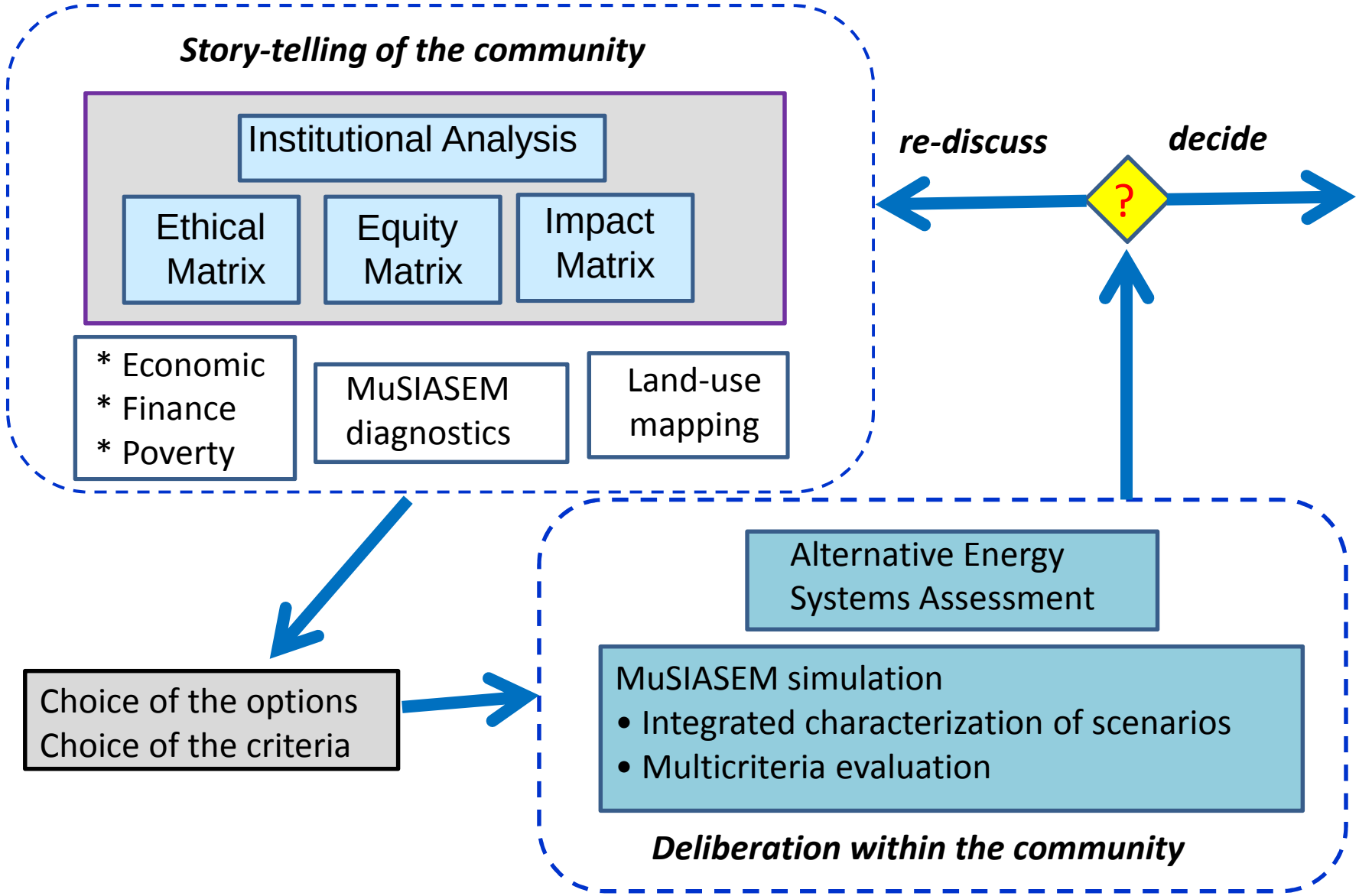
Discusing the quality of the representation:
Are these the more useful indicators?

ETHICAL MATRIX APPLIED TO ALTERNATIVES OF MILK PRODUCTION

ENTITIES WE SHOULD CARE FOR	ETHICAL PRINCIPLES			
	Preserve Wellbeing (health & welfare)	Improve Wellbeing (health & welfare)	Autonomy/Dignity (express identity)	Justice (fairness)
the consumer	*Preserving the existing quality of life*	*Improving the existing quality of life*	*Empowerment Informed choices (labels!)*	*sharing stress*
the produc				*sharing stress*
the country				*sharing stress*
the environment	*Conserving the environment*	*Restoring the environment*	*Let biodiversity express itself*	*sharing stress*
the cow	*Preserving the existing cow welfare*	*Improving the existing cow welfare*	*Behavioural Freedom*	*sharing stress*

