An interdisciplinary project between Economists and Computer Scientists

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Presentation Plan

I – What's Economics about?

   I.1. Economics subjects: definition and main topics

   I.2. Methods and tools

   I.3. Utility

II – Simulation of land-uses by utilitarian agents with environmental quality perception

I – What's Economics about?

I.1. Economics subjects: definition and main topics (1/3)

Economics is the science which studies how scarce resources are employed for the satisfaction of the needs of men living in society: on the one hand, it is interested in the essential operations of production, distribution and consumption of goods, and on the other hand, in the institutions and activities whose object is to facilitate these operations

Malinvaud E. [1972]: **Lectures on microeconomic theory**

I – What's Economics about?

I.1. Economics subjects: definition and main topics (2/3)

3 important notions and some restrictions

Notions
- ➢ Satisfaction of the needs
- ➢ Men living in society
- ➢ Scarce resources

Observation:

Human needs are infinite then resources are limited

$\Rightarrow$ Compatility Problems

$\Rightarrow$ Decision Problems

$\Rightarrow$ Allocation's decision rules (individual or collective level)

I – What's Economics about?

I.1. Economics subjects:
definition and main topics (3/3)

Restrictions

Notions $\Rightarrow$ Economics is concerned by all human activities:

- Consumption or production problems
- Allocation of time to tooth-brushing

Some problems are more important than others:

There is a need to restrain economics to some subjects of particular interest

- ➤ Operations of production, distribution and consumption of goods
- ➤ Institutions and activities whose object is to facilitate these operations

I – What's Economics about?
I.2. Methods and tools (1/7)

Experimentation is generally impossible in Economics (notably for ethical and political reasons) :

Some exceptions with experimental economics Vernon Smith, e.g.: Market Games

I – What's Economics about?
I.2. Methods and tools (2/7)

Problems in economics are complex:

$\Rightarrow$Several variables which interact together

$\Rightarrow$Economist job: determine which variables must be retain to study a phenomenom

$\Rightarrow$**Economic Models are inevitably reductionists**

I – What's Economics about?
I.2. Methods and tools (3/7)

Double challenge for the economists:

➢ "How does it work"

➢ "What ought to be"

⇒ "Positive" and "Normative" Economics

I – What's Economics about?
I.2. Methods and tools (4/7)

The Economics object of study is itself a problem:

- ➤ Problems from external world?

- ➤ Problems from subjective world of choices and preferences

- ⇒ Causes of objectives results can be subjective

- All this reasons ⇒ Difficulties to decide between alternative theories

In Economics a theory never totally supplants another theory

I – What's Economics about?
I.2. Methods and tools (5/7)

First methodological opposition:

- Methodological Individualism *vs* Holism
  - Methodological Individualism: explaining and understanding broad society-wide developments as the aggregation of decisions by individuals

    J. Schumpeter; F.A. Von Hayek; K. Popper

    $\Rightarrow$ Not to be confused with ethical or political individualism

    $\Rightarrow$ All global properties of a system can be interpreted as the result of individual actions and of the interrelations between individual actions (K. Arrow [1994])

  - Holism: social phenomena can be explained only by the behavior or the properties of supra-individual entities such as culture or institutions

I – What's Economics about?
I.2. Methods and tools (6/7)

Second methodological opposition:

- Microeconomics and Macroeconomics
  - Microeconomics: study of economic activities as an interaction of individual economic agents pursuing their private interests.
  - Macroeconomics: analysis of global public economic phenomena, i.e. at national or international scale.

I – What's Economics about?
I.2. Methods and tools (7/7)

$\Rightarrow$ Real distinction: dichotomy between exogenous and endogenous variables

Examples:

– Microeconomics

$\Rightarrow$ Exogenous variables: national income, level of employment, general level of prices

