An agent-based model of the Amazonian forest colonisation and oil exploitation : The Oriente study case

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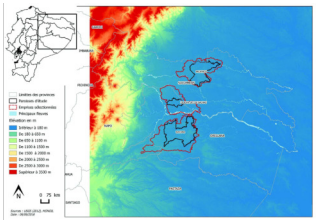
Context:



Sources : http://www.monoil.ird.fr/photos

Aim :

To reproduce the environmental and socioeconomic impacts of colonization and oil exploitation on the Oriente (Ecuadorian Amazon)

Integrating :

- colonization & oil exploitation impacts
- microeconomics behaviors of the population
- public policies & goods' prices

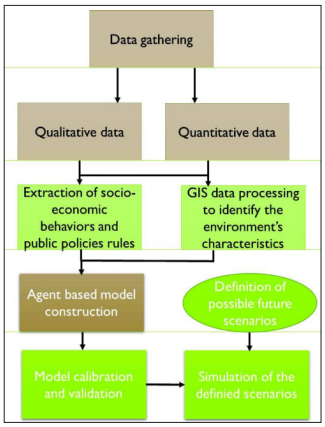
To simulate the possible futures of this territory by the means of a scenario based exploration tool

Two main steps :

- Retrospective simulation to replicate the past colonization of the environment and its effects on the environment
- Simulate the actual and possible future situtation with the social structuration of agents and their difficulties to deal with oil contamination

To use the results obtained as decision-support tools

Method :



Construction of the MONOIL model

Modules created :

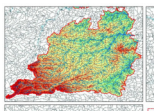
Steps of the project :

Data processing

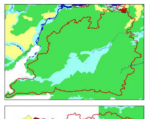
- Building a meaningful GIS dataset for feeding the model
- Creation of watersheds and rivers
- Demarcation of the study areas (Parish of Dayuma, Pacayacu, La joya de los sachas) using the DEM (Digital Elevation Model) including the upperstream watersheds
- Selection of rainfall data for each study site (Hijmans, et al. 2005)
- Classification of the pollutions sources according to their effect area and persistence on the environment
- Calculation of pollutions accidents' periodicity and volume variability
- Processing demographics data
- Definition of soils characteristics of our study areas using USDA (United State Department of Agriculture) data
- Computation of the fertility and flooding indices of our study areas' soils

Biophysical module

- Various pollution sources
- Environmental, hydrographic, climatic dynamics and soils characteristics
- Road network and health centers
- Model background

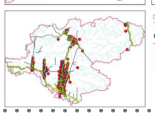


Relief and hydrography



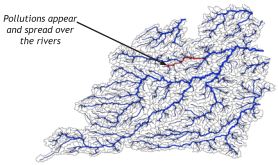
Soils characteristics

Roads & health centers

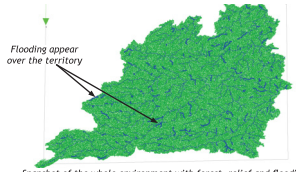


Pollution sources

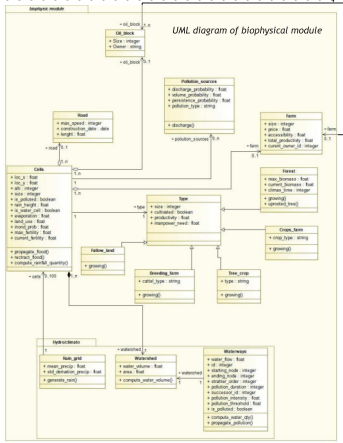
- Compute pollution sreading over the environment as function of the previous pollution calculation
- Implement flooding dynamics according to elevation and soils types
- Calculate the forest growth depending on fertility



