Mario GIAMPIETRO
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icta
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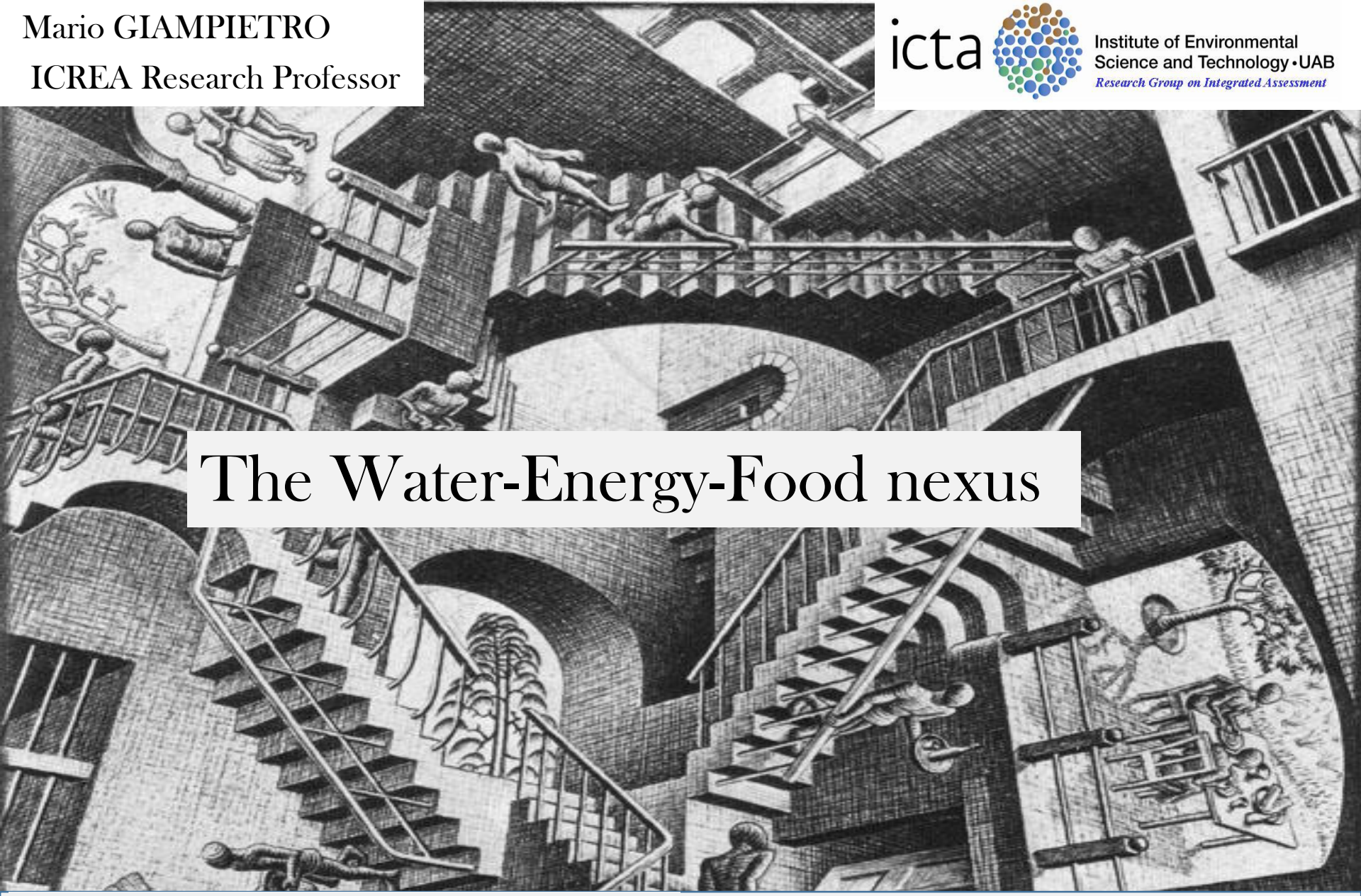
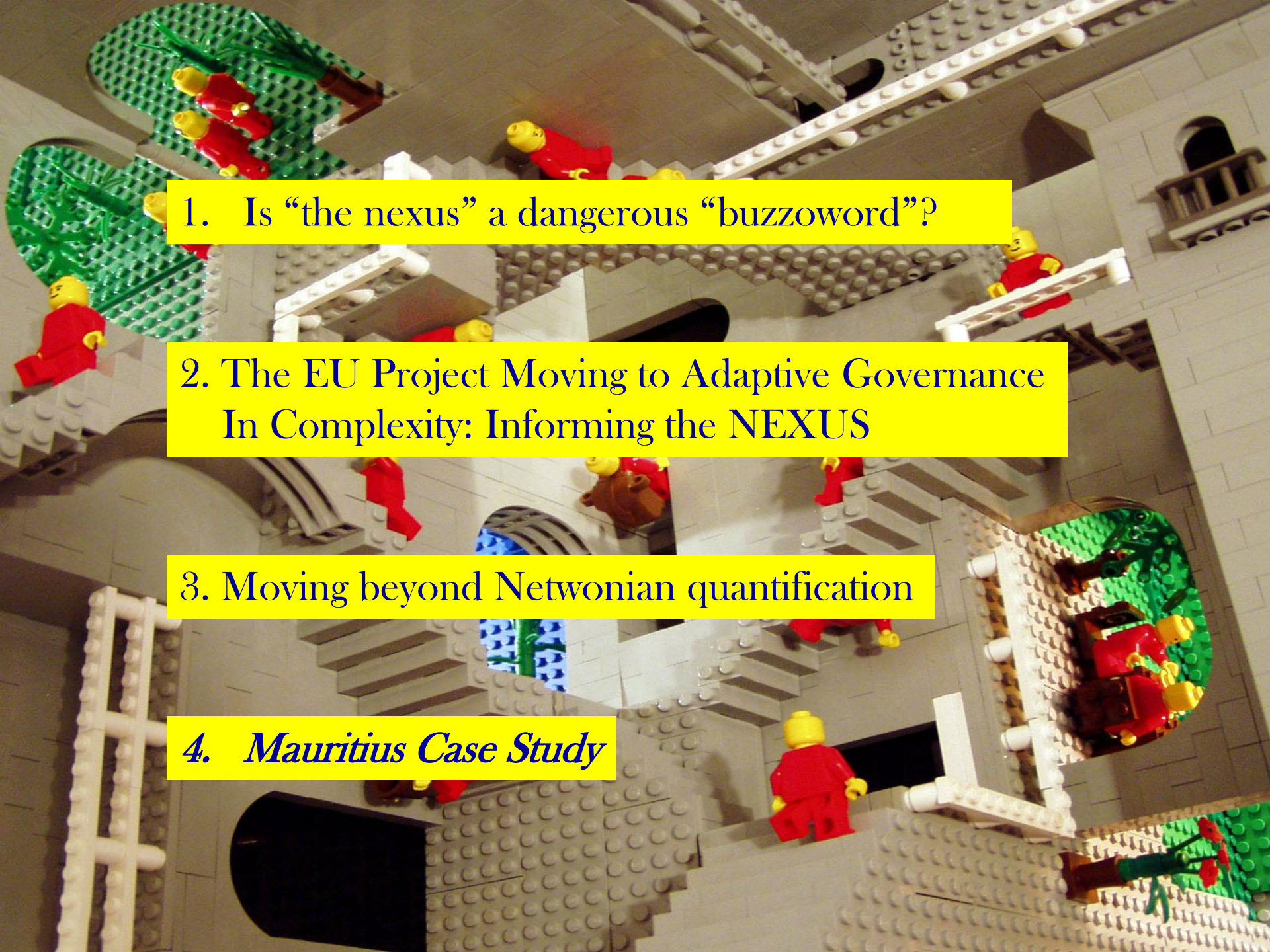


The Water-Energy-Food nexus

Workshop on Systems Approaches for sustainable agriculture – Part 1

Philippe Le Bon Building
December 5th, 2016
Brussels



1. Is “the nexus” a dangerous “buzzoword”?

2. The EU Project Moving to Adaptive Governance In Complexity: Informing the NEXUS

3. Moving beyond Netwonian quantification

4. ***Mauritius Case Study***

Autopoietic Process in society

IDENTITY ⟷ **PURPOSES**

Defining Institutions for Governance

What we want to sustain?

Whose values count?

Struggles for the definition of Story-telling

GOVERNANCE

Rediscussing power relations between institutions

Updating priorities over competing narratives

Restructuring organization within and across institutions

TRANSDUCE

Learning by doing

TRANSDUCE

Definition of priorities over integrated problems

Implementation of integrated policies

APPLY

Diagnoses & Scenarios

REPRESENT

EXTERNAL WORLD

Demand and supply for Water, Energy and Food

Sectors and flows interfaced with land uses, ecosystems, non-renewable resources, atmosphere and climate

Semiotic process associated with THE NEXUS

SCIENTIFIC INQUIRY

* ~~"Cartesian Prediction and Control" based on evidence based policy~~
* "Post-Normal Science": quantitative analysis compatible with uncertainty wisdom, fairness and adaptability

Understanding what is generating the entanglement

Dealing with non-equivalent descriptive domains, non-reducible models and large doses of uncertainty

Autopoietic Process in society

IDENTITY ⟷ **PURPOSES**

Addressing the existence of power asymmetries

APOLITICAL FRAMING
NO NATIONAL BOUNDARIES
What we want to sustain?

