

Mario GIAMPIETRO
ICREA Research Professor



**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





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”

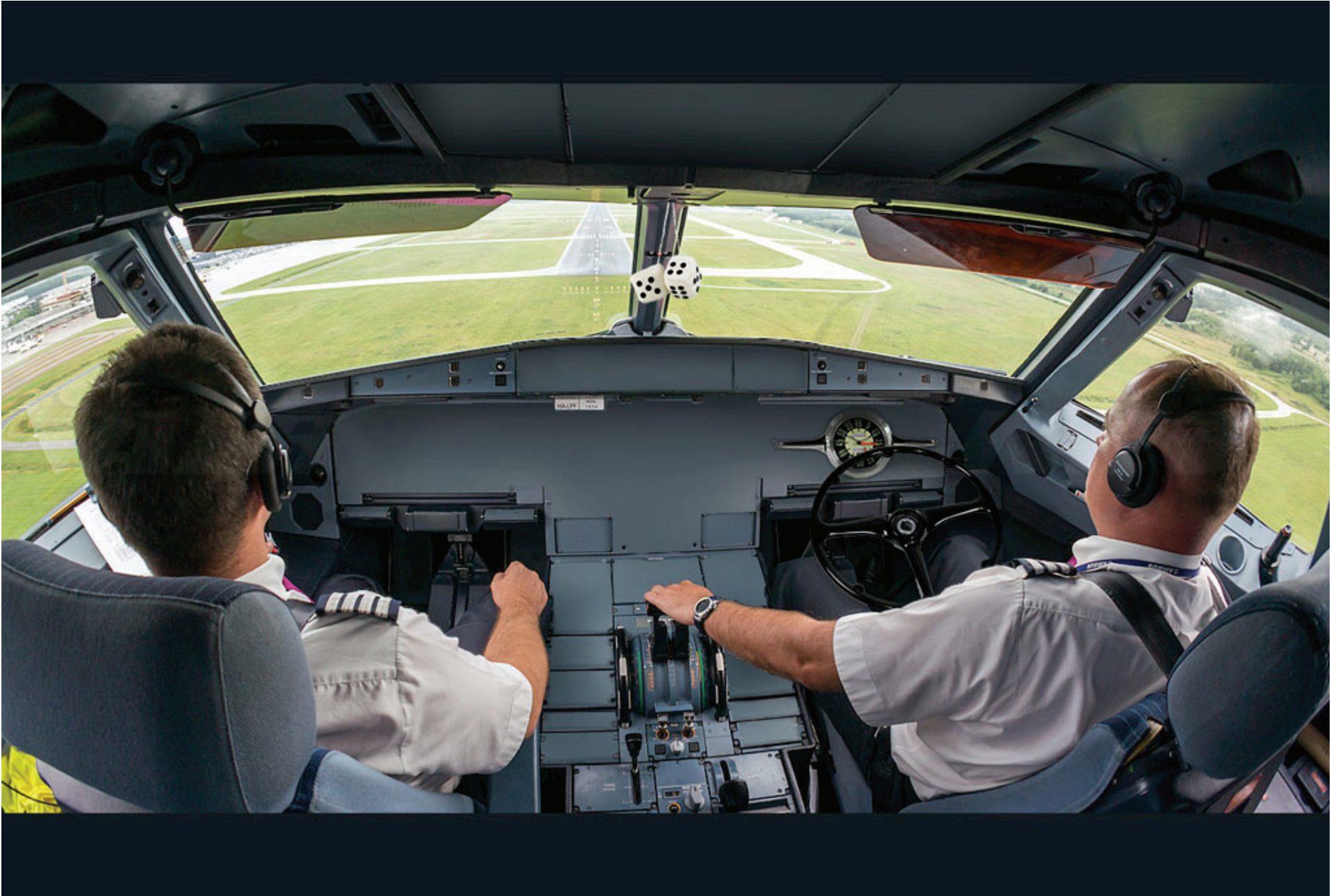
BUT . . .

“Make everything as simple as possible, but not simpler”



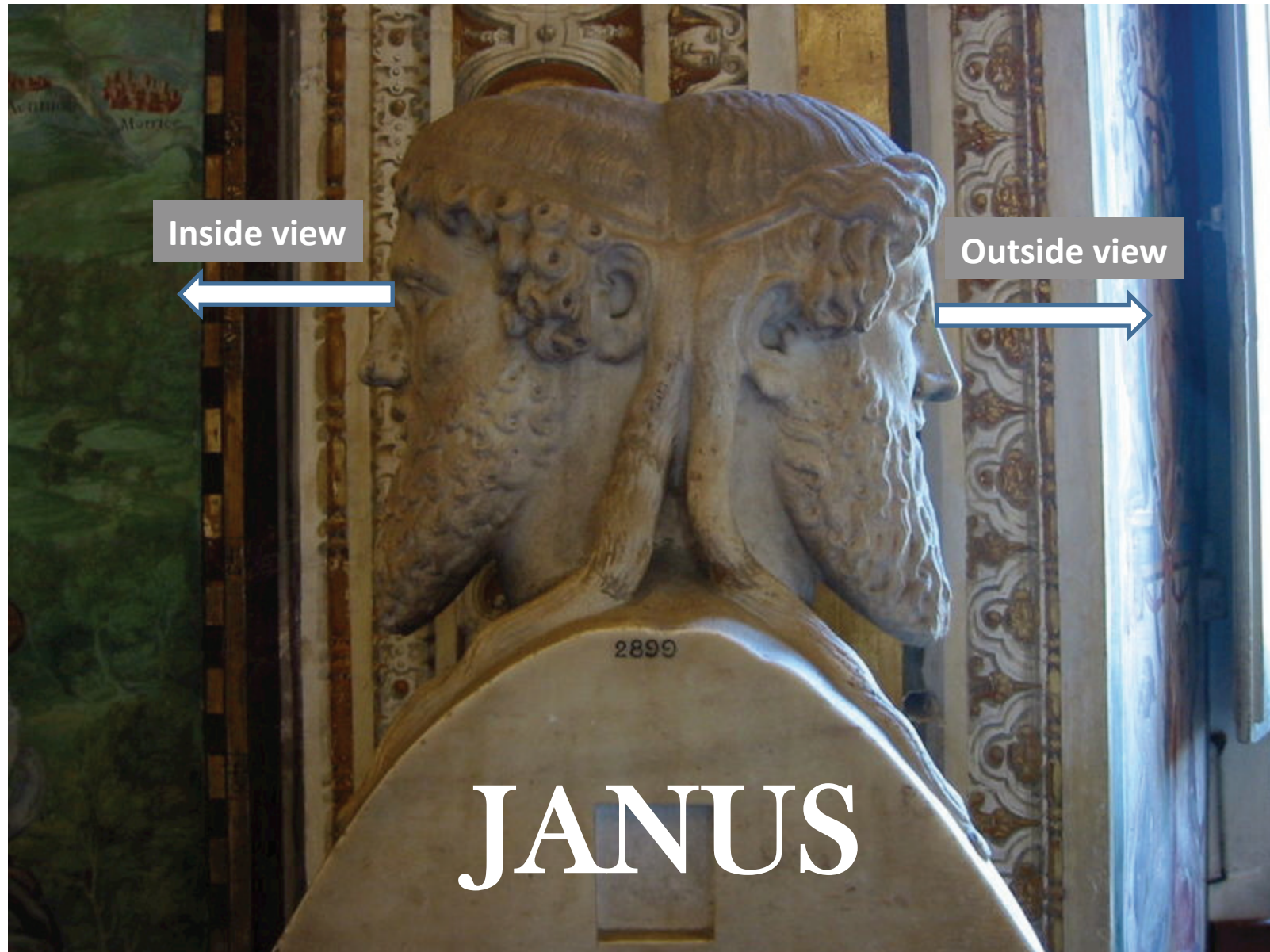


The amount of controls and commands needed by a pilot



Would you fly on this airplane?

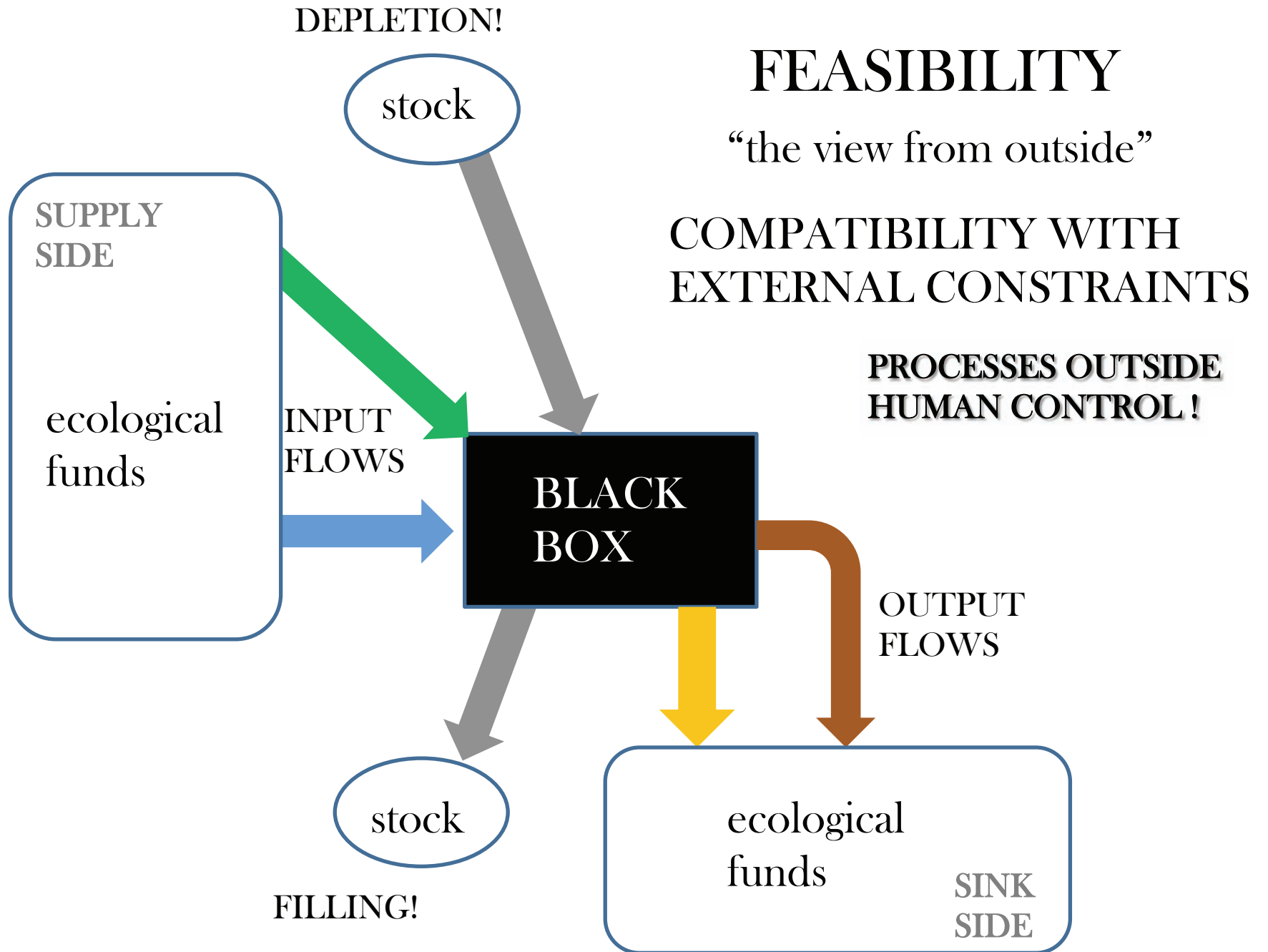
This is where the concept of “HOLON” enters into play . . .