Snapshot of the watersheds and the rivers network under GAMA plateform



Snapshot of the whole environment with forest, relief and flooding



UML diagram of biophysical module

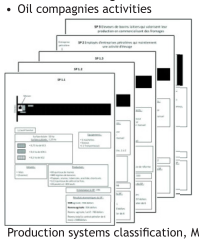
Agents module

INEC data base

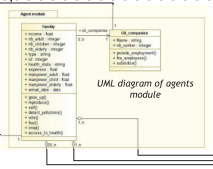
- Total population by parishes
- Population density by parishes
- Intercensal growth rate by parishes
- Households by dweling types and parishes
- Population by age range and parishes
- Population by ethnic groups and parishes
- Population by revenue
- Households size

Morin, L., 2015

- Farming production systems (Cocoa, coffee, corn, casava, banana)
- Livestock production systems (cows, porks, chickens)
- Productivity of each systems
- Manpower needed for each production
- Farmers social organisation
- Oil compagnies activities



Production systems classification, Morin, 2015



UML diagram of agents module

Agents represent households and oil compagnies.

Households :

- vary according to size, age & gender of its members
- settle on lots progressively depending on soils fertility, accesibility & price
- choose their production system according to needs, manpower, land & expected gains
- are subjected to oil contamination, implying health affections

Oil compagnies :

- exploit their petroleum blocks and recruit saesonal workers among the local population

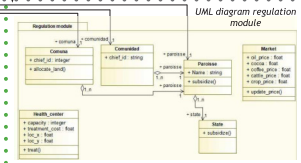
Regulation module

Definition of rules from MSc & Phd thesis and experts' opinion :

- Agricultural policies,
- Oil producer policies,
- Political and social structuration,
- Public and private subsidies system,
- Market prices,
- Healthcare system.

Readings

- *Elies & Mettetal, 1985*
- *Bilsborrow et al., 2006*
- *Engelman, 2011*
- *Juteau, 2012*
- *Paichard, 2012*
- *Dumont, 2013*
- *Wasserstrom & Southgate, 2013*
- *Morin, 2015*
- *Boyon, 2015*



UML diagram regulation module

Regulation rules :

- Two land tenures
  - In Comuna ownership is collective. Each indigenous has temporary land lots
  - Settlers gather themselves in Comunidad where people keep their plots private
- Market prices vary following historical variations
- Farmers rationality balance between family needs securization & investing projects
- Government allocate agricultural subsidies to population. It also provides the healthcare services
- Oil compagnies offer subsidies in order to counterbalance the effects of pollution and prospecting on farmers' plots but also create road to exploit oil ressources

Model building and implementation

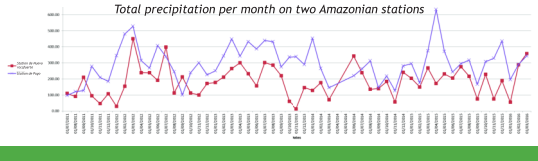
Conception of the model entities using UML language.

Implementation of the model :

- Implementation of the elevation using the DEM
- Implementation of the rainfall, watersheds and rivers. Computation of the water flow
- Implementation of the flooding dynamics
- Implementation of pollutions and their spreading over rivers and soils
- Implementation of the agents dynamics
- Implementation of the model rules

Model calibration

- Using external data to calibrate the environment and the agents behaviors :
  - GIS land use data (GAD, Gobierno Autonomo Descentralizado & PRAS, Programa de Reparacion Ambiente y Social)
  - Perception based map of pollution (Maestripieri & Saqalli, 2015)
  - USGS (United State Geological Survey) precipitation data
  - Pollution data (MONOIL project, work in progress)



Perspectives :

A field mission is scheduled in october. During this mission we will discuss about our model with experts and MONOIL project actors :

- Does the model look like they expect ?
- Does the dynamics of the model fit with the reality ?

It will also be an opportunity to define Oriente future development scenarios with the project stakeholders :

- survey local population and project stakeholders on the future of the territory
- create with them plausible future scenarios
- simulate these scenarios to help stakeholders in decision making process

This work is still on progress until the end of october 2016.

We also hope funding to lead a thesis on «migrations retrospective and prospective modelling over the colonisation of Amazonian forest : the ecuadorian case».