DANGEROUS BECAUSE OF
"SEMANTIC APPROPRIATION"
Whose values count?

NEED OF TRANSPARENCY
AVOID TECHNOCRATIC APPROACHES

System Efficiency
vs
Sector efficiency

Avoid externalization

TRANSDUCE

Link to climate change

Integrating policies

Food security,
Energy security
Water security

Technological innovation & jobs

APPLY

GOVERNANCE

Integrating policy goals
Integrating policy fields

Equity/Livelihood

Coordination & Partnership

Reducing trade-offs & Building synergies

Management concept

A way of thinking about the whole system

TRANSDUCE

Interaction over problems

Conceptual framework

Integrative imaginary

Conceptual tool

CONCERNS
vs
FACTS

REPRESENT

BALANCE OF DIFFERENT GOALS AND INTERESTS

Complex relationship

EXTERNAL WORLD

Environment & Resources

Sectors, Systems, Flows

Interwoven, Interrelated
Interdependent, interacting
Interconnected, trade-offs

SCIENTIFIC INQUIRY

Transdisciplinarity vs conventional
Different scales and dimensions
Impossible to grasp within academia
A largely disconnected knowledge base
Unbounded definition & Uncertainty

Knowledge gaps

Different meanings associated with "THE NEXUS"

BUZZWORD?

Ambiguous meaning and strong normative resonance . . .

Inextricable links

Academia has lost its way

Moving Towards Adaptive Governance in Complexity: Informing NEXUS Security

MAGIC NEXUS

Open a new path towards a new way of managing the water-energy-food nexus in which researchers and decision makers work together in search of development strategies and alternative policy options

UAB Universitat Autònoma de Barcelona

The James Hutton Institute

WAGENINGEN UR For quality of life

University of Twente The Netherlands

Universitas Bergensis

European Commission Joint Research Centre

Università degli Studi di Napoli Federico II

CLIMATE ANALYTICS

itc INSTITUTO TECNOLÓGICO DE CANARIAS

External Partner:

Yale University

Research project funded by the EU under the H2020-WATER-2015 call (GA 689669)
Duration: 4 years
Budget: 7.5 Million €

What is MAGIC?

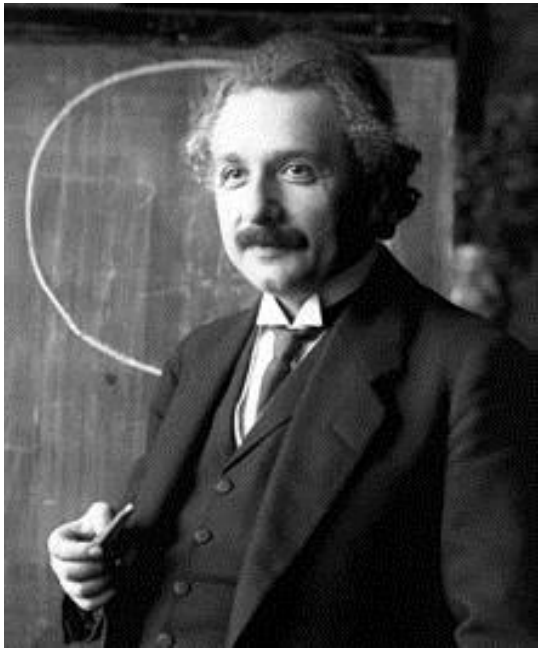
- H2020 *Moving Towards Adaptive Governance in Complexity: Informing Nexus Security* project
- Considers both the perceptions (qualitative grammar) and formal representations (quantitative syntax) of way the Water-Energy-Food (WEF) Nexus is expressed
- Using **Quantitative Story-Telling** in 5 policy case-studies:
  - Themes and controversies within Water Framework Directive, Habitats Directive, EU Energy Strategy, EU Circular Economy Strategy & Common Agricultural Policy
- And 5 innovation case-studies
  - Themes and controversies within Fracking, GMOs, Biofuels, Desalinisation and Trade of Emission Permits

MAGIC NEXUS

http://magic-nexus.eu/project-overview/

We are still generating quantitative analysis as it was done by Newton!

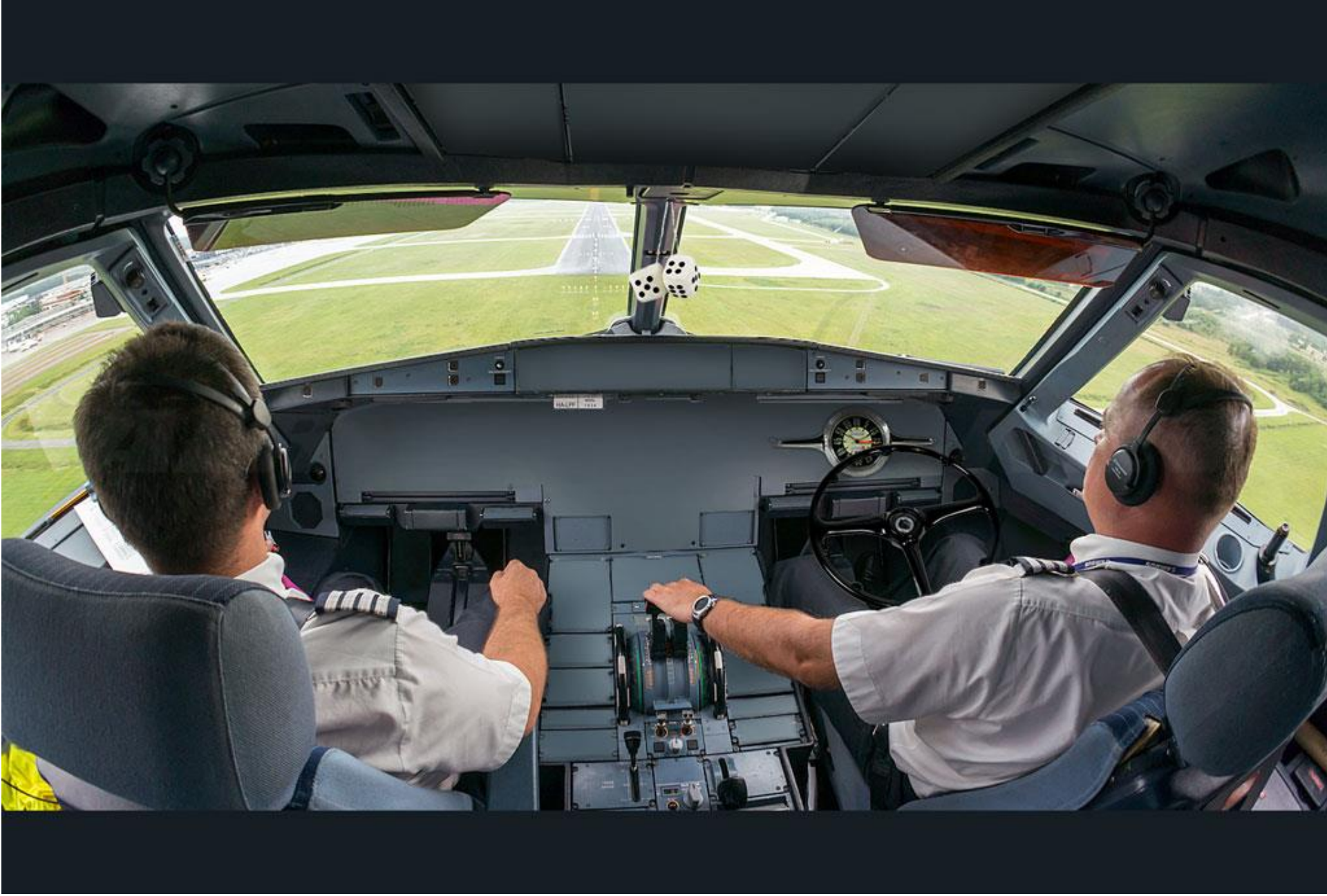
using **reductionism . . .**
a scale and a dimension
at the time . . .



WHAT IS THE PROBLEM?

"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?

MuSIASEM is an accounting method useful to carry out a relational analysis across non-equivalent perceptions-representations of complex systems (1)

Moving away from assessments based on individual numbers

to assessments based on given relations over arrays of numbers . . .