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** – compatibility 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 handle multiple scales and multiple dimensions



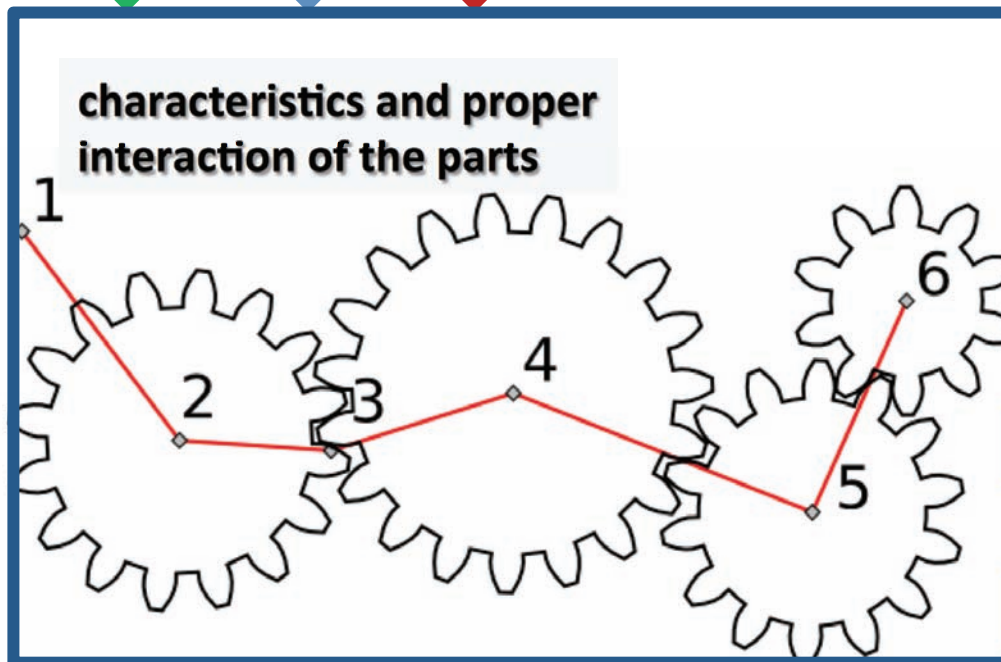
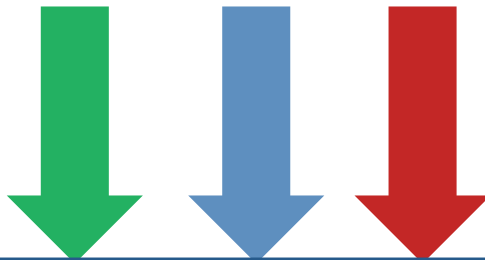
VIABILITY

“the view from inside”

COMPATIBILITY WITH
INTERNAL CONSTRAINTS

PROCESSES UNDER
HUMAN CONTROL

SUPPLY OF NEEDED
INFLOWS AVAILABLE
“BY DEFAULT”



NEEDED SINK CAPACITY
FOR OUTFLOWS AVAILABLE
“BY DEFAULT”



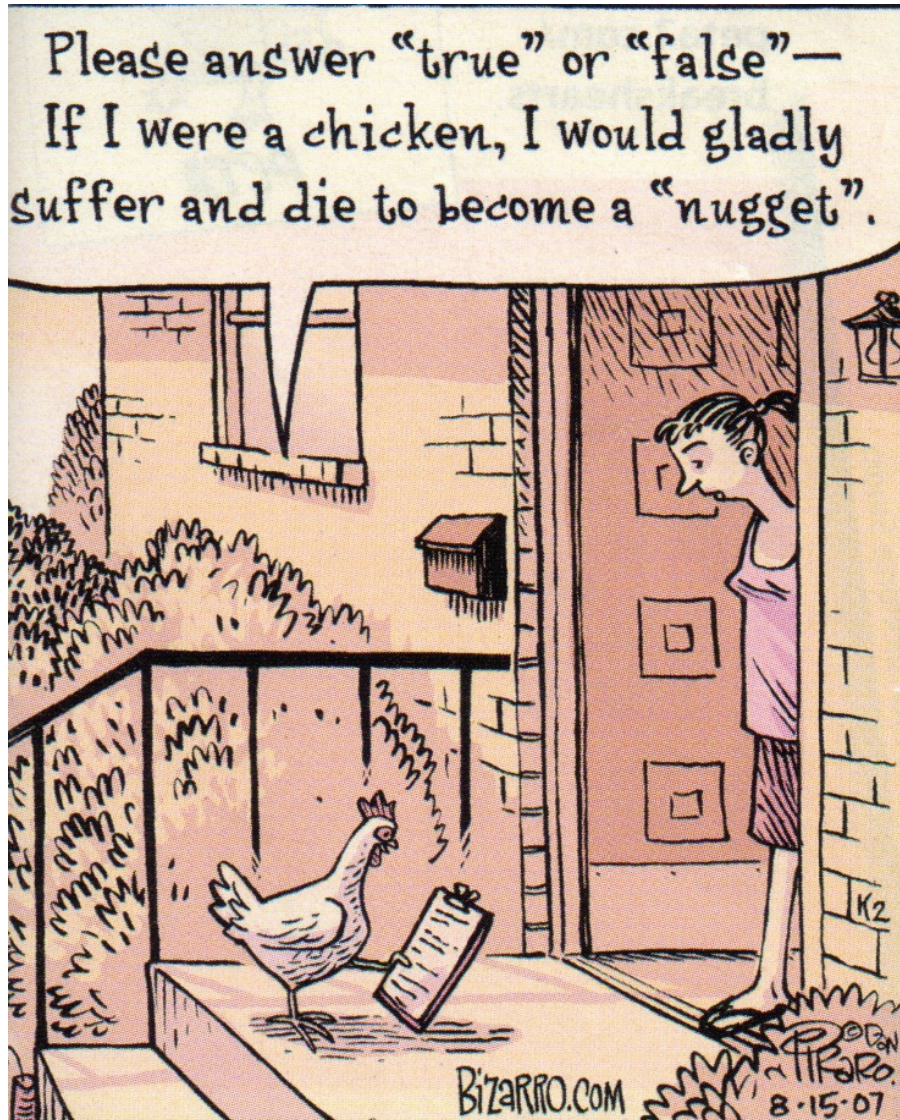
Values, Taboos, Cultural Identity
Path Dependence (history matters . . .)

DESIRABILITY

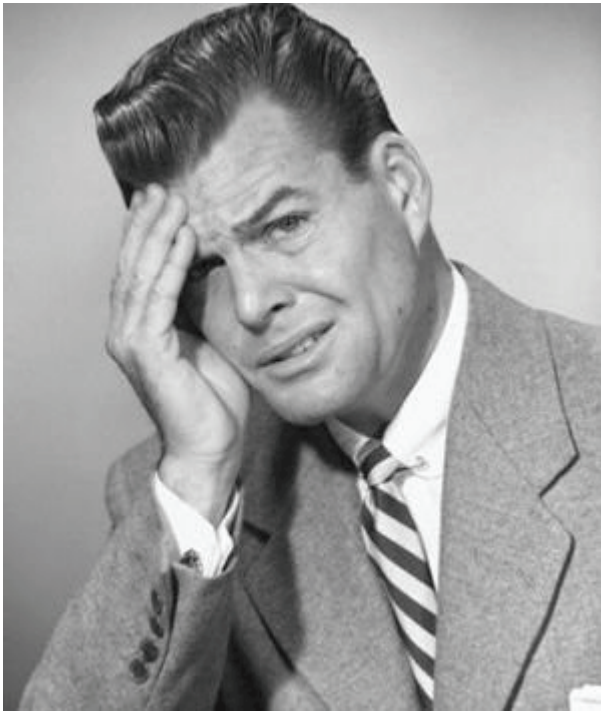
“whose view counts?”

COMPATIBILITY WITH
SOCIAL INSTITUTIONS

PROCESSES UNDER
HUMAN CONTROL



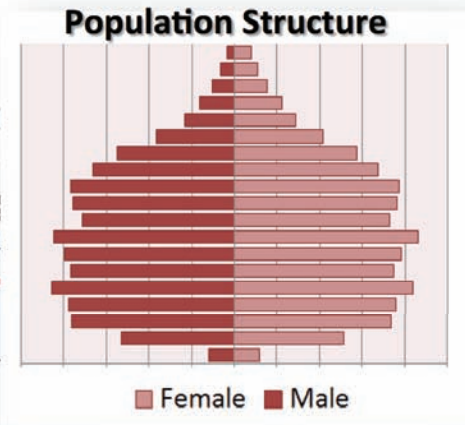
Lessons learned from the FAO-GIZ project
the nexus between food, energy, water and land use
<http://nexus-assessment.info/>



The epistemological predicament faced
when accounting food flows

Dietary needs of the population

Inside view



FLOW elements

	Food (PJ)	Energy (PJ-G)
HH	5.9	15
SG	0.8 losses	21
BM		23 250
AG	1.3	0 110 50
EM	negl	2 260 8
exp		0

