International Institute for Applied Systems Analysis
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Future deforestation projections: comparison of different approaches

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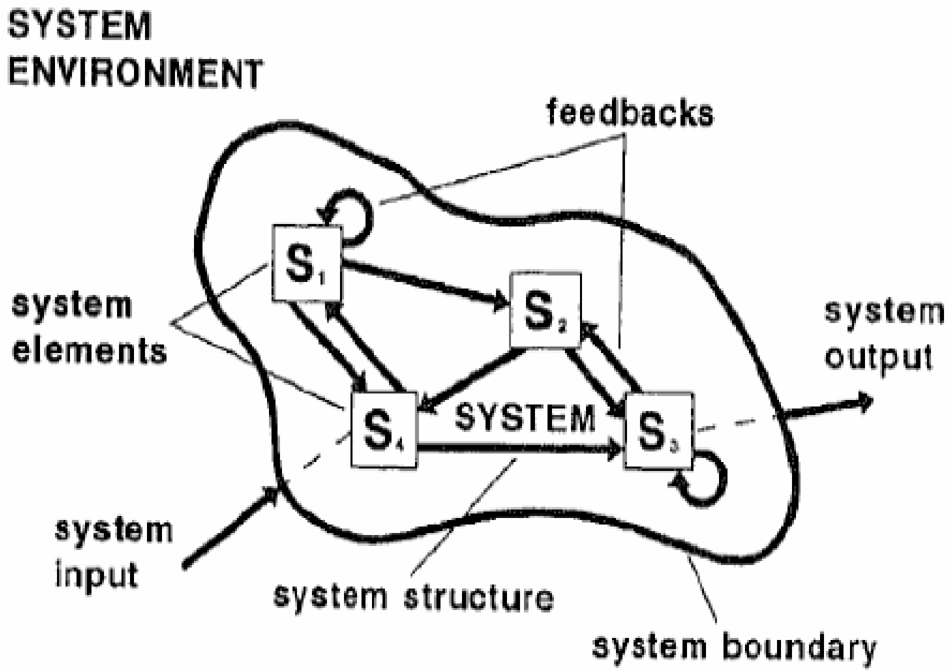
Introduction

What is a model?

- A simplification of the reality where we try to single out the most important components of the system and to determine how they are related to each other



What is a model for?

- A model is created to answer a specific question: depending on the question we want to address, we have to choose the appropriate model
- Models are wrong –due to their simplification - but they could be useful to better understand a complex reality (mechanisms, indirect effects,…)
- Possible to isolate the impact of a single factor while in the reality since many things evolve in parallel it is hard to identify the impacts of one single factor
- Give estimations on the future under different conditions than past and present and discuss plausible futures and main uncertainties ➔ prospective exercise
- It is a tool to help action!

Challenges in the context of REDD+

- REDD+ is an international mechanism that offers financial compensation to developing countries who reduce their emissions from deforestation and forest degradation and enhance carbon stocks

- 2 principles are very important:
  - **additionality** = REDD+ must subsidize activities leading to emissions reduction that would not be observed otherwise
  - **performance-based payments** = require first the establishment of a counterfactual –the business as usual (BAU) baseline- which is the level of emissions that would occur without REDD+ activities

- Methodology to compute baselines should be transparent, complete, consistent, comparable and accurate

Challenges in the context of REDD+

- What will be the level of deforestation and emissions from deforestation, forest degradation and enhancement of carbon stocks without REDD+ policies?
  - Depends on the total amount of forest converted to other uses → demand for forest land
  - Depends on the forest carbon content →localization of the deforestation is important due to spatial heterogeneity in forest carbon content

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Approaches to compute future deforestation and related emissions

- Extrapolation of past trends
- Set of assumptions
- Macroeconomic models
- Regression models
- GLOBIOM approach

