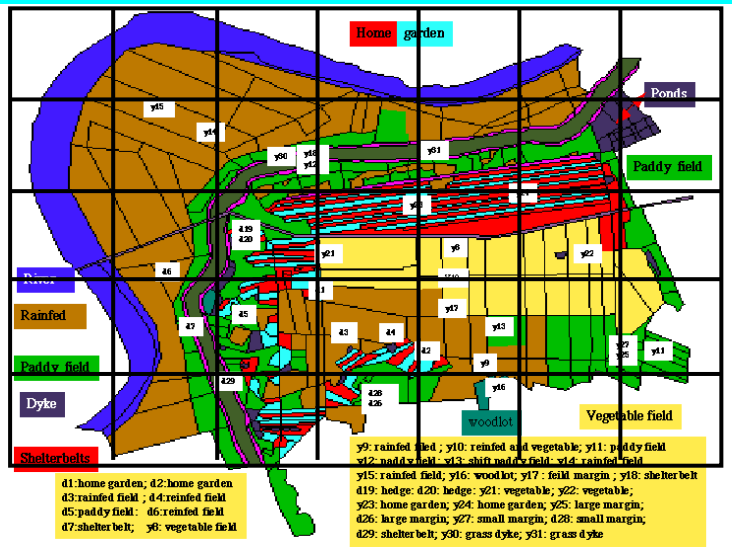
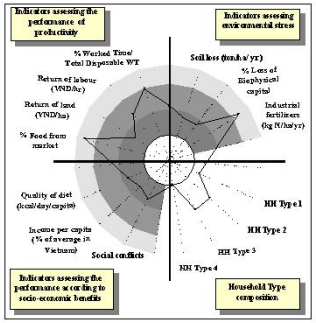
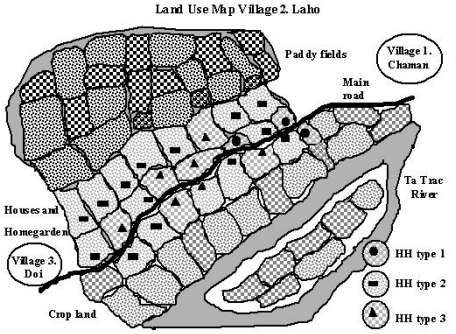
A Multi-Scale Integrated Analysis of rural development:

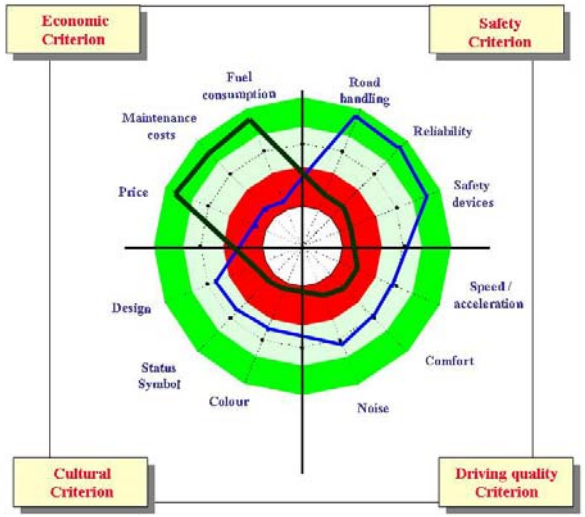
- Wuhan, Hubei Province in China;
- Nam Dong District, Thua Thien Hue Province, Vietnam

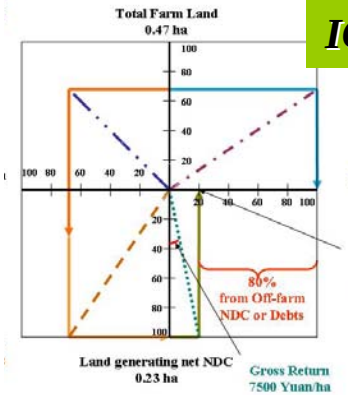


Characterization of MCPS









Mario GIAMPIETRO, ICREA-Professor
ICTA-Universitat Autonoma Barcelona, Spain

Content of the presentation

#1 Multi-Scale Integrated Analysis of Farming Systems

#2 How to look for relevant types and categories,
which can be bridged among levels and scales

#3 An overview of results from two case studies:
*** Wuhan, Hubei Province in China**
*** Nam Dong District, Thua Thien Hue Province, Vietnam**

#4 Lessons about the methodology

#1

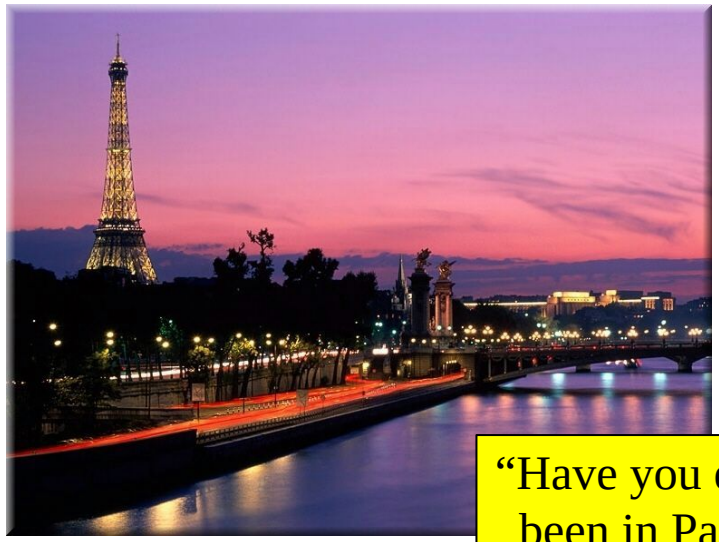
Multi-Scale Integrated Analysis of a farming system

The ultimate wisdom of agroecology: the recycling of night-soil: nutrients are going from plants to humans and back to plants . . .

Ask the lady!

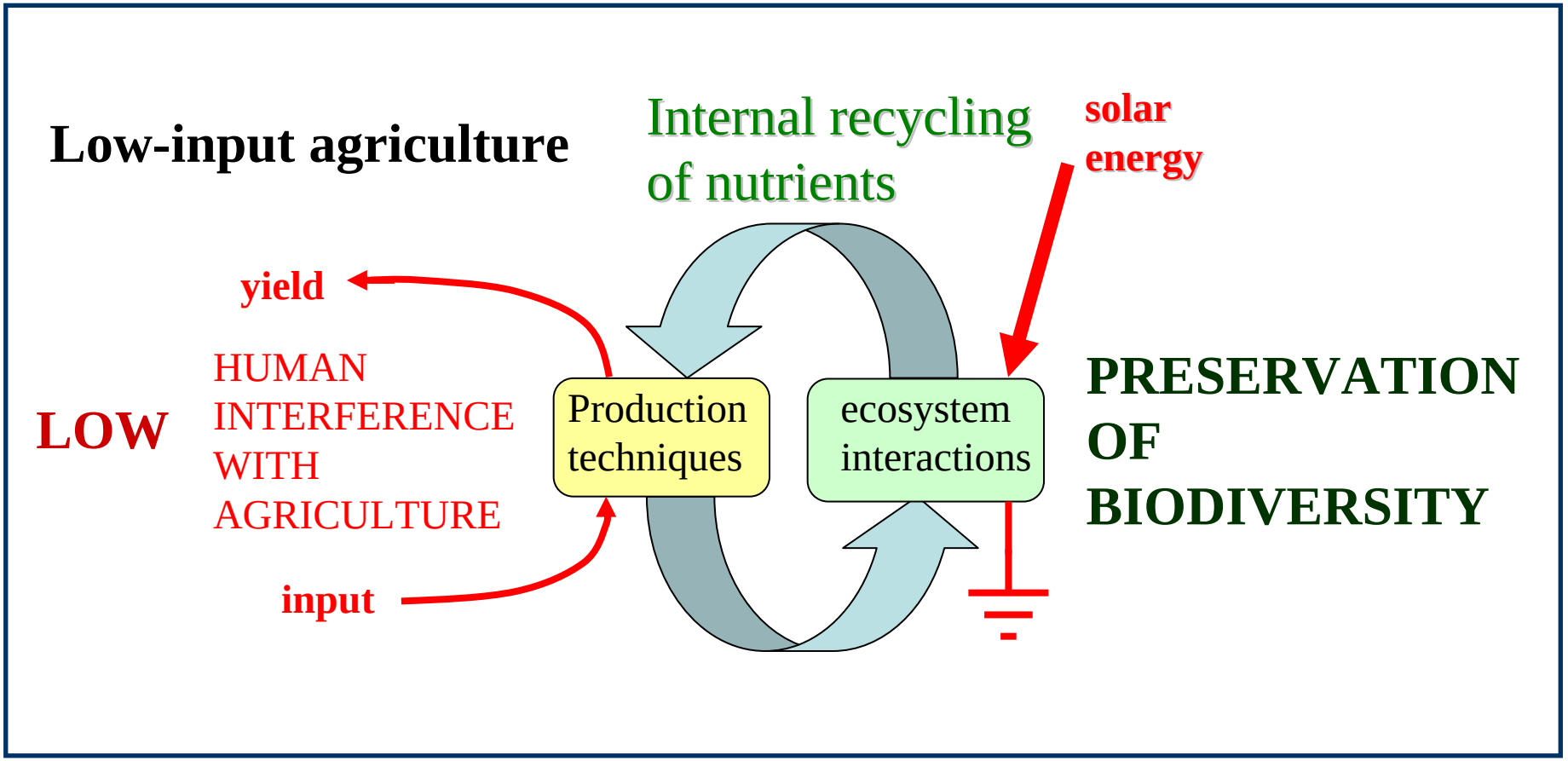
"I have never been in Paris!"

"and you want to know why? Because I have been closing nutrient cycles all the time ..."



"Have you ever been in Paris?"

What is wrong with preserving traditional agricultural practices?



This is the relevant narrative abut the future of agriculture when adopting as **identity of the story teller**:

AN AGROECOLOGIST WITH A GOOD SALARY FROM A UNIVERSITY

Chinese ethnic fashion
by Qi Chunying

International fashion week
Beijing

This is the relevant narrative abut the future of agriculture when adopting as **identity of the story teller**:

A FARMER THINKING ABOUT THE FUTURE OF HER DAUGHTERS

For a scientific model there is something which is much worse than being wrong …

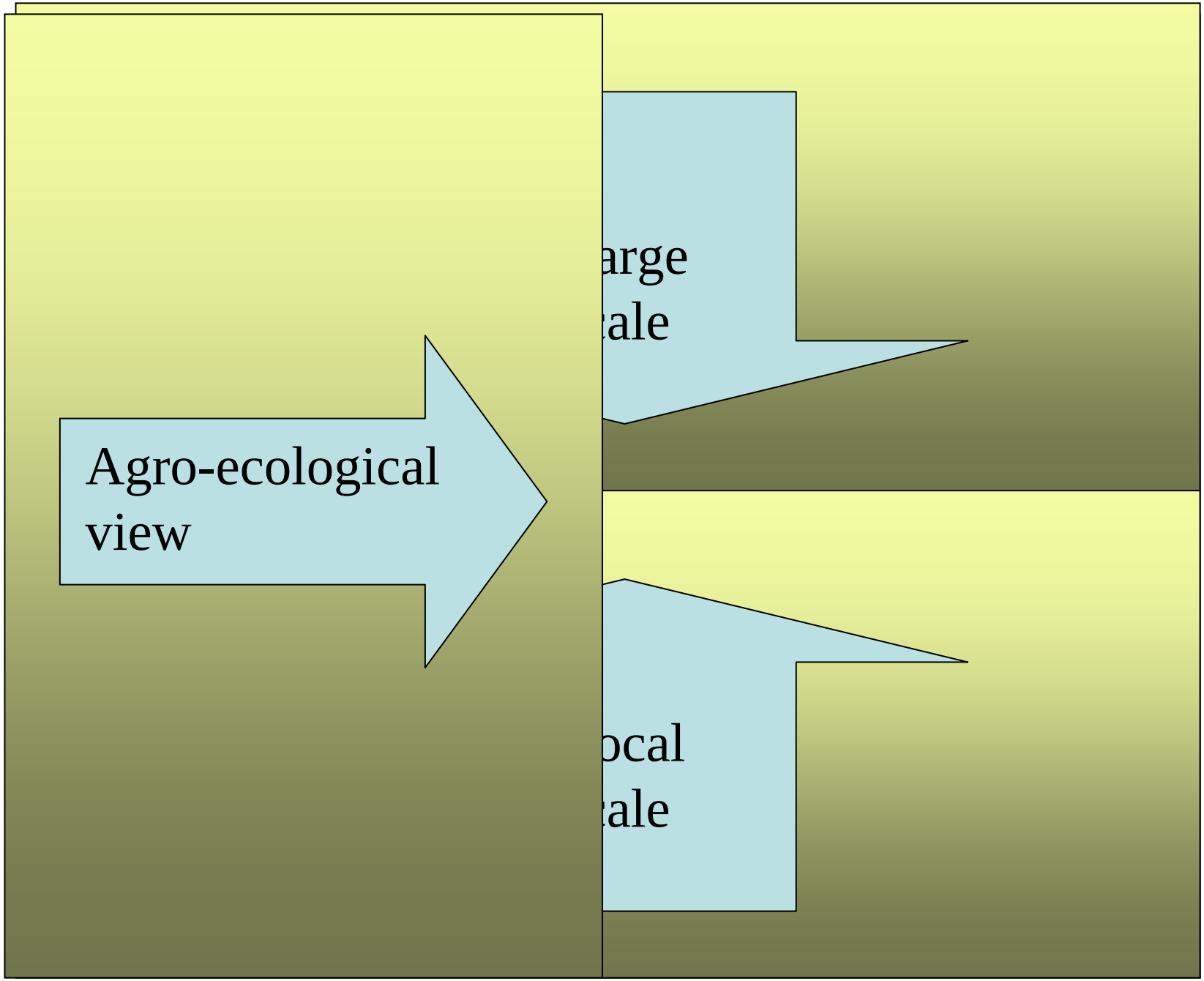
That is, being developed within an irrelevant narrative

FIRST - start the study from a relevant issue definition . . .

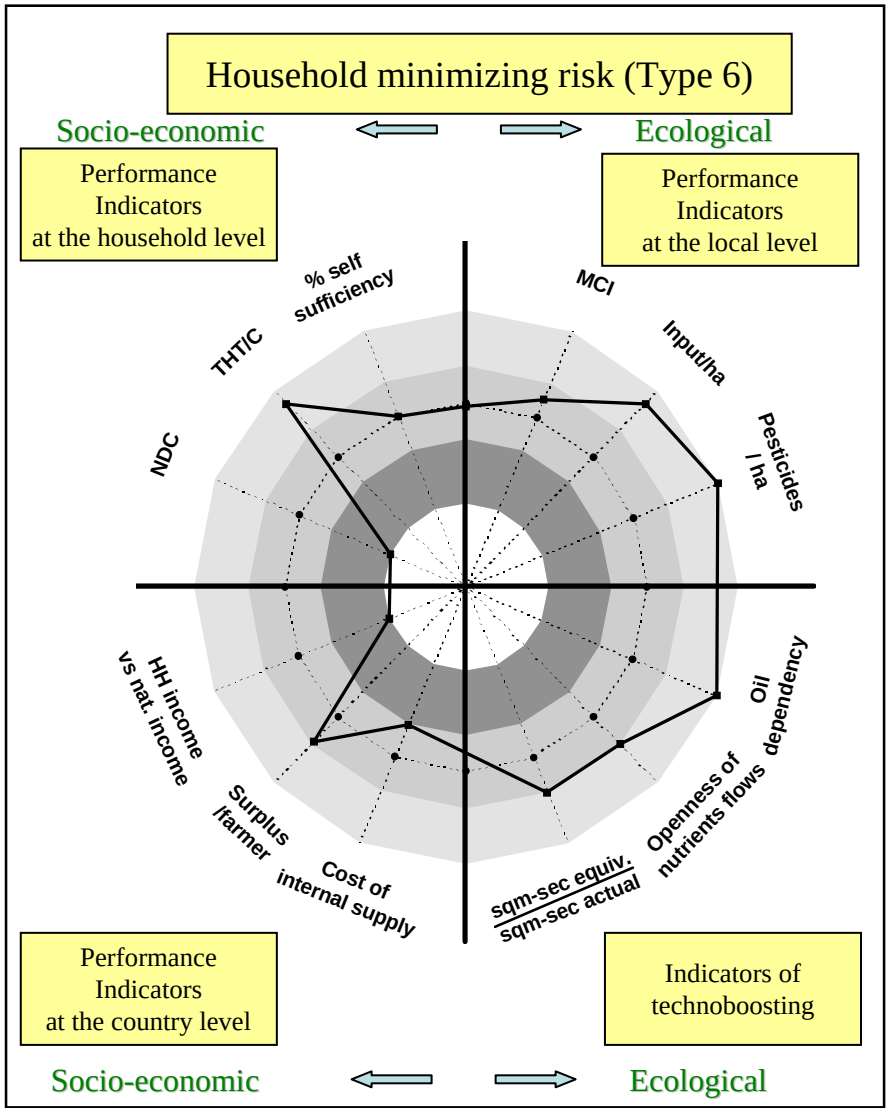
How to characterize the performance of the farming system using a "Multicriteria Space"

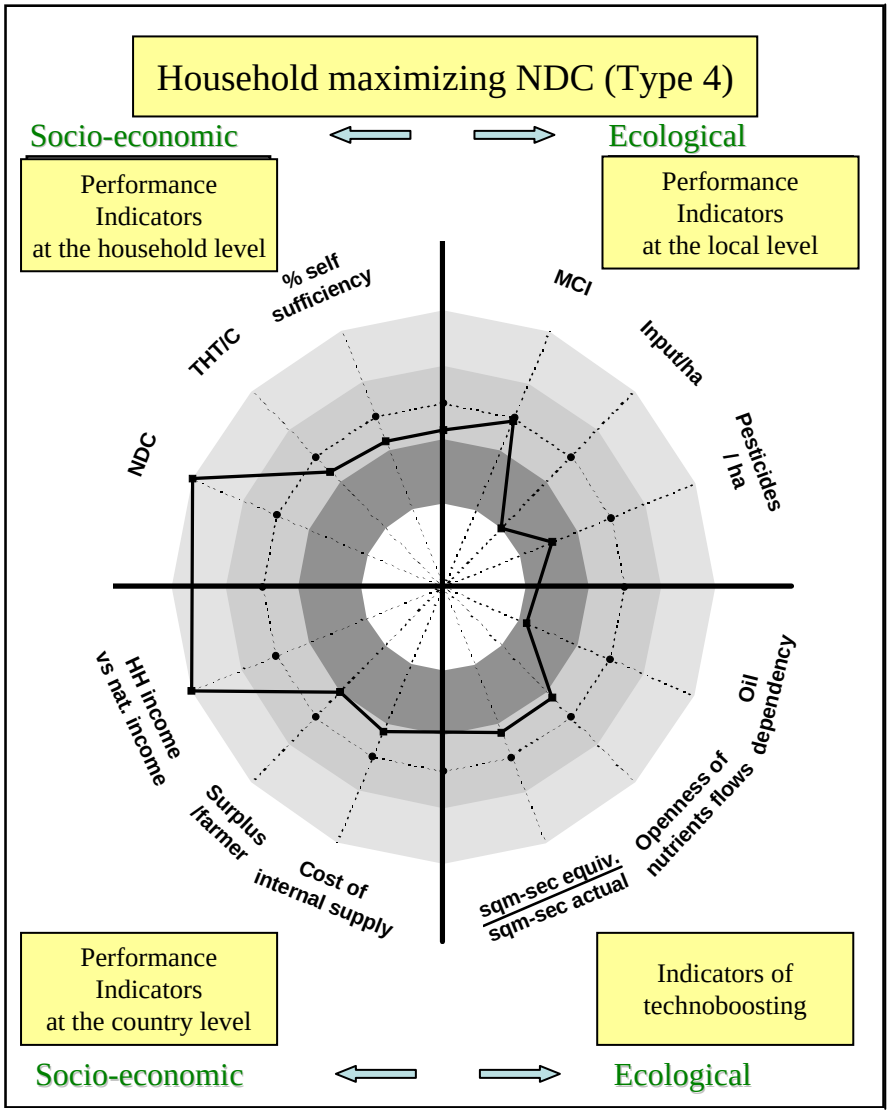
in jargon: "Multi-Objective Integrated Representation"
for an overview of this issue see:

Gomiero, T. and Giampietro, M. 2005.
Graphic tools for data representation in integrated analysis of farming systems.
***International Journal of Global Environmental Issues* 5 (3/4): 264-301.**