	FLOWS						
	FOOD (PJ)	ENERGY (PJ-GER)	WATER (hm3)	MONEY (	HA	LU	PC W)
HH	5.9	16	100	N/A	0000	28	4.5
PW*	0.8	27	44	8200	00		1.4
				220	9	21	negl.
				180	8	negl.	0.03
EXPORTS PW*	N/A	N/A	3	4900 (50%of GDP)	90	N/A	N/A
EXPORTS AG	negl.	6	1100				0.02
WHOLE	8	5	1700				6
IMPORTS	6.7	0	N/A				N/A
DOMESTIC SUPPLY	1.3		00				6
VIRTUAL IMPORTS	N/A	N/A	70				N/A

Women Carb. 0.7 Prot. 0.1 Fat 0.3 (PJ/year)

Men Carb. 0.8 Prot. 0.2 Fat 0.4 (PJ/year)

Household Consumption Carb. 3.6 Prot. 0.7 Fat 1.6 (PJ/year)

URBAN Carb. 1.5 Prot. 0.3 Fat 0.7 (PJ/year)

RURAL Carb. 2.1 Prot. 0.4 Fat 0.9 (PJ/year)

Tourists Carb. 0.07 Prot. 0.01 Fat 0.03 (PJ/year)

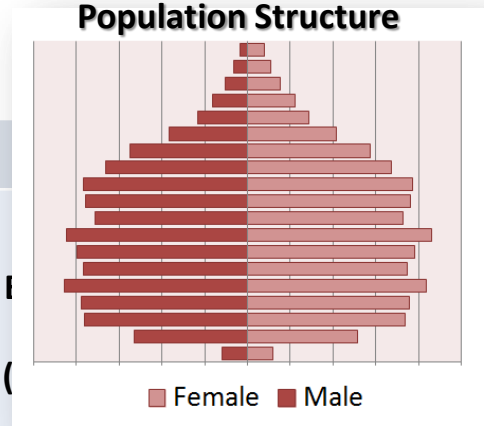
Multi-level multi d

MuSIASEM is an accounting method useful to carry out a relational analysis across non-equivalent perceptions-representations of complex systems (2)

Moving away from assessments based on conventional alfa-numeric data

to assessments based on datasets organized in **GIS**

Dietary needs of the population



Inside view

	FOOD (PJ)				HA		
HH	5.9	16	100	N/			
PW*	0.8	37	44	82			
AG	1.3	egl.	190	220	39	21	negl.
EM	N/A		260			ne	0.03
		N	3	4900 (50%of GDP)	590	N/	N/A
		0.36					
		56					
		49					
		7					
		N/A					

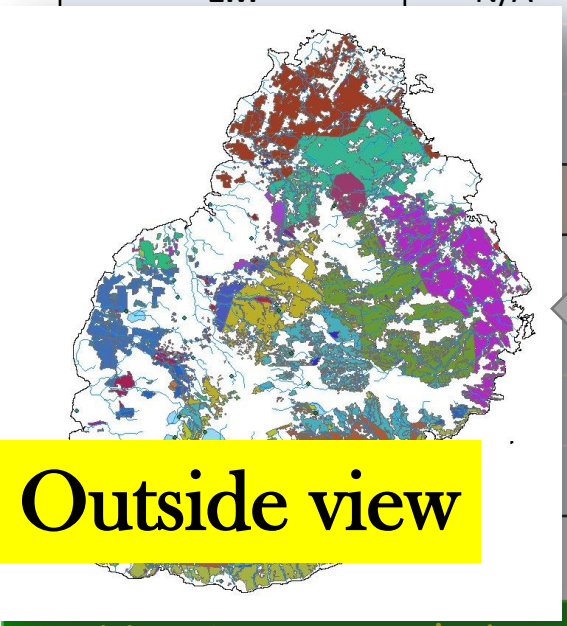
Diet Requirement

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

Peta Joule	CARB	PROT	FAT
Final requir.	3.6	0.7	1.6

Unit: PJoule	CARB	PROT	FAT
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

Nutrients supply by agriculture or imports

nal matrix of Mauritius

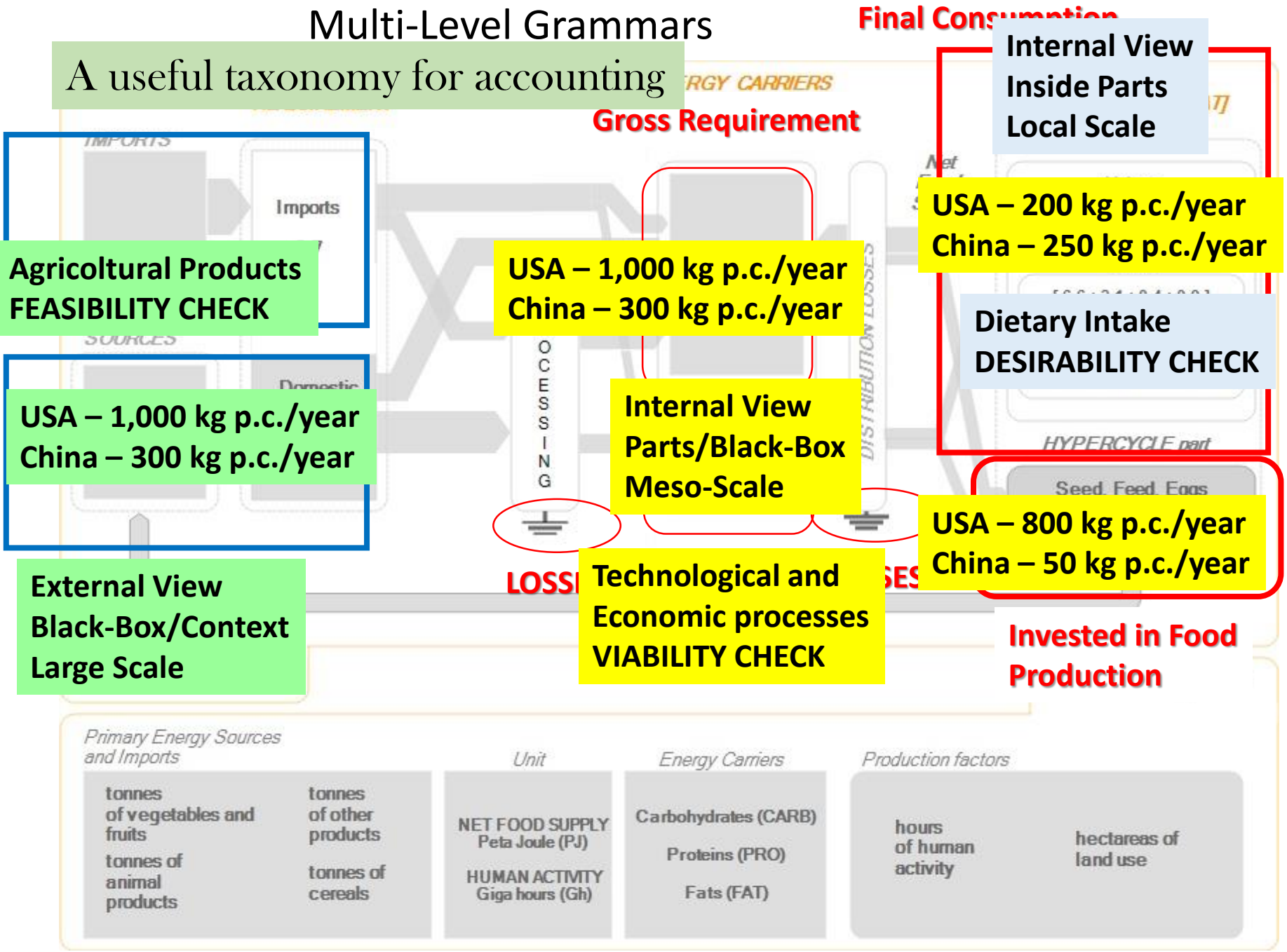
MuSIASEM is an accounting method useful to carry out a relational analysis across non-equivalent perceptions-representations of complex systems (3)

Moving away from assessments based on the adoption of a single level of analysis at the time

to quantitative characterizations based on expected relations over representations referring to different scales