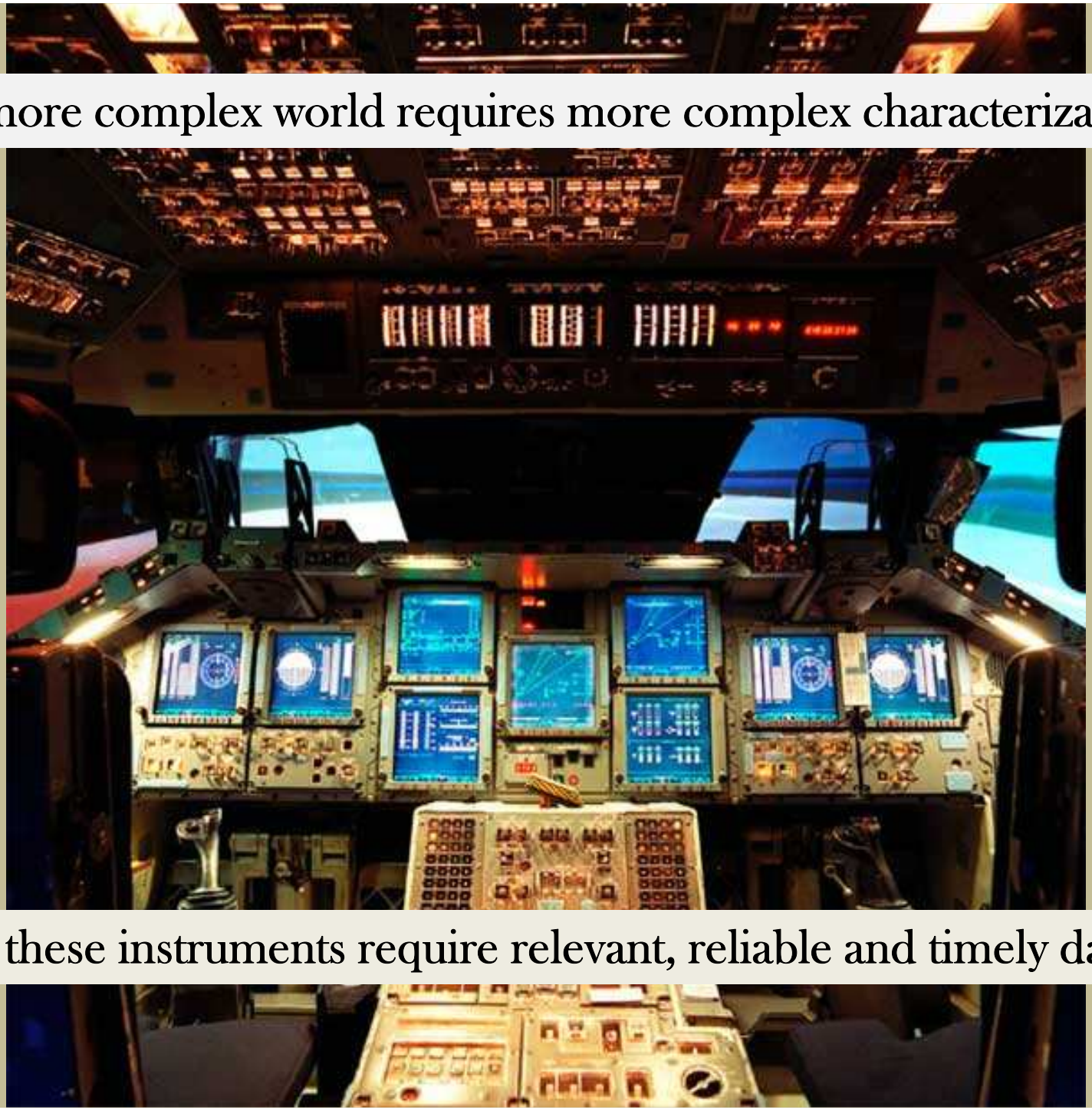
Discusing the quality of the process:
Are we including all the relevant entities that "***we***" should care for?

PARTICIPATORY INTEGRATED ASSESSMENT



MuSIASEM: Multi-scale Integrated Analysis of Societal and Ecosystem Metabolism

A more complex world requires more complex characterizations



All these instruments require relevant, reliable and timely data!

Mario GIAMPIETRO

Jesus RAMOS

Sandra BUKKENS

Pedro LOMAS

François MAURIN

Alevgul SORMAN

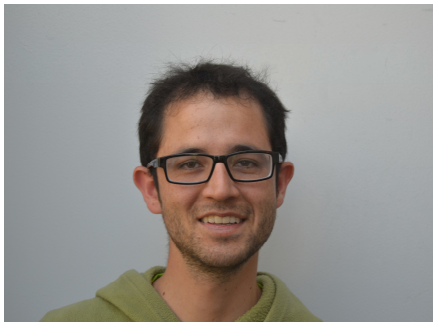
Tiziano GOMIERO

Gonzalo GAMBOA

Zora KOVACIC

Cristina MADRID

Juan CADILLO



Tarik SERRANO

IASTE

Integrated Assessment:
Sociology Technology
and the Environment