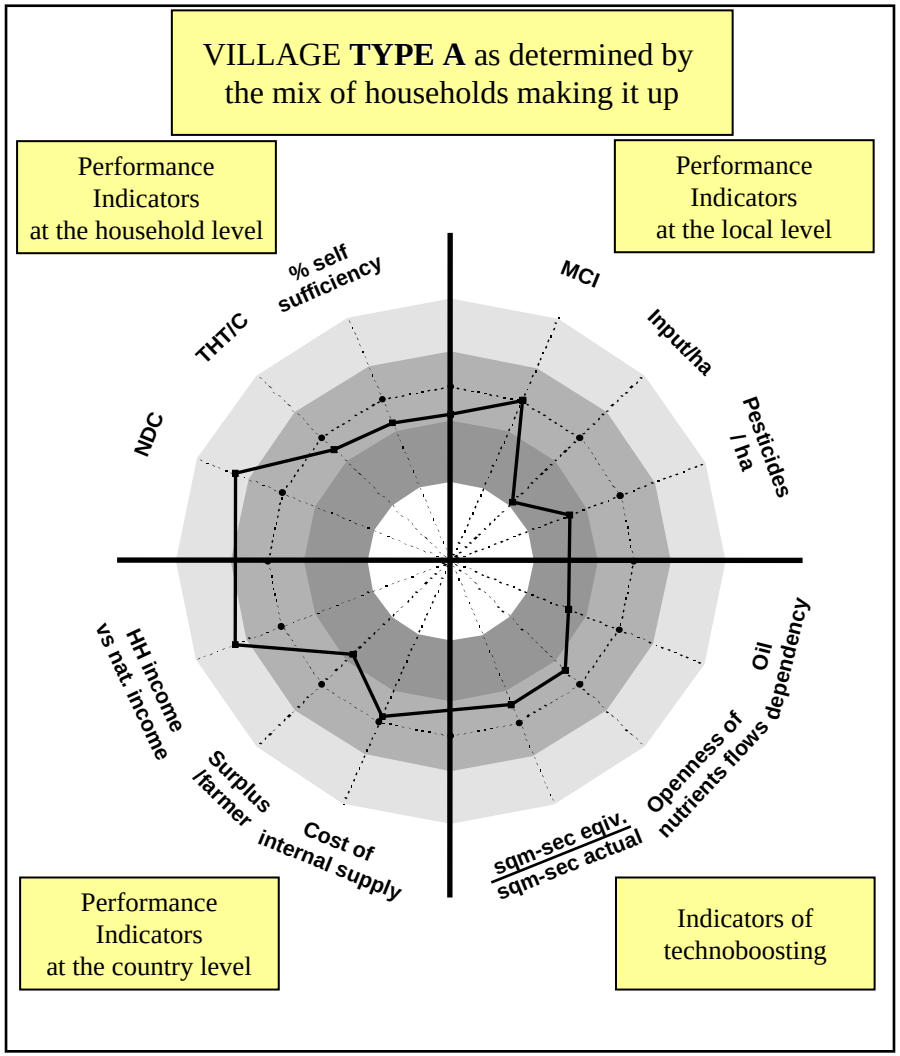

Agro-ecological
view

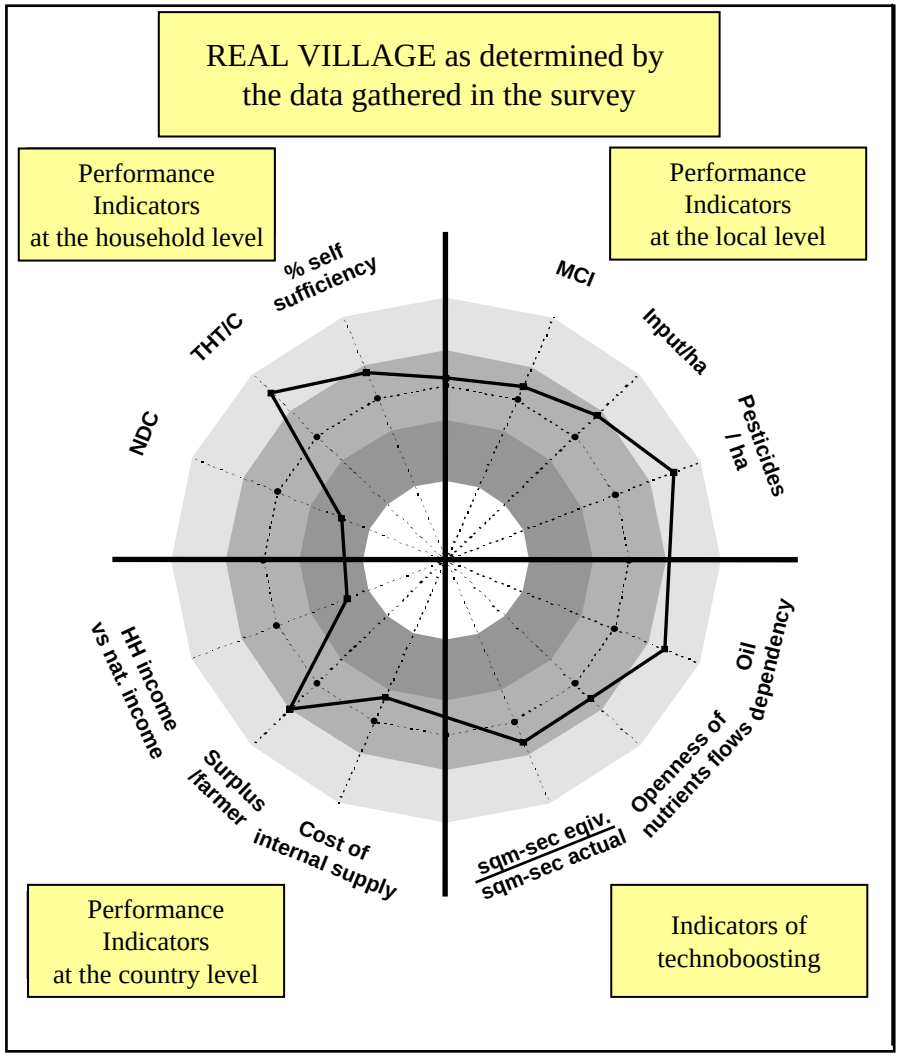
Typologies of household on a Multi-Criteria performance space





Typologies of rural village reflecting a different mix of household types





This entailed facing two tough questions:

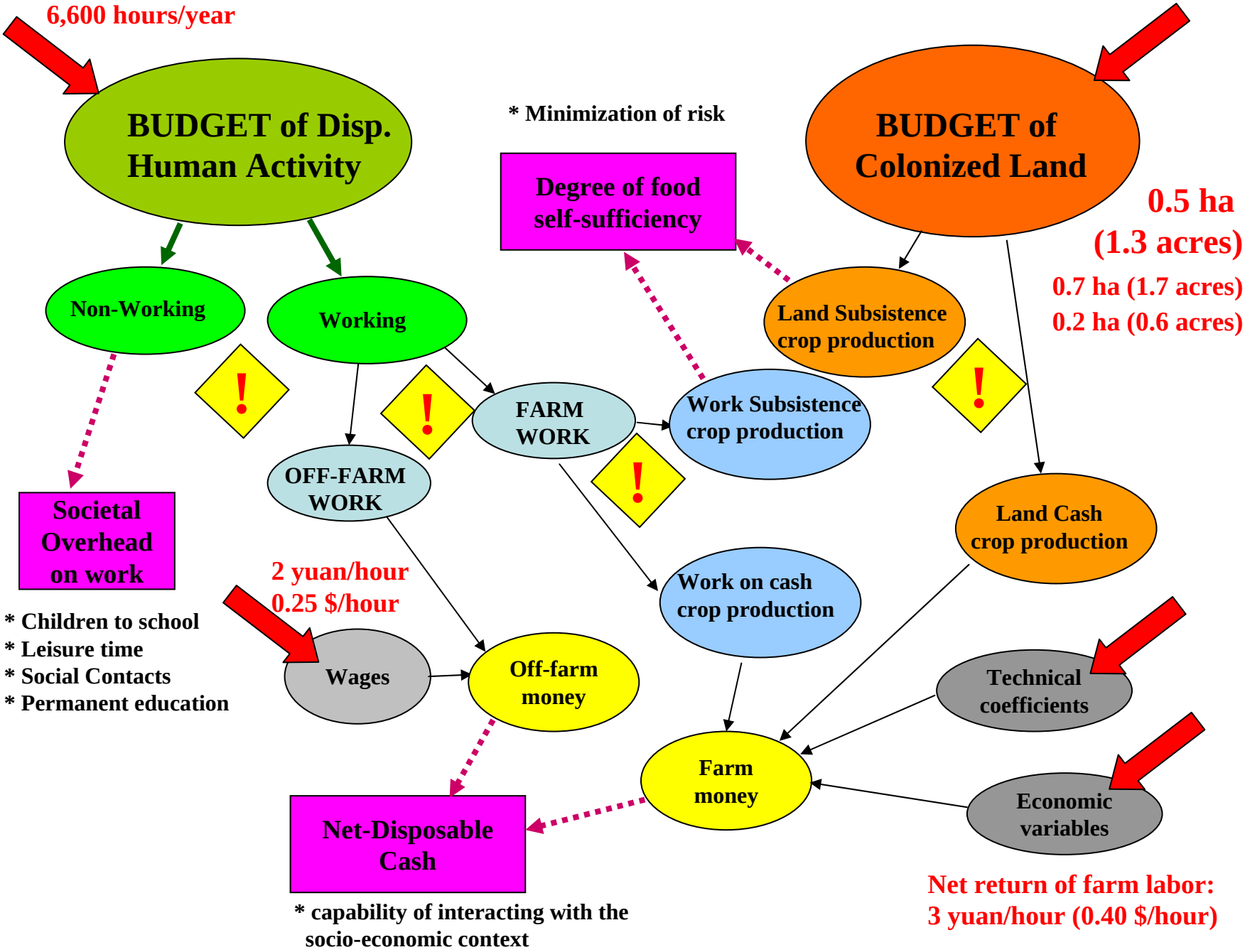
1. **How to explain the existence of types (how to check if they were relevant)**

2. **How to establish a bridge across levels (how to keep coherence across scales)**

#2

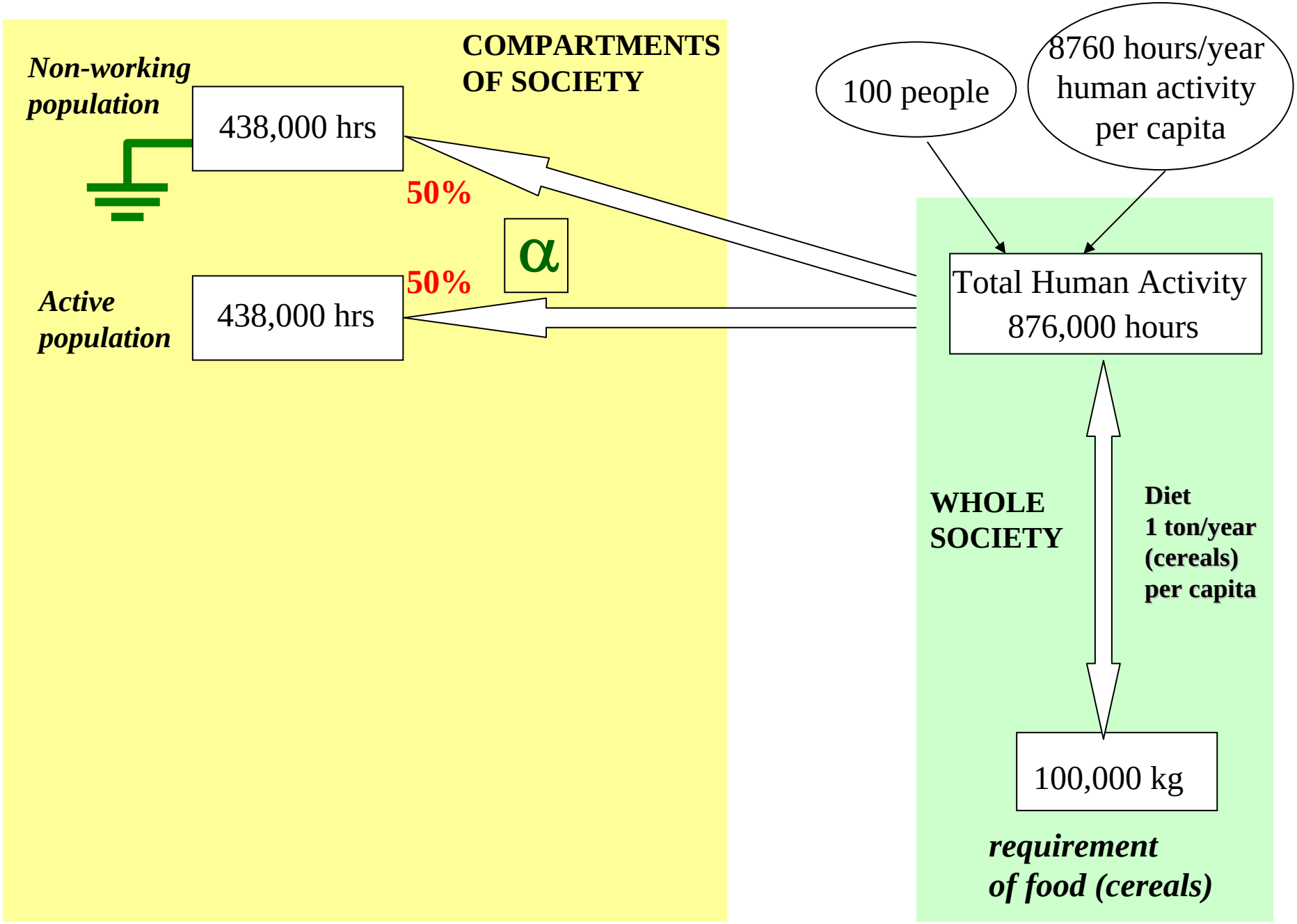
How to explain the existence of types?
(how to check if they were relevant?)

Impredicative Loop Analysis


6,600 hours/year
BUDGET of Disp. Human Activity
* Minimization of risk
Degree of food self-sufficiency
BUDGET of Colonized Land
0.5 ha (1.3 acres)
0.7 ha (1.7 acres)
0.2 ha (0.6 acres)
Non-Working
Working
Land Subsistence crop production
!
!
!
!
FARM WORK
Work Subsistence crop production
OFF-FARM WORK
Societal Overhead on work
Land Cash crop production
2 yuan/hour
0.25 $/hour
Work on cash crop production
* Children to school
* Leisure time
* Social Contacts
* Permanent education
Wages
Off-farm money
Technical coefficients
Farm money
Economic variables
Net-Disposable Cash
* capability of interacting with the socio-economic context
Net return of farm labor:
3 yuan/hour (0.40 $/hour)

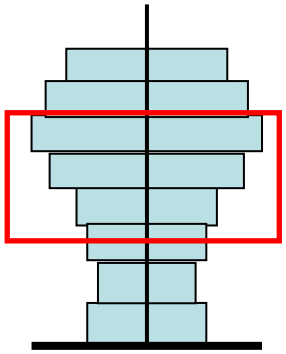
There is a mechanism that "quantize" so to speak the possible outcomes of farmer decisions?

Let's explore this idea in general terms


COMPARTMENTS OF SOCIETY
Non-working population
438,000 hrs
50%
α
50%
Active population
438,000 hrs
100 people
8760 hours/year human activity per capita
Total Human Activity 876,000 hours
WHOLE SOCIETY
Diet 1 ton/year (cereals) per capita
100,000 kg
requirement of food (cereals)

Demographic structure, social rules and work supply

ITALY

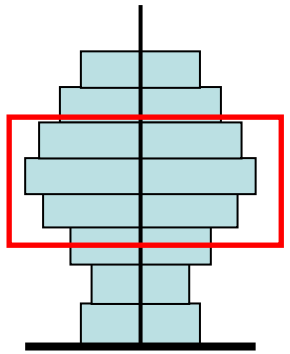


population economically active
40%

workload/year per worker
1,700 hours

680,000 hours of work
per 1,000 people

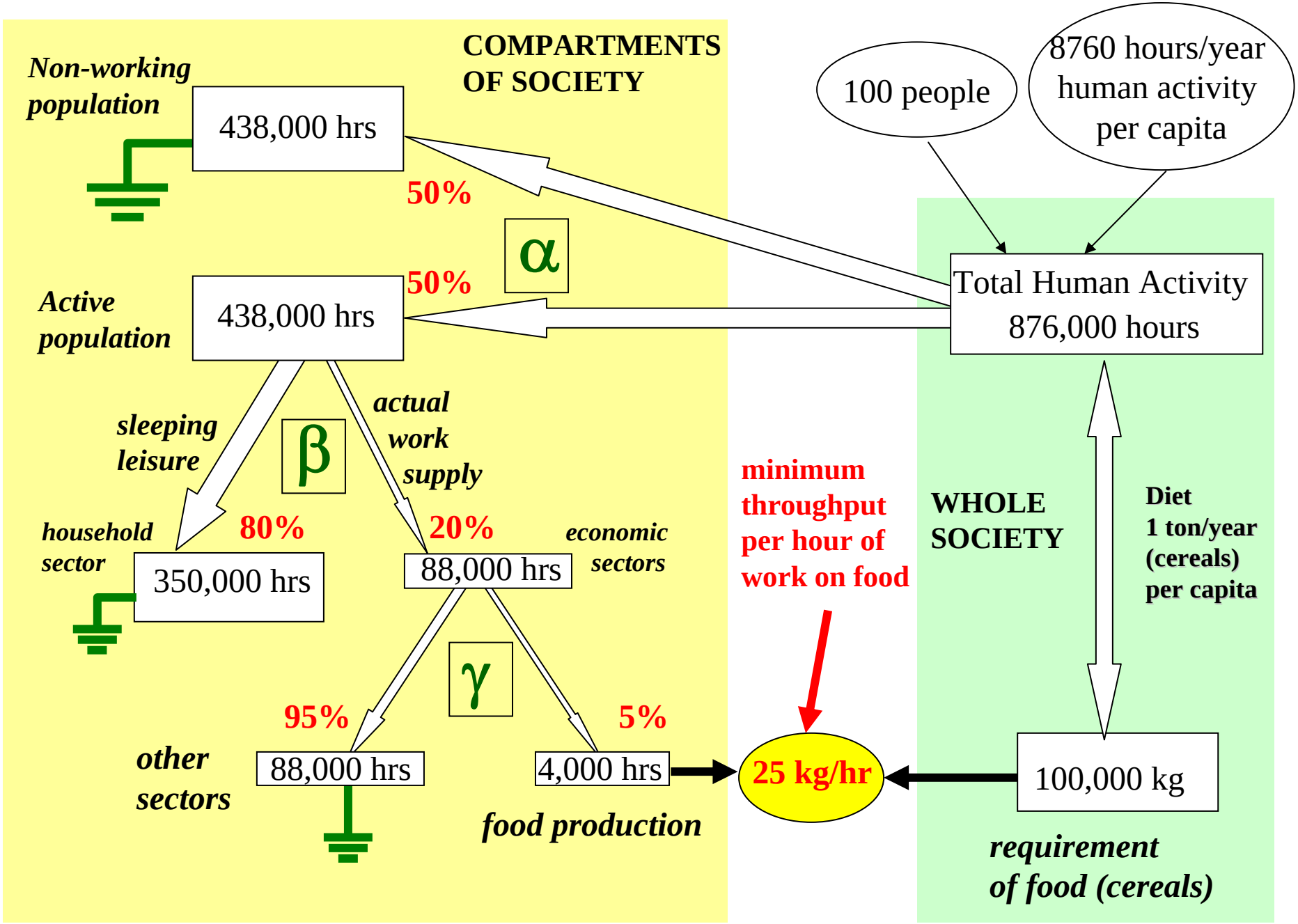
CHINA

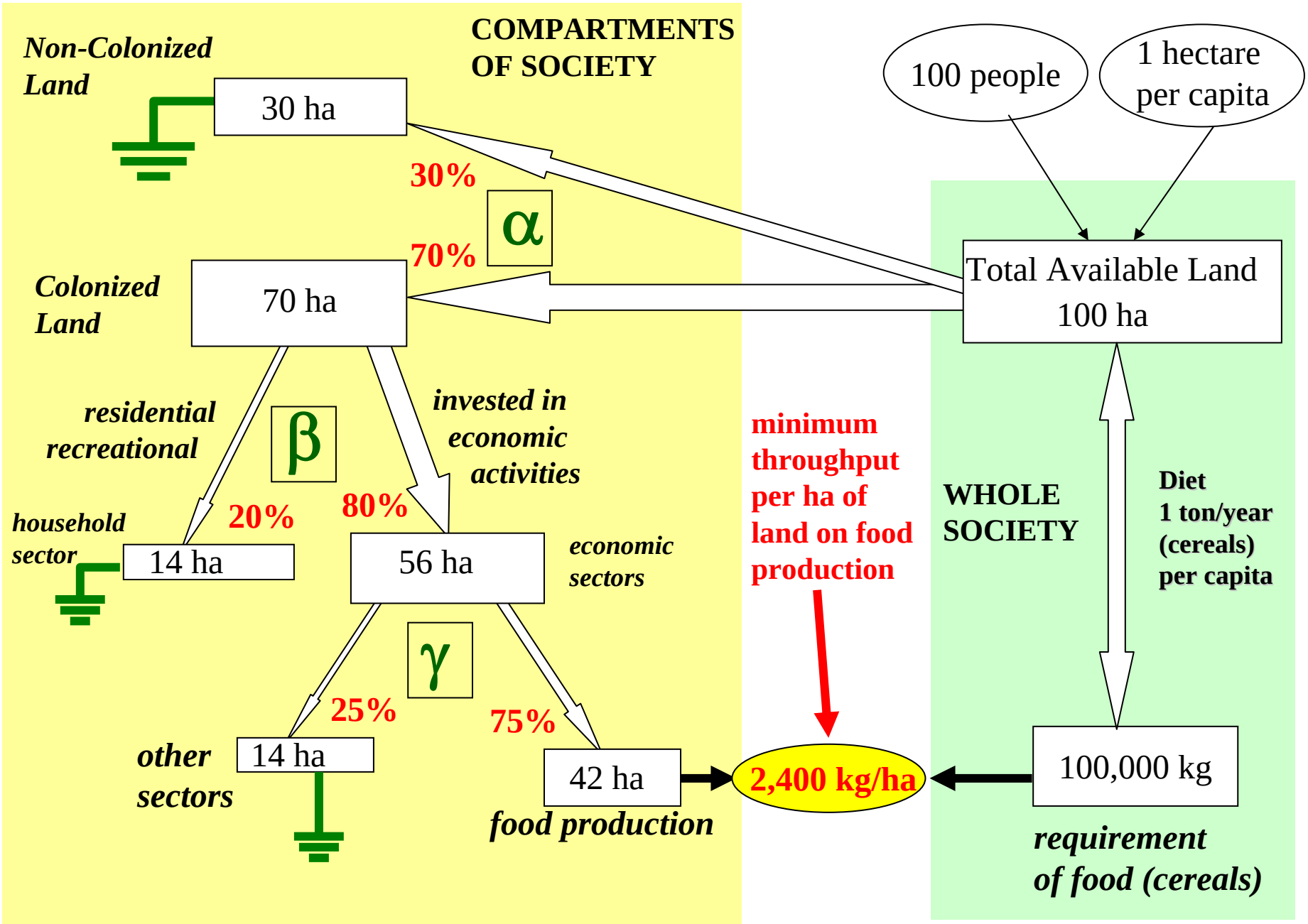


population economically active
60%

workload/year per worker
2,820 hours

1,650,000 hours of work
per 1,000 people


COMPARTMENTS OF SOCIETY
Non-working population
438,000 hrs
50%
α
50%
Active population
438,000 hrs
sleeping leisure
β
actual work supply
household sector
80%
350,000 hrs
20%
88,000 hrs
economic sectors
γ
95%
other sectors
88,000 hrs
5%
4,000 hrs
food production
100 people
8760 hours/year human activity per capita
Total Human Activity 876,000 hours
minimum throughput per hour of work on food
25 kg/hr
WHOLE SOCIETY
Diet 1 ton/year (cereals) per capita
100,000 kg
requirement of food (cereals)