Multi-Level Grammars

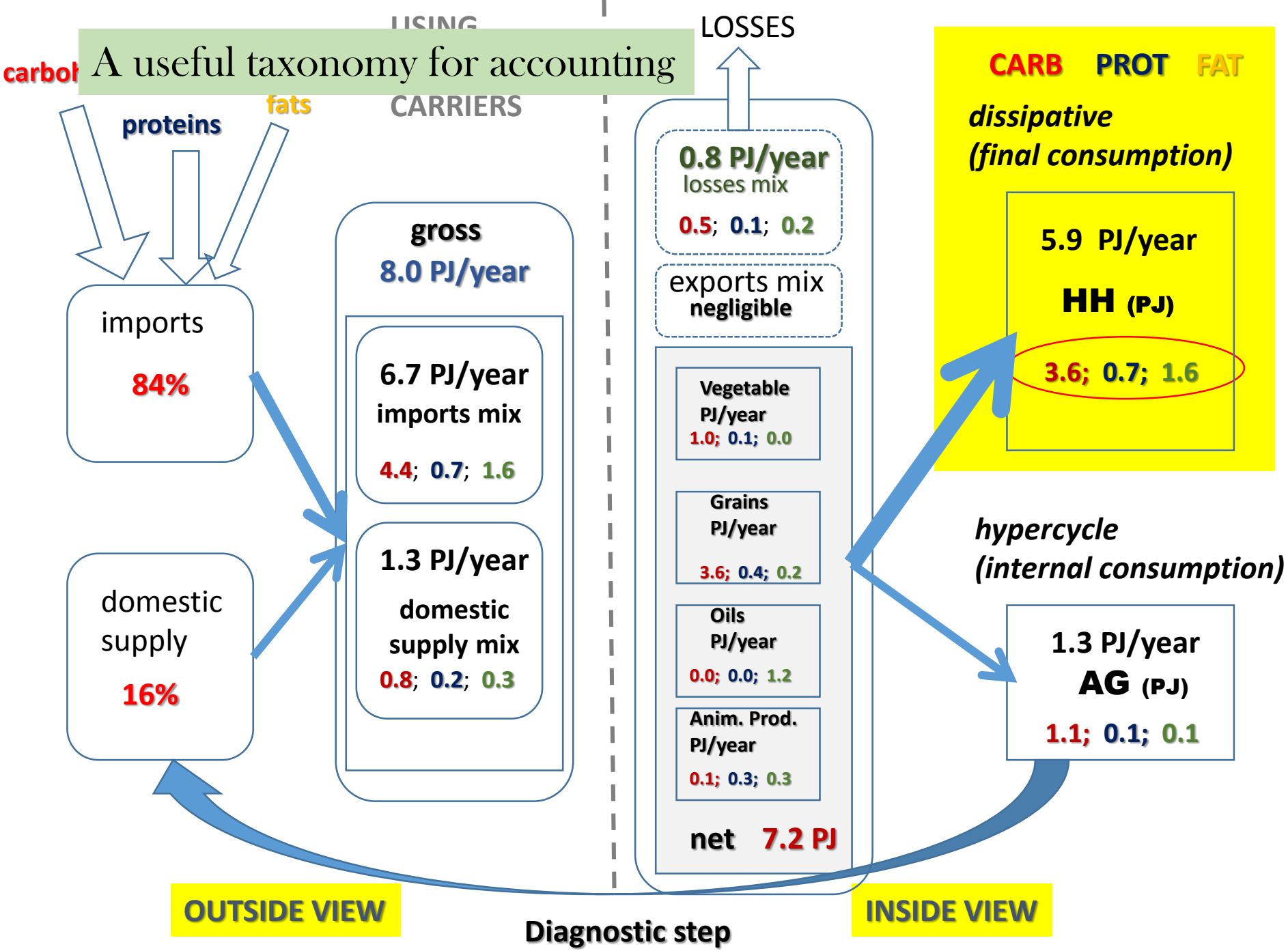
A useful taxonomy for accounting



Political relevance of your “number crunching” . . .

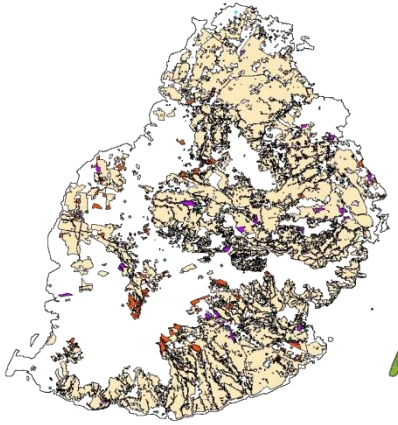
Do we guarantee an adequate diet to the population?

A useful taxonomy for accounting



Political relevance of your "number crunching" . . .