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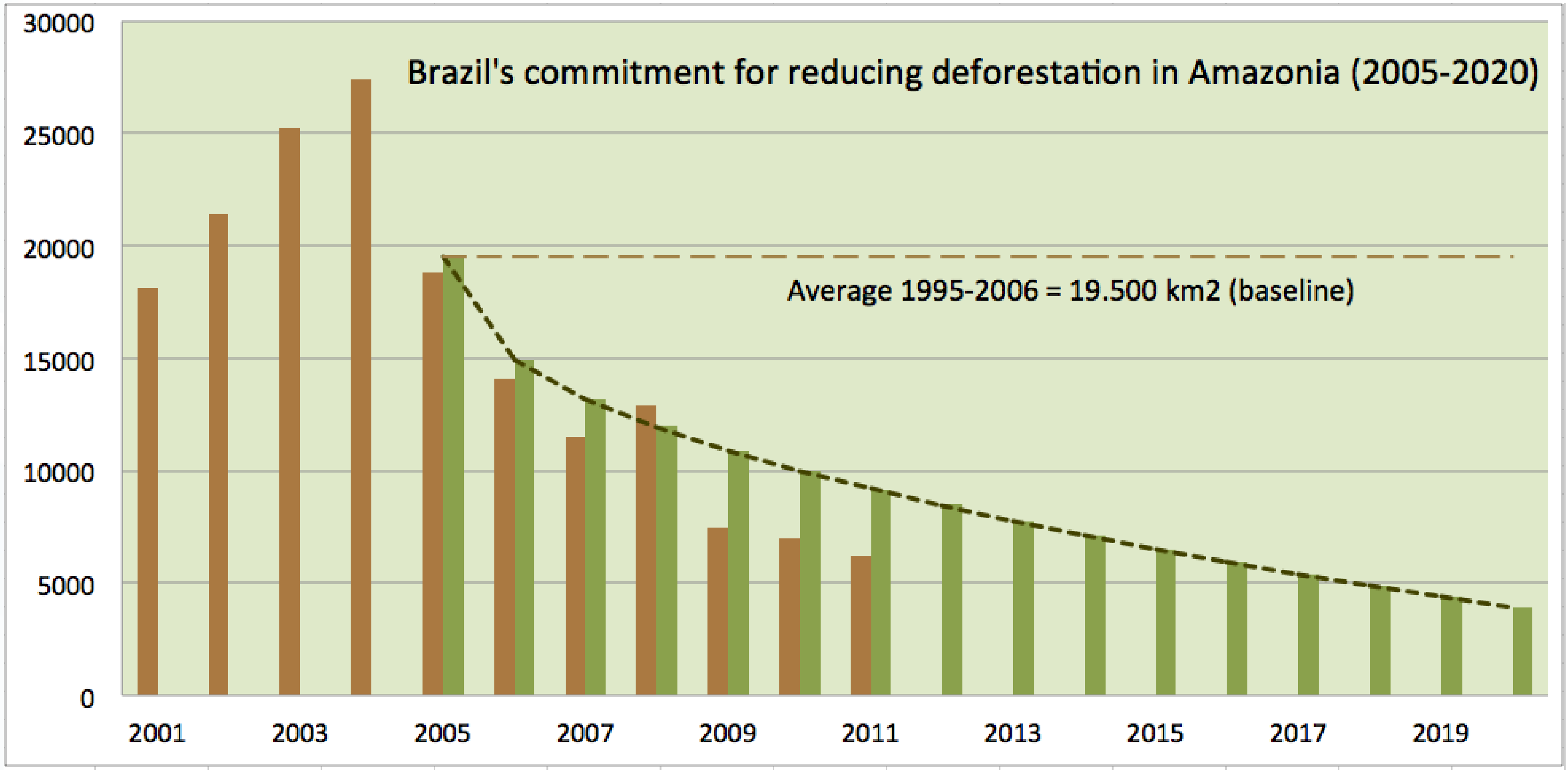
Extrapolation of past trends