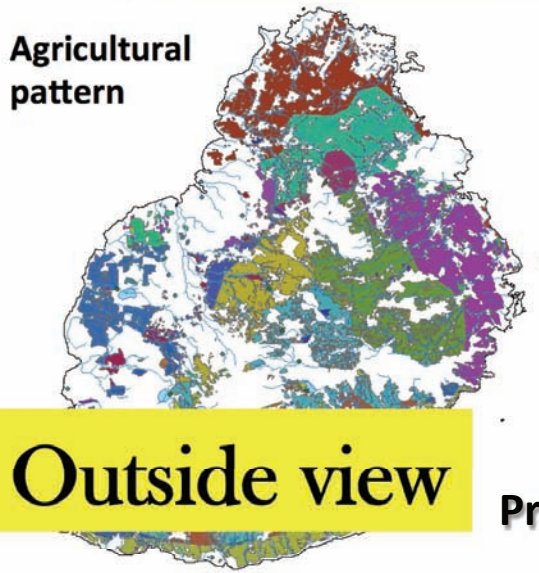
elements

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

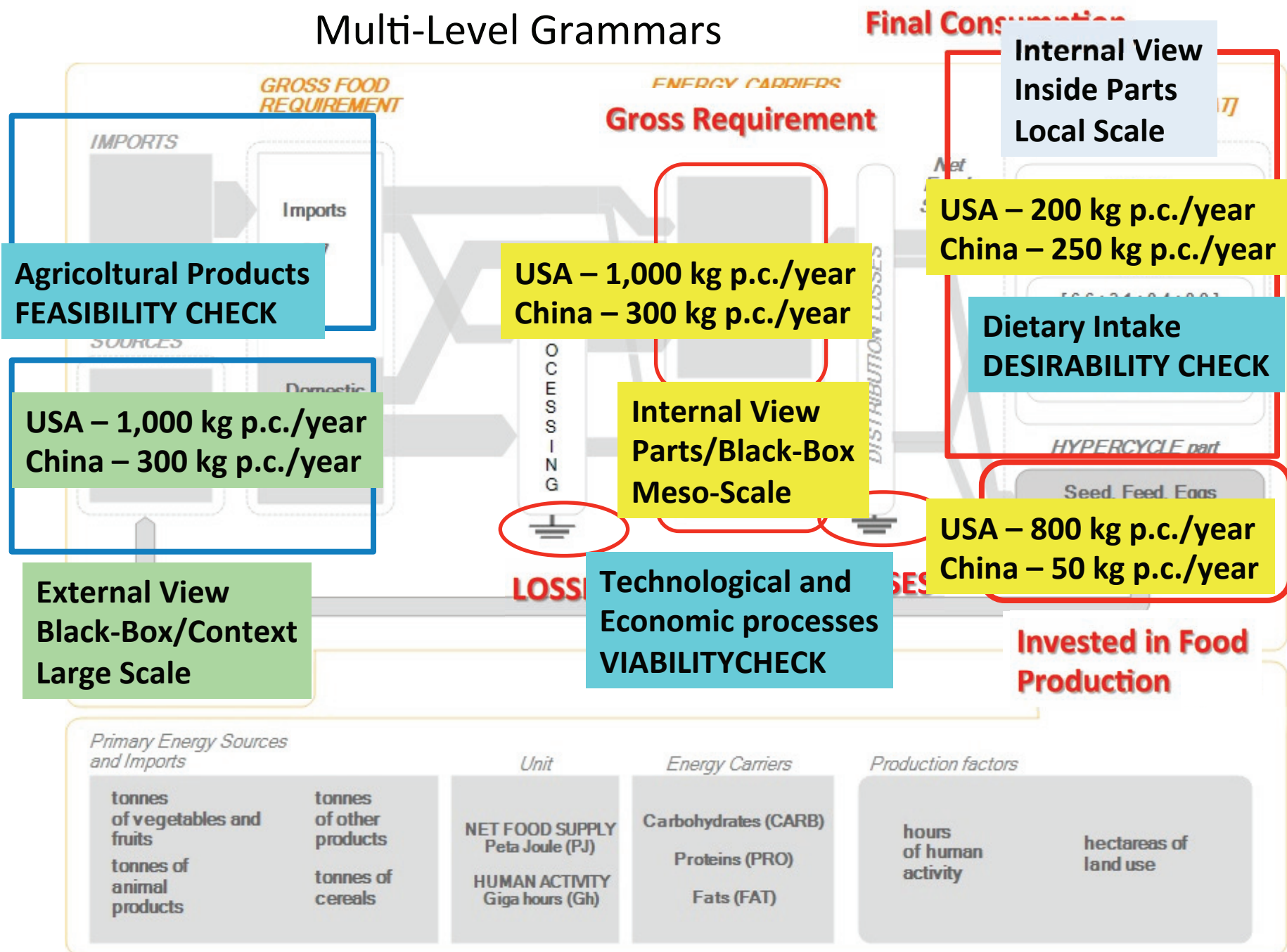


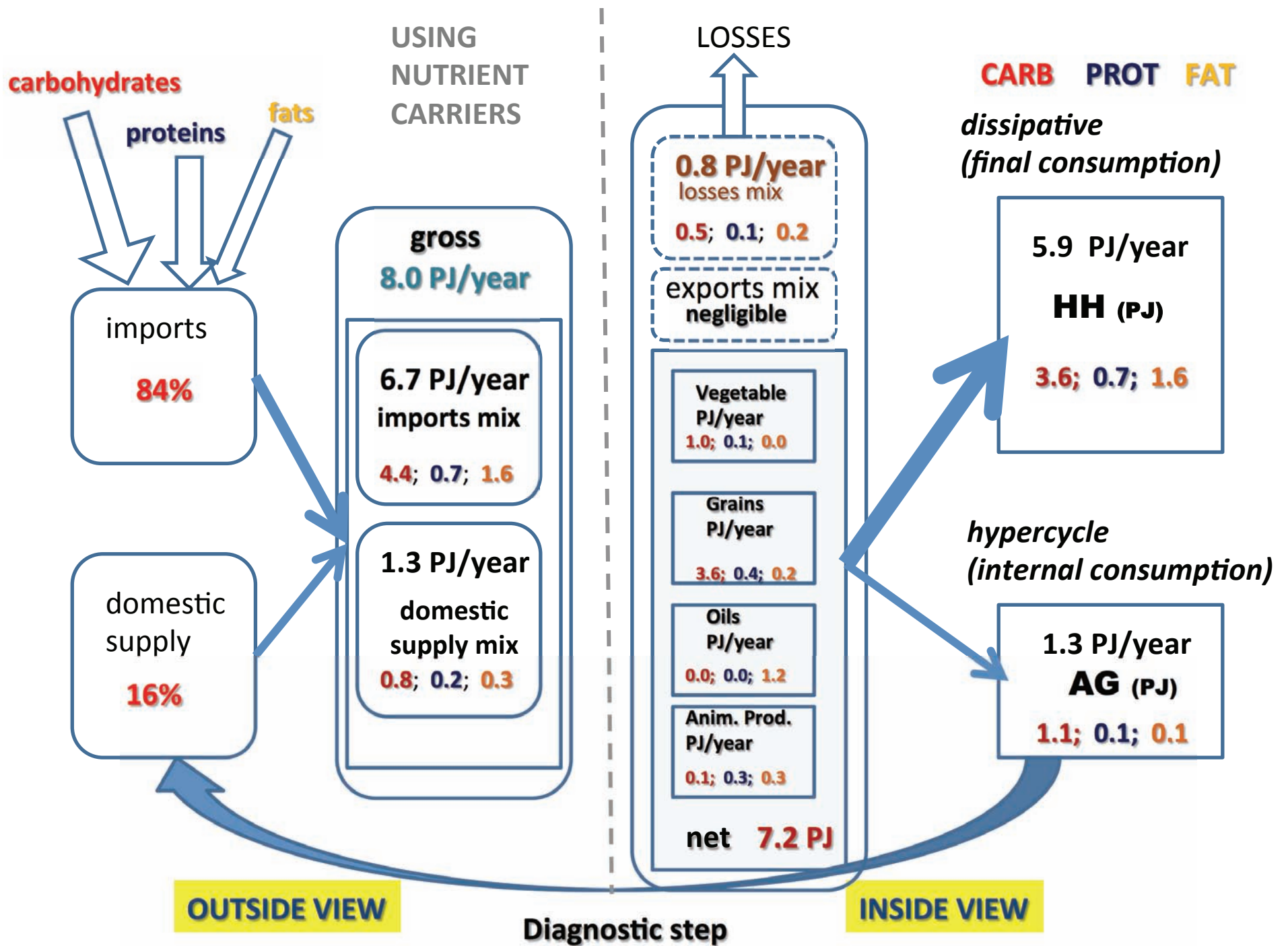
Outside view

Primary Agricultural Products

Nutrients supply by agriculture or imports

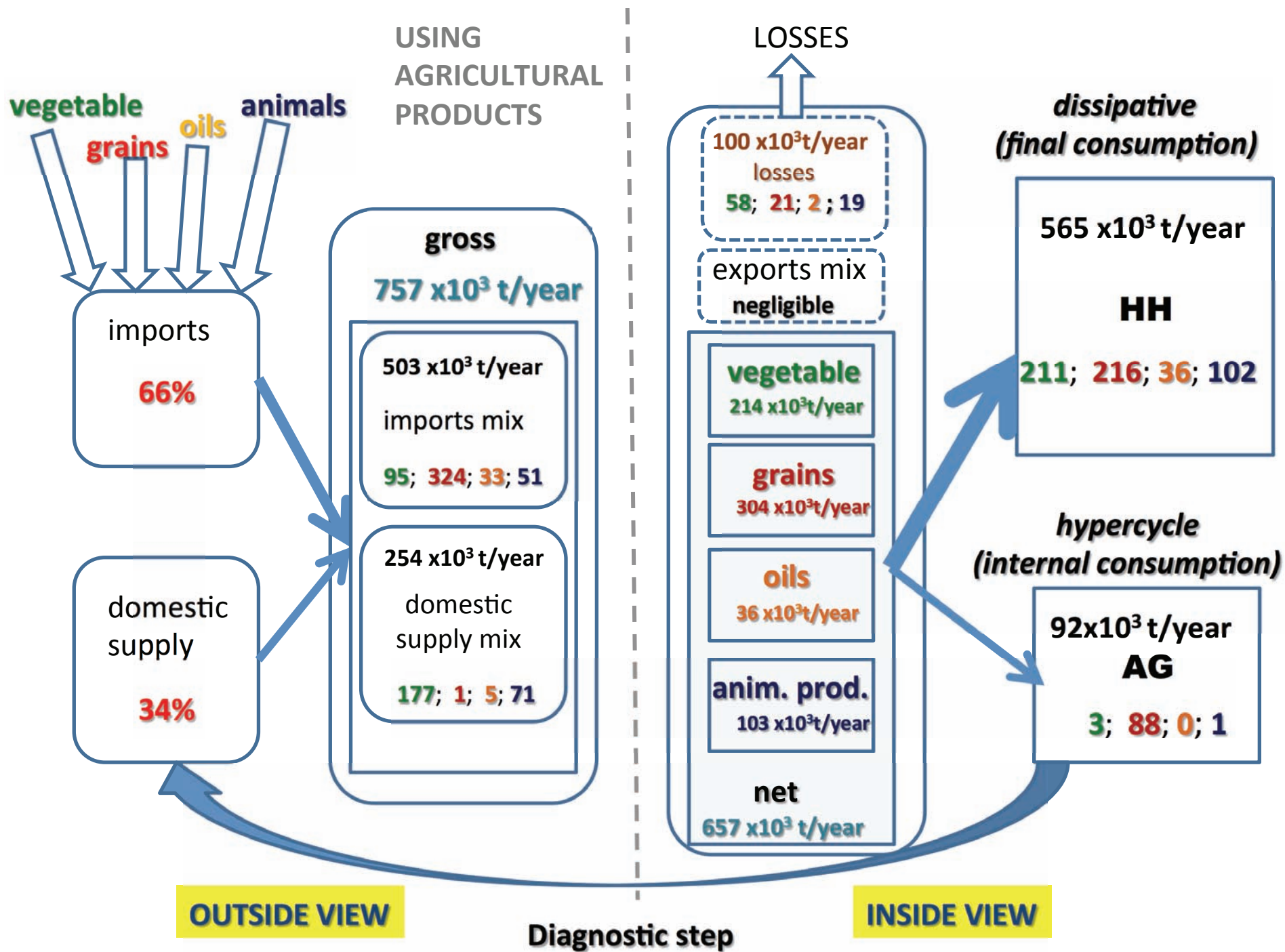
Multi-Level Grammars





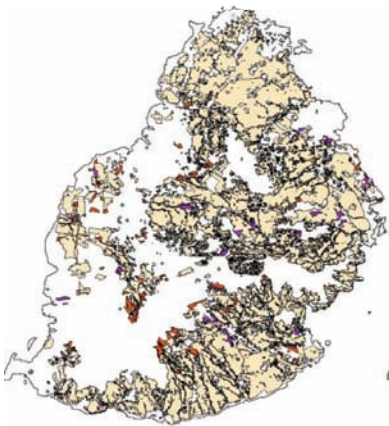
What if we want to implement this food grammar to check the requirement of land and water availability?

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



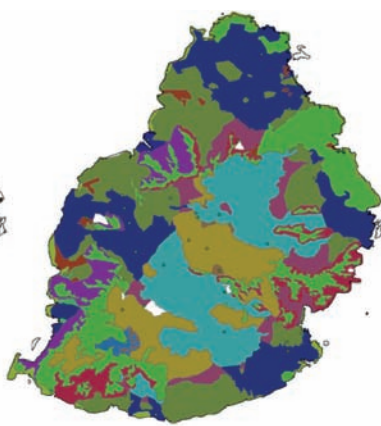
External constraints: checking suitable lands