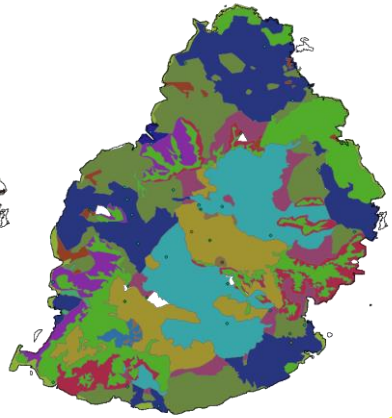
Sugar Cane



Check of Previous Locations

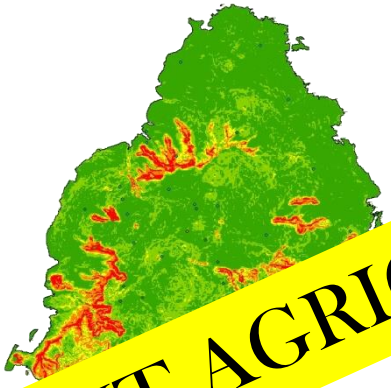
+

Types of Soil



Comp

Slope



Slope compatibility

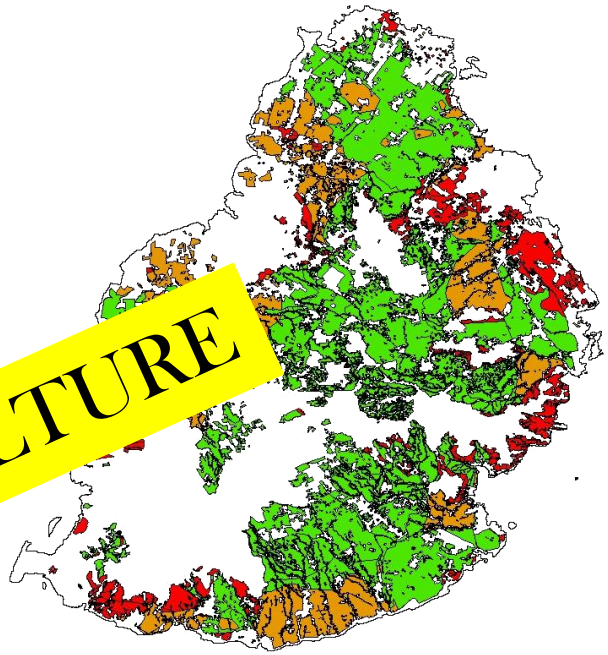
STORY ABOUT AGRICULTURE

Suitable for new crop mix

Suitable for maize

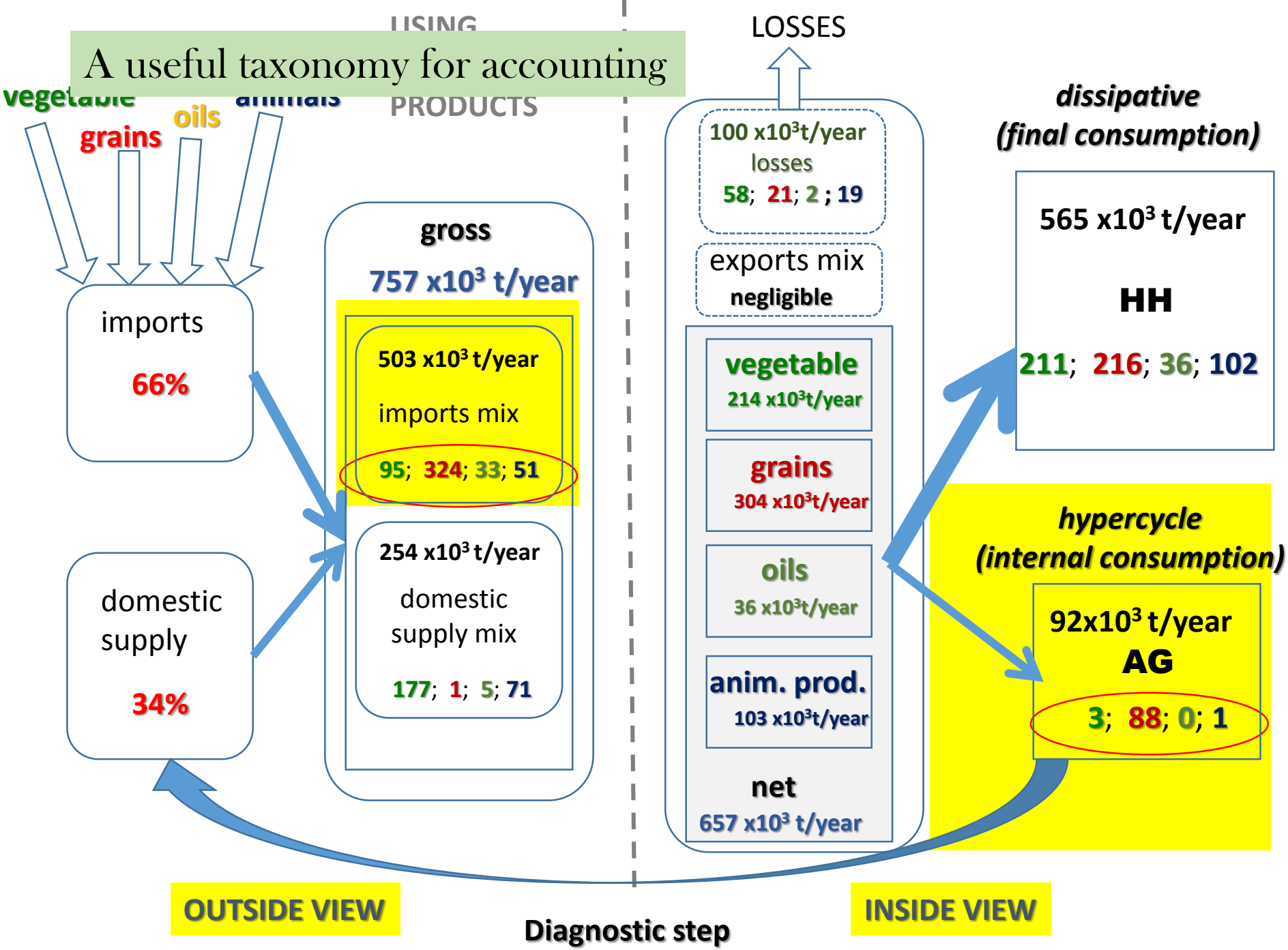
Only suitable for sugarcane

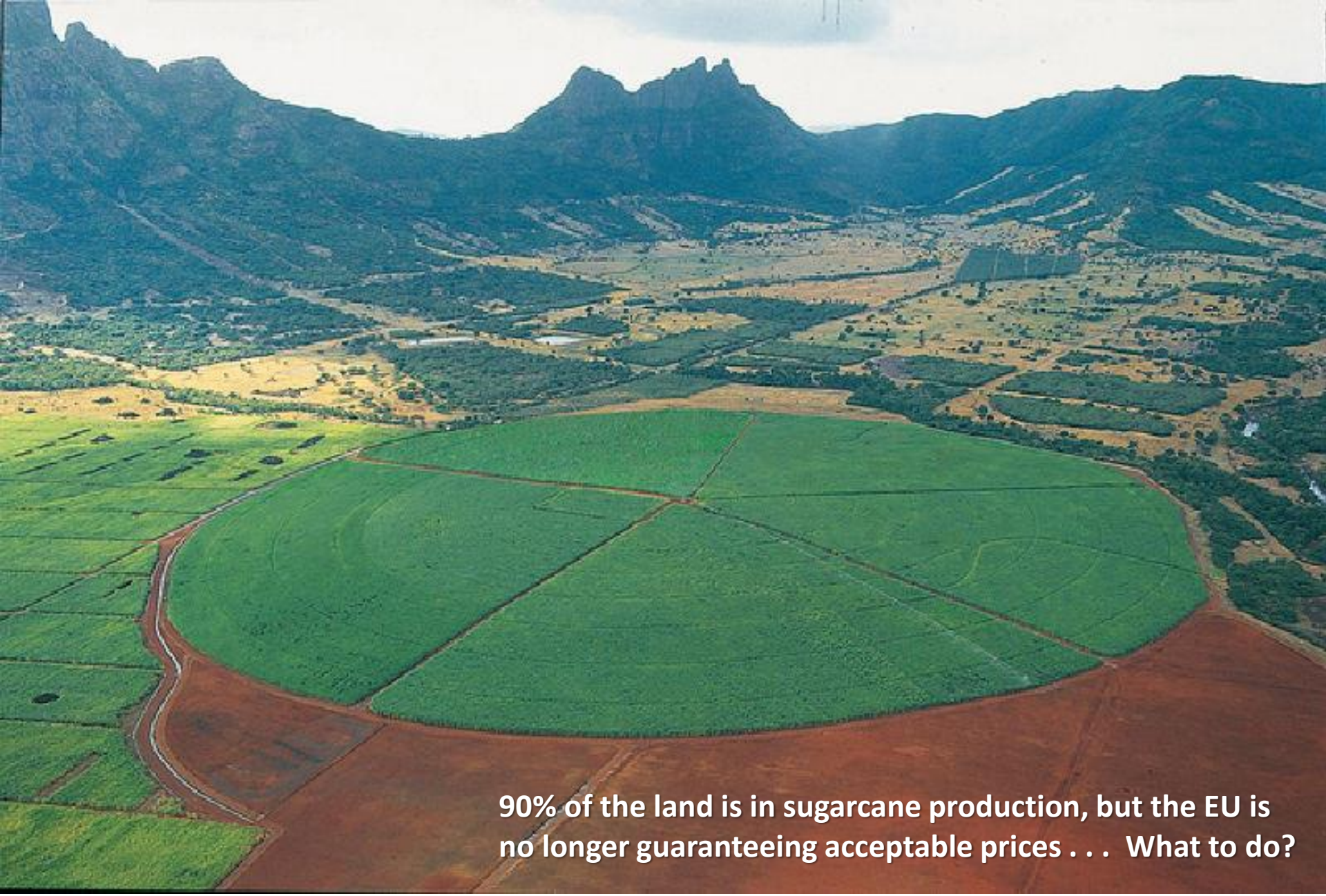
suitable land for a different location of crops mix



Do we have an adequate amount of land for agriculture?

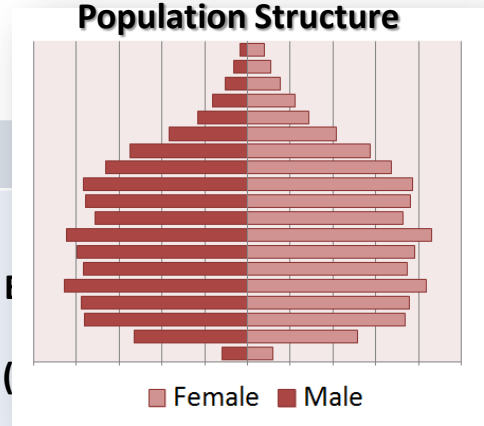
A useful taxonomy for accounting





Mauritius case study

Dietary needs of the population



Inside view

	FOOD (PJ)				HA		
HH	5.9	16	100	N/			
PW*	0.8	37	44	82			
AG	1.3	egl.	190	220	39	21	negl.
EM	N/A		260			ne	0.03
		N	3	4900 (50%of GDP)	590	N/	N/A
		0.36					
		56					
		49					
		7					
		N/A					

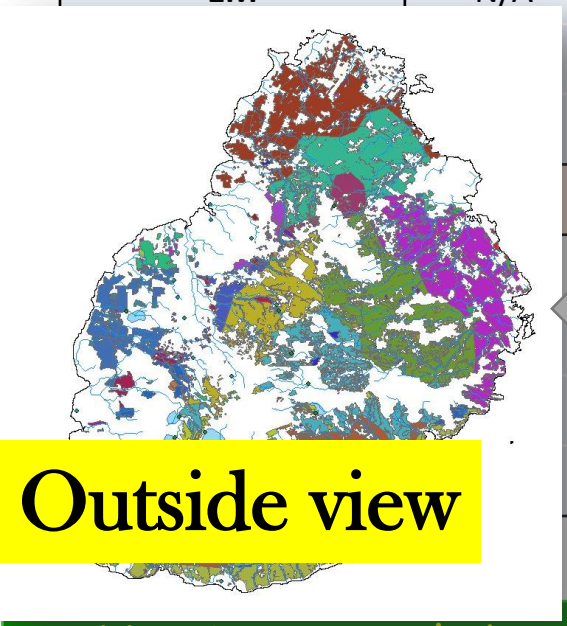
Diet Requirement

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

Peta Joule	CARB	PROT	FAT
Final requir.	3.6	0.7	1.6

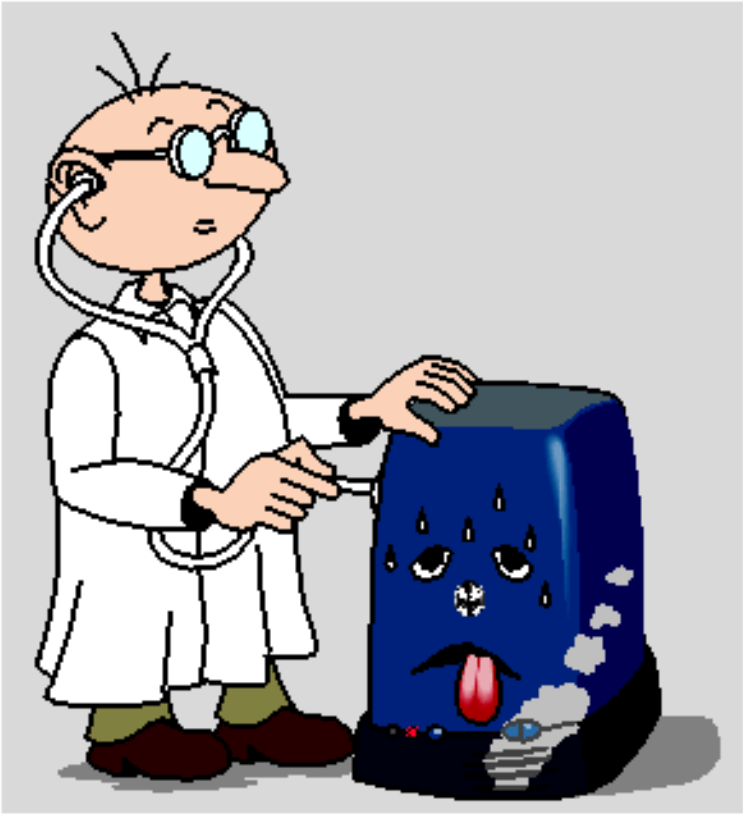
Unit: PJoule	CARB	PROT	FAT
Cereals, roots	2.7	0.3	Negl
Animals products	0.1	0.3	0.3
Veg. and fruits	0.1	Negl	Negl
Oil	Negl	Negl	1.2
Others	0.7	Negl	Negl