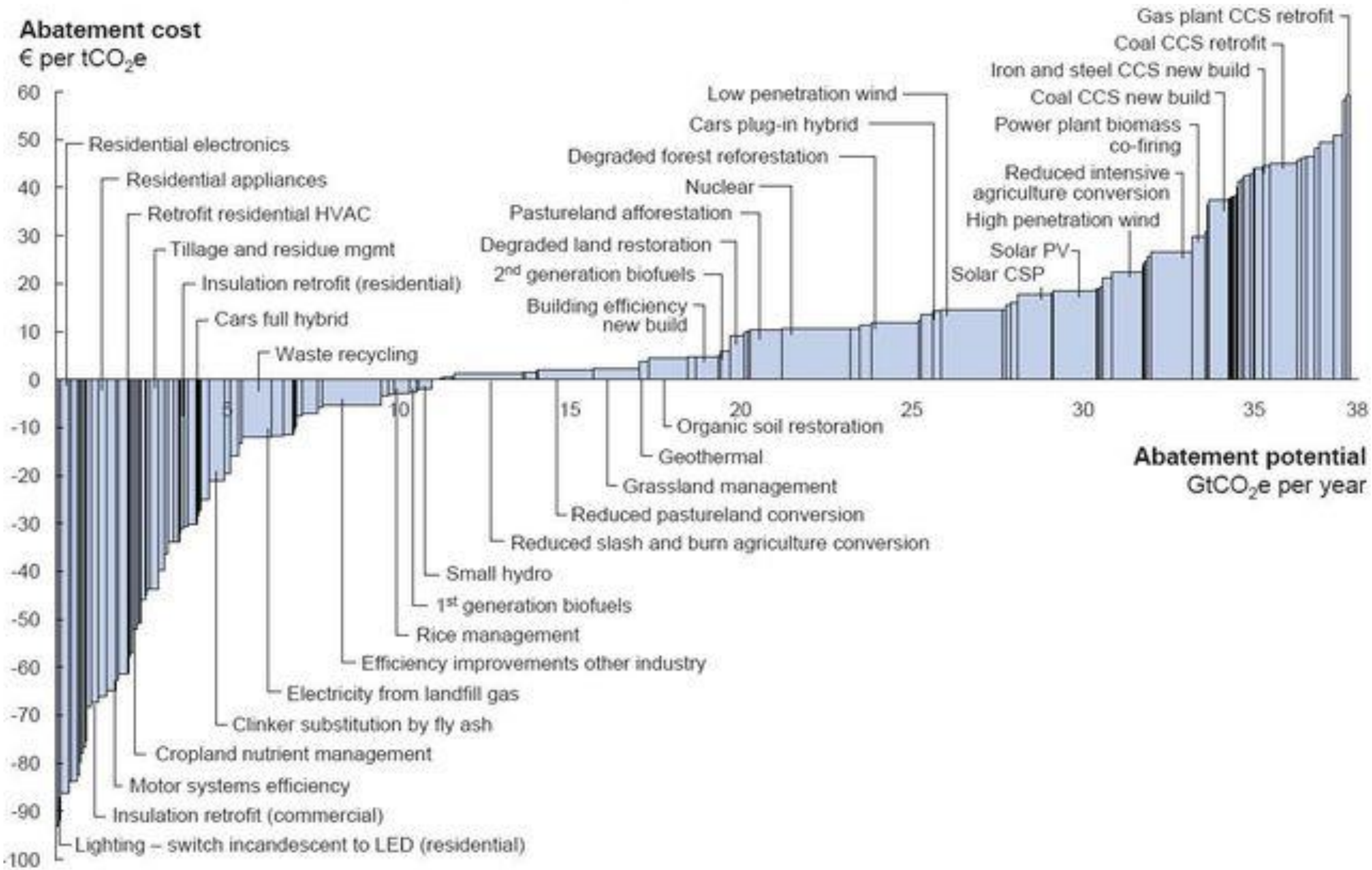
Brazil's projected reduction in deforestation (green bars) and actual rates (brown bars) measured in km^2 per year

McKinsey approach

McKinsey approach does not use a model but rather **a set of assumptions** and produce emissions projection at the national level:

- Identification of major causes of deforestation and forest degradation and levers of carbon sequestration
- Link of these factors to the growth of the country’s economic sectors and the national and regional demographics
- Each identified factor is projected until 2030 to derive the number of deforested and degraded hectares
- Emissions from deforestation and degradation volumes by ecosystem and activity are computed based on scientific literature and interviews with expert

McKinsey approach



Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below €60 per tCO_2e if each lever was pursued aggressively. It is not a forecast of what role different abatement measures and technologies will play.
Source: Global GHG Abatement Cost Curve v2.0