COMPARTMENTS OF SOCIETY
Non-Colonized Land
30 ha
30%
α
70%
Colonized Land
70 ha
100 people
1 hectare per capita
Total Available Land 100 ha
residential recreational
β
invested in economic activities
20%
80%
household sector
14 ha
56 ha
economic sectors
γ
25%
75%
other sectors
14 ha
42 ha
food production
minimum throughput per ha of land on food production
2,400 kg/ha
WHOLE SOCIETY
Diet 1 ton/year (cereals) per capita
100,000 kg
requirement of food (cereals)

Application of ILA to farming system analysis
Hours Human Activity versus *Yuan flow*

Rice based
Hubei, China

4.5 persons

Total Human Activity
39400 hours/ year

Physiological Overhead (72%)

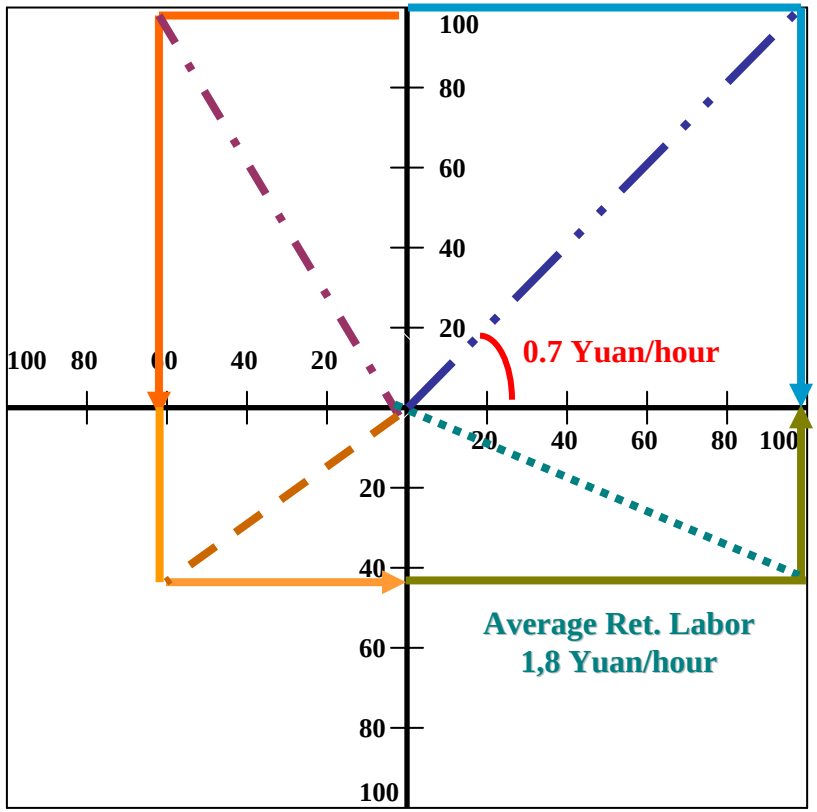
HOUSEHOLD SIZE

Max. Disposable Human Activity
14,000 hours

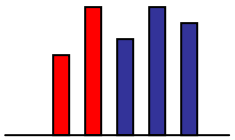
Working Time Satutarion Index
61%

Indicator of quality of life → 39% invested in education, leisure, social interactions

Net Disposable Cash flow household level
0.25 Yuan/hour



Disposable Working Time
8,560 hours



Profile of allocation of working time

% Working Time in subsistence activities (including chores)
29%

Labor on Net Disp. Cash
6,080 hours

Cash Crop#1 = 3 Yuan/hour
Cash Crop#2 = 2 Yuan/hour
Wage#1 = 6 Yuan/hour
Wage#2 = 1 Yuan/hour
Aquaculture = 6 Yuan/hour

Rice based
Hubei, China

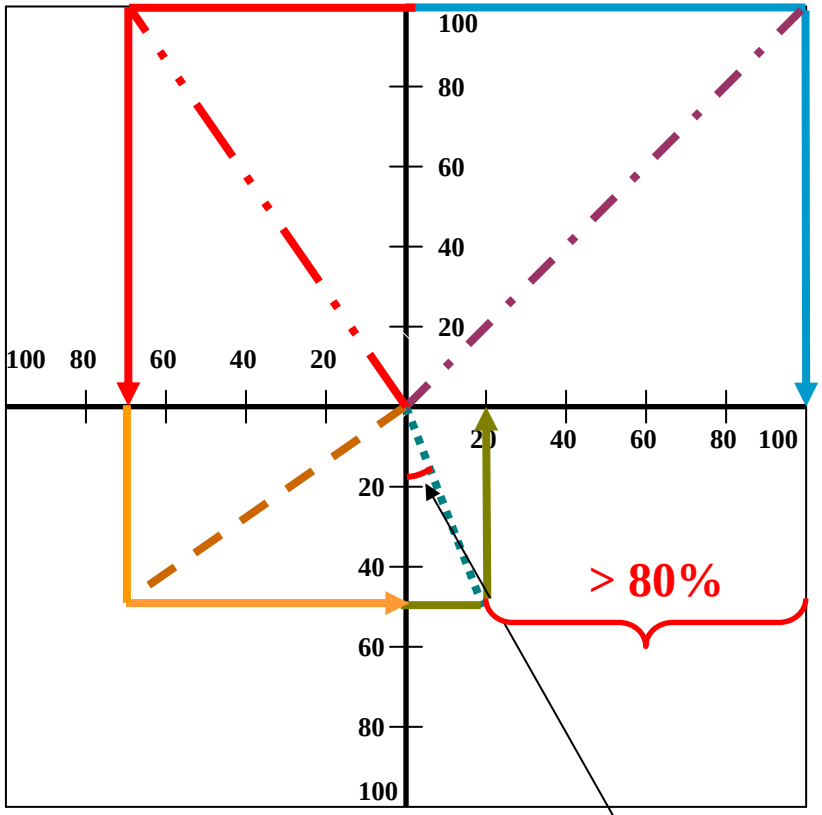
Application of ILA to farming system analysis
hectares of colonized land versus *Yuan flow*

Overhead related to competing land uses
30% (0.14 ha)

* conservation
* subsistence
* housing & infrastructure

Total Farm Land
0.47 ha

Net Disposable Cash flow household level
20,600 Yuan/ha/year



Land in Cash Production
0,33 ha

NDC Requirement
(household expenditure)
10,000 Yuan/year

20% NDC Supply from farming
1,700 Yuan/ year

80% NDC Supply from off-farm or debts
8,300 Yuan/year

% Land Use to pay for inputs and taxes
31% (0.10 ha)

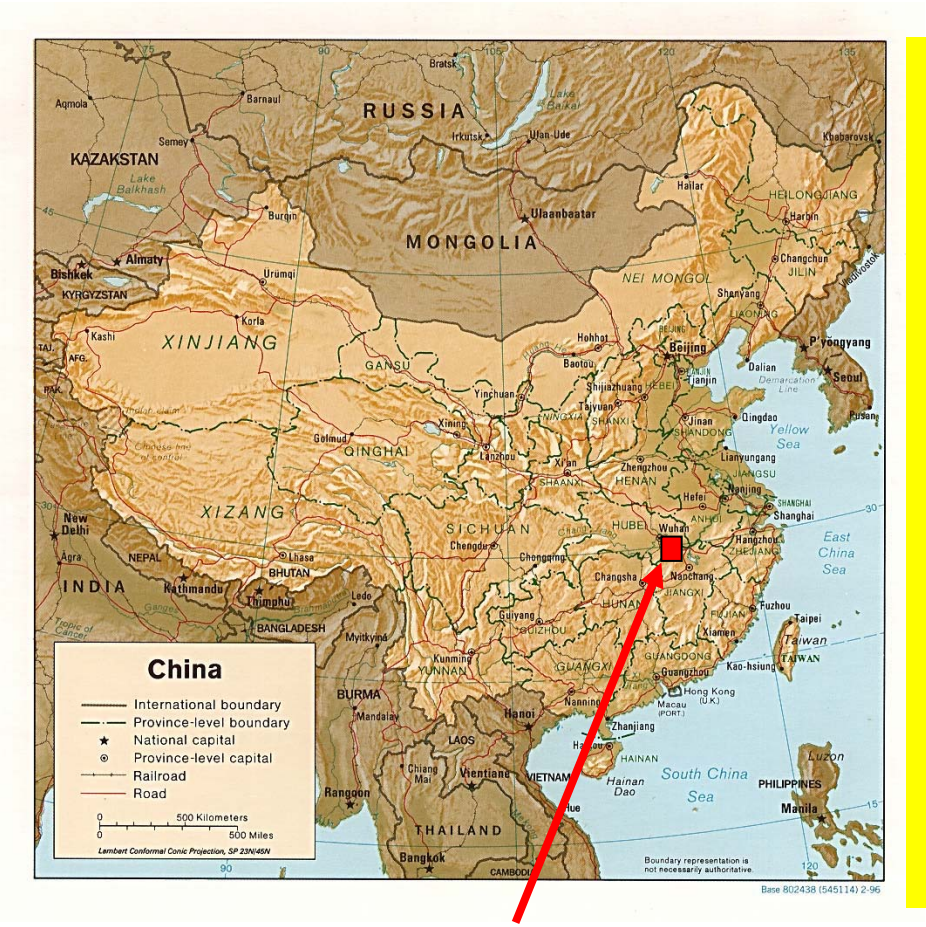
Land generating net NDC
0.23 ha

Return
7500 Yuan/ha

* mix of crops
* return per crop

#3

An overview of results of two case studies



Giampietro, M., Bukkens, S.G.F. and Pimentel, D. 1999. General trends of technological changes in agriculture. *Critical Reviews in Plant Sciences* 18 (3): 261-282.

Li Ji, Giampietro, M., Pastore, G., Cai Liewan and Luo Huaer 1999. Factors affecting technical changes in rice-based farming systems in southern China: Case study of Qianjiang municipality. *Critical Reviews in Plant Sciences* 18 (3): 283-298.

Giampietro, M. and Pastore G. 1999. Multidimensional reading of the dynamics of rural intensification in China: the AMOEBA approach. *Critical Reviews in Plant Sciences* 18 (3): 299-330.

Pastore, G., Giampietro, M. and Li Ji 1999. Conventional and land-time budget analysis of rural villages in Hubei province, China. *Critical Reviews in Plant Sciences* 18 (3): 331-358.

Wuhan (city) – Yangtze River
Hubei Province

TITLE OF THE PROJECT 1993-1997

"Impacts of agricultural intensification on resources use sustainability and food safety and measures for its solution in highly-populated subtropical rural areas in China"

Project in China – main results

*** In rural areas the *mu* is variable**

*** Almost 60% of farmer income is not coming from crop related activities**

*** The goals of this project for rural development were incompatible with existing constraints**

*** Unless cash flow is brought into the system to enlarge the option space of paid activities there is no possibility of having sustainable development just by using existing pieces of the puzzle**

*** A tool kit of Multi-Scale Integrated Analysis may help the discussion of alternatives and policy options**

The Multi-Scale Integrated Analysis of the farming system

Households seen as agents

The decision of household type i

* Kg/ha
* Kg/hour
* $/outputs
* $/inputs
* taxes

parameters

Budget of Land

Budget of Human Activity

Budget of Capital

constraints

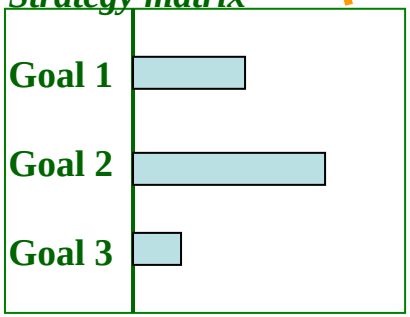
* Diet mix
* NDC expenditures mix
* WORK/NO WORK
* WORK off-farm/farm
* LAND cash/subsistence
* Jobs mix
* Crop mix

variables

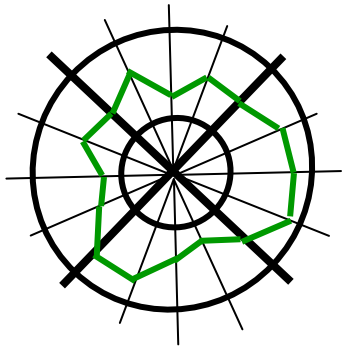
CHOICE

OPTION SPACE

Strategy matrix



LAND USE PATTERN

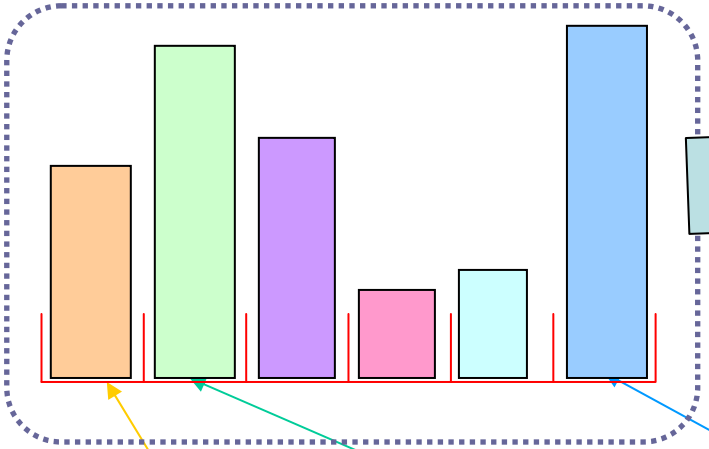


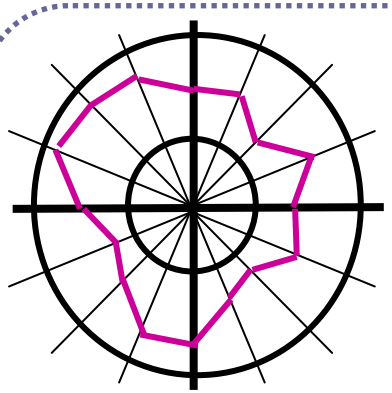
MOIR

Pay-off matrix INTEGRATED ASSESSMENT

Scaling up the effect of household choices

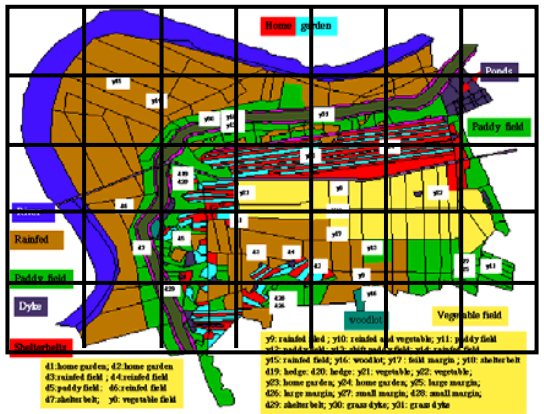
The aggregate effect of the decisions of the population of households