Sugar Cane



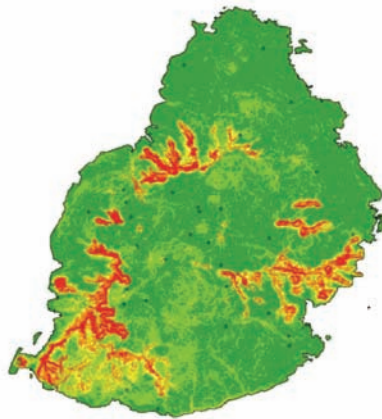
Check of Previous Locations

Types of Soil

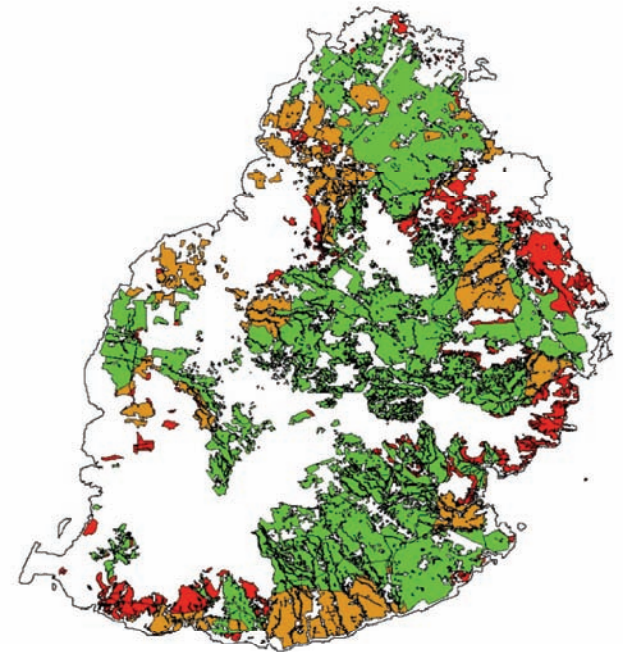


+ Compatibility with soils

Slope



+ Slope compatibility



⇒ suitable land for a different location of crops mix

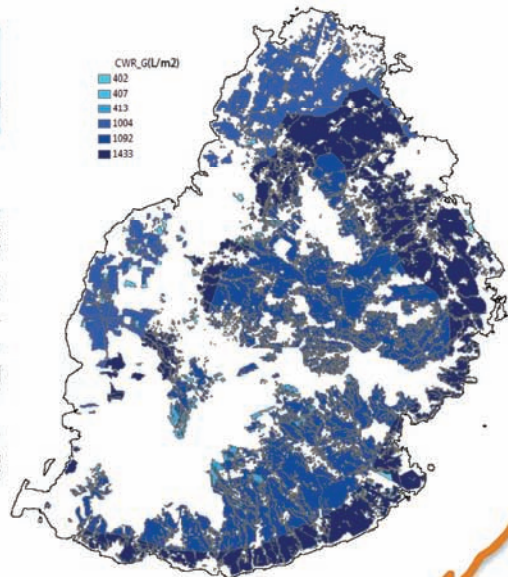
Suitable for new crop mix

Suitable for maize

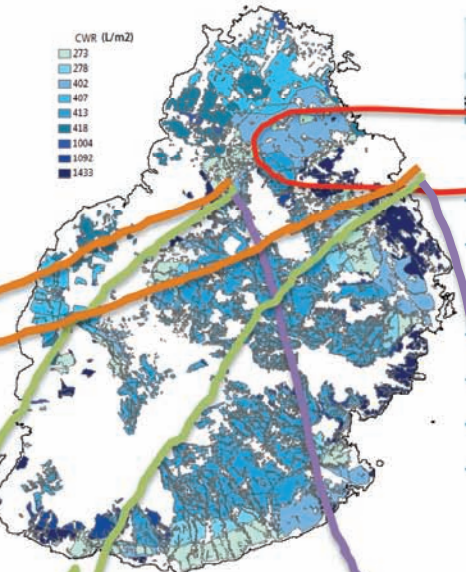
Only suitable for sugarcane



Unit
Crop/
Group
Maize
Potato
Sweet
Cassava
Taro
Beans



	hm3	hm3
g-2	USE g-2	USE b -3
0	1	
0	0	
0		
0		
0		
0		
0		
0		



	hm3	
seen	USE total	
6	6	
1	1	
4	4	
0	0	
0	0	
0	0	
1	1	

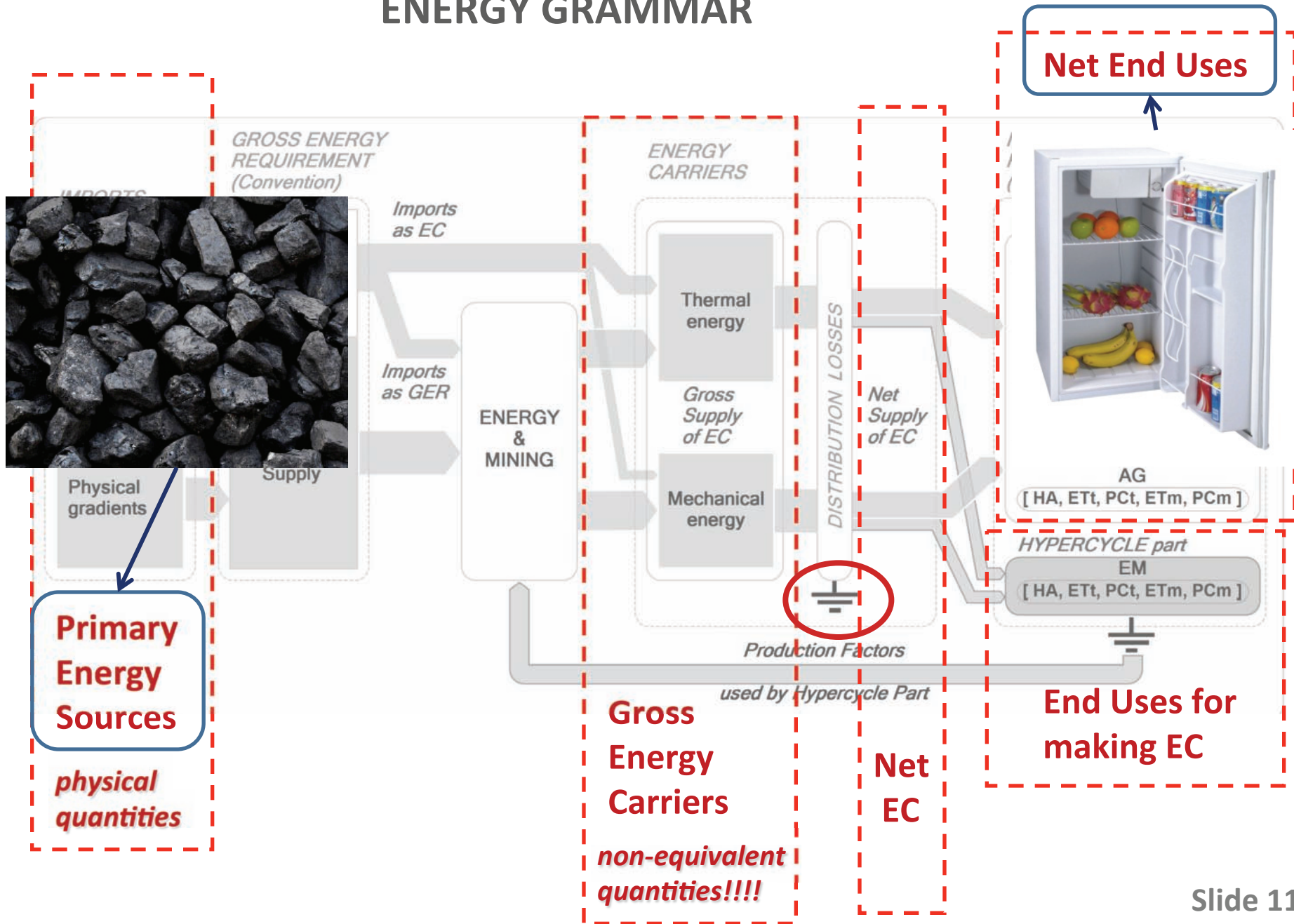
Unit	ha	mm (l/m2)	mm (l/m2)	ha	mm (l/m2)	mm (l/m2)	ha	mm (l/m2)	mm (l/m2)	ha
Crop/Indicator	Area Harvested	BCWR 1	GCWR 1	AREA 1	BCWR 2	GCWR 2	AREA 2	BCWR 3	GCWR 3	AREA 3
Group 1	1,880	0	300	1,122	0	289	445	0	386	312
Maize	335	0	278	200	0	273	79	0	418	56
Potatoes	1,072	0	320	640	0	316	254	0	478	178
Sweet 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	

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 energy flows

ENERGY GRAMMAR



Slide 11

EXTERNAL VIEW

INTERNAL VIEW

REQUIRED PHYSICAL GRADIENTS

Stock-flow
(non-renewable PES)

Fund-flow
(renewable PES)

Sink Capacity

domestic	Sink-side	Supply-side
coal	27.4 Mton CO ₂	9.3 Mtonnes
oil	0.9 Mton CO ₂	0.3 Mtonnes
gas	0.9 Mton CO ₂	0.4 Gm ³
nuclear	mine wastes	see imports
hydro/wind	heat	kinetic energy
biofuels	N, P, Pesticides	land, water, soil
coal	60.2 Mton CO ₂	20.4 Mtonnes
oil	221.7 Mton CO ₂	69 Mtonnes
gas	59.1 Mton CO ₂	27 Gm ³
uranium	2.14 kton HLW	1,244 tonnes
imports		

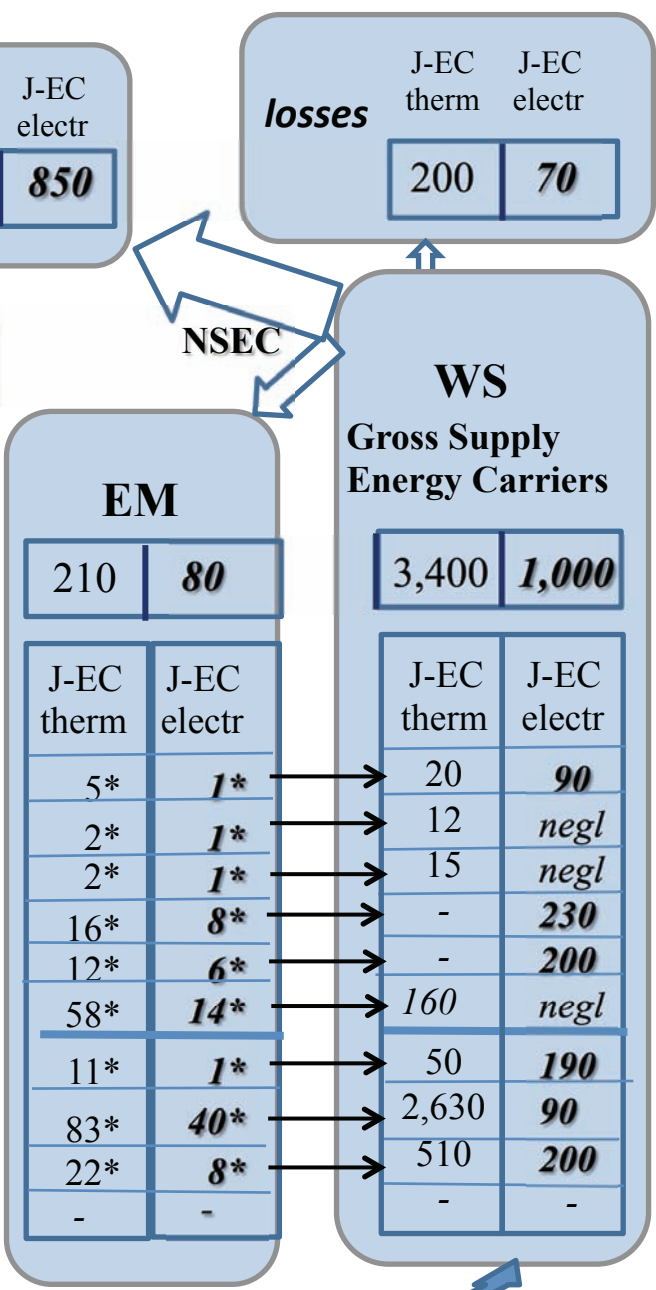
ENERGY SYSTEMS CONVERTING PES → EC within EM

PRIMARY ENERGY SOURCES

Proxies [5,720] 3,400 [2,670] 6,070

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

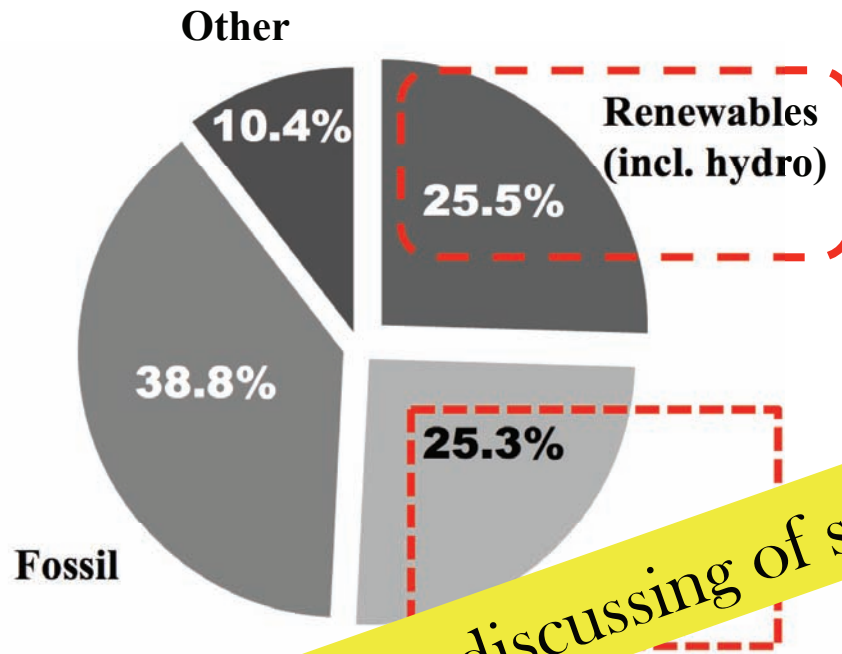


Spain 2004

Data are in PJ

BP statistics
US statistics

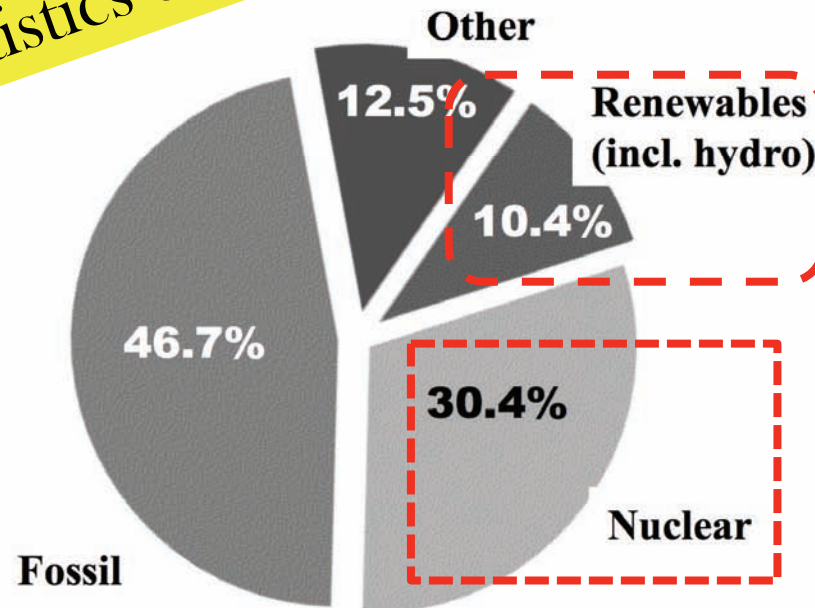
Partial
Substitution
Method



SWEDEN

Eurostat statistics
IEA

Physical
Energy
Content
Method



Are energy statistics useful for discussing of sustainability?