Existing models to assess future deforestation

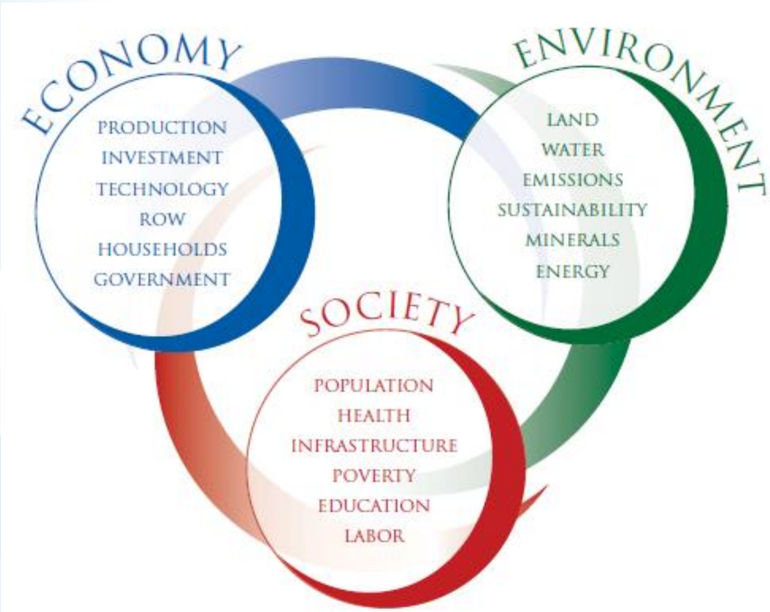
Name and institution	Description	Region	Reference
CLUE (Wageningen University)	Non-spatial demand module + spatially explicit allocation procedure	Klang-Langat watershed in Malaysia Brazil	Verburg et al. 2002
DINAMICA (Federal University of Minas Gerais)	Non-spatial demand module + cellular automata	Amazon	Soares-Filho et al. 2006
T21 (Millennium Institute)	Dynamic system model	Africa, DRC	Ochola 2005
Von Thunen Land rent model	Von Thunen Land rent model	DRC	Knoke et al. 2013; Phelps et al. 2013

System dynamic approach

The **T21 model** is a dynamic macroeconomic model which employs a system dynamic approach: evaluation of sets of **simultaneous differential equations** which calculate the value of a variable at the next time step given the values of other causal variables at the current time step

- Major production sectors (industry, agriculture and services) characterized by Cobb-Douglas production functions with inputs of resources (e.g. land), labor, capital and technology
- Demand is based on population and per capita income growth and distributed among sub-sectors using Engel's curves

System dynamic approach



T21 model

- Feedback loops from one sphere to another (e.g. social sphere influences population growth which influences demand and labor productivity which affects the level of production)