Outside view

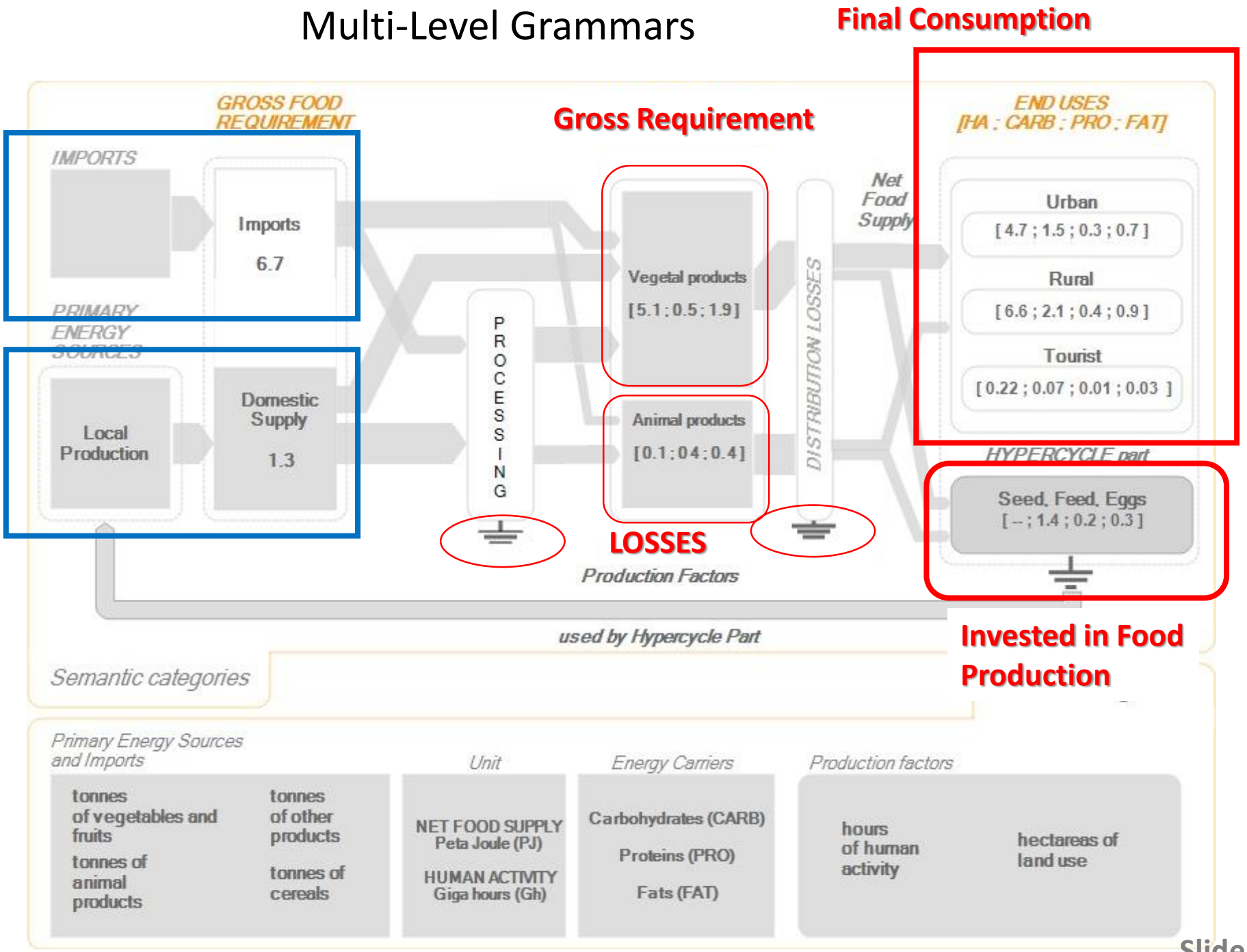
Nutrients supply by agriculture or imports

nal matrix of Mauritius



Diagnostic-simulator tool

Multi-Level Grammars



GROSS FOOD REQUIREMENT

ENERGY CARRIERS [CARB : PRO : FAT]

END USES [HA : CARB : PRO : FAT]

IMPORTS

		Flow ele	
		Food (PJ)	Energy (PJ-GER)
Consumption	HH	5.9	16
	PW*	0.8	37
	AG	1.3	negl
	EM	n/a	2.2
	exp_{PW*}	n/a	n/a
	exp_{AG}	negl	0.4
	Whole	8	56
Supply	Imports	6.7	49
	Domestic Supply	1.3	7

LOSSES

		Flow elements			Fund elements		
		Food (PJ)	Energy (PJ-GER)	Water (hm3 extraction)	HA (Mhr)	PC (GW)	Land (k ha)
Consumption	HH	5.9	16	100	10,000	4.5	28
	PW*	0.8	37	44	606	1.4	
	AG	1.3	negl	190	39	negl	21
	EM	n/a	2.2	260	8	0.03	negl
	exp_{PW*}	n/a	n/a	3	590	n/a	n/a
	exp_{AG}	negl	0.4	1,100	33	0.02	54
	Whole	8	56	1,700	11,300	6.0	103
Supply	Imports	6.7	49	n/a	n/a	n/a	n/a
	Domestic Supply	1.3	7	1,700	11,300	6.0	103

tonnes of animal products

tonnes of cereals

HUMAN ACTIVITY Giga hours (Gh)

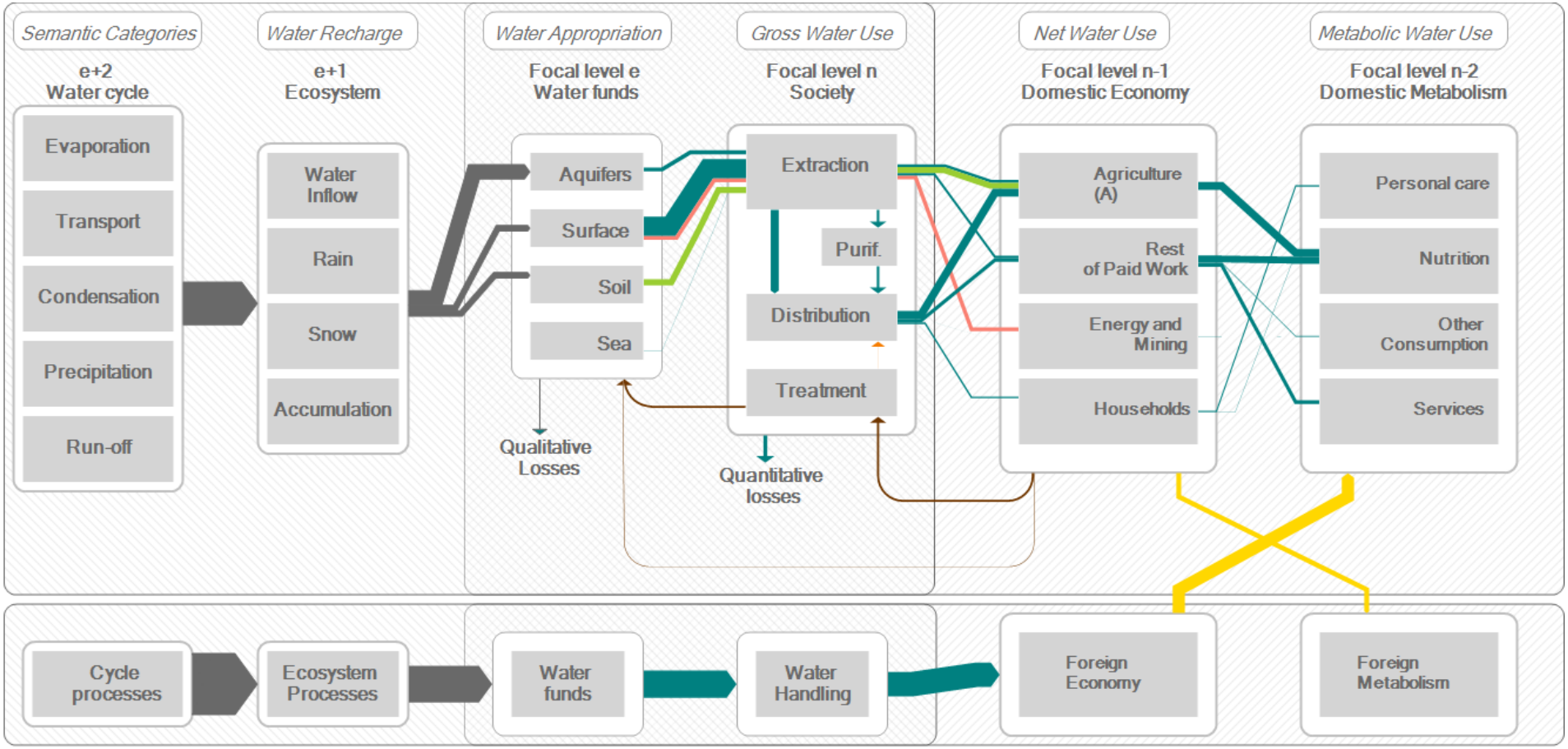
Proteins (PRO)

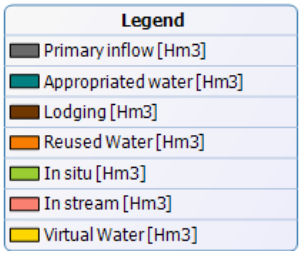
Fats (FAT)