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

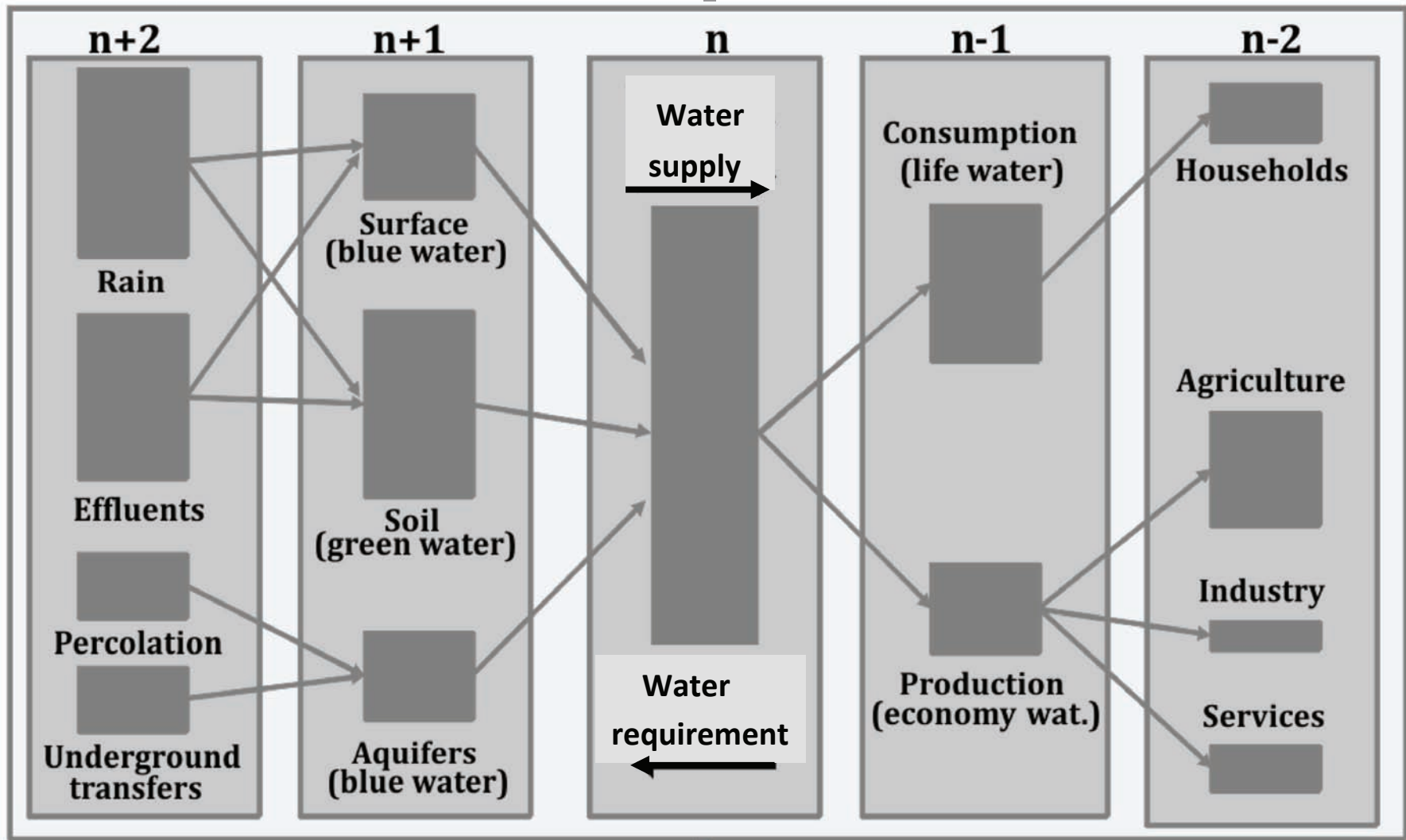
Lessons learned from the FAO-GIZ project
the nexus between food, energy, water and land use
<http://nexus-assessment.info/>



The epistemological predicament faced
when accounting water flows

Large scale

Local scale



Triadic reading 1: "the external view"

Triadic reading 2: "the internal view"

Figure 5: Example of water grammar

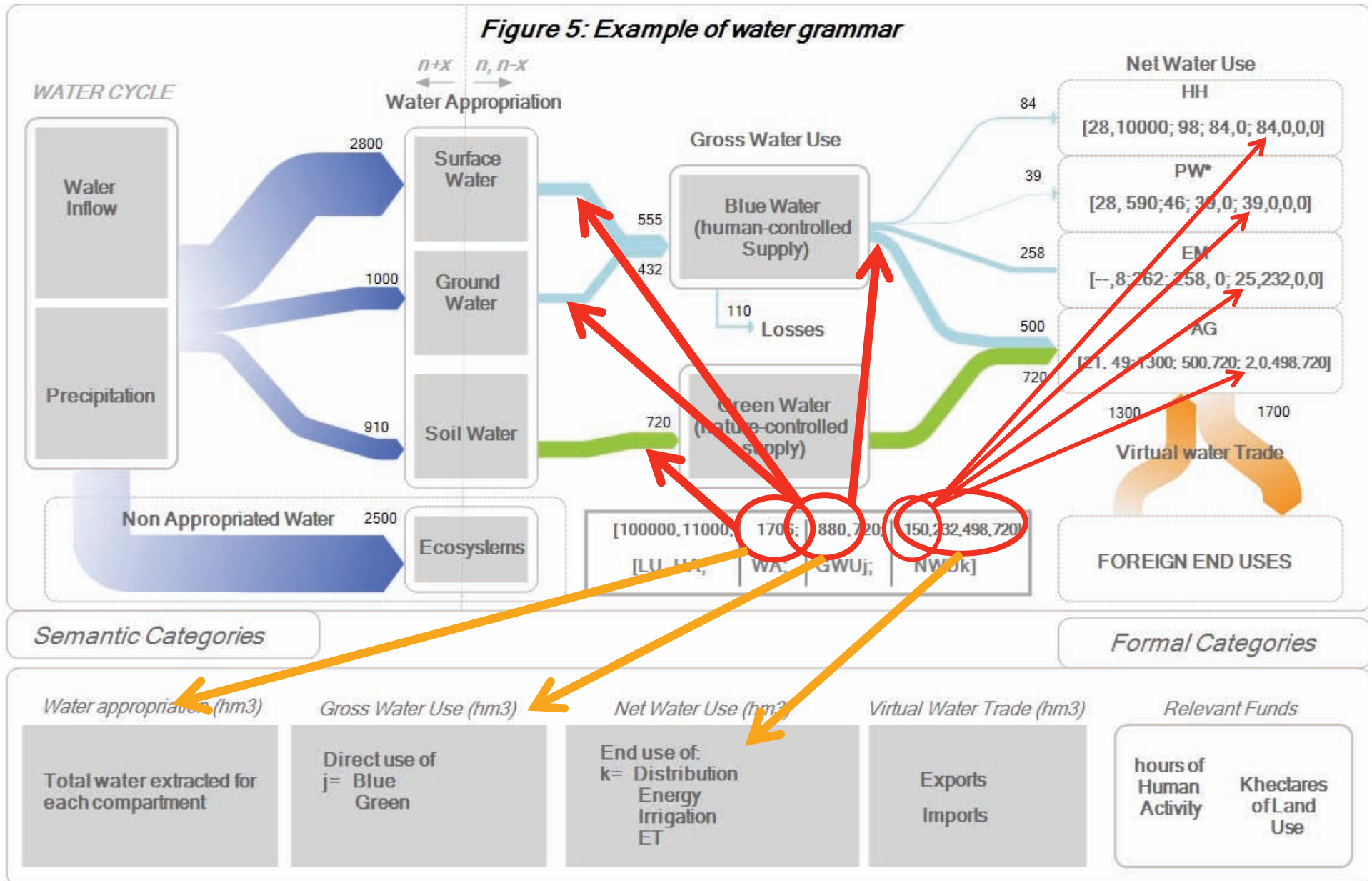
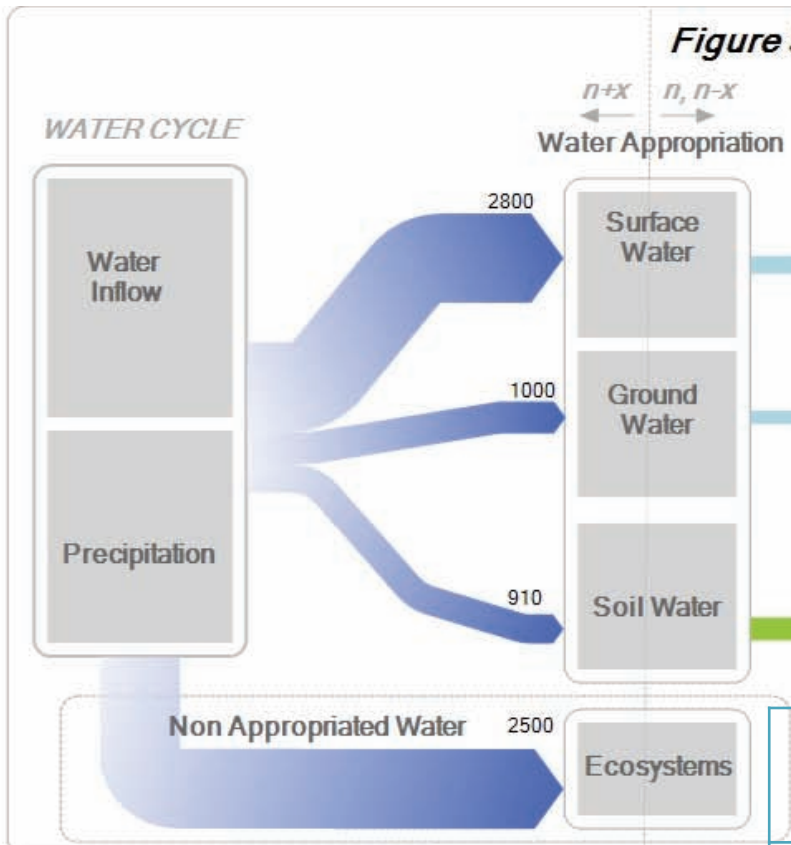


Figure 5: Examp



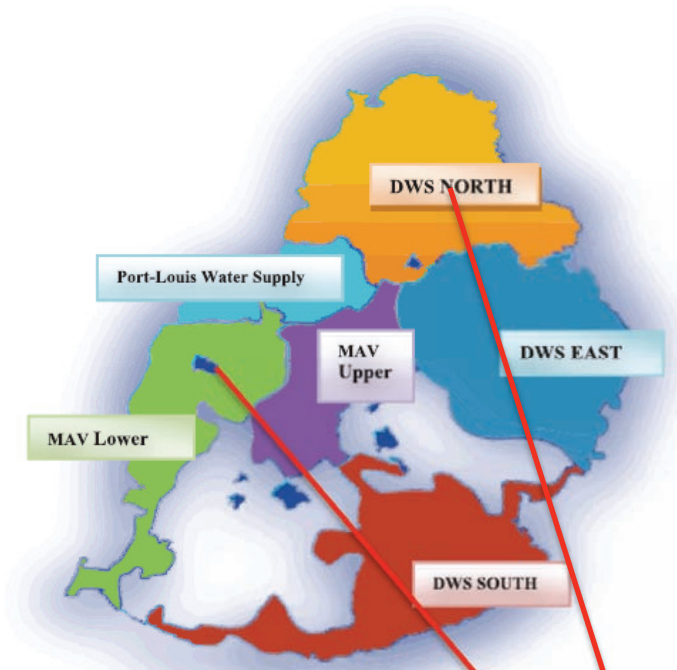
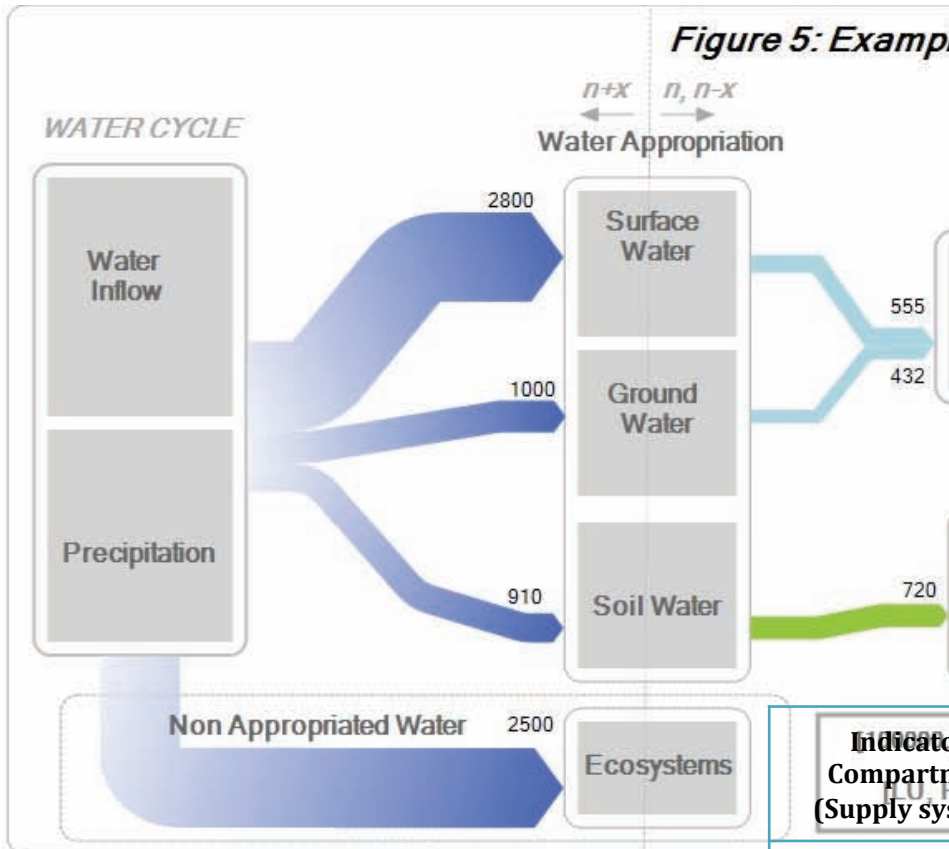
Indicator/Compartment	Extraction Total	EXT Blue-Surface	EXT Blue-Ground	EXT Green	USE Losses	USE Total
Whole (n)	1,706	555	432	718	108	1,599
HH (n-1)	98	74	24	0	14	84
HH-Urban (n-2)	41	31	10	0	0	35
HH-Rural (n-2)	57	43	14	0	0	49
PW (n-1)	1,608	481	408	718	94	1,515
PW-SG (n-2)	17	13	4	0	2	15
PW-TR (n-2)	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 Resources (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