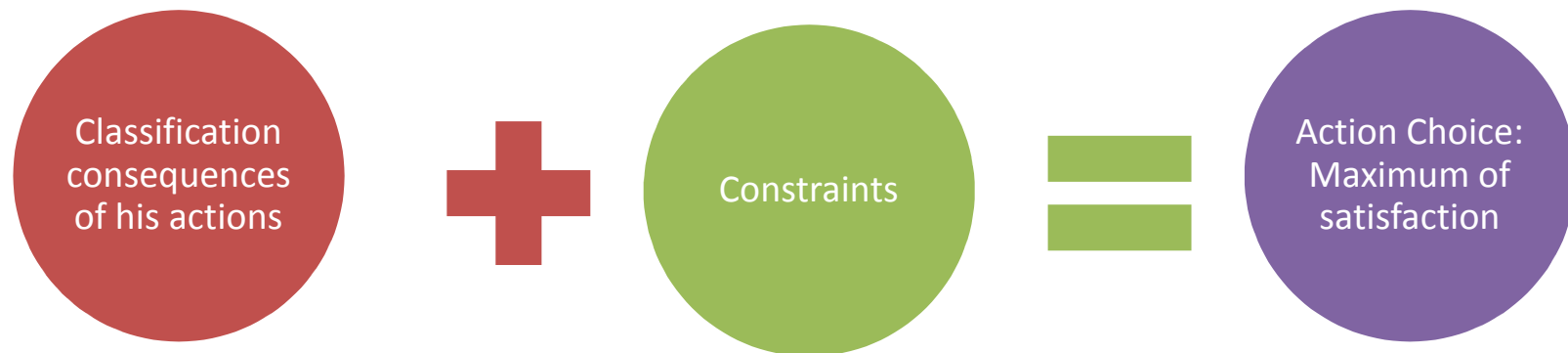$\Rightarrow$ Endogenous variables: composition of the individual consumption, relative price determination amongst goods and services

– Macroeconomics $\Rightarrow$ reverse dichotomy

I – What's Economics about?
I.3. Utility (1/7)

- Assumption concerning the way in which individuals make their decisions: agents are economically rational

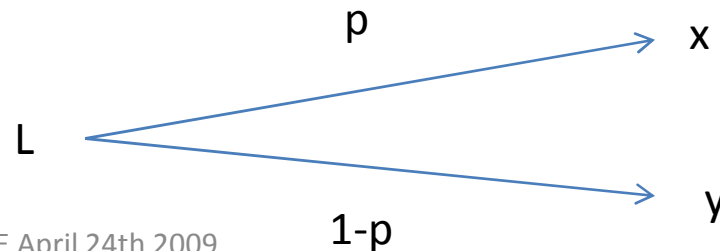- Substantive *(full or perfect)* rationality

Classification consequences of his actions **+** Constraints **=** Action Choice: Maximum of satisfaction

I – What's Economics about?
I.3. Utility (2/7)

- Consequences: x and y

- Notation:

  - $x \succ y \Rightarrow$ x is preferred to y

  - $x \sim y \Rightarrow$ x is indifferent to y

  - $x \succsim y \Rightarrow$ x is at least as good as y

- Lotteries: situations with uncertain issues

  L=[x;y/p;1-p]

I – What's Economics about?
I.3. Utility (3/7)

John Von Neumann and Oskar Morgenstern [1944]:
Theory of Games and Economic Behavior

Preferences of a rational agent must obey to 4 axioms of rationality

Axiom 1 – Completude

$x \succ y \lor y \succ x \lor x \sim y$

I – What's Economics about?
I.3. Utility (4/7)

John Von Neumann and Oskar Morgenstern [1944]:
Theory of Games and Economic Behavior

Axiom 2 – Transitivity

$$x \succ y \land y \succ z \Rightarrow x \succ z$$

John Von Neumann and Oskar Morgenstern [1944]: *Theory of Games and Economic Behavior*

Axiom 3 – Continuity

$$x \succ y \wedge y \succ z \Rightarrow \exists\ p \in\ ]0;1[\ /\ y \sim [x;z/p;1\text{-}p]$$

e.g.: x: "beautiful and uneventful trip by car"; y: "staying at home" and z: "death by car accident"

$\Rightarrow$**Lexicographic preferences ("safety first") ruled out**

Concerning environmental assets as land uses some individuals base their decision on a hierarchy of values which can give rise to lexicographic preferences

John Von Neumann and Oskar Morgenstern [1944]:
Theory of Games and Economic Behavior