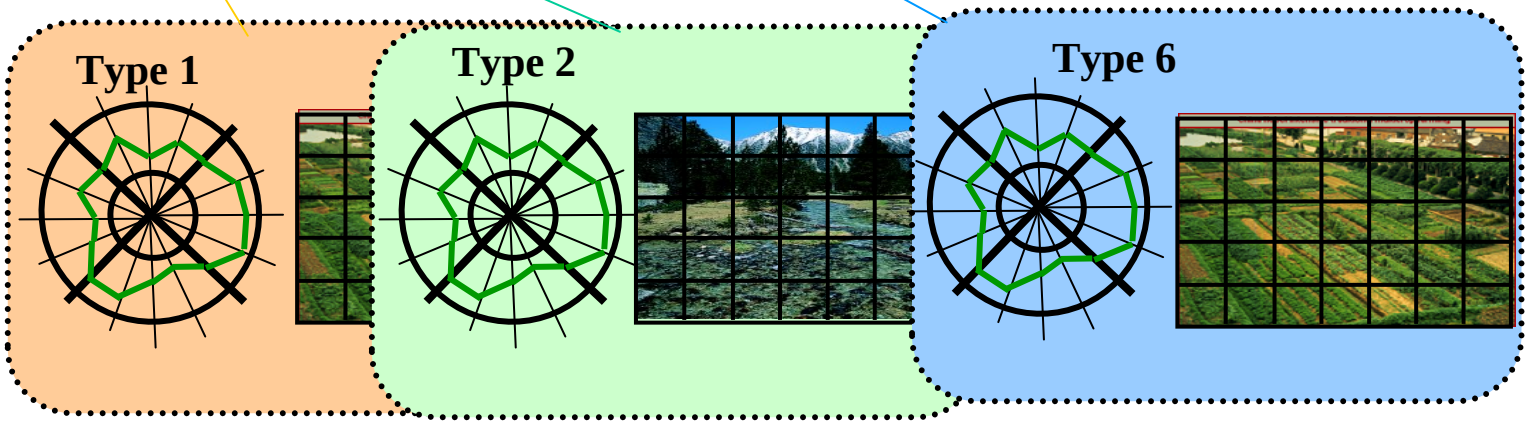
MOIR at the village level

Integrated Assessment at level n+1



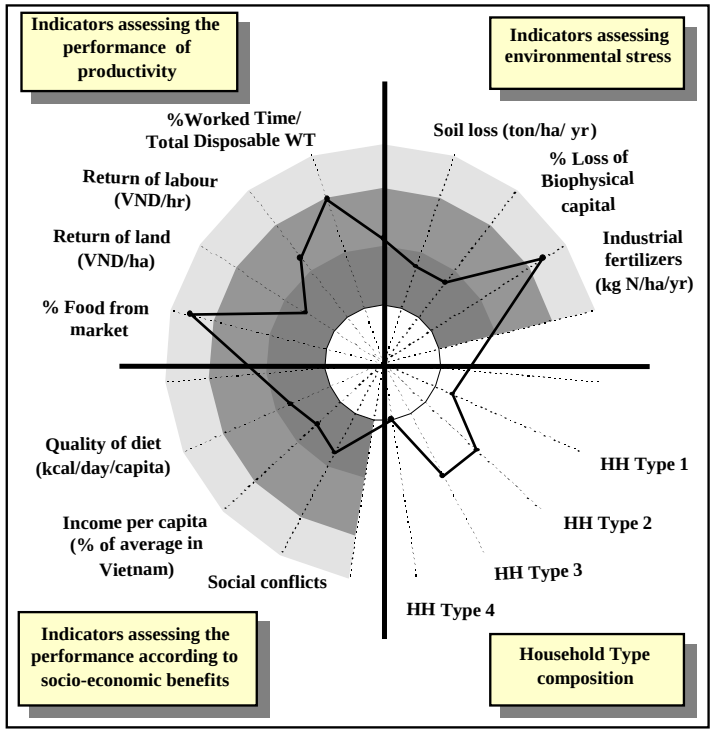
Land use map - village

Profile of distribution of household types

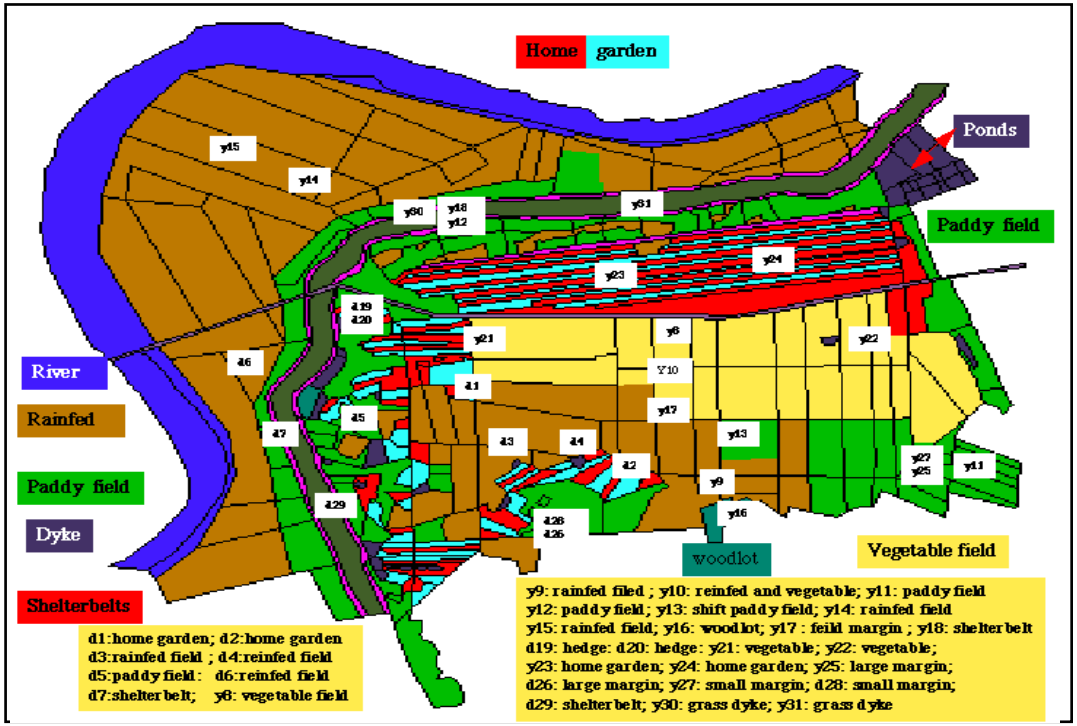


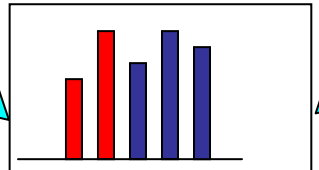
TYPE ⟷ INDIVIDUAL

MOIR - household types

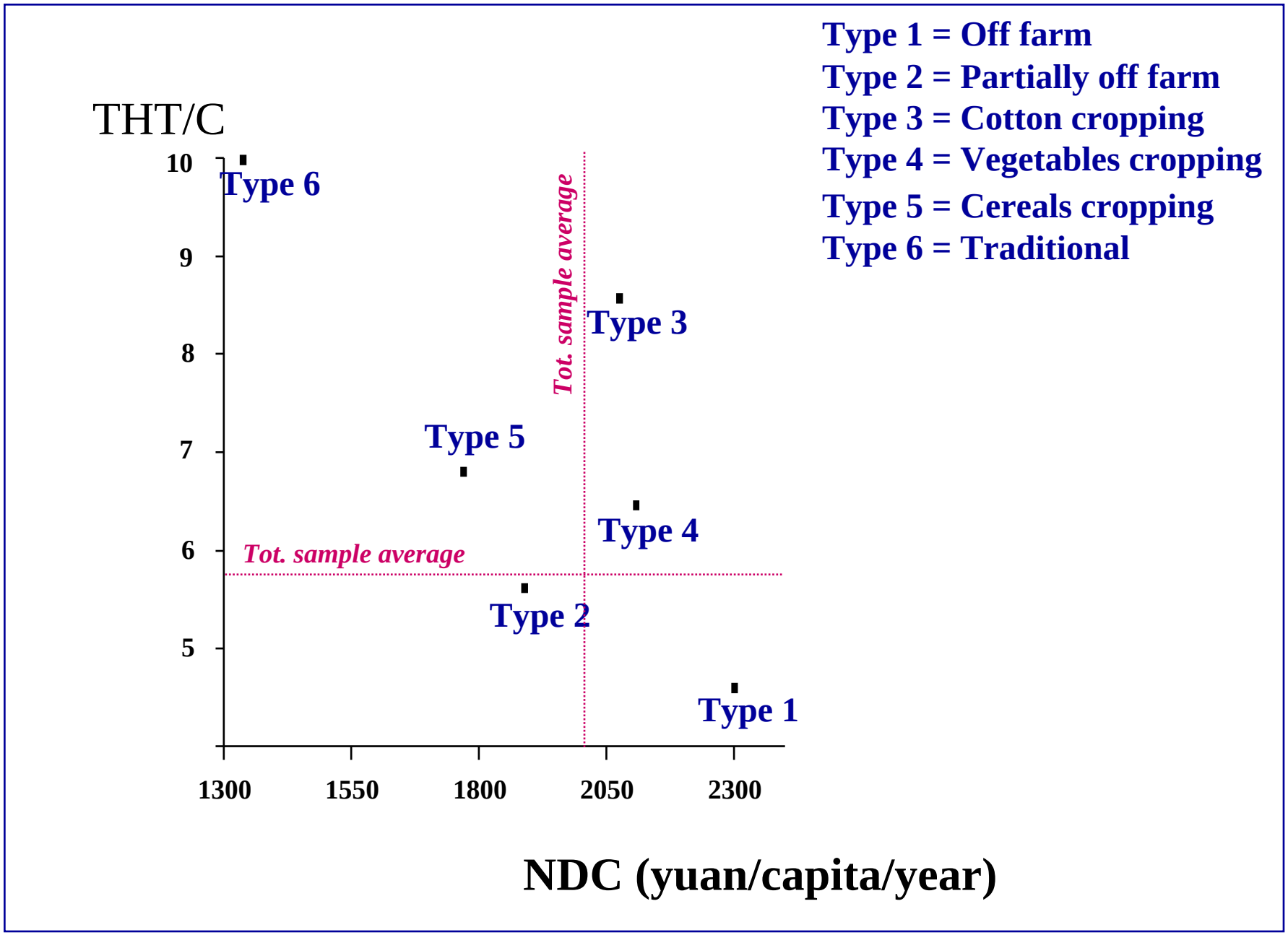


Land Uses Map Village

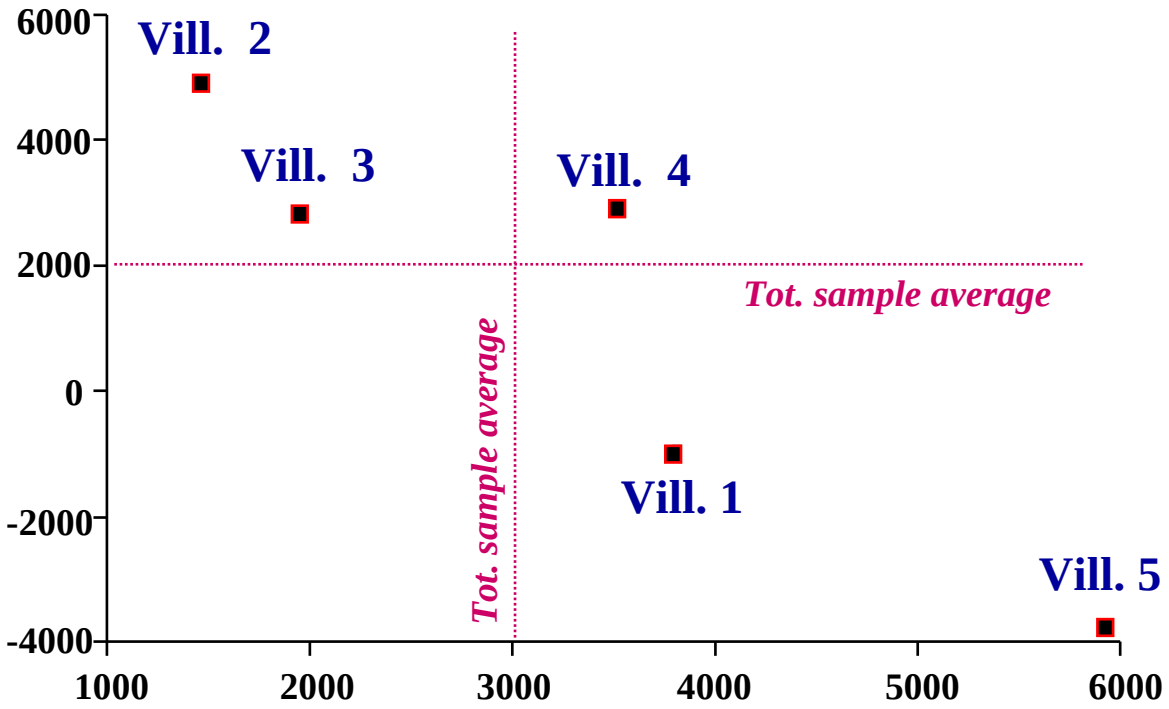


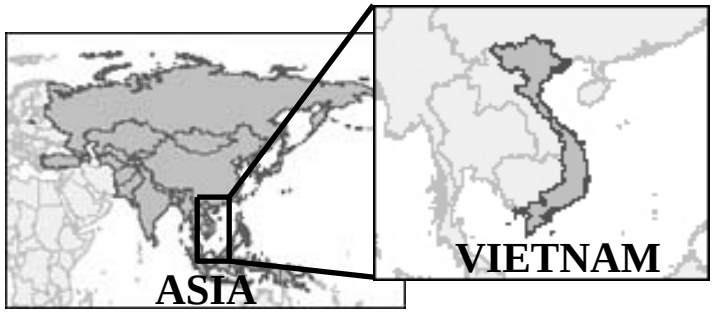


Profile of allocation of working time


Type 1 = Off farm
Type 2 = Partially off farm
Type 3 = Cotton cropping
Type 4 = Vegetables cropping
Type 5 = Cereals cropping
Type 6 = Traditional
THT/C
10
9
8
7
6
5
Type 6
Type 3
Type 5
Type 4
Type 2
Type 1
Tot. sample average
Tot. sample average
1300
1550
1800
2050
2300
NDC (yuan/capita/year)

Vill. 1 = Near the market - off-farm
Vill. 2 = Cereals - far away from market
Vill. 3 = Subsistence traditional farms
Vill. 4 = Near the market - farm
Vill. 5 = Cotton cropping





Thuong Lo Commune
Nam Dong District
Thua Thien Hue Province

Gomiero, T. and Giampietro, M. 2001.
Multiple-scale integrated analysis of farming systems: The Thuong Lo commune case study. (Vietnamese uplands)
***Population and Environment* 22 (3): 315 -352.**

ex-post analysis of high-land Vietnam – main results

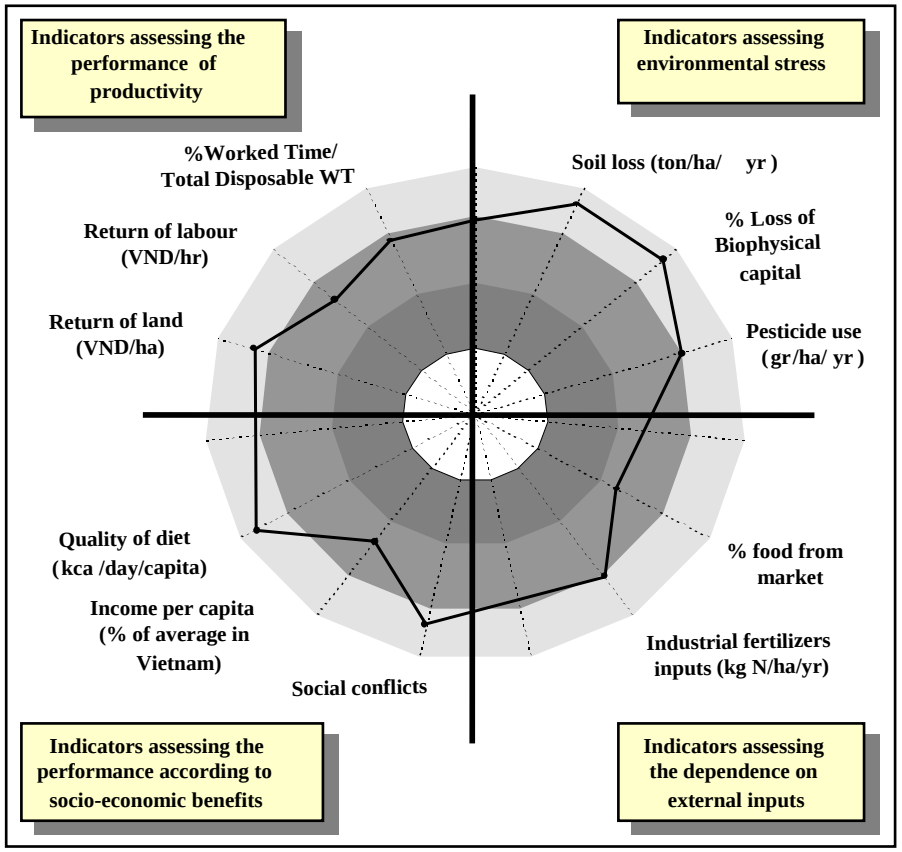
*** It is not true that Slash & Burn is the villain in the area. The impact on the forest per unit of GDP by ethnic minority is much smaller than the impact of national timber industry.**

*** What offered by the scrutinized FAO program was not an option for the targeted farmers**

*** The goals of this project for rural development were incompatible with existing constraints**

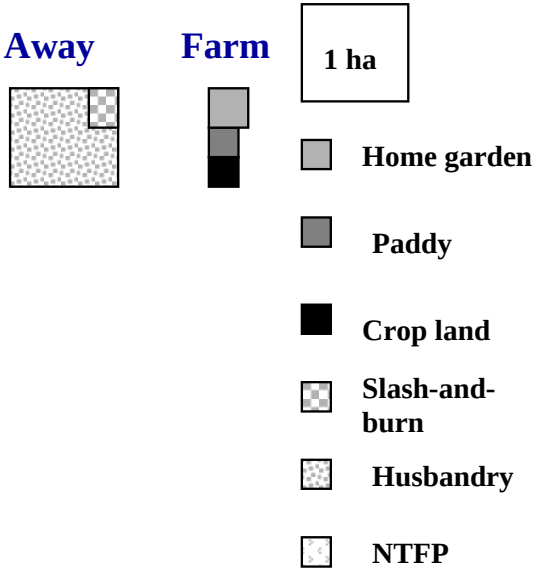
*** A tool kit of Multi-Scale Integrated Analysis may help the discussion of alternatives and policy options**

MOIR - HH Type 1 (Off-farm+Crop mix)

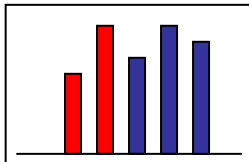


Household type #1 Vietnam Upland

Land use pattern

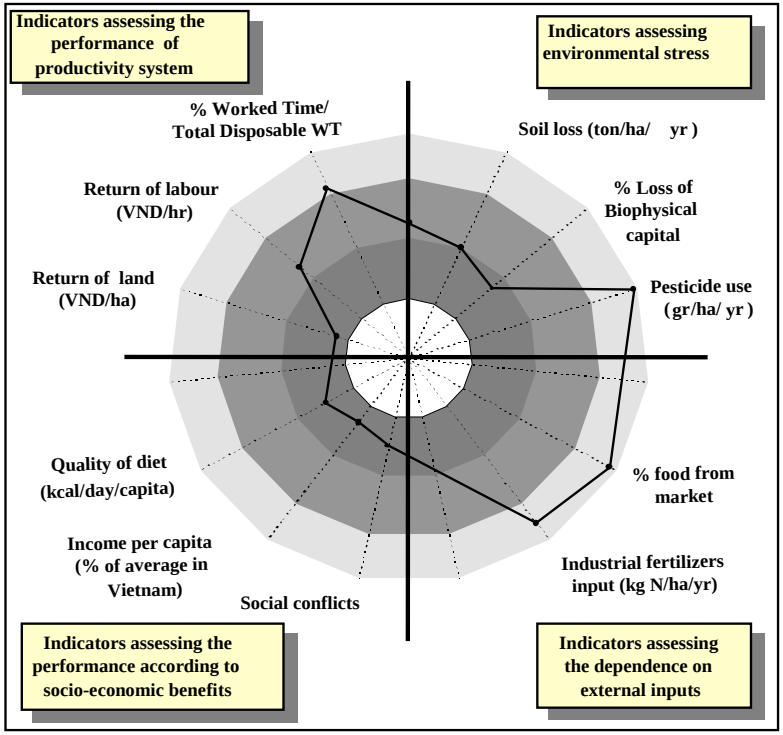


Identification of household farmer types



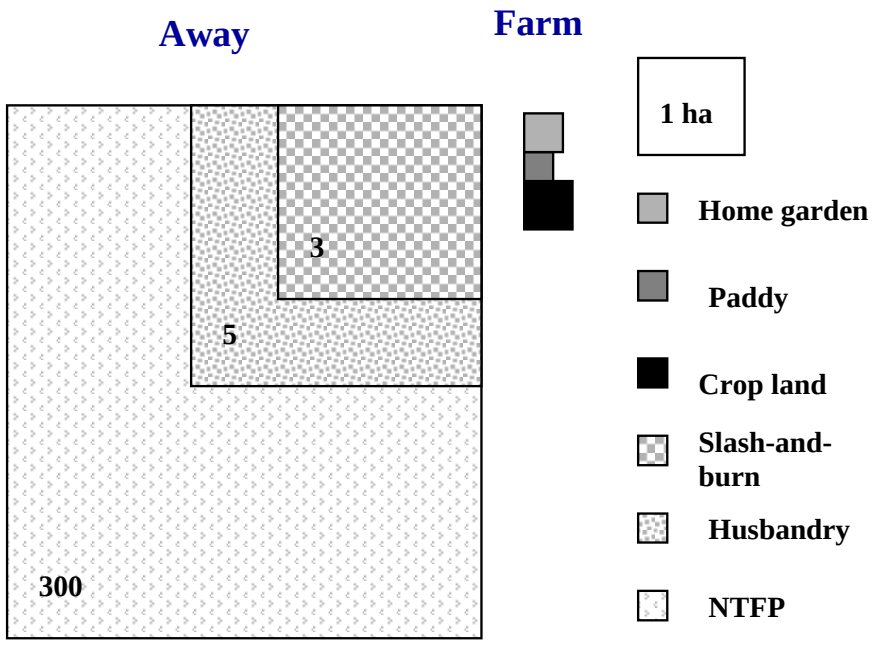
Profile of allocation of colonized land

MOIR - HH Type 3 (Slash-and-Burn+Crop $_{mix}$)

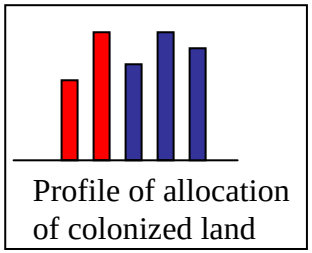


Household Type #3 Upland Vietnam

Land use pattern

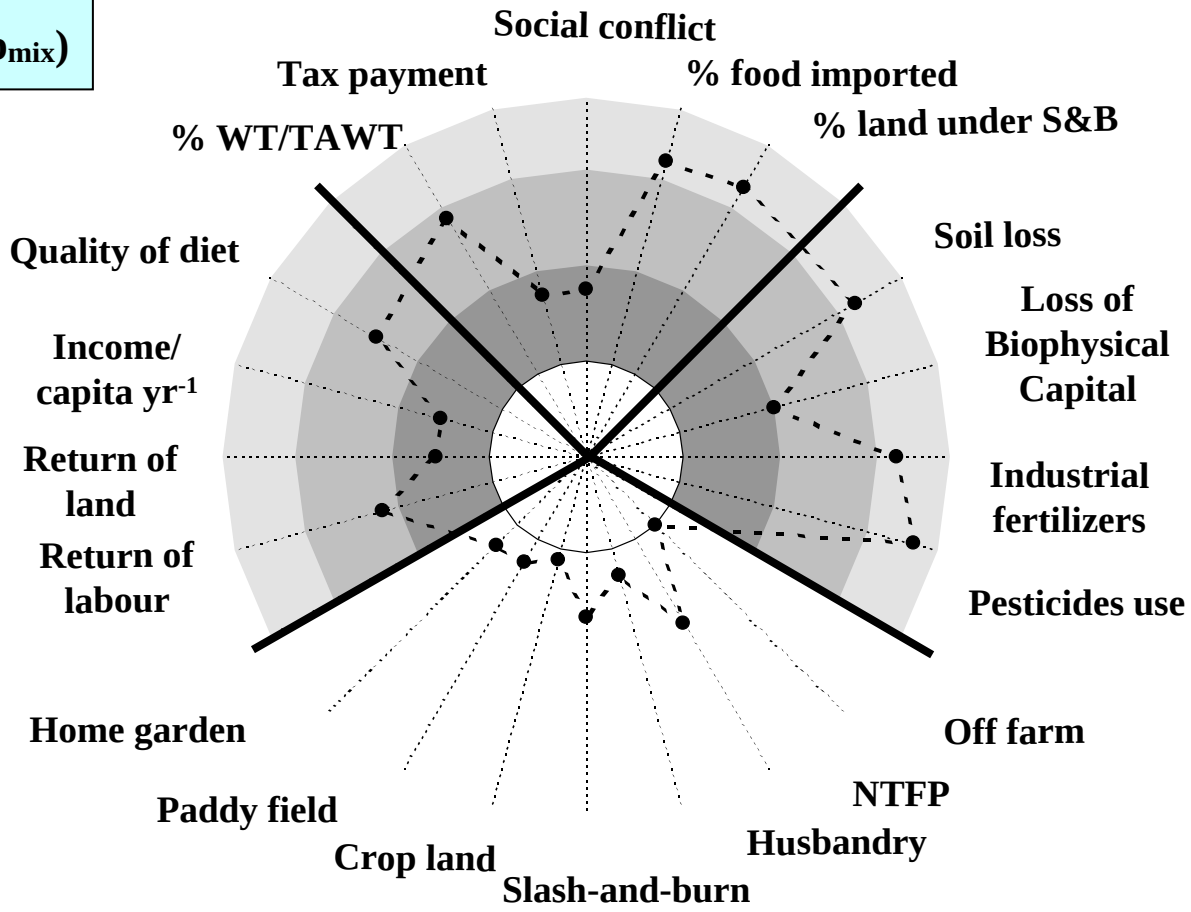


Identification of household farmer types

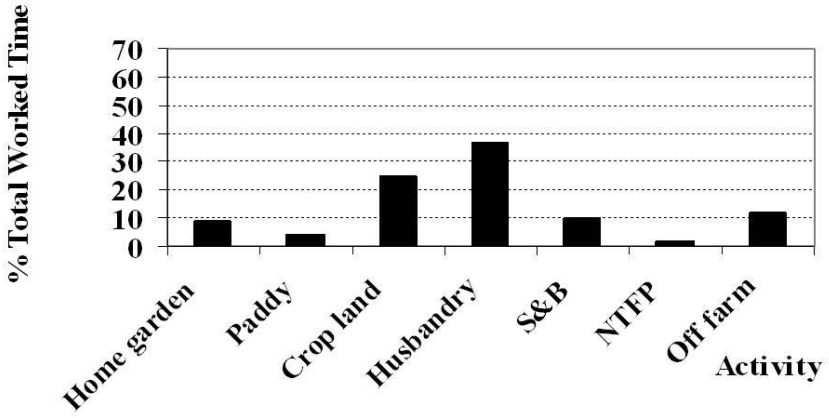


HH Type 2 (Husbandry+Crop$_{mix}$)