Semantic Categories

Water appropriation (hm3)	Gross Water Use (hm3)
Total water extracted for each compartment	Direct use of j= Blue Green

Figure 5: Examp



Semantic Categories

Water appropriation (hm ³)	Gross Water Use (hm ³)
Total water extracted for each compartment	Direct use of j= Blue Green

Indicator/ Compartment (Supply system)	Extraction- TOTAL	Water Renewable Resources (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

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

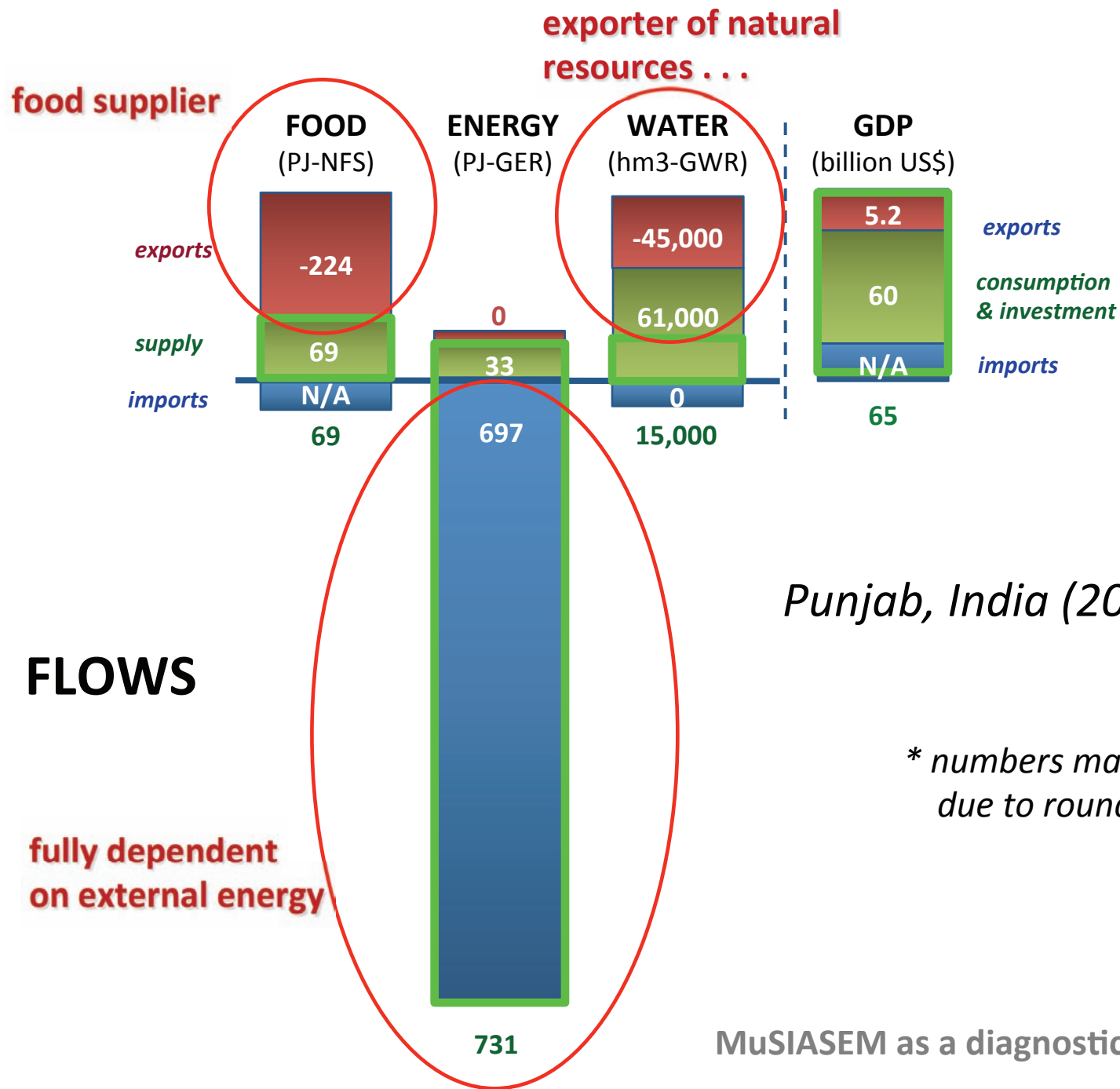
MuSIASEM as a simulator tool: scenarios in Mauritius

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



MuSIASEM as a diagnostic tool: Punjab

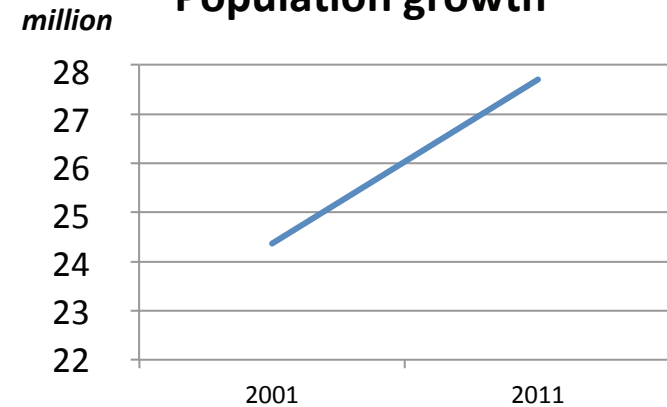
MuSIASEM as a diagnostic tool: Punjab

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

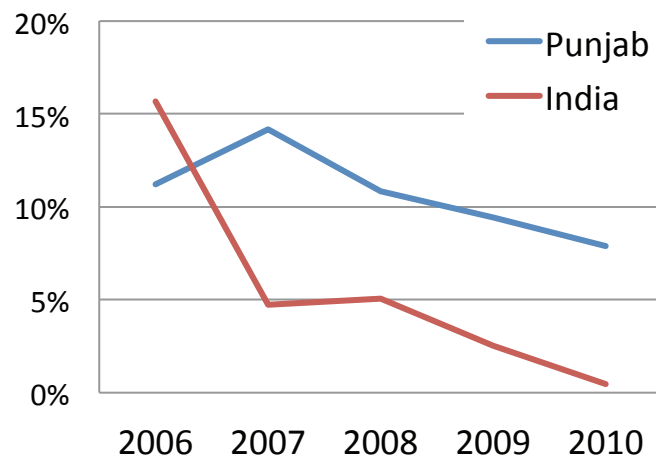
Population growth



Economic Labour Productivity

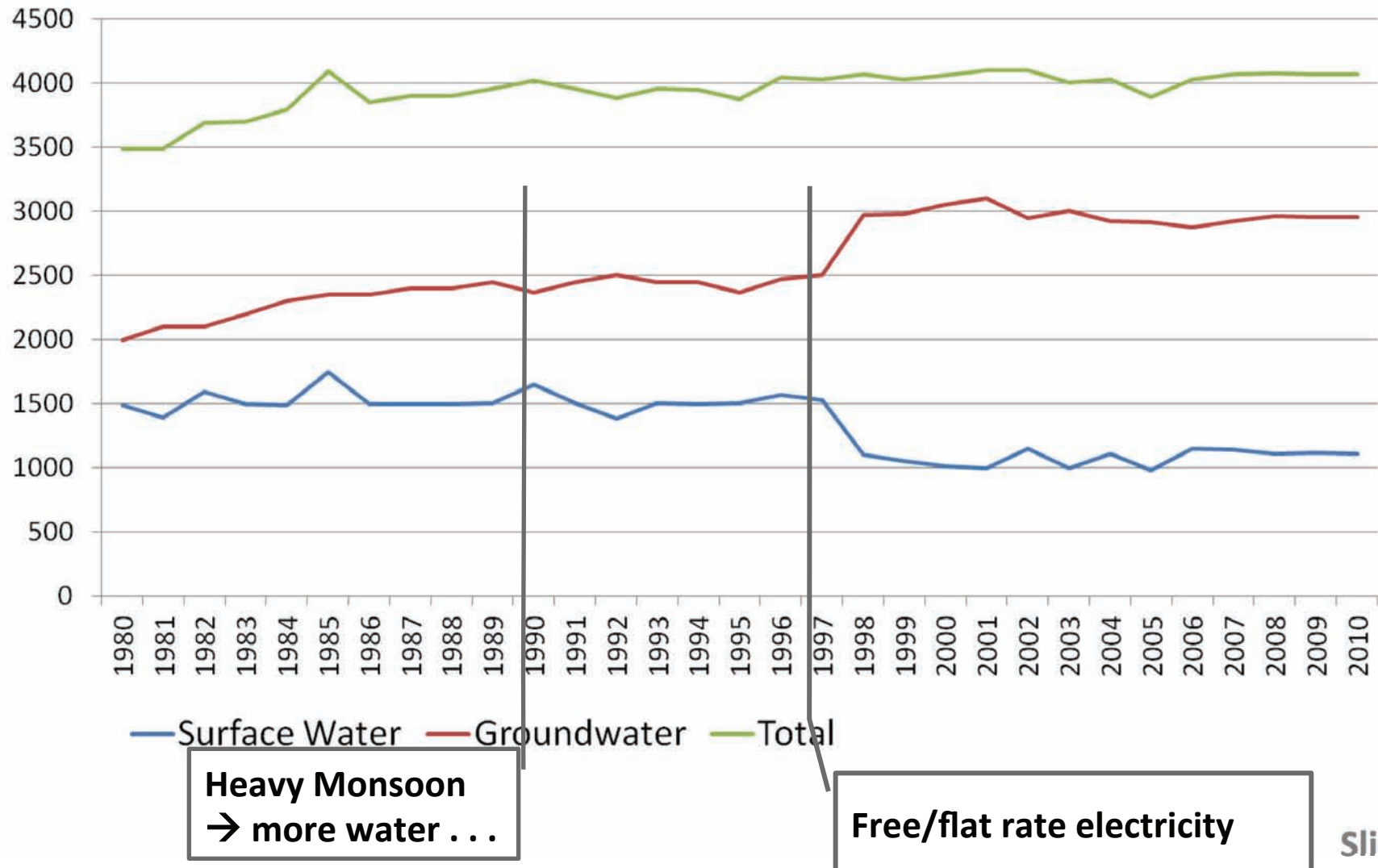
Economic Sector	Economic Labour Productivity (\$/hour)
Agriculture, forestry and fishing	1.6
Manufacturing	3.6
Construction	1.2
Wholesale, retail trade	3.1
Transport, storage	4.2
Financing, insurance	3.1