Axiom 4 – Independence

$$x \succ y \Rightarrow \forall z; \ \forall p \in \ ]0;1[; \ [x;z/p;1-p] \succ [y;z/p;1-p]$$

Allais [1953] Paradox $\Rightarrow$ Inconsistency of actual observed choices with Independence axiom

Allais [1953] Paradox

First Prize	Second Prize	Third Prize
x: 2.5 millions €	y: 500 000 €	z:0€

Two choice tests

First choice: $L_1=[y;z/10\%;90\%]$; $L_2=[x;z/9\%;91\%]$

Second choice: $L_3=[y/100\%]$; $L_4=[x;z/90\%;10\%]$

Results: $L_2 \succ L_1$ and $L_3 \succ L_4$

$\Rightarrow$ Inconsistency with Independence axiom

$L_1=[L_3;z /10\%;90\%]$ and $L_2=[L_4;z /10\%;90\%]$

3 reactions:

1. Marshack and Savage: correction of mistakes
2. Limited significance for economics as whole: payoffs out of ordinary and probabilities close to 0 and 1
3. Axiomatics giving up the independence axiom and based on something weaker

I – What's Economics about?
I.3. Utility (7/7)

Maximum Expected Utility Theorem

Given any preferences satisfying these constraints, there exists a real-valued function U such that:

$$U(x) \geq U(y) \Leftrightarrow x \succsim y$$

$$U[P_1; ...; P_i; ...; P_n / p_1; ...; p_i; ...; p_n] = \sum_i p_i \, U(P_i)$$
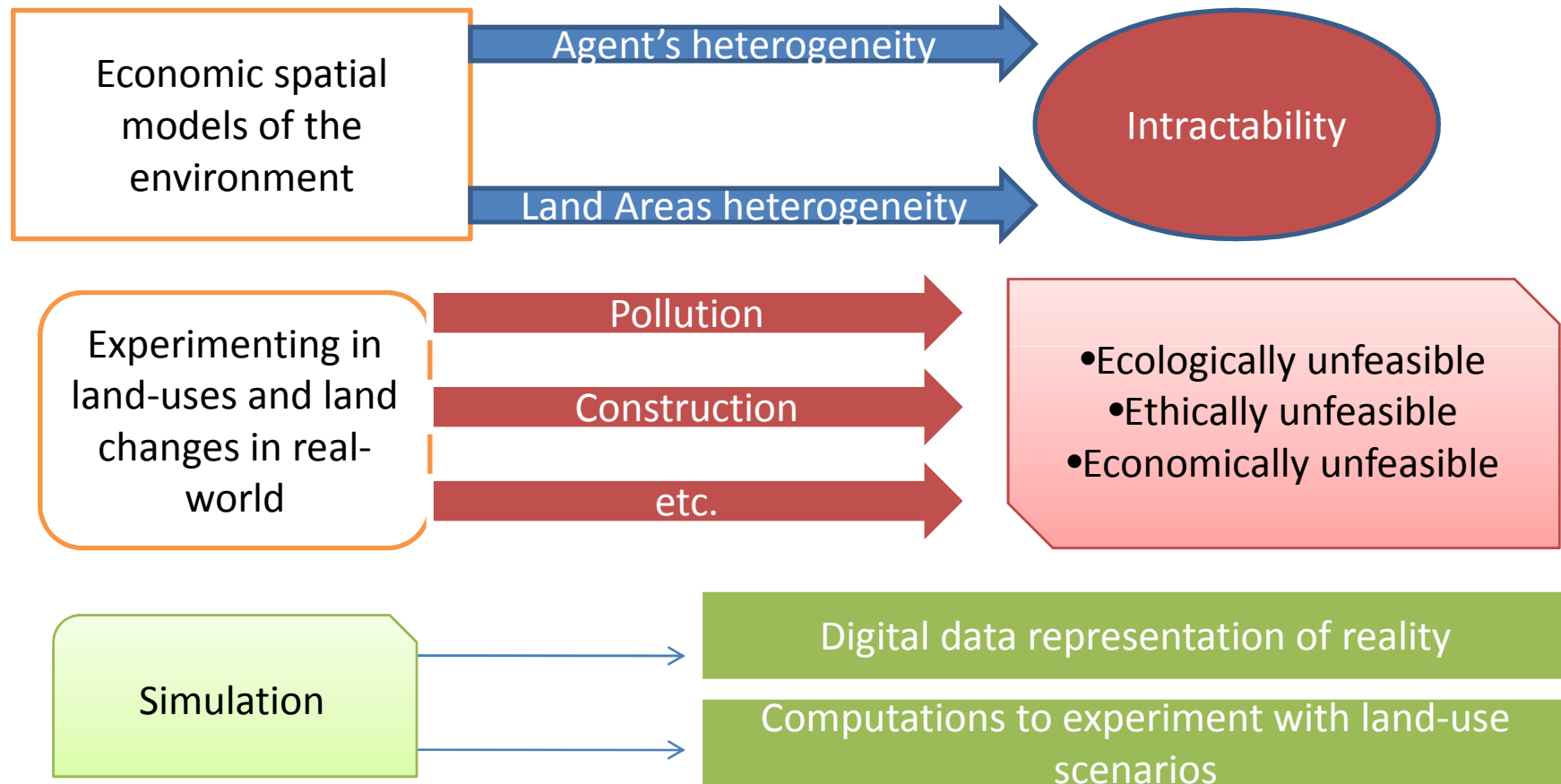
II
Simulation of land-uses by utilitarian agents with environmental quality perception
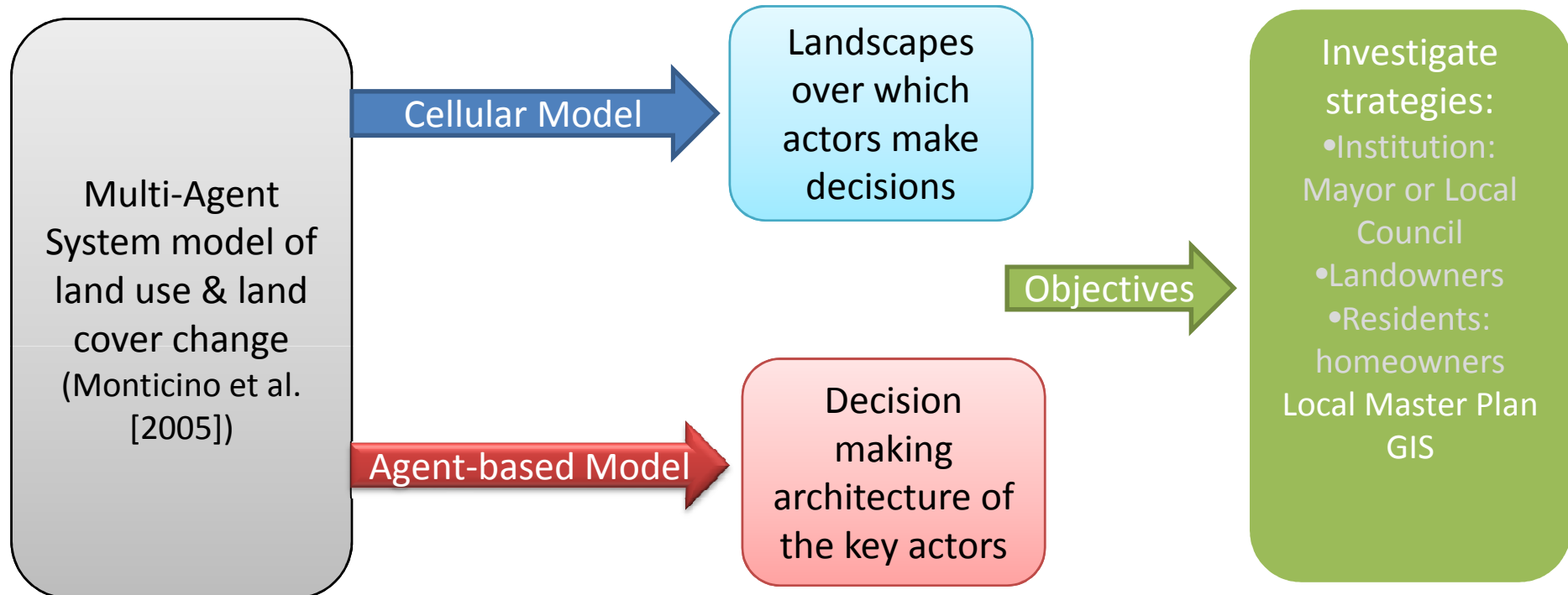# (Work in Progress)