Indicators assessing the socio-economic performance

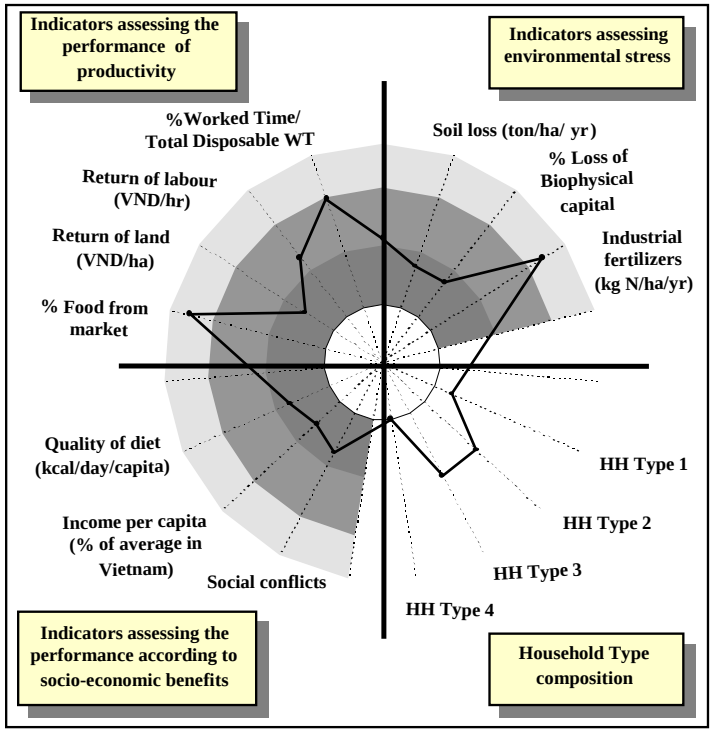


Indicators assessing environmental stress

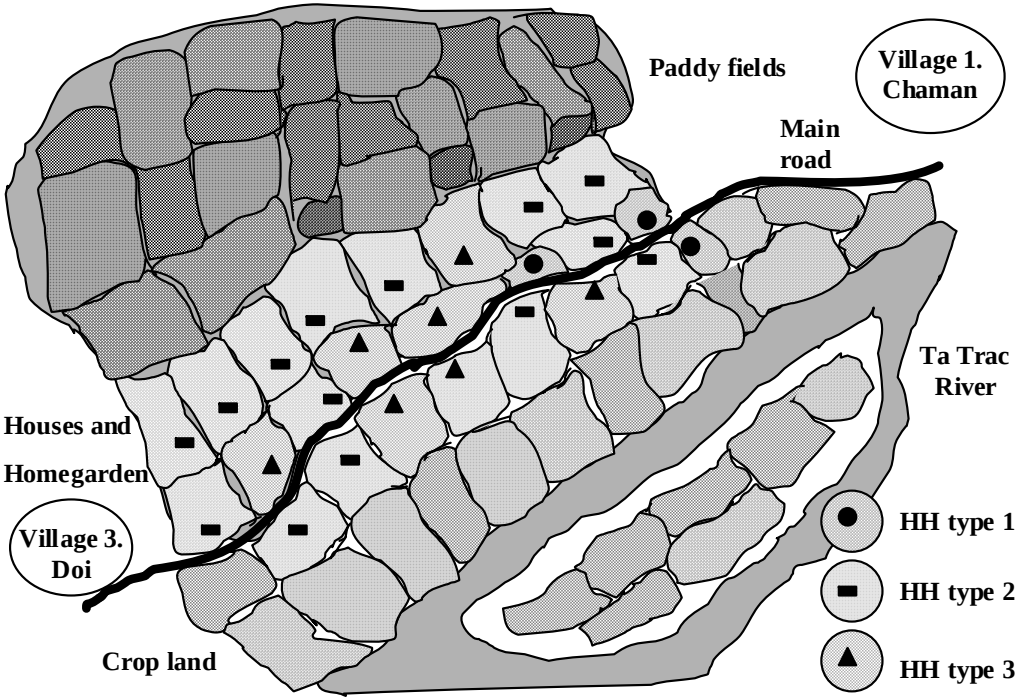


Distribution of activities for the household type (% of worked time)

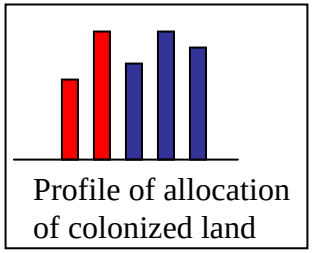
MOIR - Village 2 (Laho)

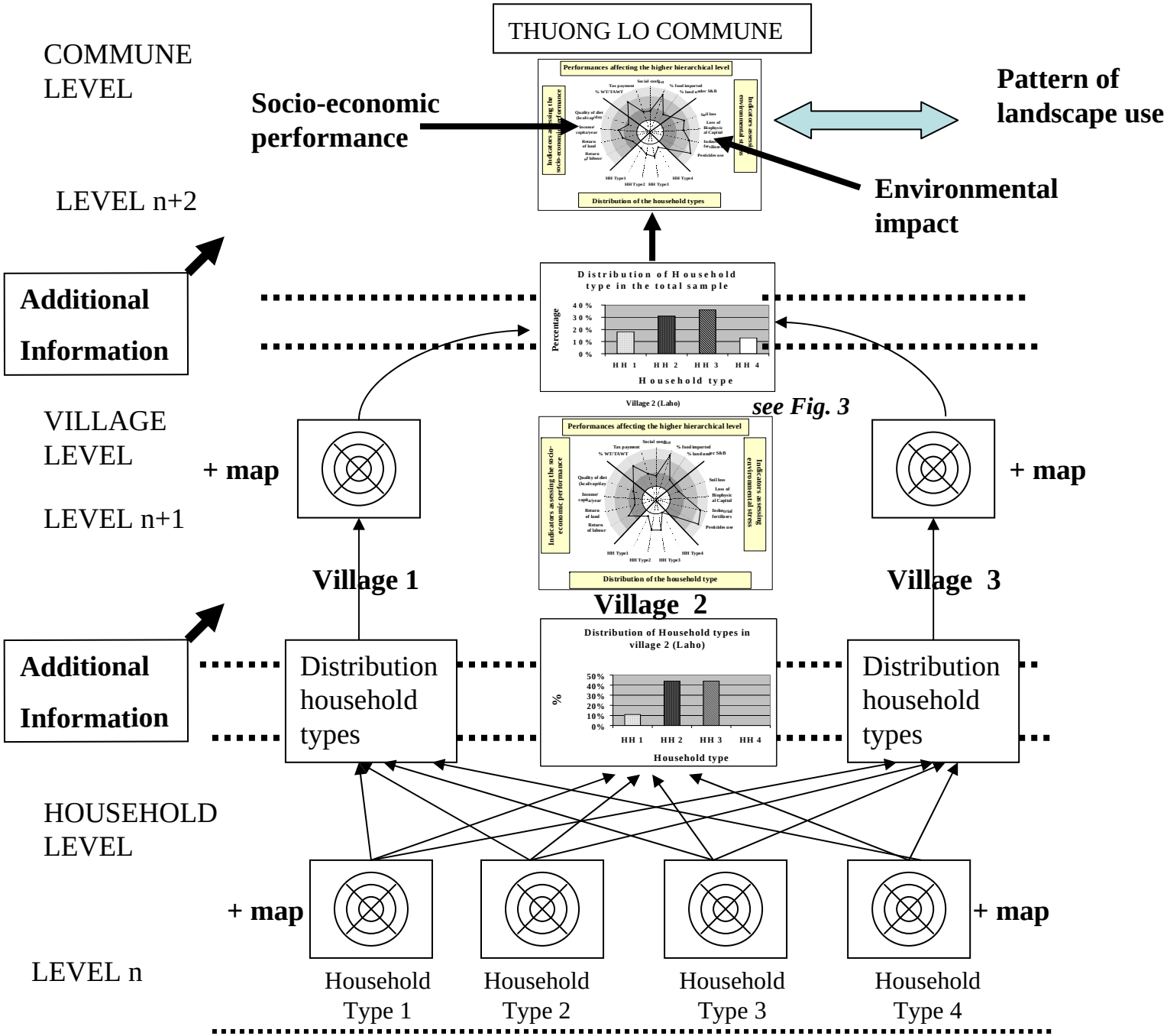


Land Use Map Village 2. Laho

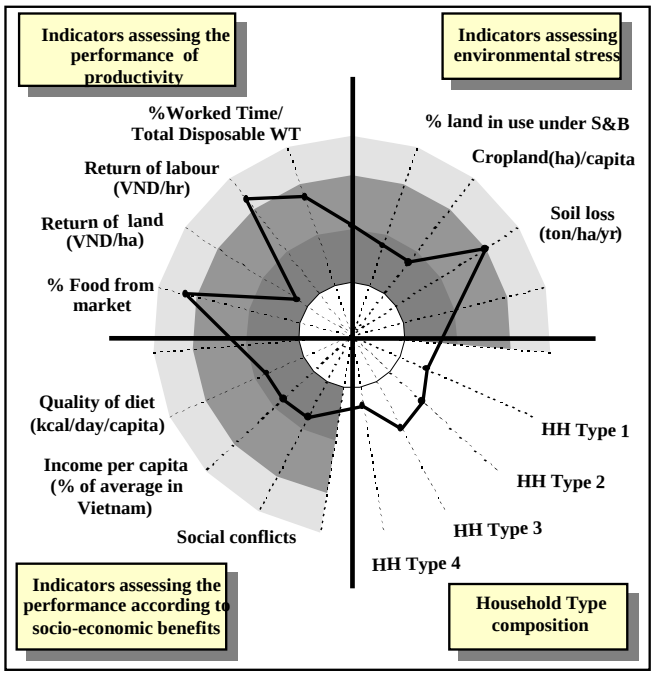


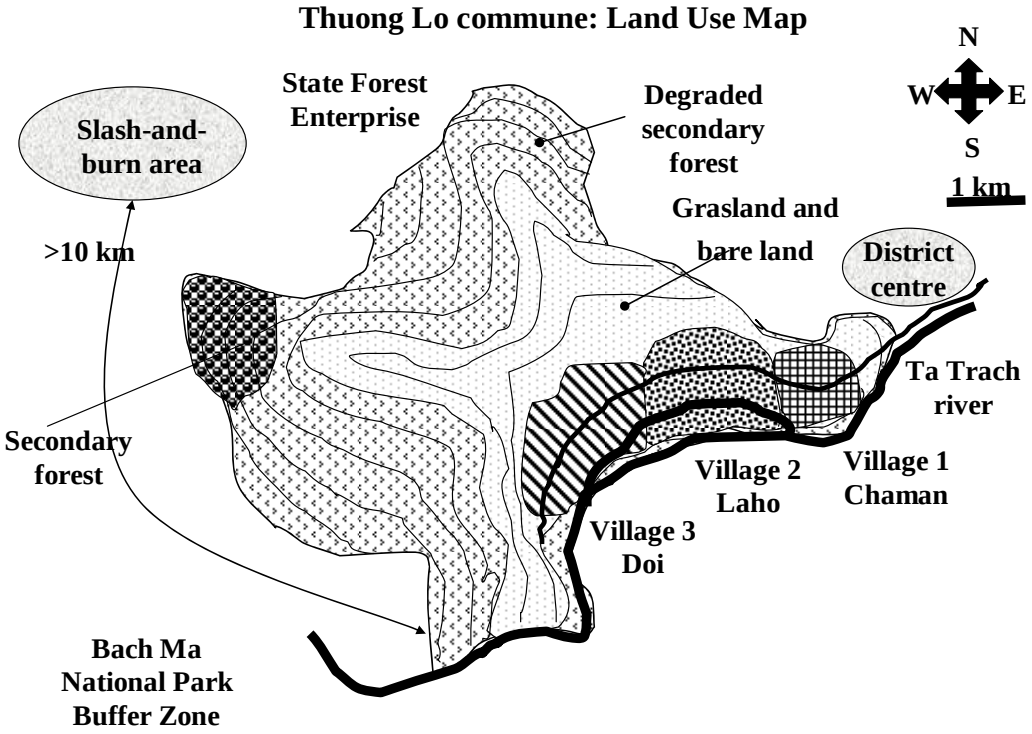
Village 2 (Laho): MOIR and land use map

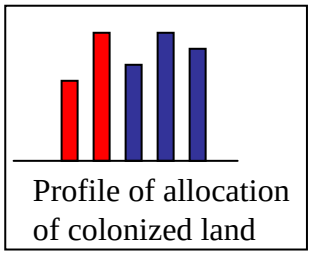



COMMUNE LEVEL
THUONG LO COMMUNE
Socio-economic performance
Pattern of landscape use
Environmental impact
LEVEL n+2
Additional Information
Performances affecting the higher hierarchical level
Distribution of the household types
Distribution of Household type in the total sample
Percentage
Household type
HH 1
HH 2
HH 3
HH 4
Village 2 (Laho)
see Fig. 3
VILLAGE LEVEL
+ map
LEVEL n+1
Village 1
Village 2
Village 3
Distribution of Household types in village 2 (Laho)
%
Distribution household types
HOUSEHOLD LEVEL
LEVEL n
Household Type 1
Household Type 2
Household Type 3
Household Type 4

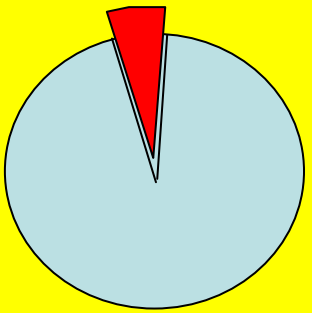
Thuong Lo commune - MOIR and land use map.






Profile of allocation of colonized land

90% of the area of forest exploitation is not controlled by the villagers!

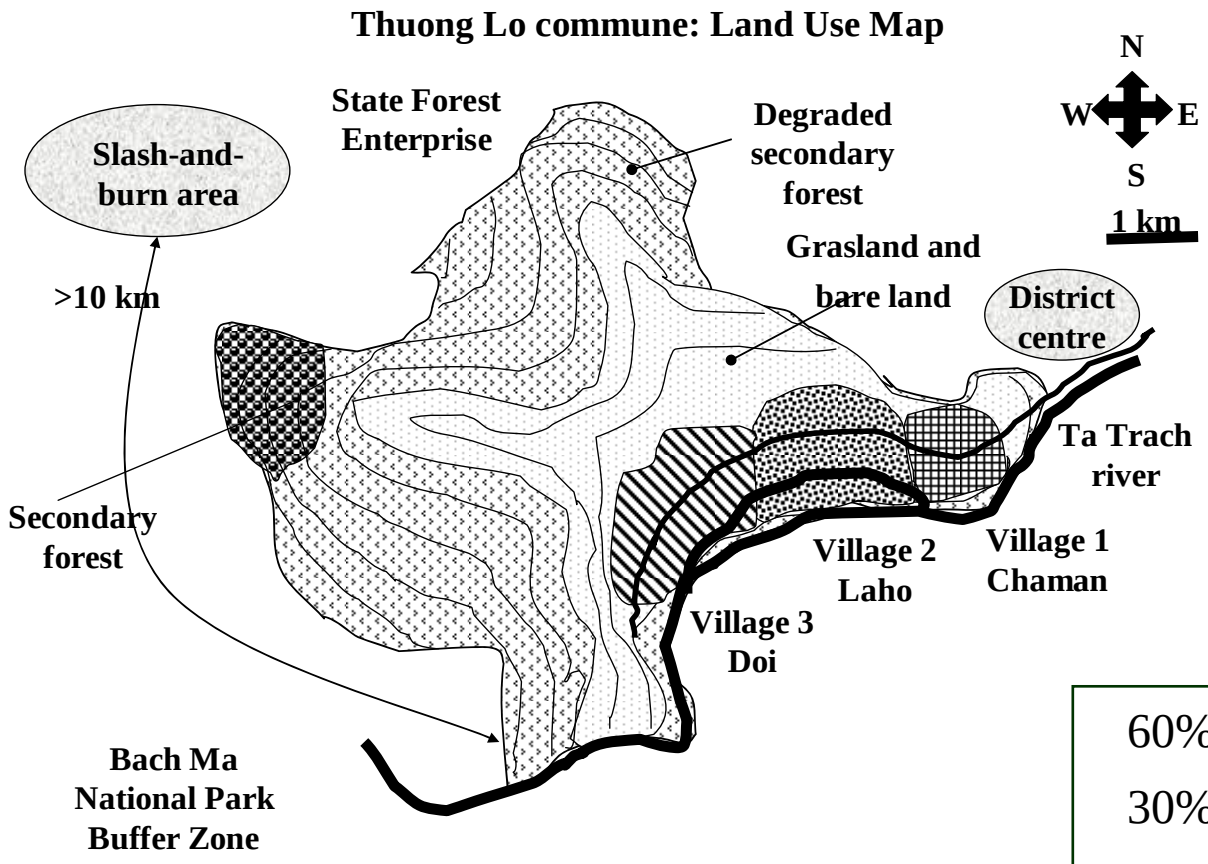


#4

Lessons about the methodology

Lesson 1

Interfacing the analysis of
“household and village metabolism”
with that of “ecosystem metabolism”



Degree of disturbance to the natural levels of ecosystem metabolism per land use

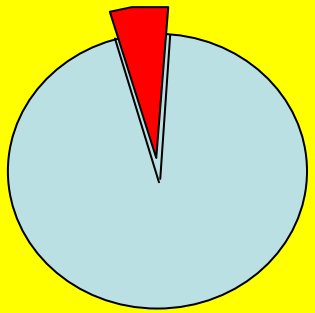
→ relative flow of $

60% State Forest Enterprise

30% Bach Ma National Park

10% Villagers

90% of the area of forest exploitation is out of the control of the villagers!