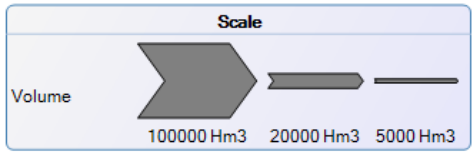
urs of human activity

hectareas of land use

2. Grammar

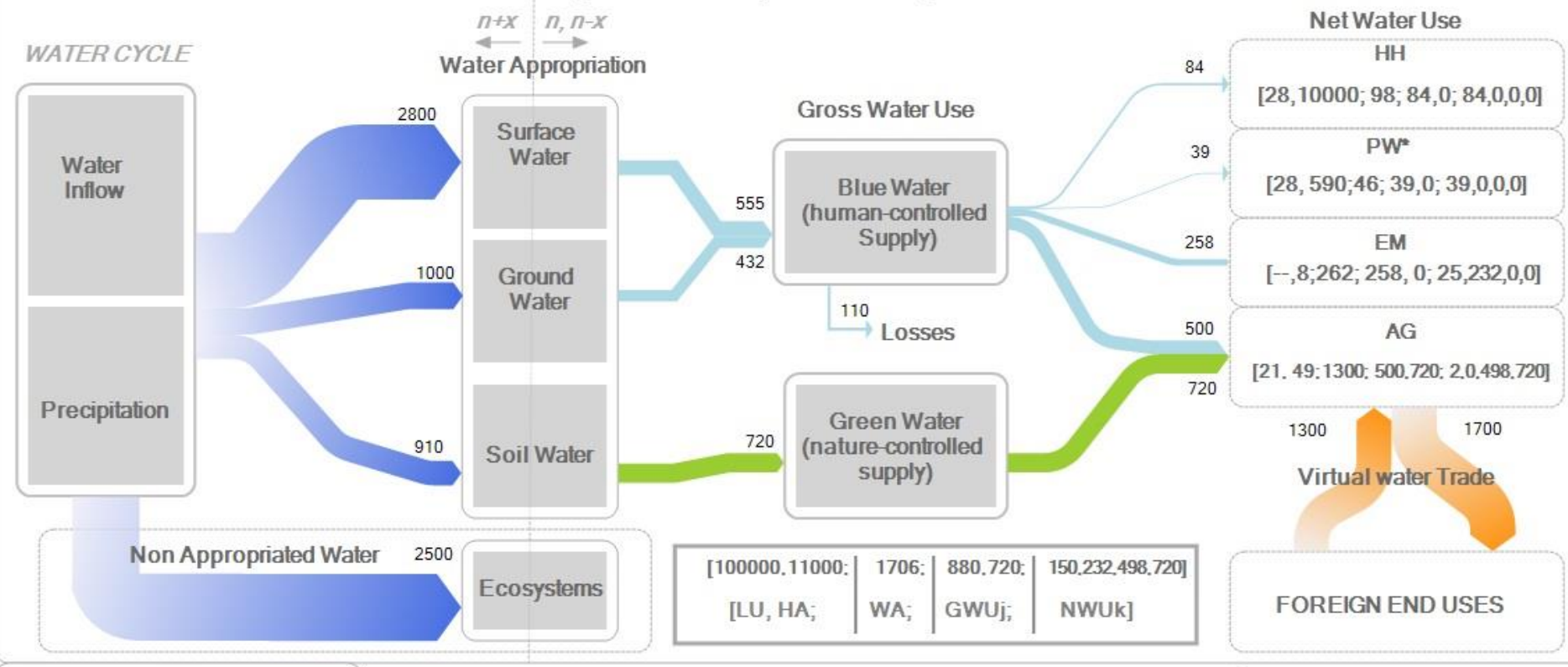

Semantic Categories
e+2
Water cycle
Water Recharge
e+1
Ecosystem
Water Appropriation
Focal level e
Water funds
Gross Water Use
Focal level n
Society
Net Water Use
Focal level n-1
Domestic Economy
Metabolic Water Use
Focal level n-2
Domestic Metabolism
Evaporation
Transport
Condensation
Precipitation
Run-off
Water Inflow
Rain
Snow
Accumulation
Aquifers
Surface
Soil
Sea
Extraction
Purif.
Distribution
Treatment
Qualitative Losses
Quantitative losses
Agriculture (A)
Rest of Paid Work
Energy and Mining
Households
Personal care
Nutrition
Other Consumption
Services
Cycle processes
Ecosystem Processes
Water funds
Water Handling
Foreign Economy
Foreign Metabolism


Legend
Primary inflow [Hm3]
Appropriated water [Hm3]
Lodging [Hm3]
Reused Water [Hm3]
In situ [Hm3]
In stream [Hm3]
Virtual Water [Hm3]


Scale
Volume
100000 Hm3
20000 Hm3
5000 Hm3

4. Environment

Figure 5: Example of water grammar

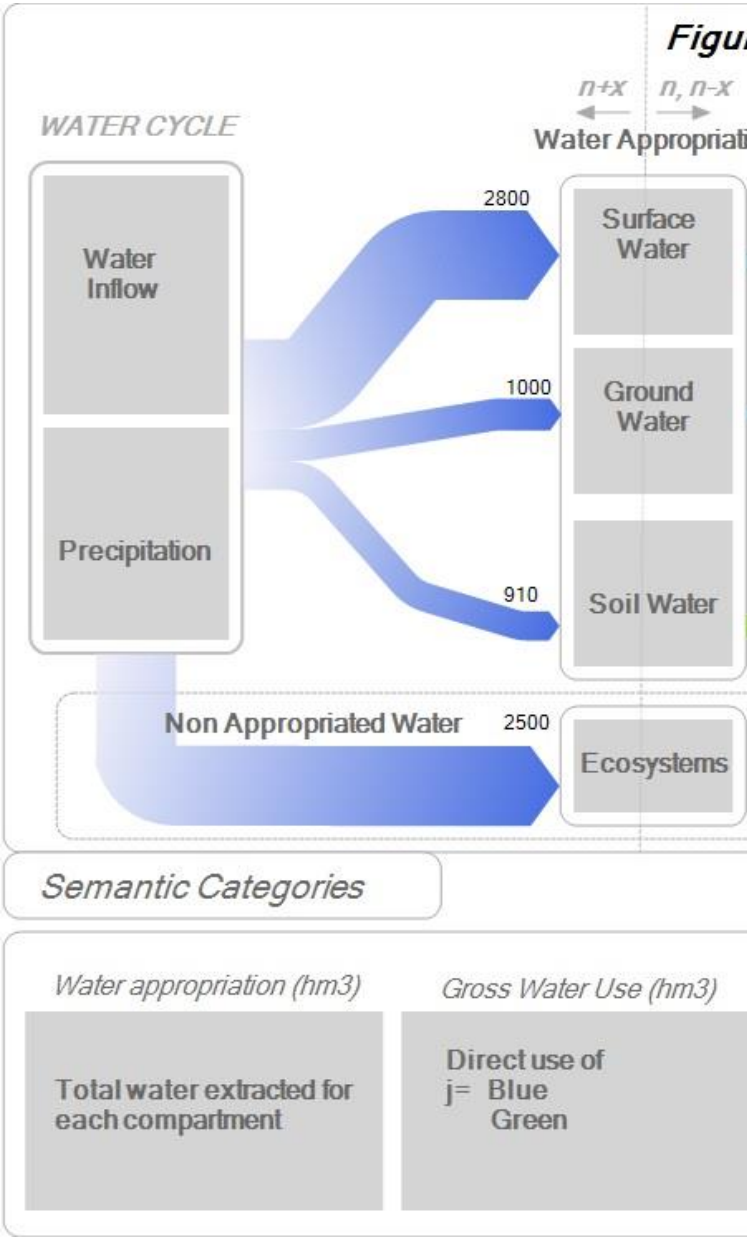


Semantic Categories

Formal Categories

Water appropriation (hm3)	*Gross Water Use (hm3)*	*Net Water Use (hm3)*	*Virtual Water Trade (hm3)*	*Relevant Funds*
Total water extracted for each compartment	Direct use of j= Blue Green	End use of: k= Distribution Energy Irrigation ET	Exports Imports	hours of Human Activity Khectares of Land Use

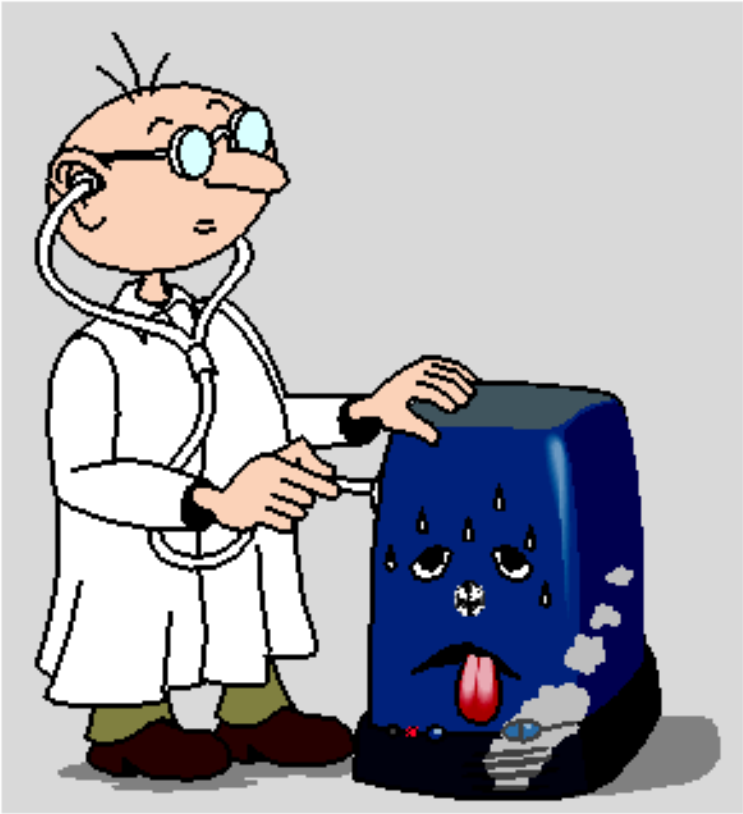
4. Environment



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

Water Accounting



Diagnostic-simulator tool

Current metabolic pattern

Moving the vector of production factors of sugarcane from “exports” to “EM”

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	10,000	28,000	11
	PW (n-1)	N/A	39	409	8,700	1,200	74,500	2.78
	SG (n-2)	N/A	8	15	5,200	680	N/A	0.96
	TR (n-2)	N/A	13	1.5	800	92	N/A	0.63
	BM (n-2)	N/A	16	23	2,200	410	N/A	1.09
	AG (n-2)	N/A	0	110	300	50	20,500	0.04
	EM (n-2)	N/A	2	260	180	8	negligible	0.07
	LOSSES	2.1	1	110	N/A	N/A	N/A	N/A
WHOLE (n)		8.0	56	1,700	N/A	11,500	102,500	14.00
EXPORTS (n-2)		negligible	0	1,100	5,100	33	54,000	N/A