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Experimenting in land-uses and land changes

Economic spatial models of the environment

— Agent's heterogeneity →

— Land Areas heterogeneity →

Intractability

Experimenting in land-uses and land changes in real-world

— Pollution →

— Construction →

— etc. →

- Ecologically unfeasible
- Ethically unfeasible
- Economically unfeasible

Simulation

Digital data representation of reality

Computations to experiment with land-use scenarios

MAS / LUCC

Multi-Agent System model of land use & land cover change (Monticino et al. [2005])

Cellular Model → Landscapes over which actors make decisions

Agent-based Model → Decision making architecture of the key actors

Objectives → Investigate strategies:
- Institution: Mayor or Local Council
- Landowners
- Residents: homeowners

Local Master Plan GIS

Activities

INDUSTRIAL	• Very High Tax Revenue • Very High Environmental Damages
COMMERCIAL	• High Tax Revenue • High Environmental Damages
RESIDENTIAL	• Low Tax Revenue • Low Environmental Damages
WILD	• Very Low Tax Revenue • Very Low Environmental Damages

Environmental Quality

$$Q_j = \begin{cases} Q_{j0} - \sum_{i=1}^{N} B_i - B_j \ if \ Q_{j0} - \sum_{i=1}^{N} B_i - B_j > 0 \\ 0 \ if \ Q_{j0} - \sum_{i=1}^{N} B_i - B_j \leq 0 \end{cases}$$

- Environmental quality of a cell is a function of:
  - The initial environmental quality in this cell
  - The environmental damages in this cell
  - The environmental damages in the neighborhood

Overall simulation sequence

0. **Initialization:** for every cell, an activity value is attributed

1. Constructability proposal by the Mayor

2. Protestation, neutrality or adhesion decisions

3. Mayor final constructability decision

4. Selling decisions from landowners

5. Voting decisions by homeowners and landowners

Mayor's utility function and type

$$U_m = \alpha_{EN} \ln(1 + Q_j) + \alpha_{RF} \ln\left(1 + Z_i\right) + \alpha_W \ln\left(N + 2 - \rho\left(\sum_{k=1}^{M} K_k\right)\right); K_k = \frac{\sum_{l=1}^{X} K_l}{X}$$

Sum of three partial utilities with different weights:

- A partial utility relative to environmental quality
- A partial utility relative to tax revenue from the cell
- A partial utility relative to citizen welfare

Mayor's type:

- Relative weight for Citizen welfare is fixed
- Others'weights determine the Mayor's type : « ecologist » or « concerned about economical development »

Mayor Decisions for a wild cell

- β: number of cells developed;
- θ: threshold
  - if β≤θ cell will not become constructible
  - if β> θ cell becomes constructible with a probability positively linked with β
  - Mayor's final constructability decision depends on mayor's utility

Residents' utility function and types

$$U_v = \alpha_E \ln(1+Q) + \alpha_F \ln(1+F)$$

Sum of two partial utilities with different weights:

- Partial utility relative to environmental quality
- Partial utility relative to the value of his cell
- Resident's type: « **ecologist** » or « **property-value concerned** »

Residents' decision: protest or not protest

- τ: Ratio between utility in the "constructible" case and in the "non constructible" one
- Every resident is characterized by a parameter $\varepsilon \in [0;0.5]$:
  - A resident protests if: $0 \leq \tau < 1-\varepsilon$
  - A resident is neutral if: $1-\varepsilon \leq \tau \leq 1+\varepsilon$
  - A resident agrees if: $1+\varepsilon < \tau \leq +\infty$

Residents' voting decision

- Changes in residents' weights according to protestation / adhesion decisions

- Residents choose a new Mayor:
  - probability that a resident votes an "ecologist" mayor is proportional to the weight he gives to environmental quality
  - probability that a resident votes mayor more "concerned about economic development" is proportional to weight he gives to cell's value