IMPREDICATIVE LOOP

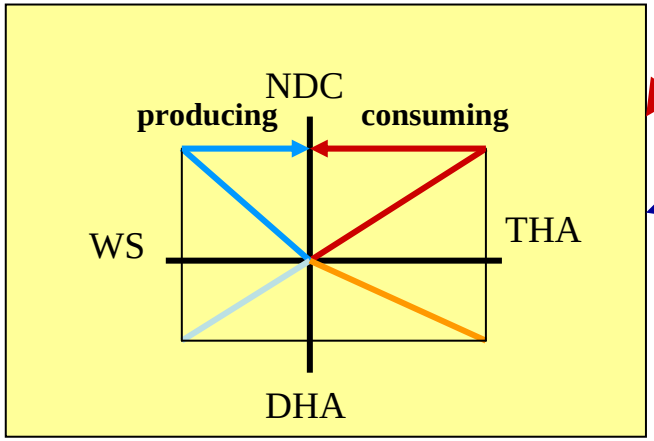
CHARACTERIZATION

Mapping flows against human time

*** SET OF ACTIVITIES (production & consumption)**
*** CHARACTERIZATION ACTIVITIES *level (n-1)***

Mapping flows against ecosystem space

Hierarchical level ***n***: household



Money flow

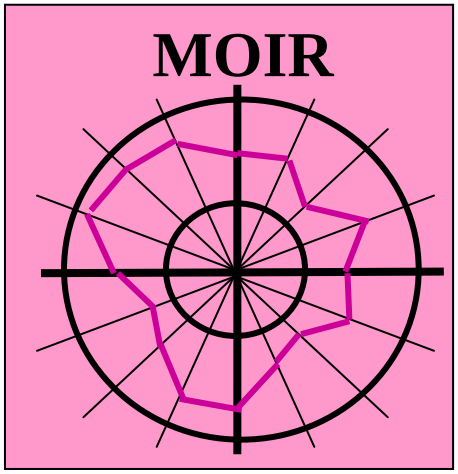
Energy flow

Matter flow

Heterogeneity of consequences of changes in different squares of the grid

Multi-Scale Integrated Assessment of Societal Metabolism

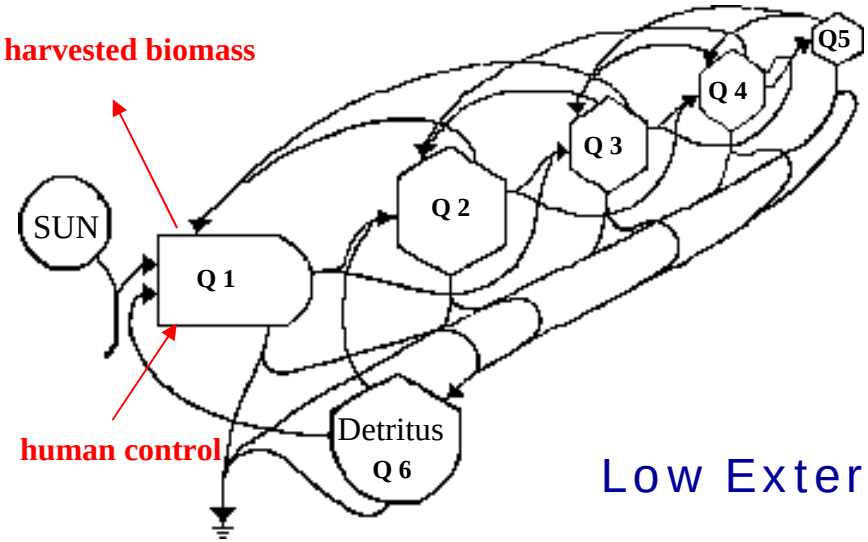
MOIR

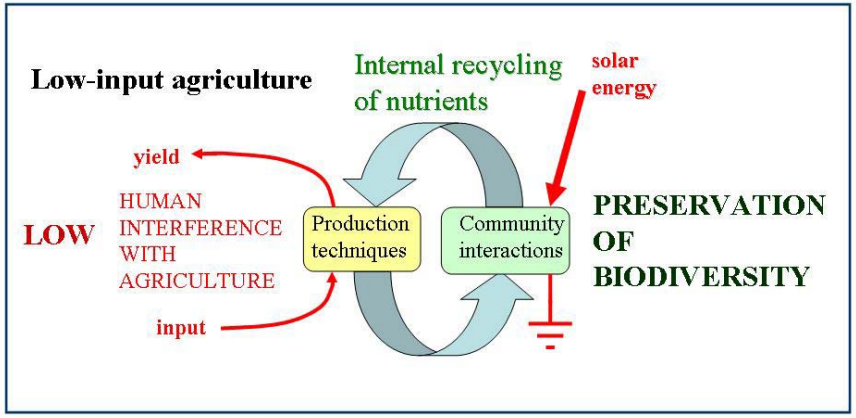


Spatial analysis of changes in energy and matter flows at different scales

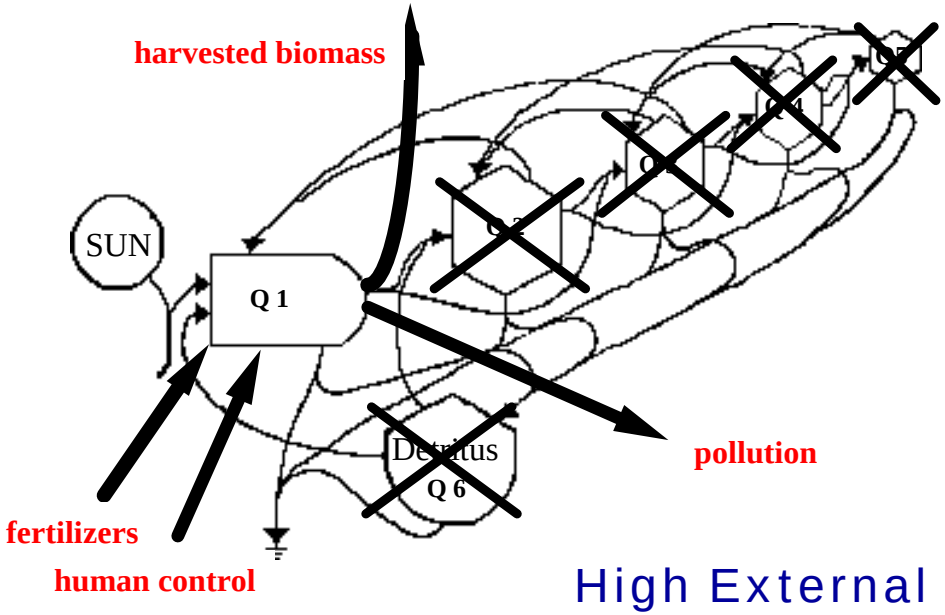
Socio-economic analysis of viability/desirability

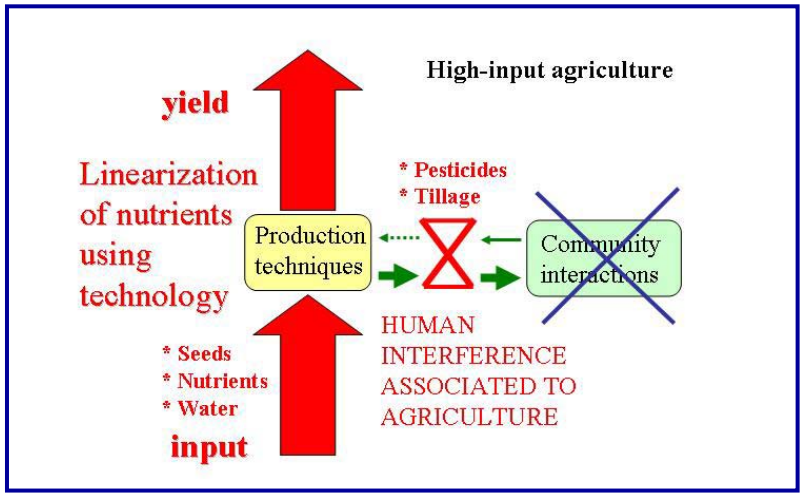
Biophysical analysis of ecological impact





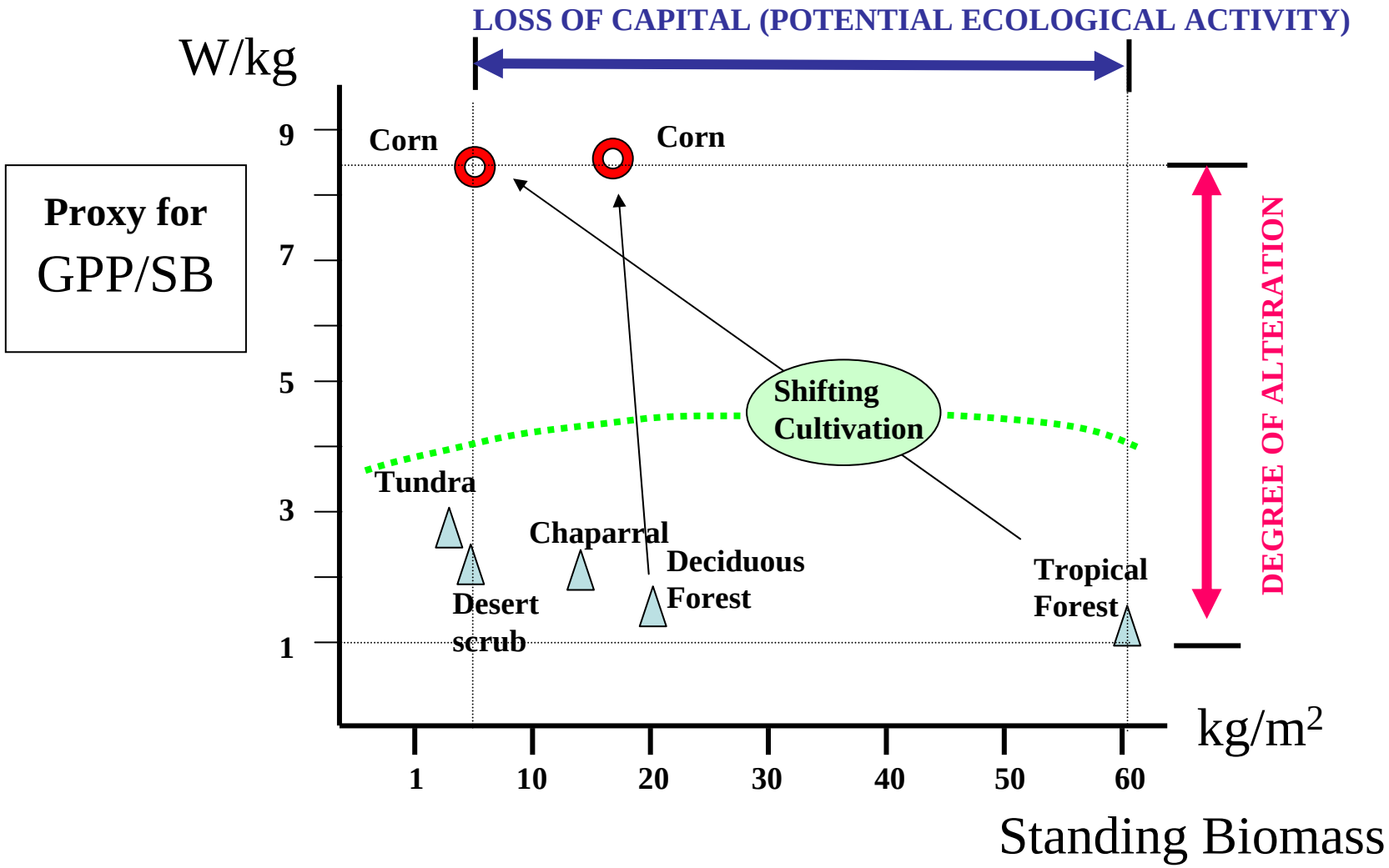
Low External Input Agriculture





High External Input Agriculture

Plane to represent the alteration of terrestrial ecosystems to define COLONIZED versus NON-COLONIZED



Giampietro, M., Pimentel, D. and Cerretelli, G. 1992. Energy analysis of agricultural ecosystem management: Human return and sustainability. *Agriculture, Ecosystems and Environment* 38: 219-244.

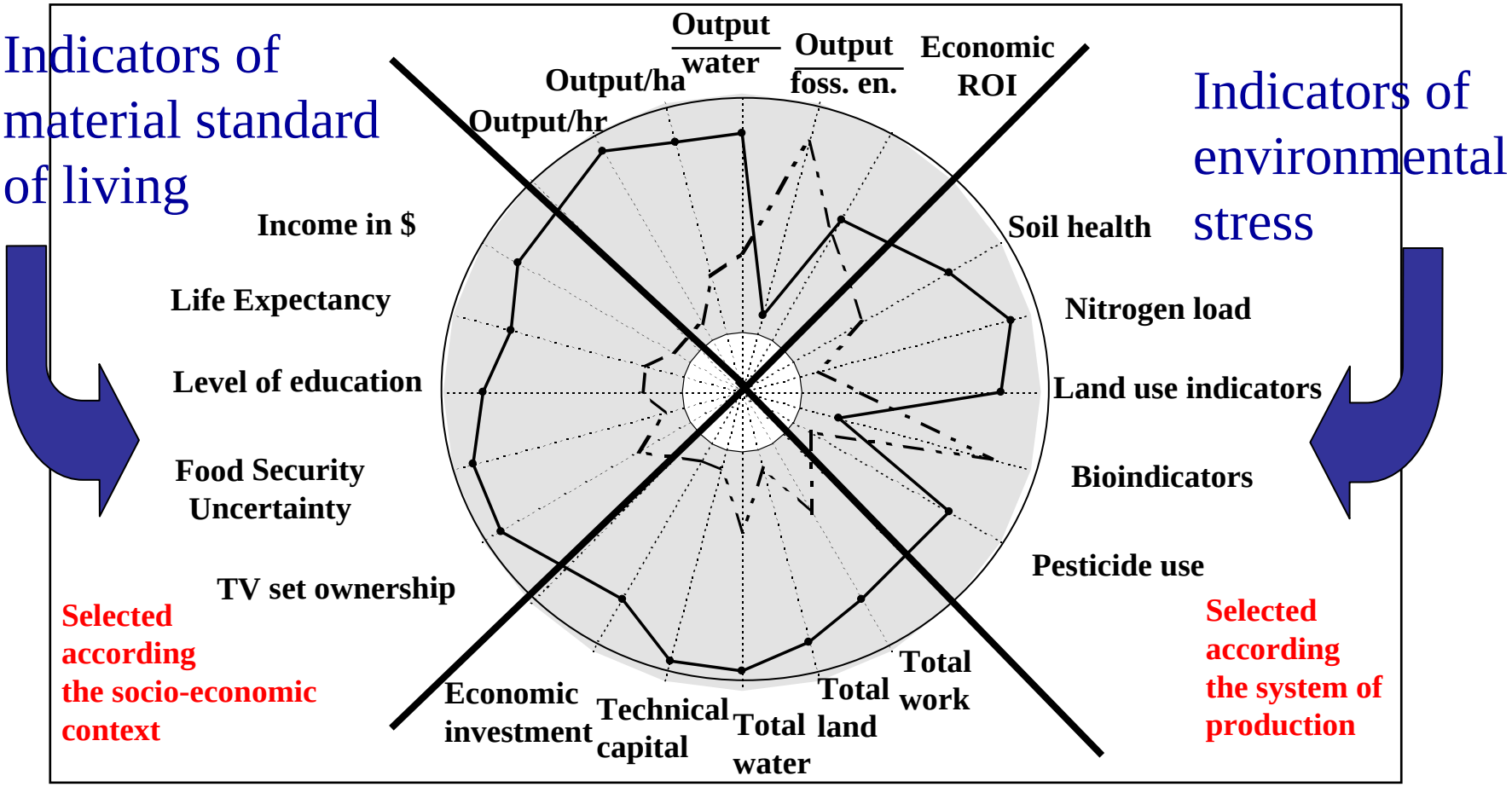
Lesson 2

benchmarking

linking the household/village interface with the national/international interface

Integrated Assessment at farm level - basic benchmarking

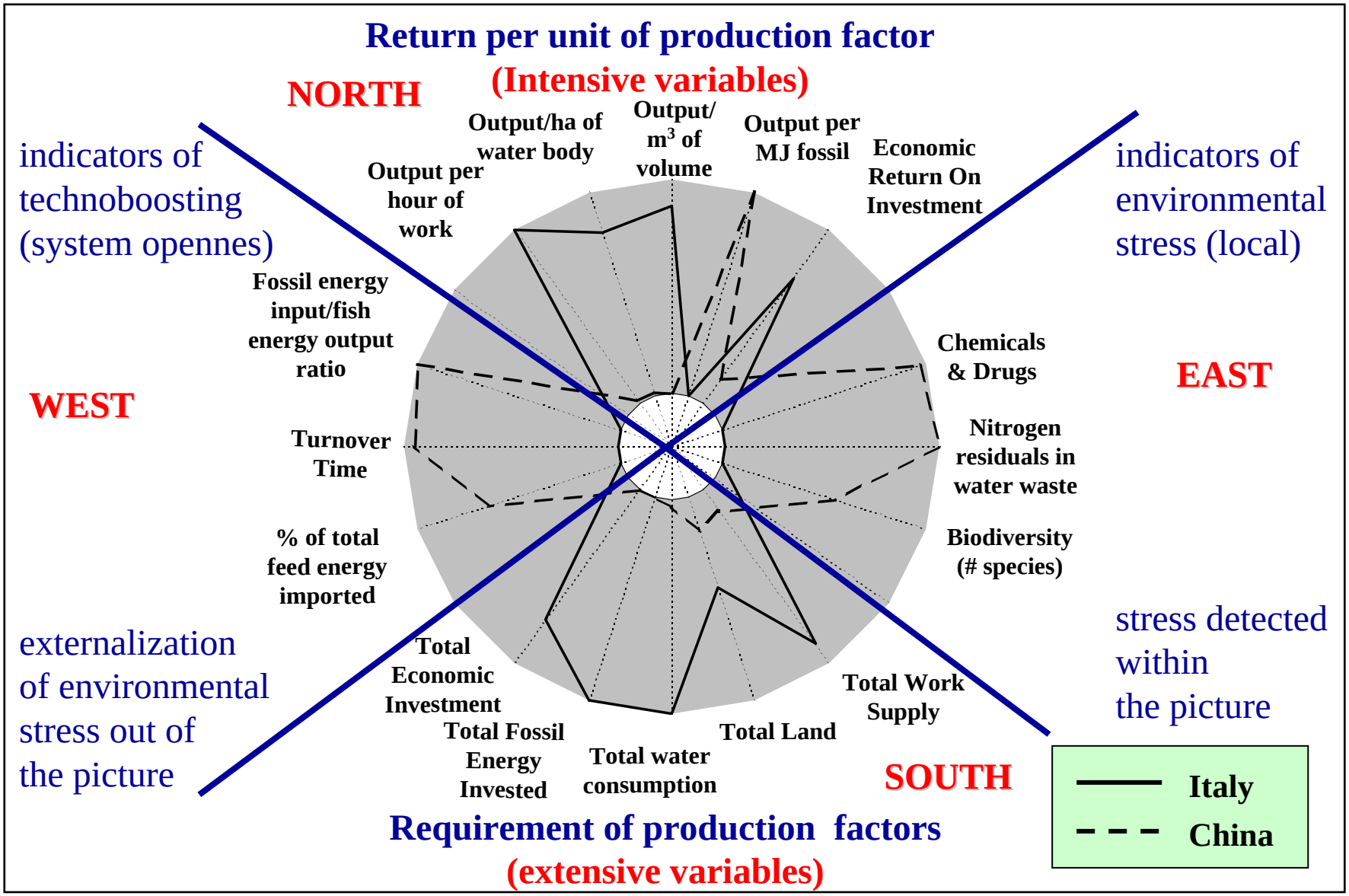
Technical/Economic performance (Intensive variable indicators)



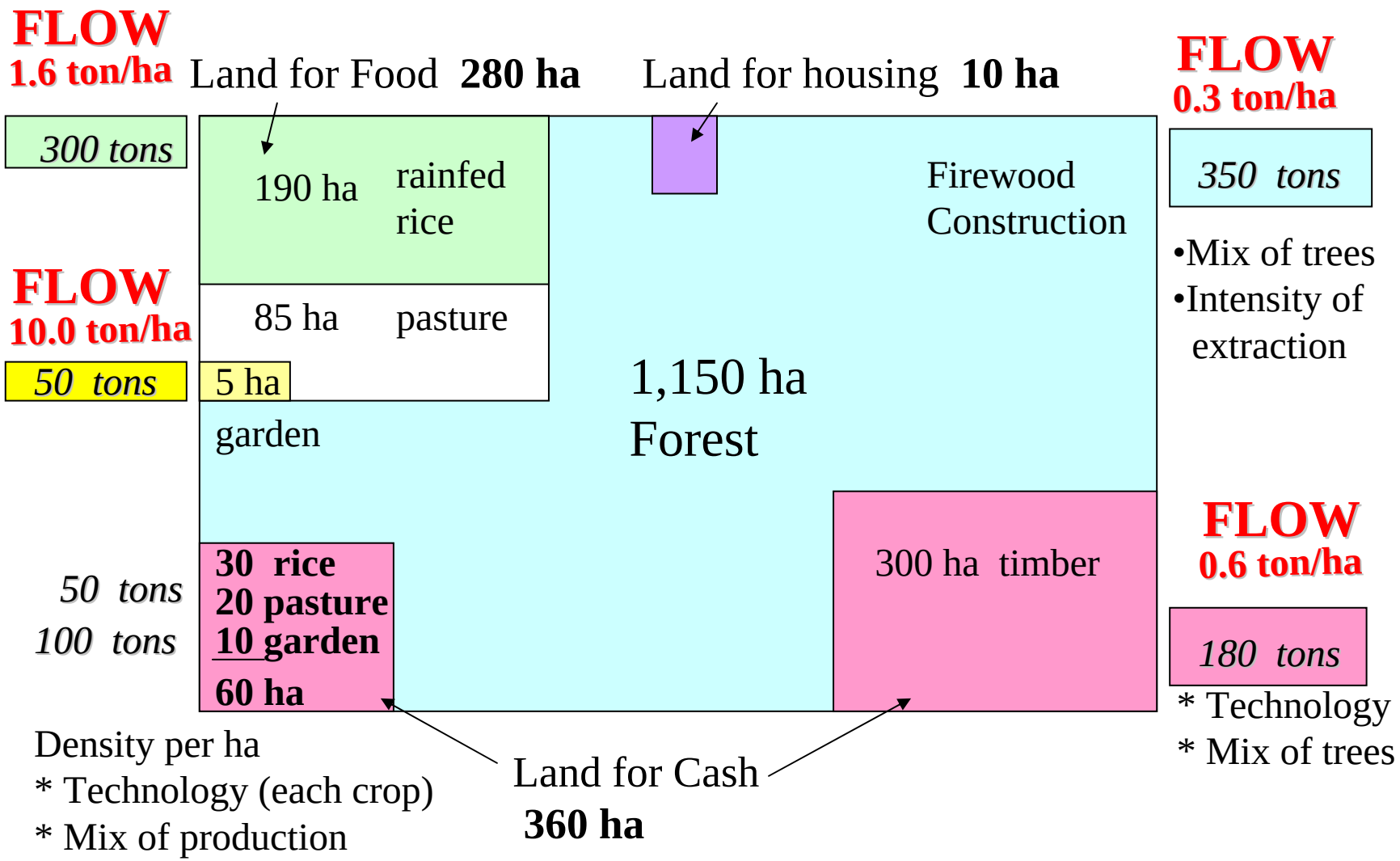
Requirement of investment (Extensive variable indicators)

Fixed investment/worker ($): 100 <---> 100,000
Land/worker (ha): 1 <---> 500
Technical capital/worker (MJ/h): 1 <---> 300
Labor Productivity (kg/h): 1 <---> 500