SUPPLY	**IMPORTS**	6.7	48	1,600	6,200	N/A	211,500	N/A
	EM				N/A	N/A	N/A	N/A
	AG				N/A	N/A	20,500	N/A

Exports of Sugar = 4% of GVA using 90% of water

Consequences of moving the vector from AG to EM

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	28,000	11
	PW (n-1)	N/A	39	**1,515**	8,658	1,273	74,500	3
	SG (n-2)	N/A	7.9	15	5,178	680	N/A	1
	TR (n-2)	N/A	13	1	826	92	N/A	1
	BM (n-2)	N/A	15	23	**1,500**	**403**	N/A	**1**
	AG (n-2)	N/A	**0.26**	110	**217**	**49**	**15,800**	**0**
	EM (n-2)	N/A	**2.5**	**1,360**	**310**	**48**	**58,700**	**0**
	LOSSES	2.1	1.2	110	N/A	N/A	N/A	N/A
WHOLE (n)		8	56	1,700	N/A	11,469	102,500	14
EXPORTS		negligible	0	0	**4,900**	N/A	negligible	N/A

SUPPLY	**IMPORTS**	6.7	40	1,600	6,094	N/A	211,466	N/A
	EM	N/A	15	N/A	N/A	N/A	N/A	N/A
	AG	1				N/A	20,516	N/A

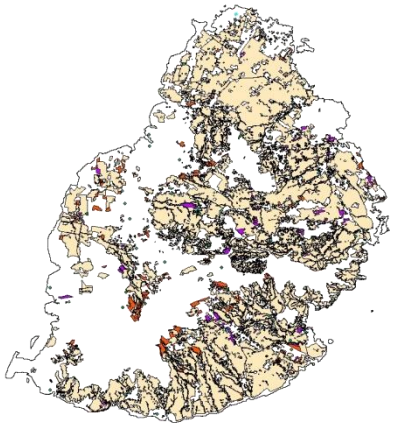
- 8 PJ = - 16% of energy imports using 90% of water

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

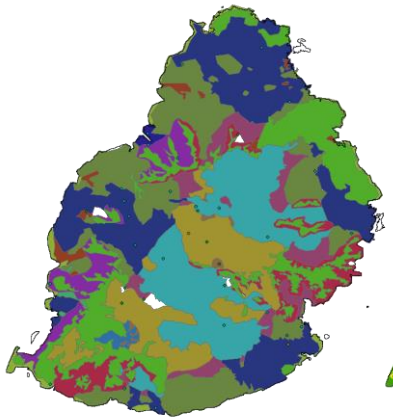
Step 1: Selection of other crops according to main food needs.

Step 2: Selection of location of cropland according to soil and slope constraints.

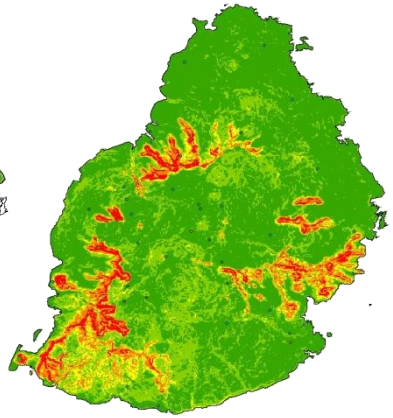
Sugar Cane



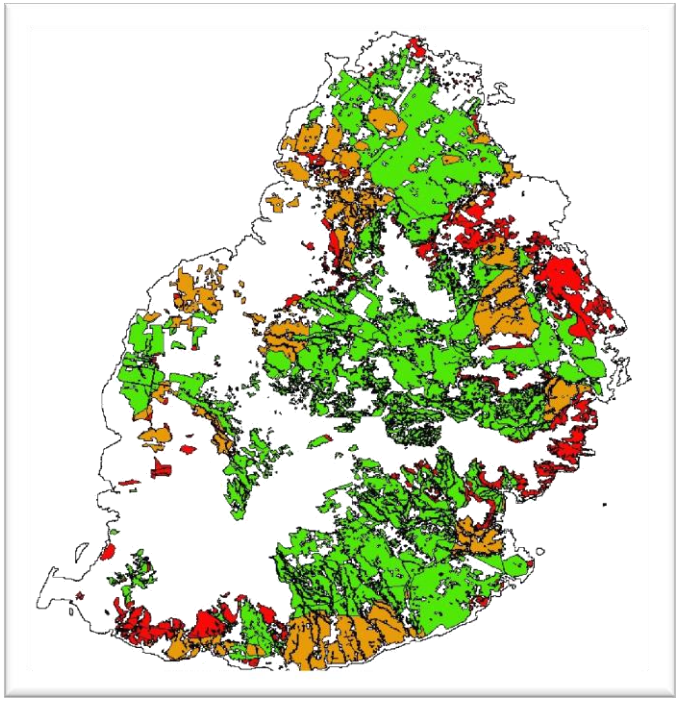
Types of Soil



Slope



Check of Previous Locations + Compatibility with soils + Slope compatibility

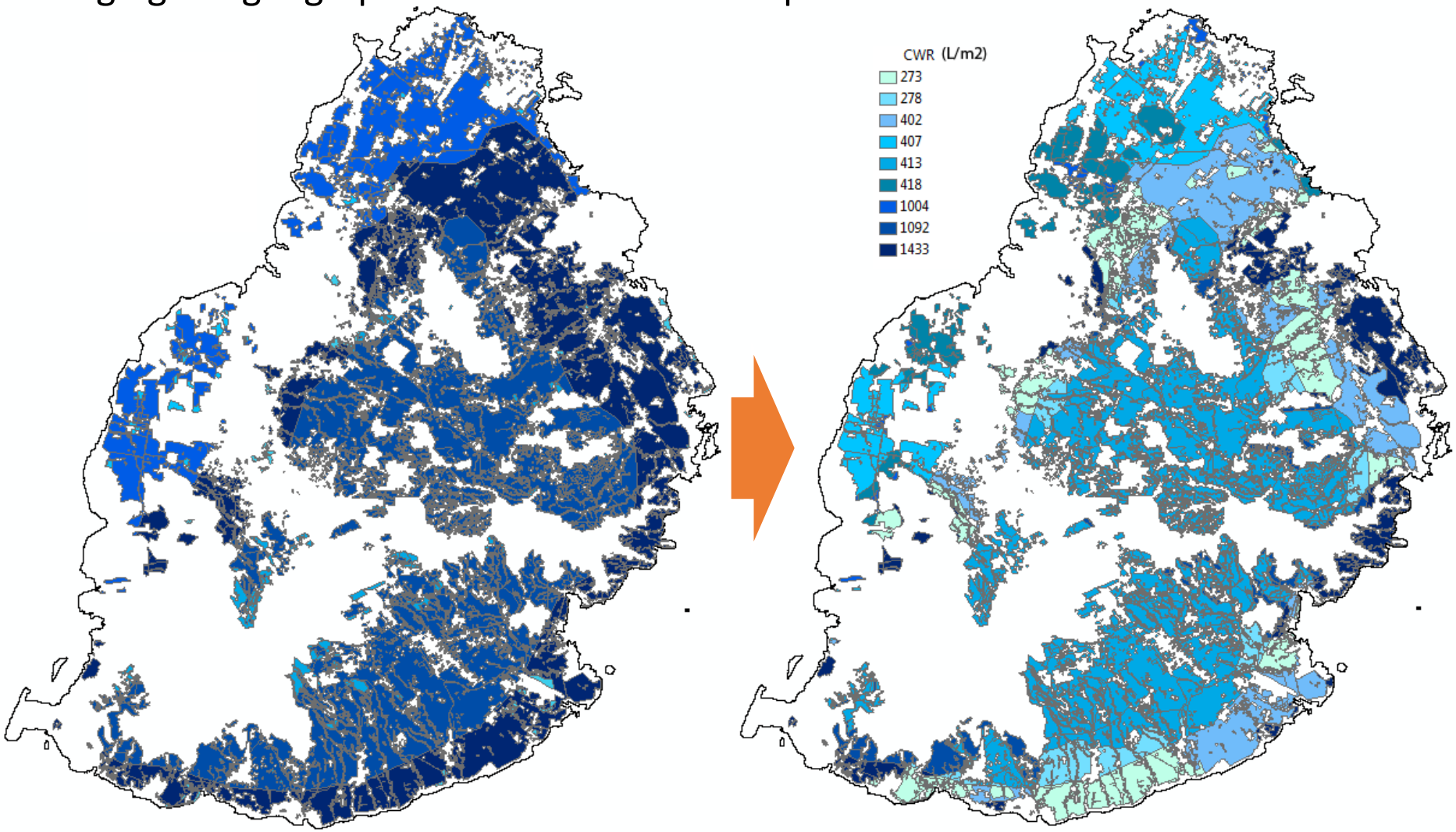


Spatial location of an alternative crop mix

4. MuSIASEM as a simulator tool: scenarios in Mauritius

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

Changing the geographical distribution of the pattern of water metabolism



Current pattern of CWR

Scenario 2 pattern of CWR

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

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

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

4. 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