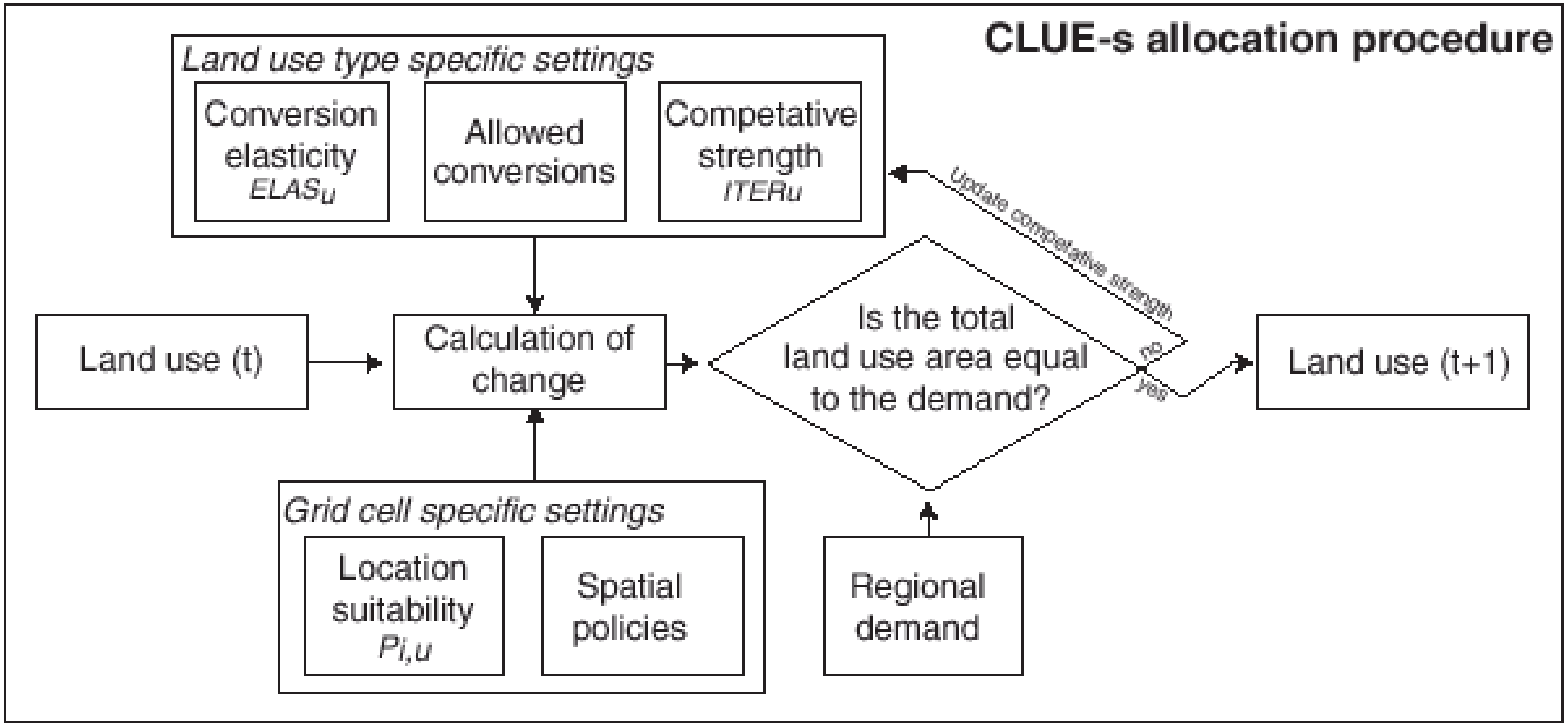
The CLUE model

The **CLUE model** uses empirically quantified relations between land use and its driving factors in combination with dynamic modelling of competition between land use types

- A **non-spatial demand module** calculates the area change for all land use types at the aggregate level: based on a range of methods, including extrapolation of past trends when necessary corrected for changes in population growth and/or diminishing land resources.

- A **spatially explicit allocation procedure** translates these demands into land use changes at different locations → spatial policies and restrictions, conversion elasticities, conversion matrix, location characteristics (empirically estimated)

The CLUE model



Source: Verburg et al. 2002

The DINAMICA model

The **Dinamica model** is considered as a cellular automata type model in which the state of each cell depends on the previous state of the cells within a cell neighborhood according to a set of transition rules

- It uses **extrapolation of past trends** and adjust them for future infrastructures and change in the governance in the Amazon

- The spatial **transition probability maps** depict the probability of a cell at position (x,y) to change from state *i* to state *j.* It is either computed using weights of evidence or logistic regression to select the areas most favorable for each type of transition using spatial variables stored in GIS