Comparing freshwater aquaculture system for China and Italy

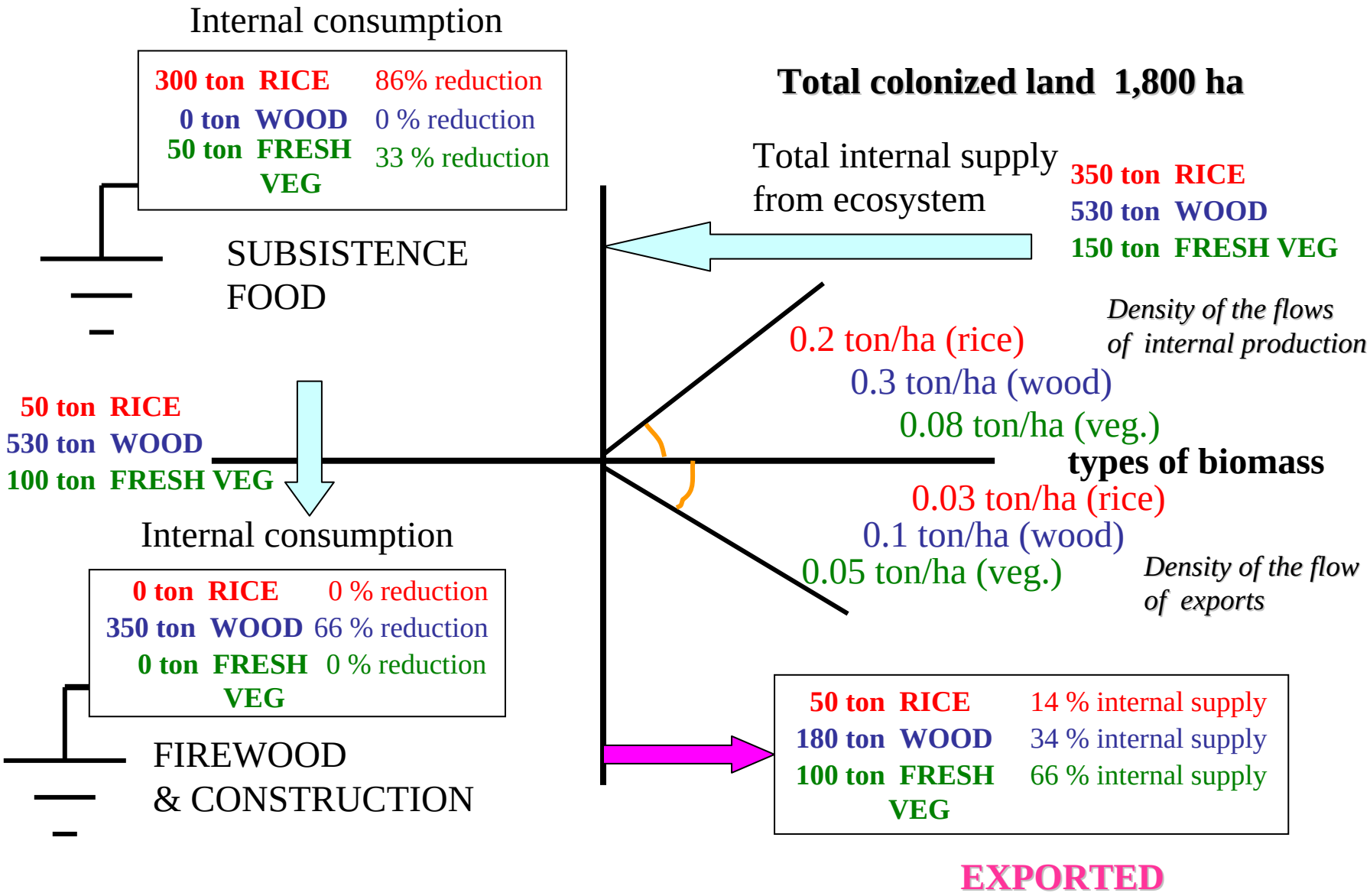


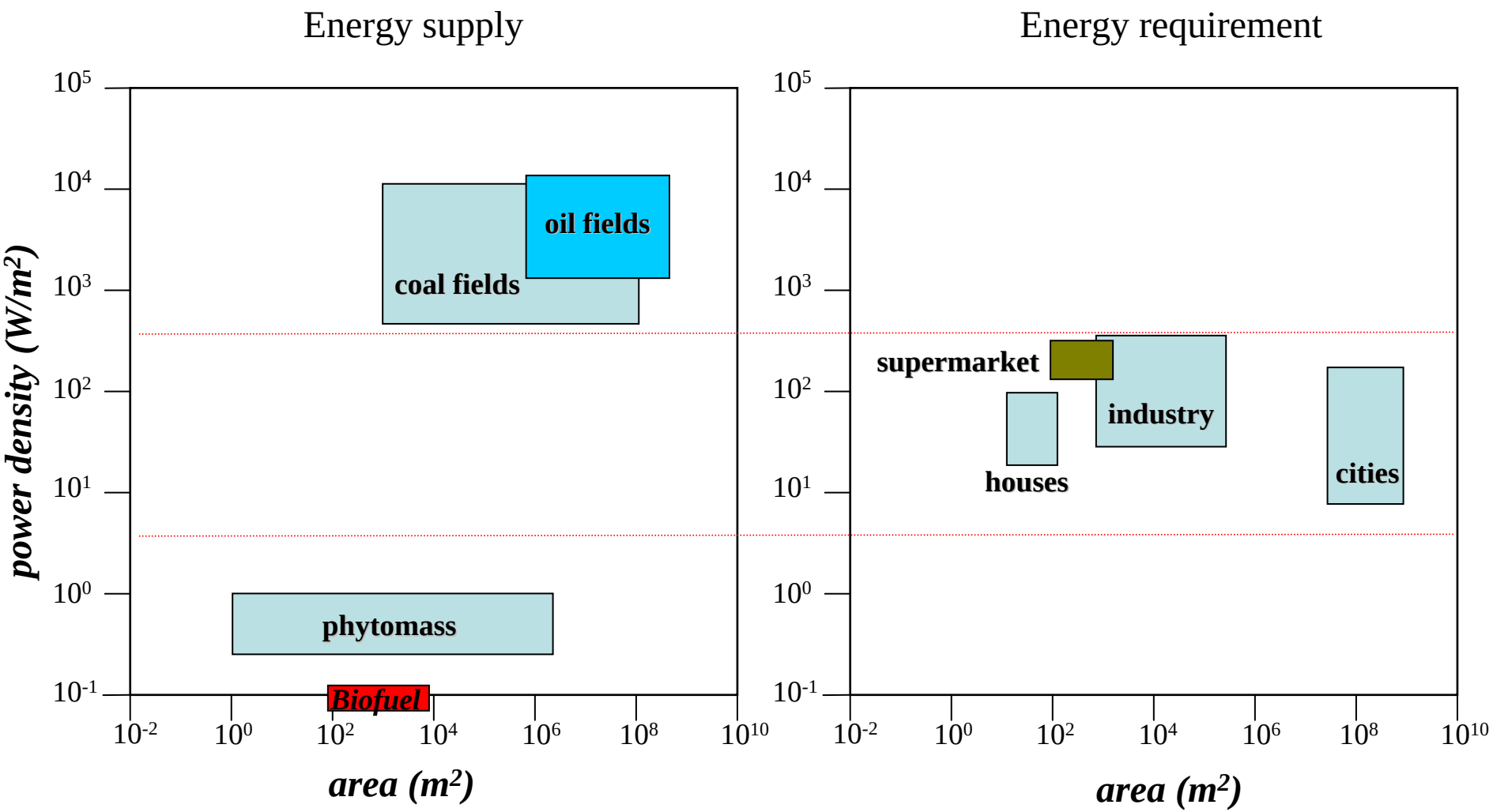
Examples of categories of land use useful to characterize a typology of farming system in high-land Laos



EV#1: 1800 ha - Total Colonized Land

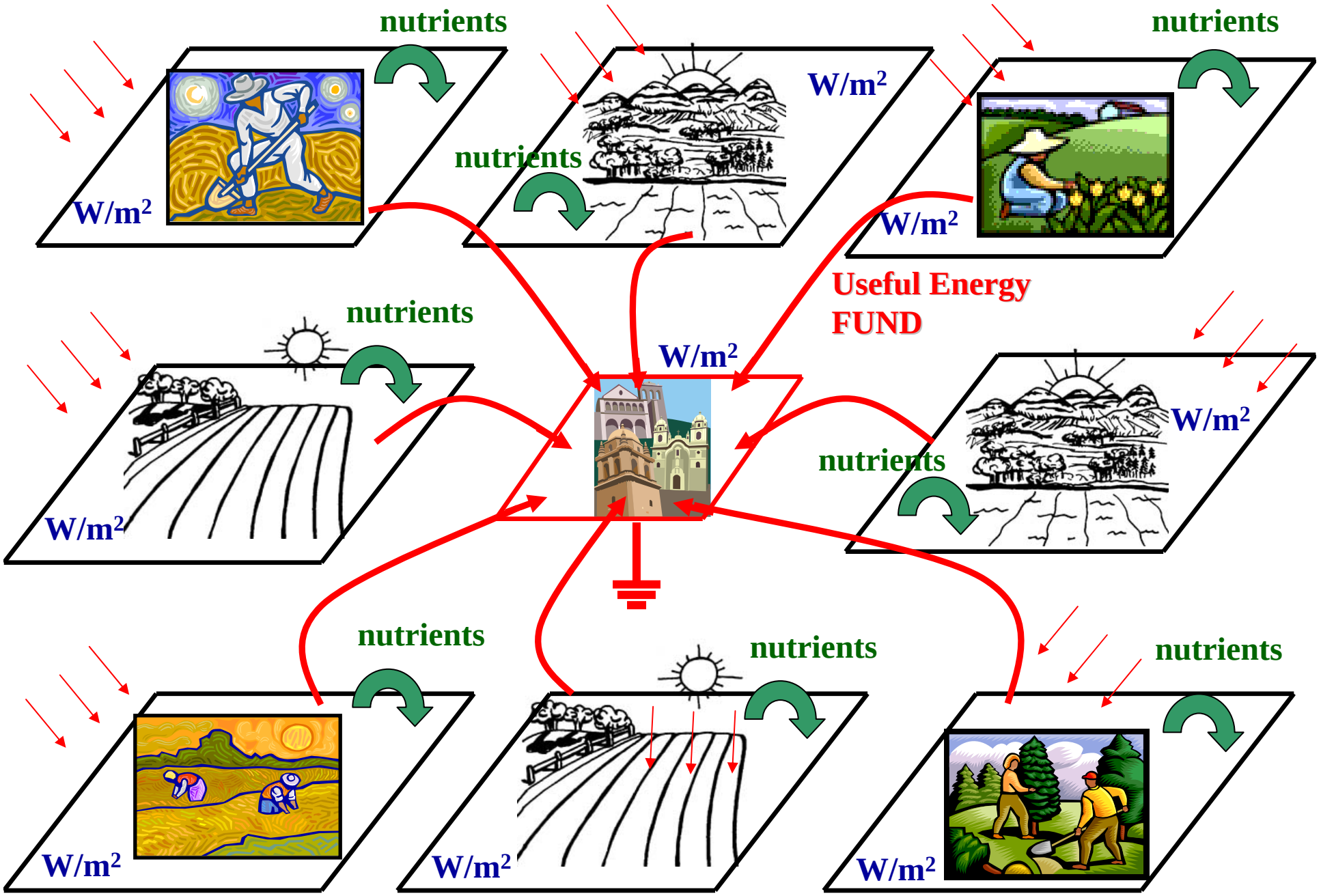
Defining the net supply that the farming system can generate for the rest of society (the contribution to the national economy)

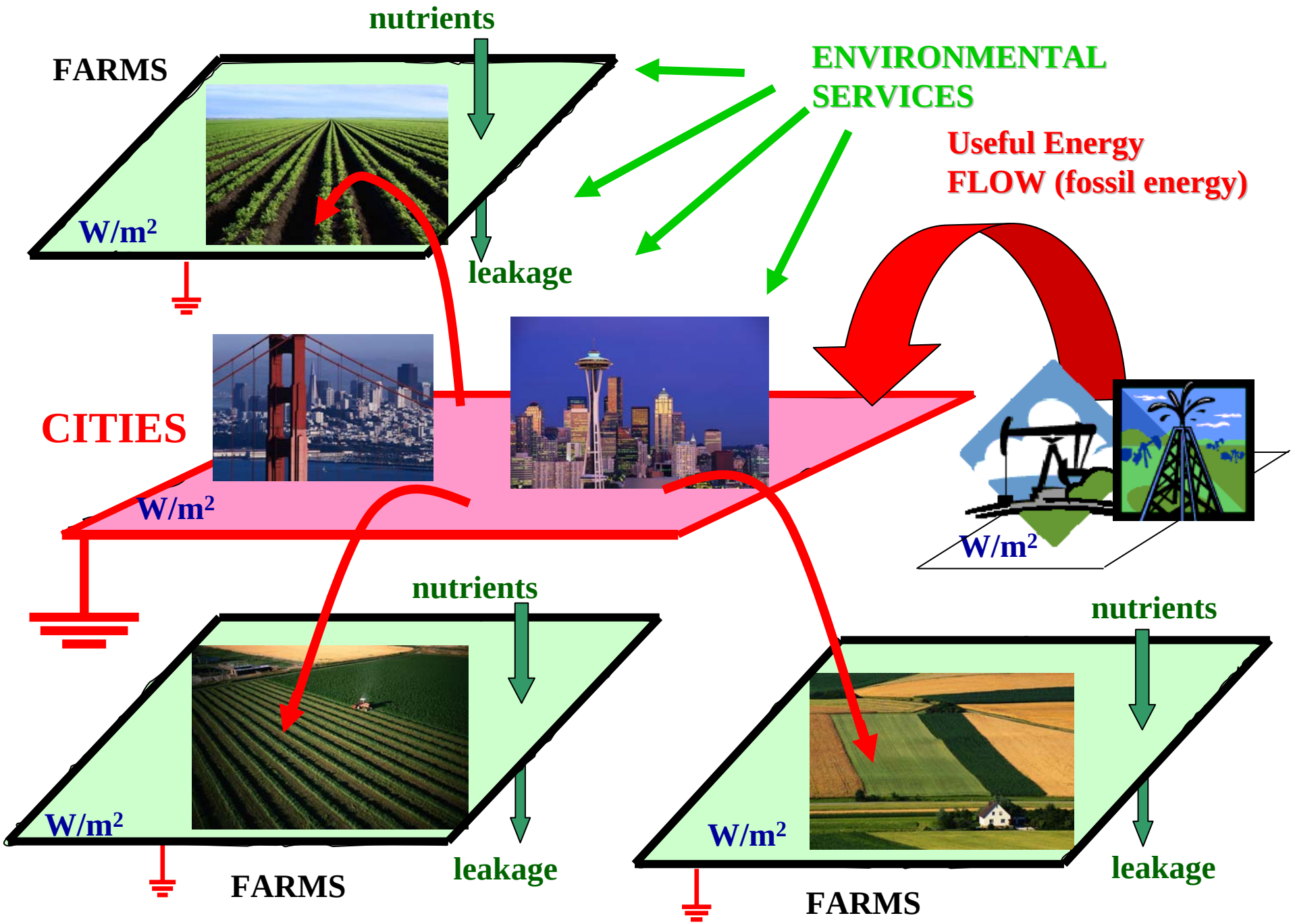




power density gaps

after Vaclav Smil 2003 Energy at the Crossroads, The MIT press
(Fig. 5.2 and Fig. 5.3)


nutrients
W/m2
nutrients
W/m2
nutrients
W/m2
Useful Energy
FUND
nutrients
W/m2
W/m2
nutrients
W/m2
nutrients
nutrients
nutrients
W/m2
W/m2
W/m2

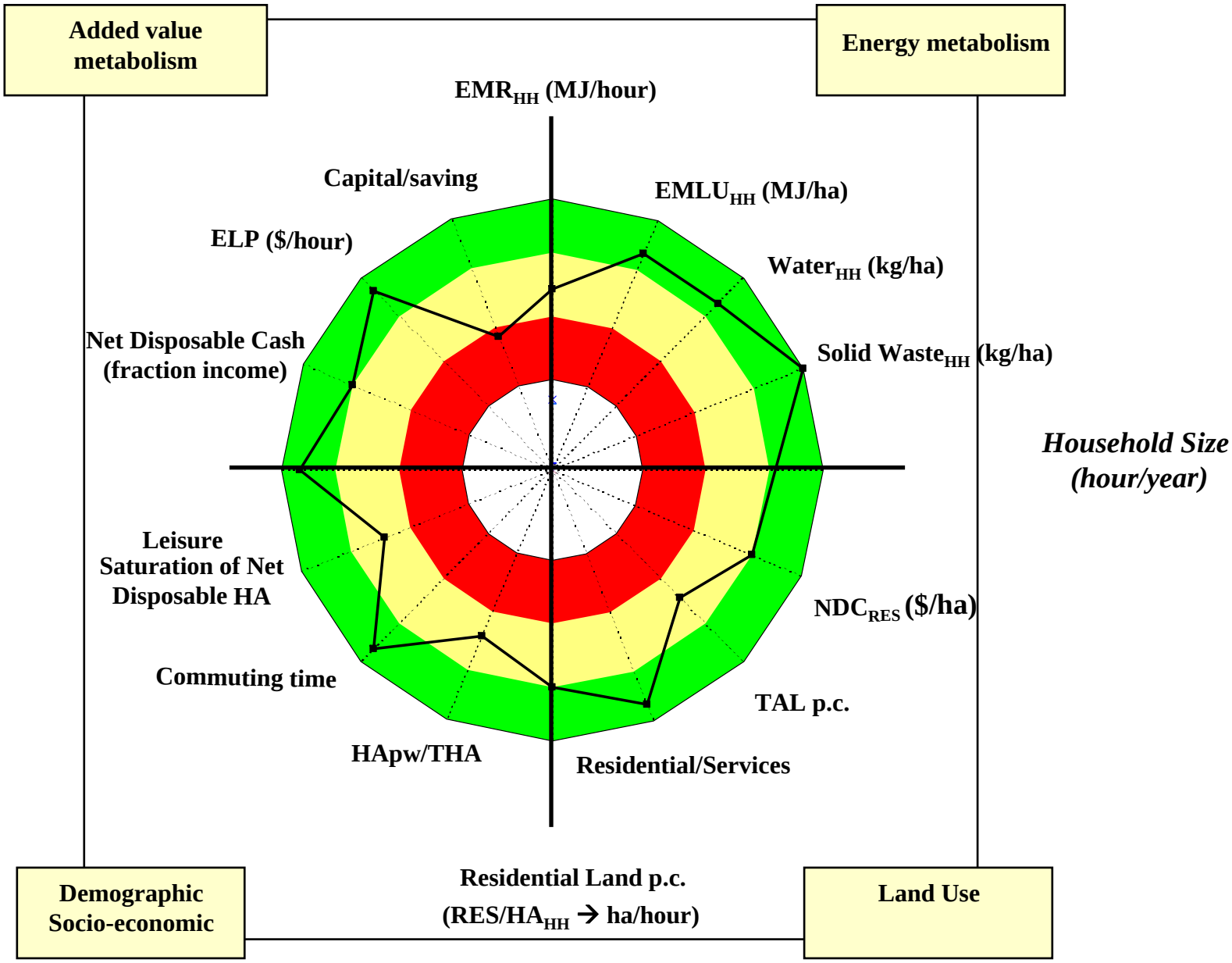

nutrients
FARMS
ENVIRONMENTAL
SERVICES
Useful Energy
FLOW (fossil energy)
W/m2
leakage
CITIES
W/m2
W/m2
nutrients
nutrients
W/m2
leakage
FARMS
W/m2
leakage
FARMS

Lesson 3

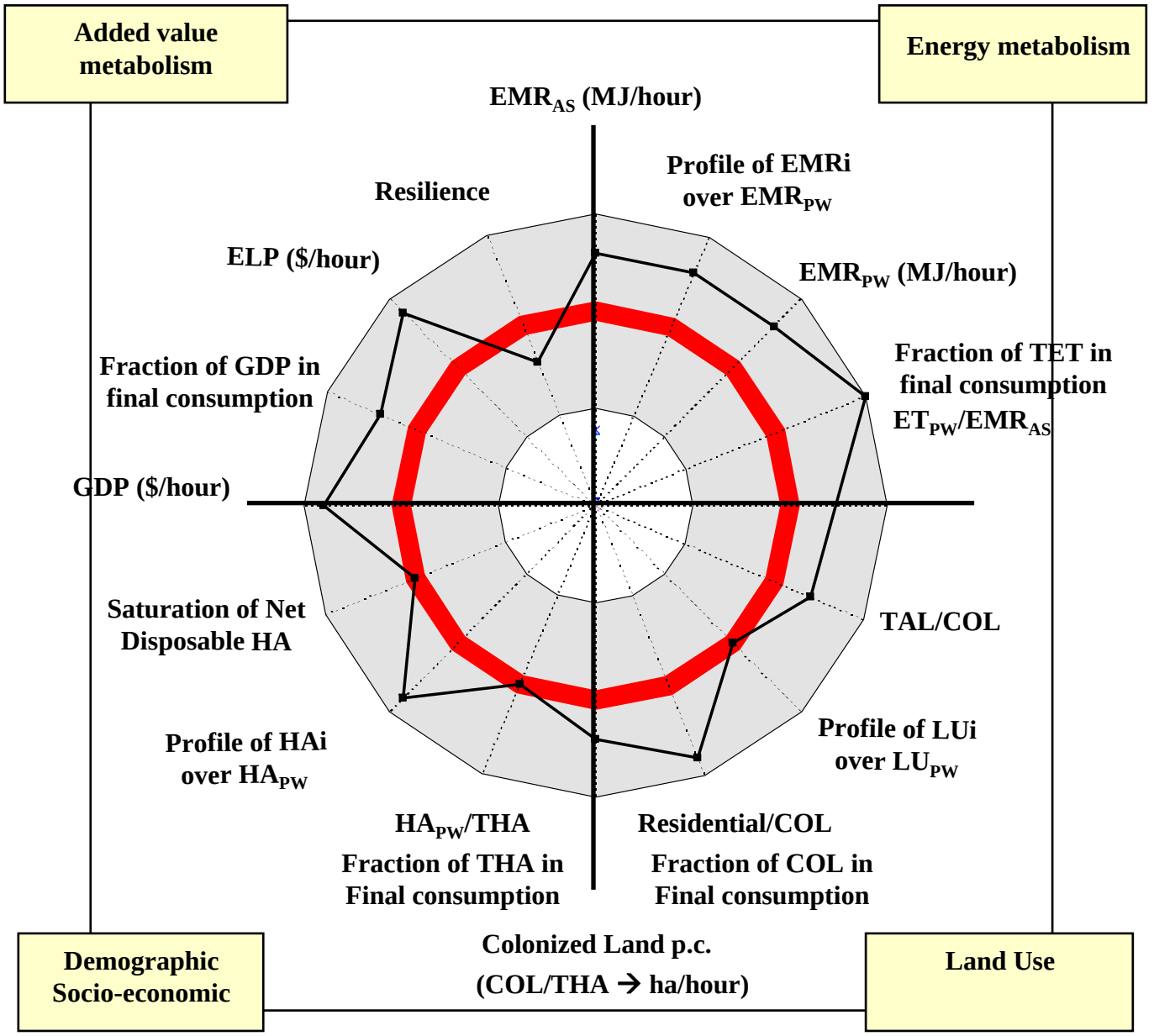
Multi-Objective Integrated Representation