Landowners' utility function and types

$$U_p = \alpha_{TR}\,\eta \ln\left(1 + \frac{t_{pos}}{25}\right) + \alpha_Q \ln(1+Q) + \alpha_R \ln\left(1+F\right)$$

Three types depending on the relative weights Landowner gives to three partial utilities:

- Tradition→ « traditionalist »

- Environmental quality → «ecologist »
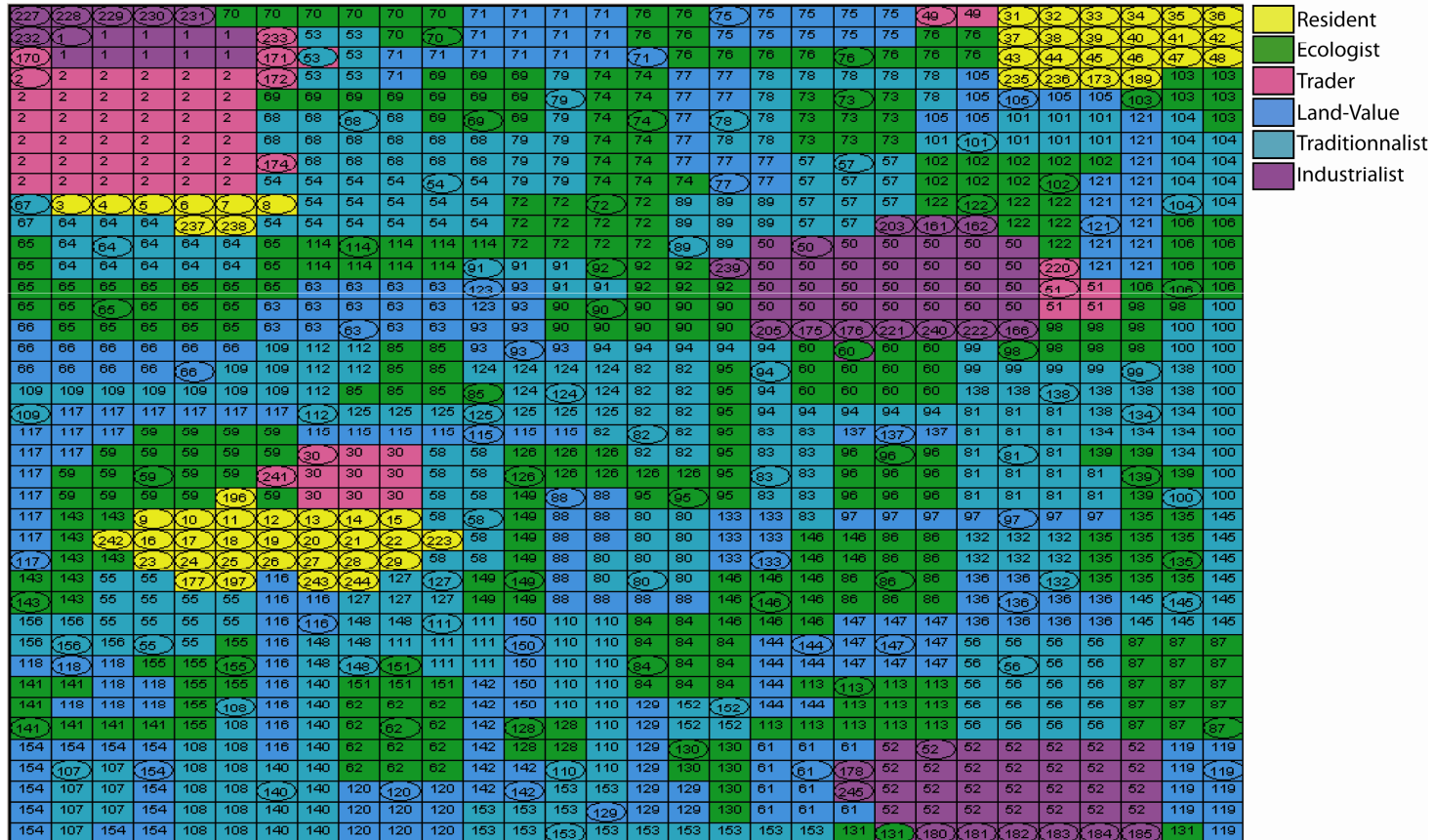
- Value of his cell → « land-value concerned »