The DINAMICA model

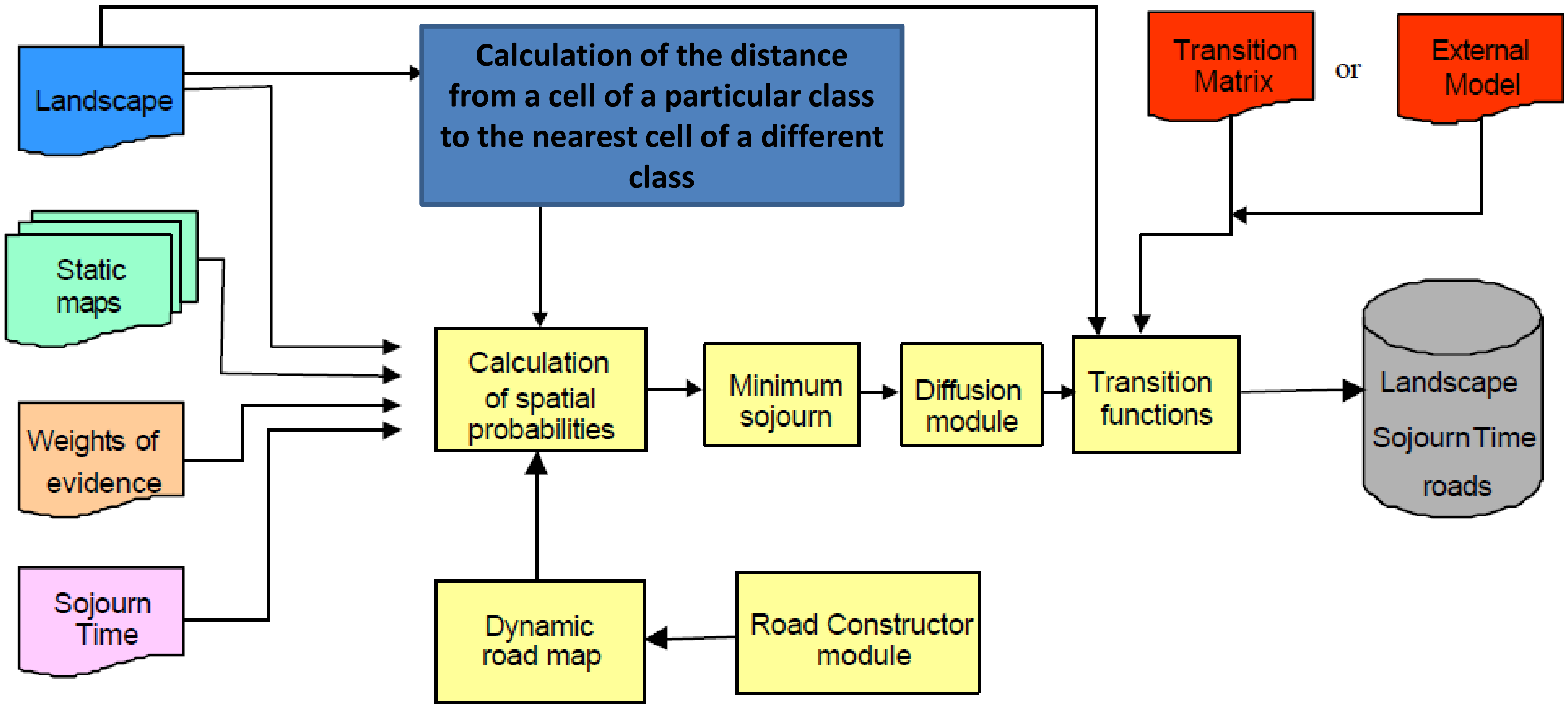


Figure 1. The DINAMICA model architecture.

Source: Soares-Filho 2003

The Von Thünen model

The **von Thünen model** (1910) was one of the first attempts to explore causal mechanisms between economic inputs and geographical patterns.

- It postulates that the location of agricultural activities is driven by two main forces: the **transport distance to the market** and the **cost of the land**

- It predicts that products that are more profitable will be the closest to the city followed by products with high transportation costs

GLOBIOM approach

GLOBIOM is a global partial equilibrium model with a bottom-up approach.

- Demand is driven by population, GDP growth and food preferences at the regional aggregated level. Both domestic demand and international demand for food, feed, wood and bioenergy are computed endogenously.
- Land use change depends on the expected benefits of the land, the production costs, the transportation costs, technological change, conversion costs and a transition matrix. It is modeled at the grid level (~number of hectares in a 50x50km pixel).
- Prices are endogenously computed

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Conclusion

Conclusion

- Good initial land cover map is always required
- Population and GDP growth are the most widely used determinants for aggregated demand for forest land and market accessibility, land suitability, and distance are the most widely used determinants for spatial patterns of deforestation
- Spatially explicit models are usually very dependent on past deforestation level and patterns
- More macro models of deforestation are usually more comprehensive in the description of feedbacks between different sectors of the economy but miss local constraints which influences a lot future deforestation

Conclusion

- Challenges in the:

  - Integration of scales : global/national/local
  - Integration of sectors : agriculture/forestry/industry/services
  - Representation of institutional components e.g. governance
  - Link to economic development and household income change