Remittances as % of GDP



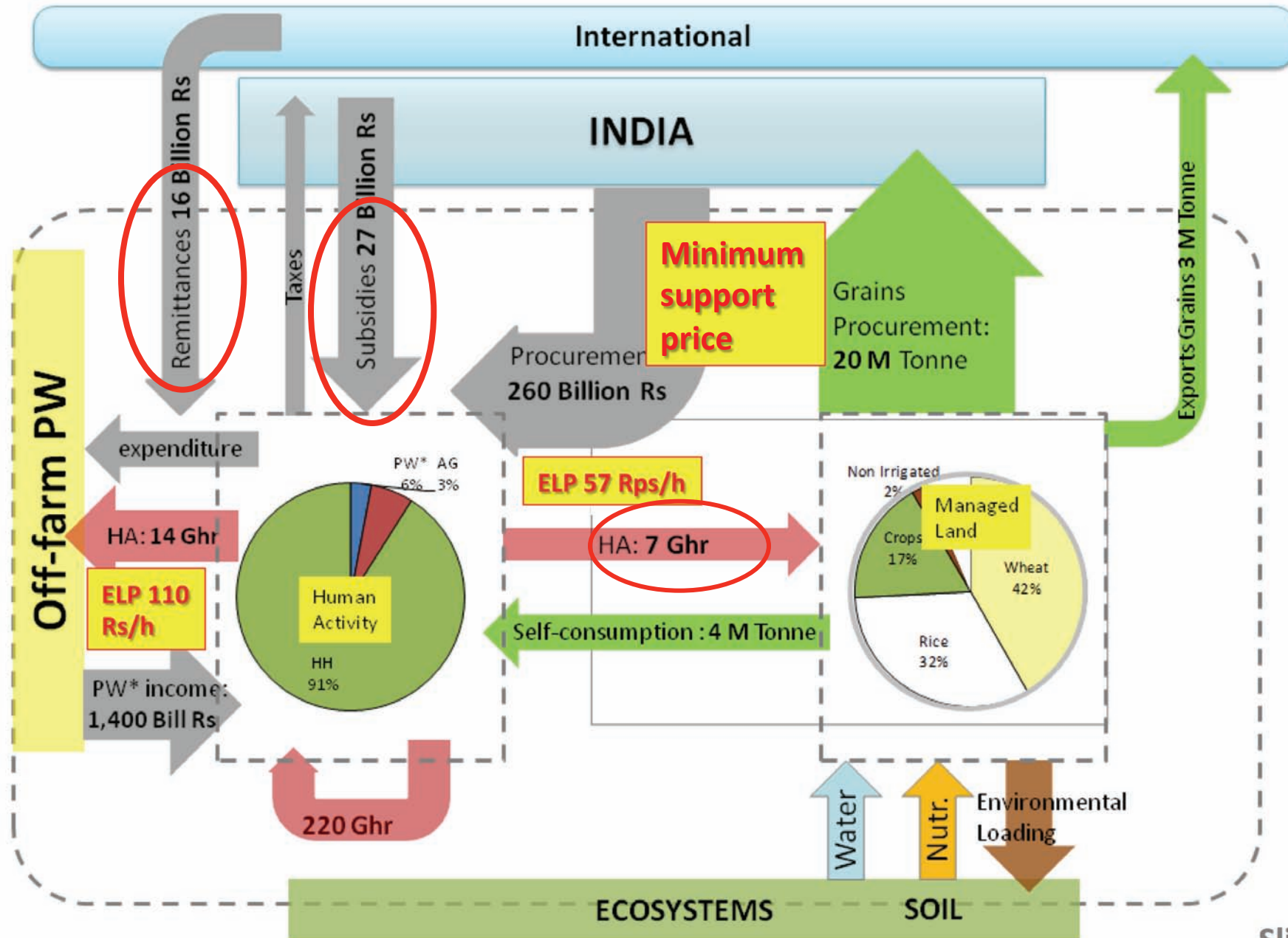
MuSIASEM as a diagnostic tool: Punjab

Subsidies: addressing an internal constraint . . .



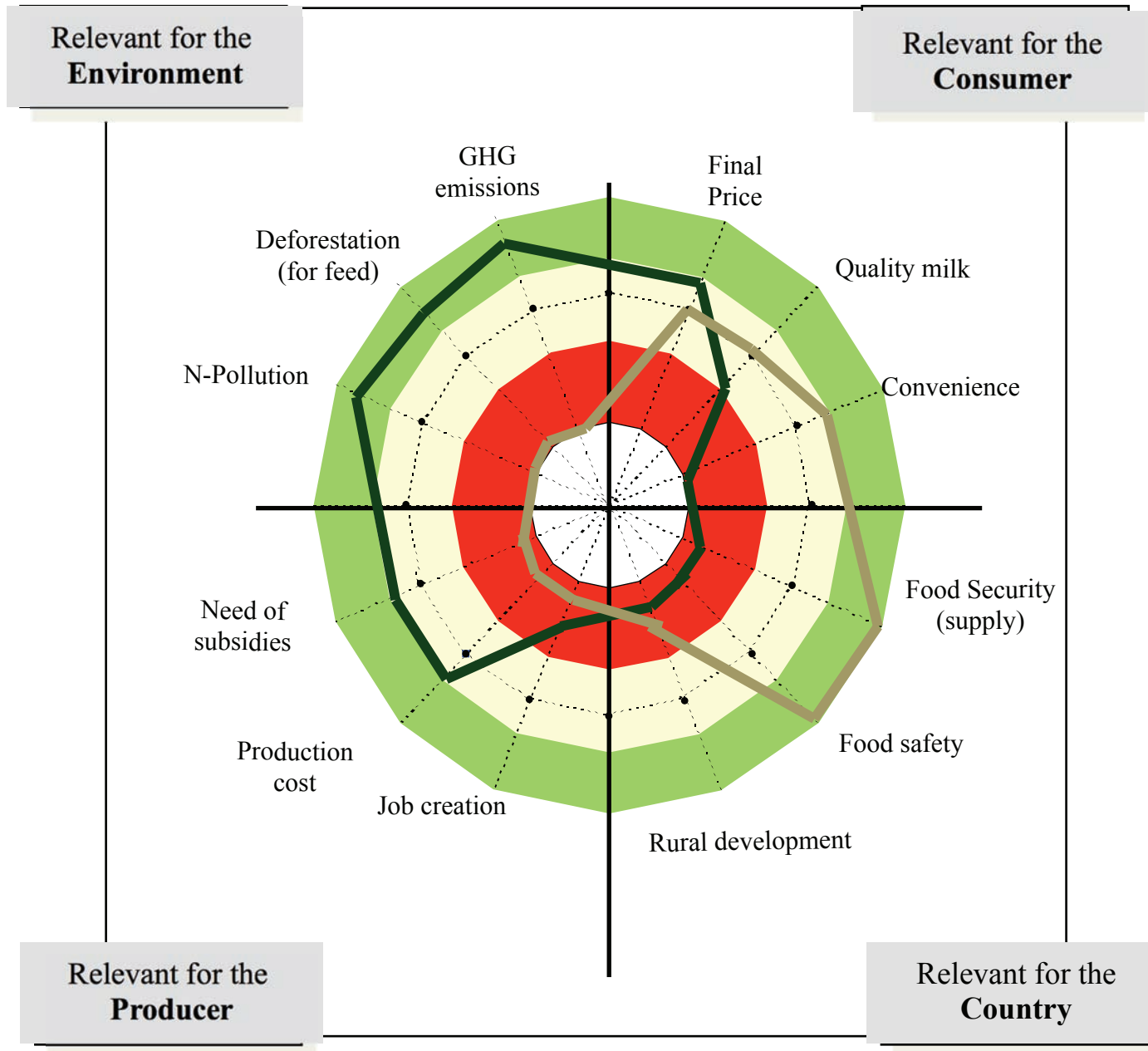
Slide 30

5. MuSIASEM as a simulator tool: scenarios in Punjab

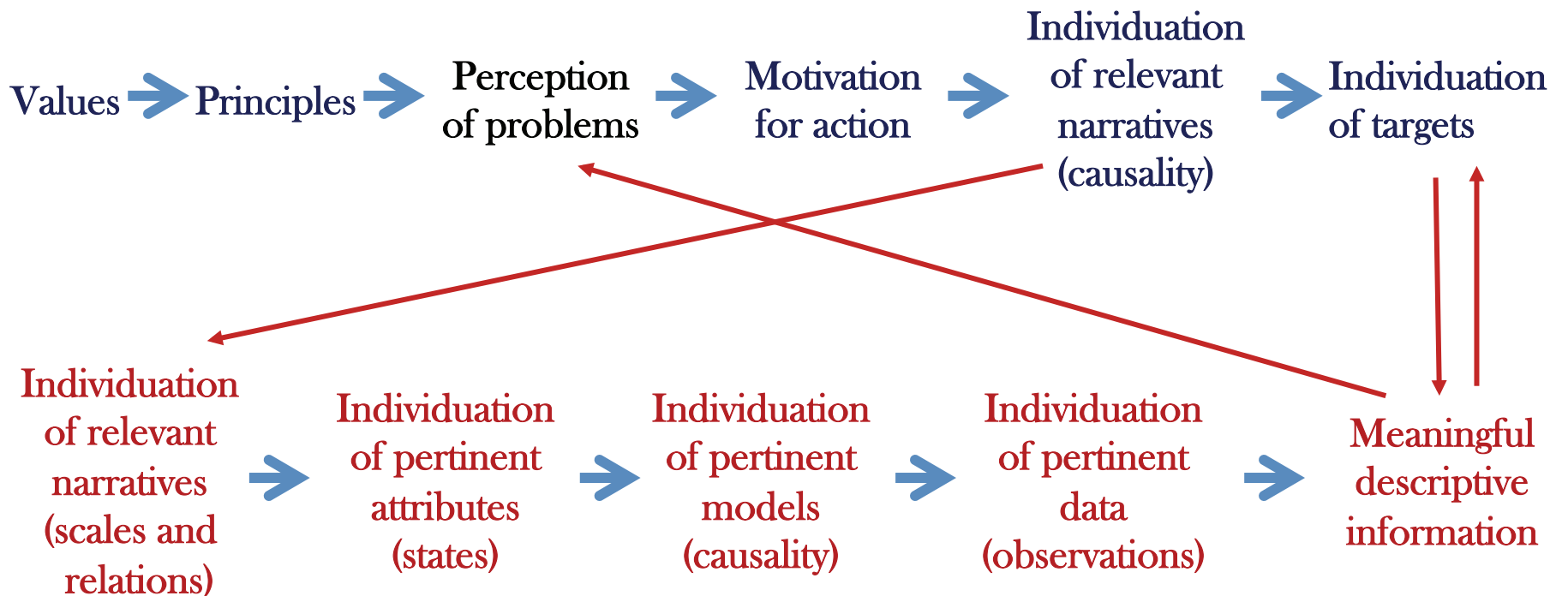


Participatory Integrated Assessment: the unavoidable entanglement between “normative” and “descriptive”

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

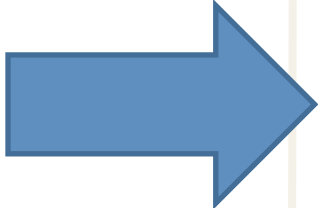


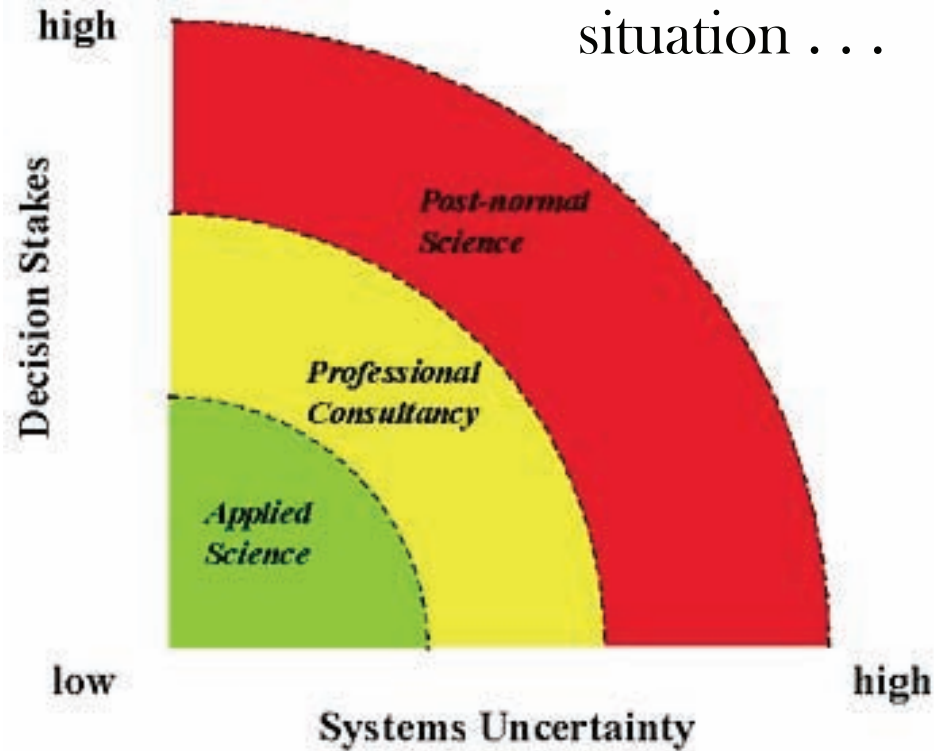
Chain of choices leading to the selection of an indicator on the **NORMATIVE SIDE**