Landowner decisions

Three decisions:

- Protest against a Mayor's constructability proposal

- To sell or not to sell his land in case of constructability
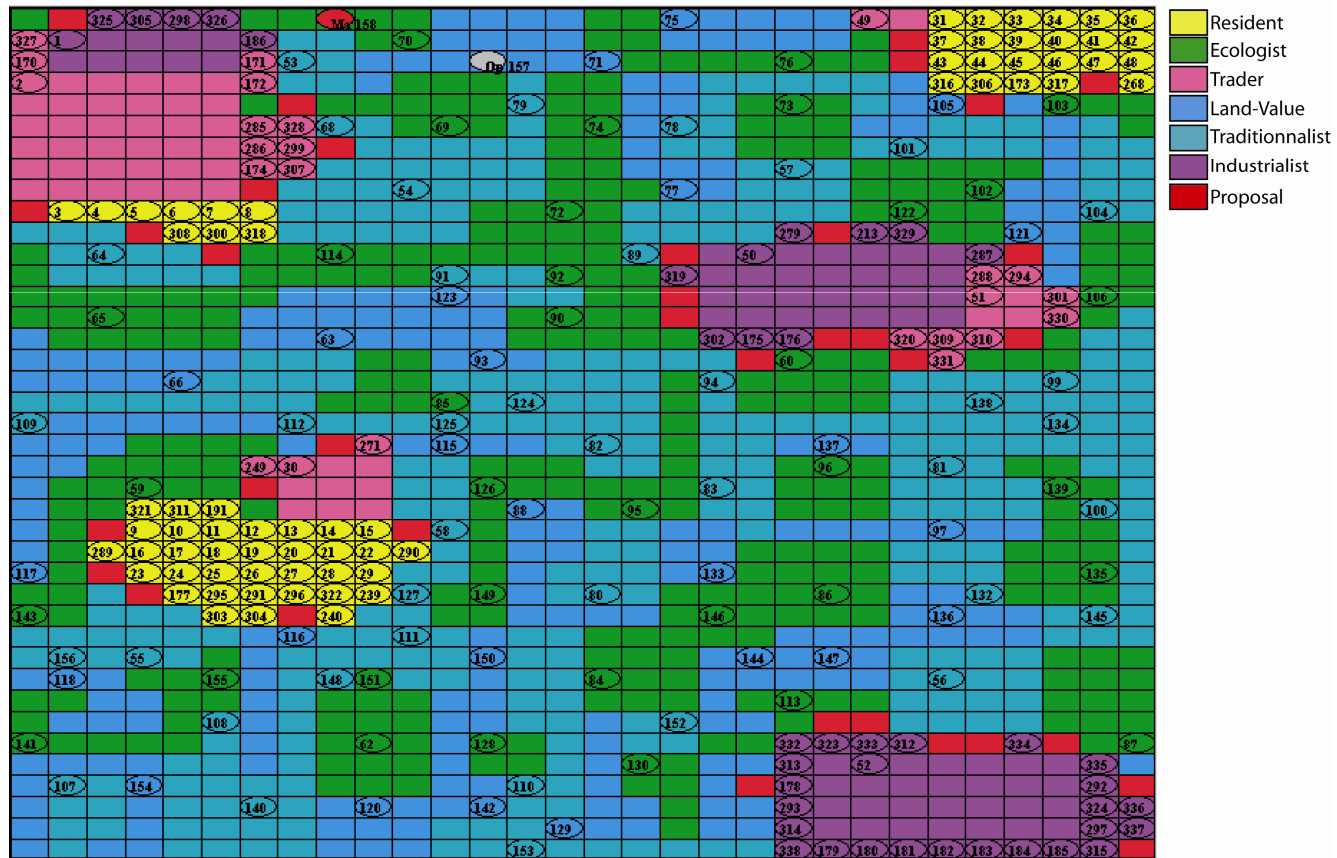
- Voting decision