Using an integrated package of indicators of performance referring to different objectives (different dimensions and different levels of analysis)

Multi-Criteria Space – Flag Model – Household level



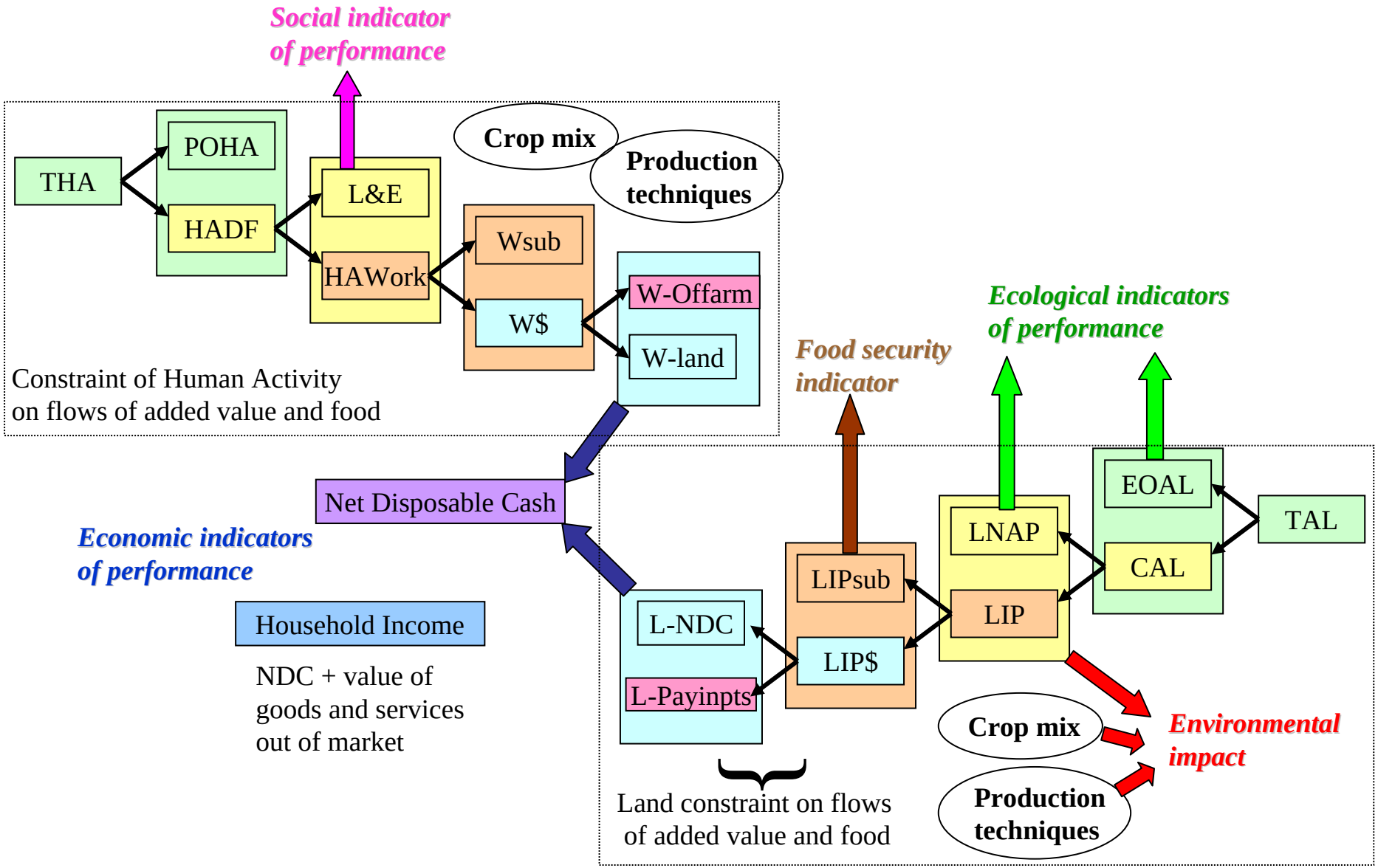
Comparison within the typology



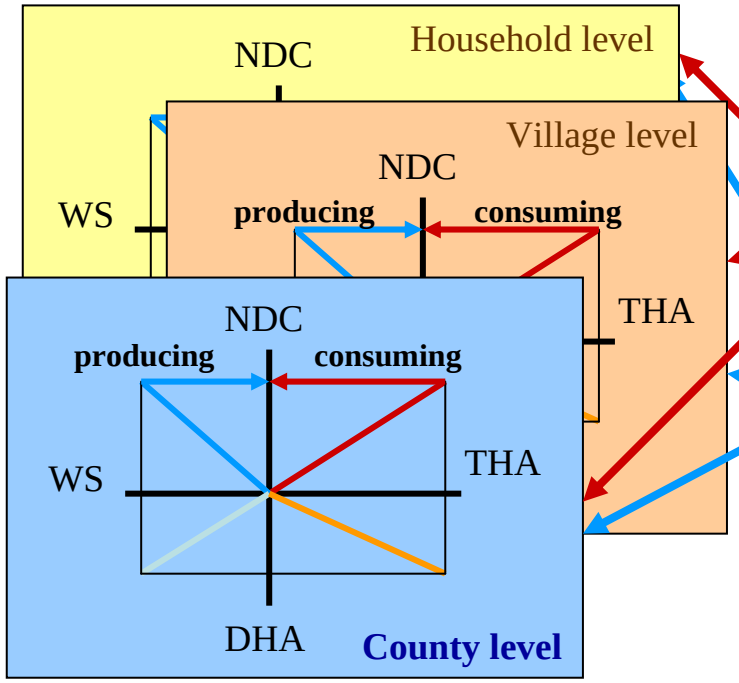
Lesson 4

Studying the mechanism establishing links over quantitative analyses carried out across different dimensions and scales

Parallel representation of the impredicative loops related to the dynamic budgets of Human Activity and Land



Mapping flows against human time



OPTION SPACE
* set of activities
* characterization of activities

Money flow

Energy flow

Matter flow

Mapping flows against ecosystem space

Heterogeneity of consequences of changes in different squares of the grid

Multi-Scale Integrated Assessment of Societal Metabolism

IN PARALLEL ON SEVERAL SCALES !

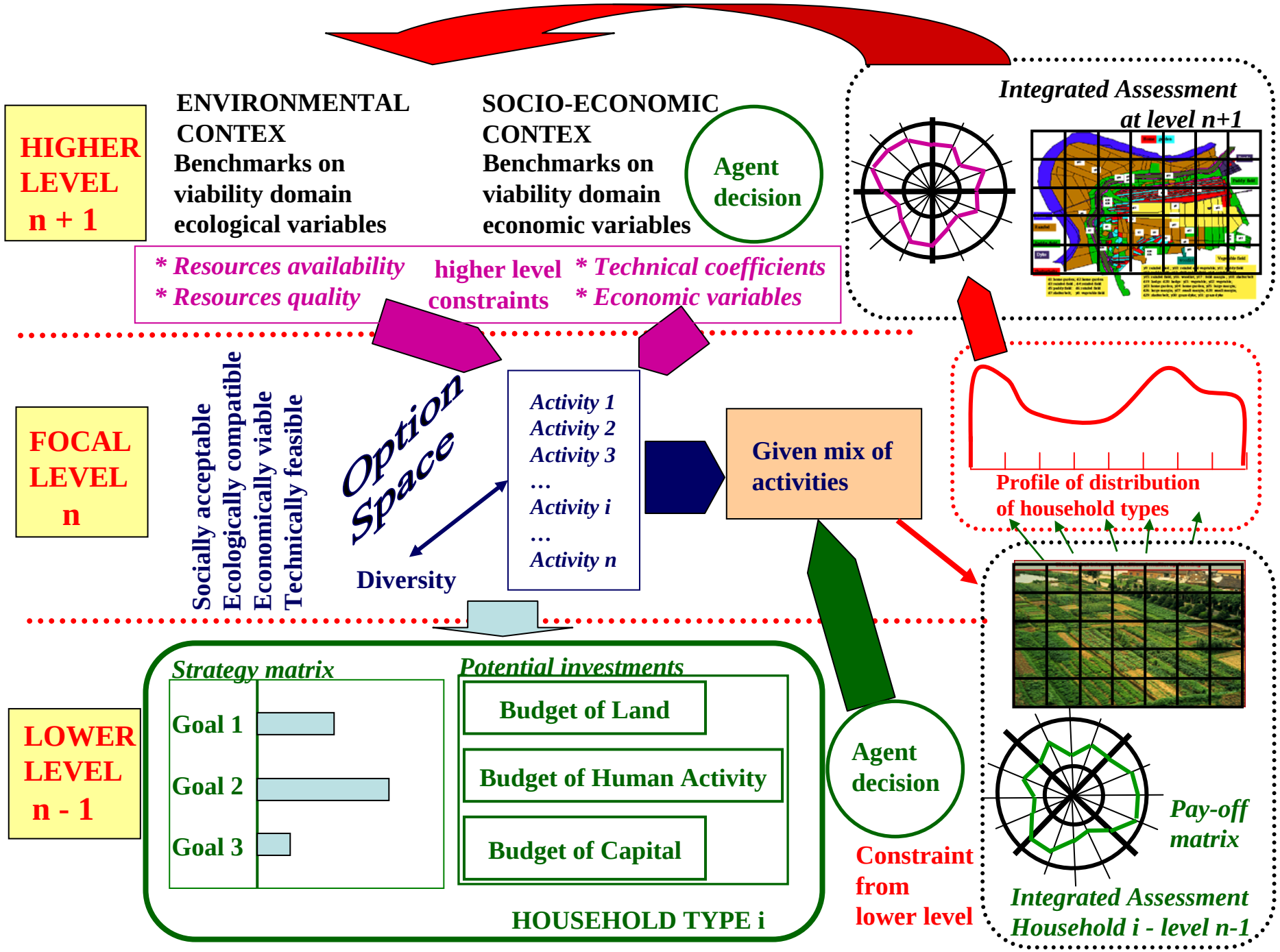
Socio-economic analysis of viability/desirability

MOMSIR

Spatial analysis of changes in energy and matter flows at different scales

IN PARALLEL ON SEVERAL SCALES !

Biophysical analysis of ecological impact

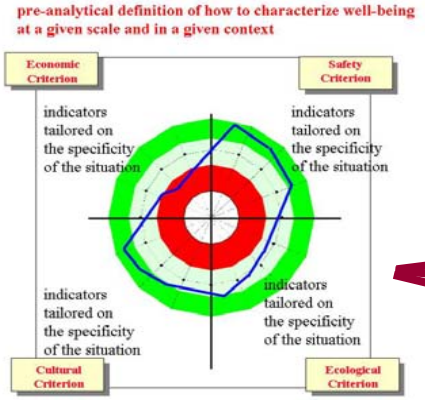

HIGHER LEVEL n + 1
ENVIRONMENTAL CONTEX
Benchmarks on viability domain ecological variables
SOCIO-ECONOMIC CONTEX
Benchmarks on viability domain economic variables
Agent decision
Integrated Assessment at level n+1
* Resources availability
* Resources quality
higher level constraints
* Technical coefficients
* Economic variables
FOCAL LEVEL n
Socially acceptable
Ecologically compatible
Economically viable
Technically feasible
Option Space
Diversity
Activity 1
Activity 2
Activity 3
…
Activity i
…
Activity n
Given mix of activities
Profile of distribution of household types
LOWER LEVEL n - 1
Strategy matrix
Goal 1
Goal 2
Goal 3
Potential investments
Budget of Land
Budget of Human Activity
Budget of Capital
HOUSEHOLD TYPE i
Agent decision
Constraint from lower level
Pay-off matrix
Integrated Assessment Household i - level n-1

Lesson 5

It makes possible to develop a multi-scale integrated analysis and characterization of scenarios on which scientists with different disciplinary background and social actors with legitimate but contrasting points of view about sustainability can discuss and debate while sharing meaning about what they are discussing about

Human Well-being and Poverty Reduction

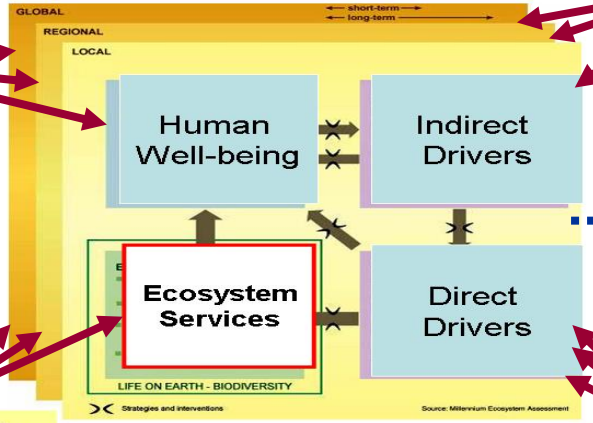
integrated analysis “à la carte” based on the choice of relevant indicators to characterize how social systems produce and consume goods and services



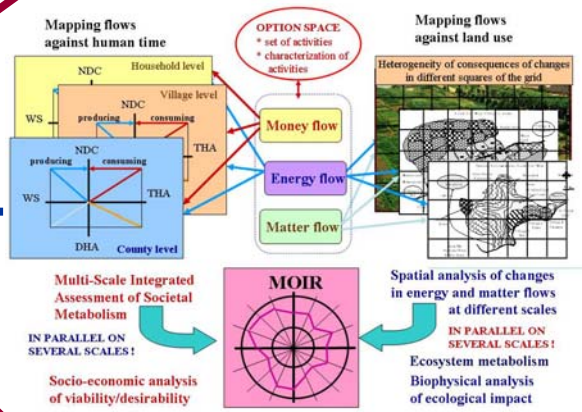
*** Demographic; * Economic; * Sociopolitical**
*** Science and Technology; * Cultural and Religious**

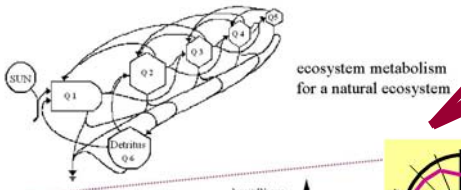
trend analysis over the changes in value for the extensive variables (population) intensive variables (metabolism per hour) →CHANGES in the definition of acceptable standards for both **what** is produced and consumed and **how** = technical coefficients tolerable levels of inequity, cultural identity.

MEA Conceptual Framework

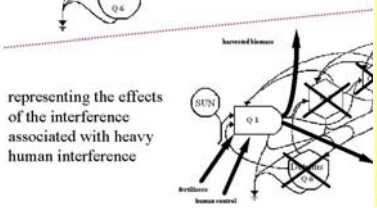


mapping flows of added value, energy and matter against a multi-level matrix of human activity





ecosystem metabolism for a natural ecosystem



representing the effects of the interference associated with heavy human interference

MOIR tailored on environmental impact assessment

using impredicative loop analysis and mosaic effect to check coherence across dimensions and scales

mapping flows of added value, energy and matter against a multi-level matrix of land-use

the concept of ecosystem metabolism entails that ecosystem integrity can be studied in terms of expected benchmarks for different ecosystem types: (intensive) flows per unit of area; (extensive) different land covers

Life on Earth: Biodiversity- Ecosystems health

trend analysis over the changes in value of the variables used to characterize societal metabolism against land uses: matter and energy intensity of flows per square meter of land use/cover
*** Changes in land use * Species introduction or removal**
*** Technology adaptation and use * Use of external inputs *(e.g., fossil energy, trade)* * Resources consumption**

Giampietro M. 2003.
***Multi-Scale Integrated Analysis of Agro-ecosystems.* CRC Press, Boca Raton, 472 pp.**

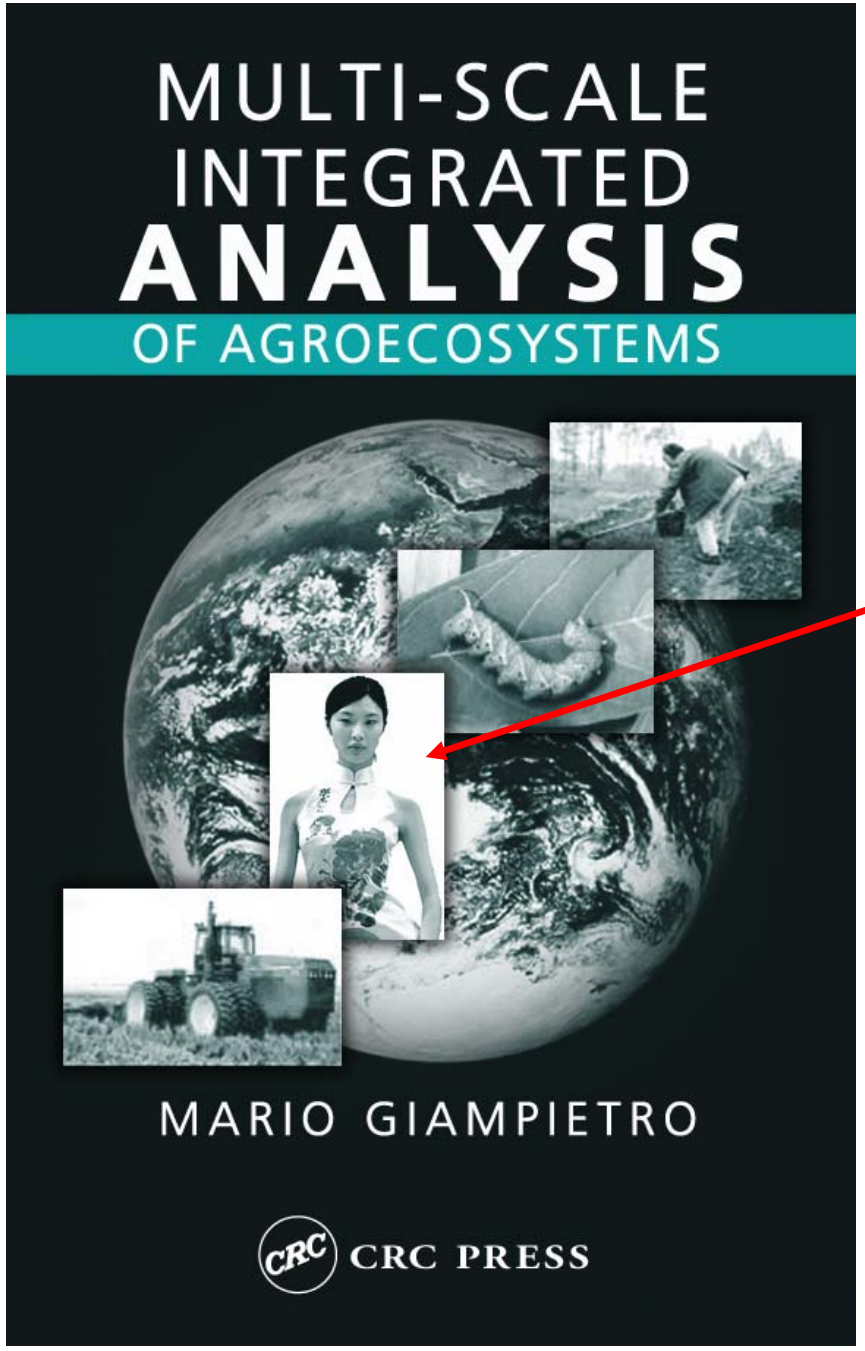
Giampietro, M., Bukkens, S.G.F. and Pimentel, D. 1999.
General trends of technological changes in agriculture.
Critical Reviews in Plant Sciences 18 (3): 261-282.

Li Ji, Giampietro, M., Pastore, G., Cai Liewan and Luo Huaer 1999.
Factors affecting technical changes in rice-based farming systems in southern China: Case study of Qianjiang municipality.
Critical Reviews in Plant Sciences 18 (3): 283-298.

Giampietro, M. and Pastore, G. 1999.
Multidimensional reading of the dynamics of rural intensification in China: the AMOEBA approach. *Critical Reviews in Plant Sciences* 18 (3): 299-330.

Pastore, G., Giampietro, M. and Li Ji 1999.
Conventional and land-time budget analysis of rural villages in Hubei province, China.
Critical Reviews in Plant Sciences 18 (3): 331-358.

Gomiero, T. and Giampietro, M. 2001.
Multiple-scale integrated analysis of farming systems: The Thuong Lo commune (Vietnamese uplands) case study. *Population and Environment* 22 (3): 315 -352.



Scientific censorship!