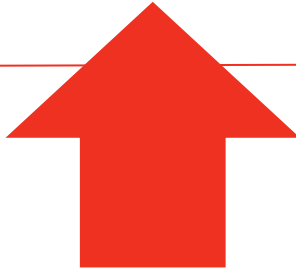
Chain of choices leading to the selection of an indicator on the **DESCRIPTIVE SIDE**

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	<i>final price</i>	GOOD	MORE OR LESS	GOOD
	<i>quality of milk</i>	MORE OR LESS	GOOD	MORE OR LESS
	<i>convenience</i>	GOOD	BAD	BAD
the producer	<i>production cost</i>	MORE OR LESS	MORE OR LESS	GOOD
	<i>available subsidies</i>	GOOD	MORE OR LESS	BAD
	<i>risk protection</i>	MORE OR LESS	MORE OR LESS	BAD
the country	<i>reliable supply</i>	GOOD	MORE OR LESS	MORE OR LESS
	<i>food safety</i>	GOOD (?)	GOOD	BAD
	<i>rural development</i>	BAD	GOOD	BAD
the environment	<i>GHG emission</i>	BAD	GOOD	GOOD
	<i>N leakages</i>	BAD	GOOD	GOOD
	<i>deforestation (feed)</i>	BAD	MORE OR LESS	GOOD

DESCRIPTIVE UNCERTAINTY

Problem Structuring: a brutal simplification of the information space

Other Social Actors

information space
virtually infinite

- * ethical principles
- * entities “we” care for
- * relevant criteria/attributes
- * data, models and targets

Decision Makers

information space small
but not always known

- * ethical principles
- * entities “we” care for
- * relevant criteria/attributes
- * data, models and targets

Scientists

information space
very large

- * ethical principles
- * entities “we” care for
- * relevant criteria/attributes
- * data, models and targets

POLITICAL DIMENSION
ETHICAL UNCERTAINTY

1st compression

NORMATIVE SIDE
deciding the identity
of the “Story-Teller”

DESCRIPTIVE SIDE
deciding the identity
of the information space

Selecting a limited set of
Alternatives, Attributes, Targets

Moving from an open
information space to a
finite information space

2nd compression

consumers	quality of milk	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	convenience	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
relevant for the economy	production cost	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	job creation	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	need of subsidies	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
relevant for the environment	GHG emissions	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	Nitrogen pollution	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	deforestation (feed)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
relevant for the country	food security (supply)	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	food safety	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
	rural development	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Scenarios Analysis

Policy selection

Need of additional data

POSSIBLE OUTPUTS

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 producer	robust supply	reducing tensions in the food chain	low price; organic quality
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

Discussing 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

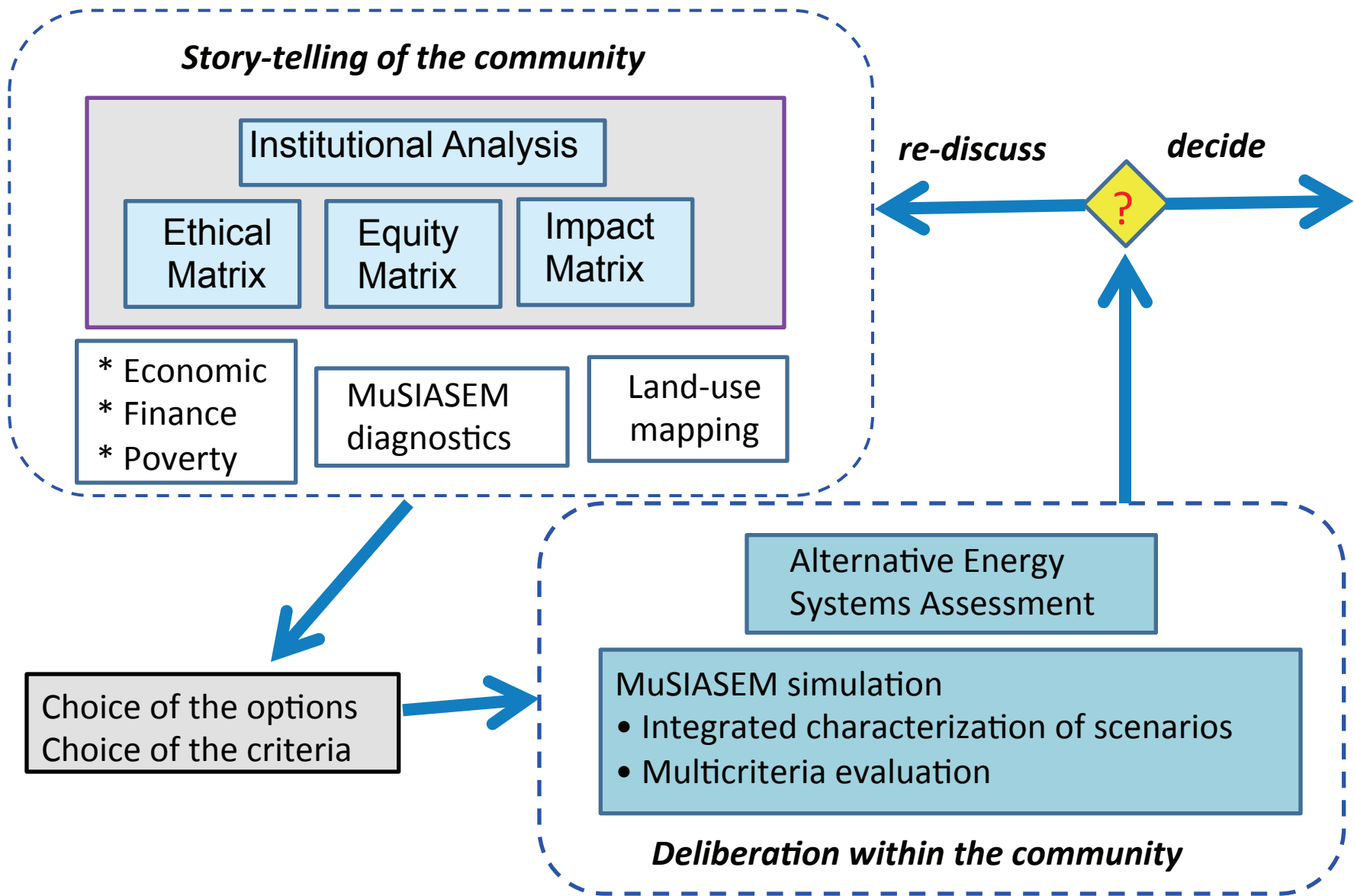
ENTITIES CONSIDERED AS RELEVANT	RELEVANT ATTRIBUTES	CONSIDERED ALTERNATIVES		
		High tech commodity for the market	Organic quality product for the market	Household subsistence
the consumer	<i>final price</i>	GOOD	MORE OR LESS	GOOD
	<i>quality of milk</i>	MORE OR LESS	GOOD	MORE OR LESS
the producer	<i>market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

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

ETHICAL MATRIX APPLIED TO ALTERNATIVES OF MILK PRODUCTION

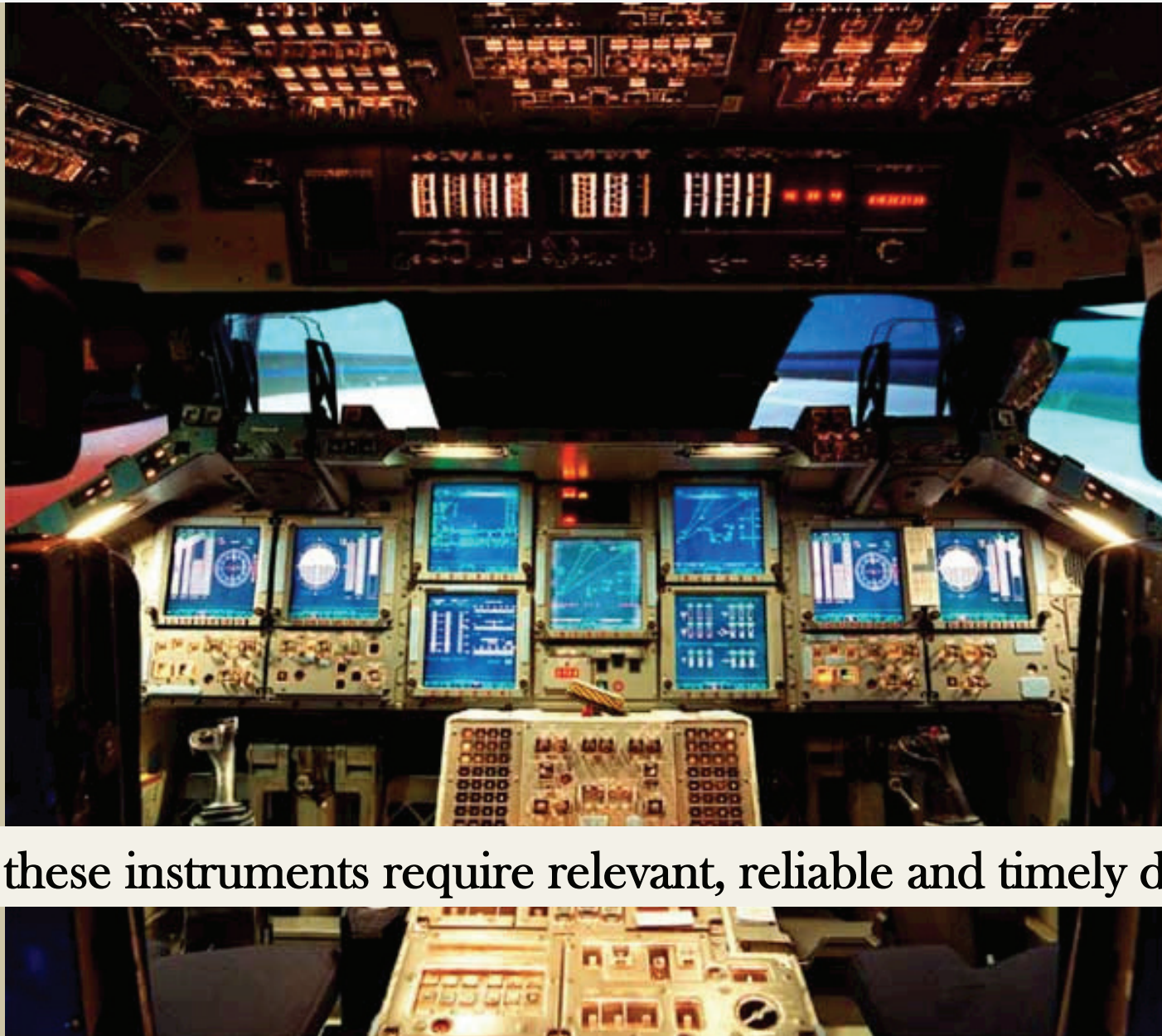
ENTITIES WE SHOULD CARE FOR	ETHICAL PRINCIPLES			
	Preserve Wellbeing (health & welfare)	Improve Wellbeing (health & welfare)	Autonomy/Dignity (express identity)	Justice (fairness)
the consumer	<i>Preserving the existing quality of life</i>	<i>Improving the existing quality of life</i>	<i>Empowerment Informed choices (labels!)</i>	<i>sharing stress</i>
the producer	<p>Discussing the quality of the process: Are we including all the relevant entities that “we” should care for?</p>			<i>sharing stress</i>
the country				<i>the country</i>
the environment	<i>Conserving the environment</i>	<i>Restoring the environment</i>	<i>Let biodiversity express itself</i>	<i>sharing stress</i>
the cow	<i>Preserving the existing cow welfare</i>	<i>Improving the existing cow welfare</i>	<i>Behavioural Freedom</i>	<i>sharing stress</i>

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



Integrated Assessment:
Sociology Technology
and the Environment