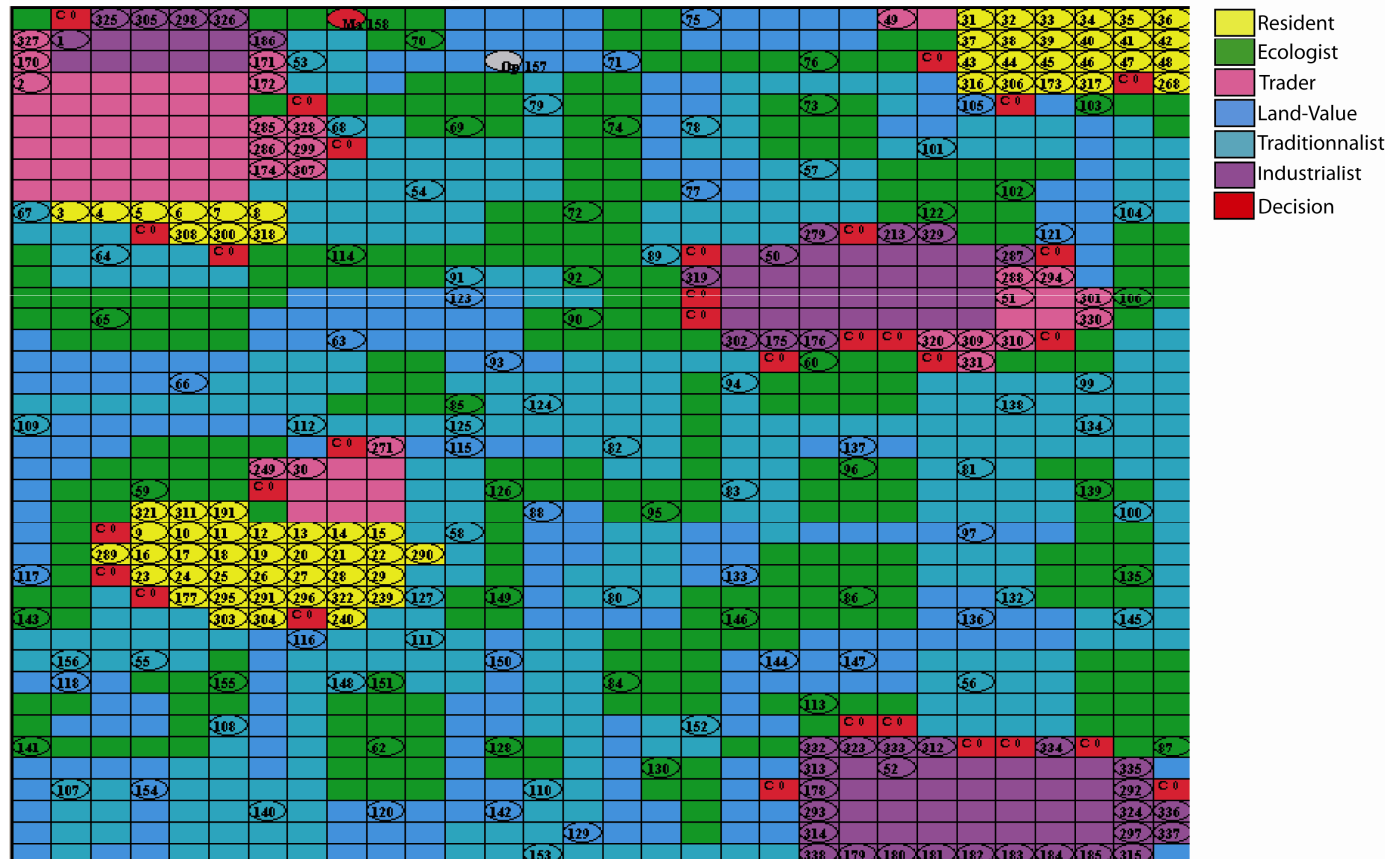# Simulator (1/5)

Propagation Map

Simulator (2/5)

Proposal Map

Simulator (3/5)

Protestation Map

Simulator (4/5)

Decision Map

Simulator (5/5)

Sells Map

Economics perspectives

- Refine activities: disaggregation and differenciation into more specific activities

- Incorporate lexicographic choices