RESEARCH PROGRAM ON Dryland Systems

Food security and better livelihoods for rural dryland communities

How to model ecological model in MAS - Examples

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Static representation of the natural environment

- Social ABMs often assums that the natural environment is static over time, remain unchanged except the impacts caused by agent actions.

- Spatial heterogeneity can be represented.

Dynamic representation of the environment, but treated as scenarios ofexogeneous factors/drivers

- The environment change over time, but is not caused by modeled processes.
  - Climate conditions, global/regional trends of population, economy, etc.

- Possible dynamics can be driven by:
  - Other models (e.g. climate models)
  - Informative scenarios analysis

- Applicable for underlying environmental factors

Representation of the natural environment as endogenous process

- Human-induced dynamic environmental process: The environmental process changes only in response to agent's actions.

- Dynamic environmental process: The process changes over time and partly caused by the modeled processes. With the absence of agent activities, the environment is still dynamic in a way beyond agent's intervention.

- Usually operated by environmental models, coupled with ABM in two possible ways:
  - Close coupling: the env. model is built-in, as a sub-model of ABM
  - Loose coupling: the env. model runs (possibly in parallel) and exchanges input-output with the ABM/MAS (e.g. model chains framework)

Agricultural production submodel: An example of patch agent's sub-model

- Agricultural production function

$$P_{a-yield} = a.I_{chem}^{\beta_1}.I_{labor}^{\beta_2}.P_{slope}^{\beta_3}.P_{As}^{\beta_4}.P_t^{\beta_5}$$

P_{slope}= slope gradient (fixed GIS raster)
P_{As} = upslope contributing area (fixed GIS raster)
P_t = cropping time-length (dynamic GIS raster)

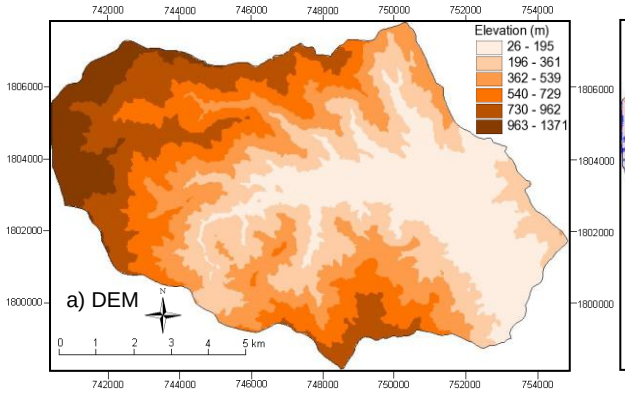
Heterogeneous landscape environment

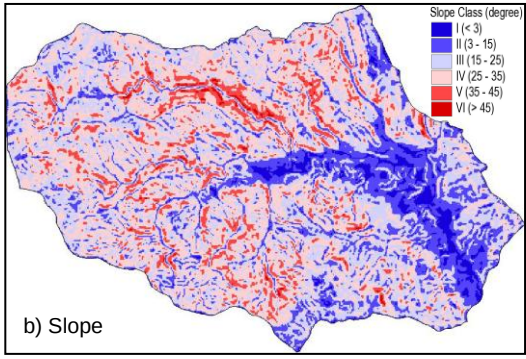
I_{chem}= agrochemical input (dynamic household variables)
I_{labor}= labor input (dynamic household variable)

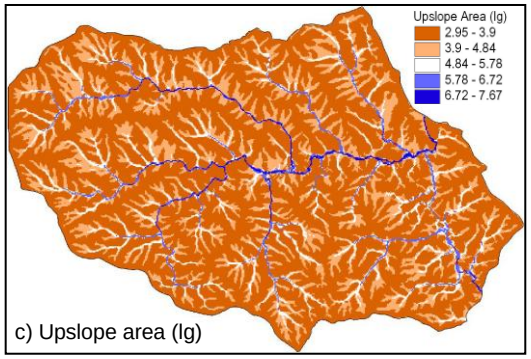
Household agent

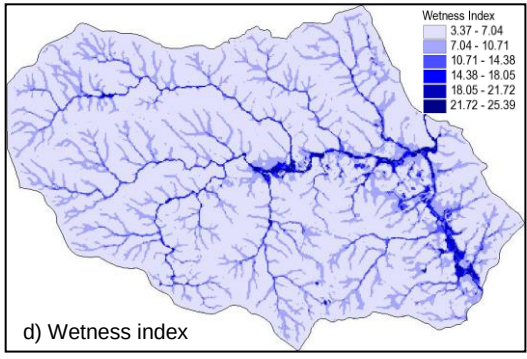
Policy driver: subsidy
Market driver: price

Source: Le (2005); Le et al. (in prep)









An environmental dynamic model embodied in landscape agent: P-Forest-Yield-Dynamics procedure

Main function/equation: $^{t}P_G = (^{t-1}P_G + ^{t-1}Z_G) - G_{removal}$

$^{t-1}P_G$ = stand basal area in the previous year (t-1)

$^{t-1}Z_G$ = natural increment of stand basal area in the previous year (t-1)

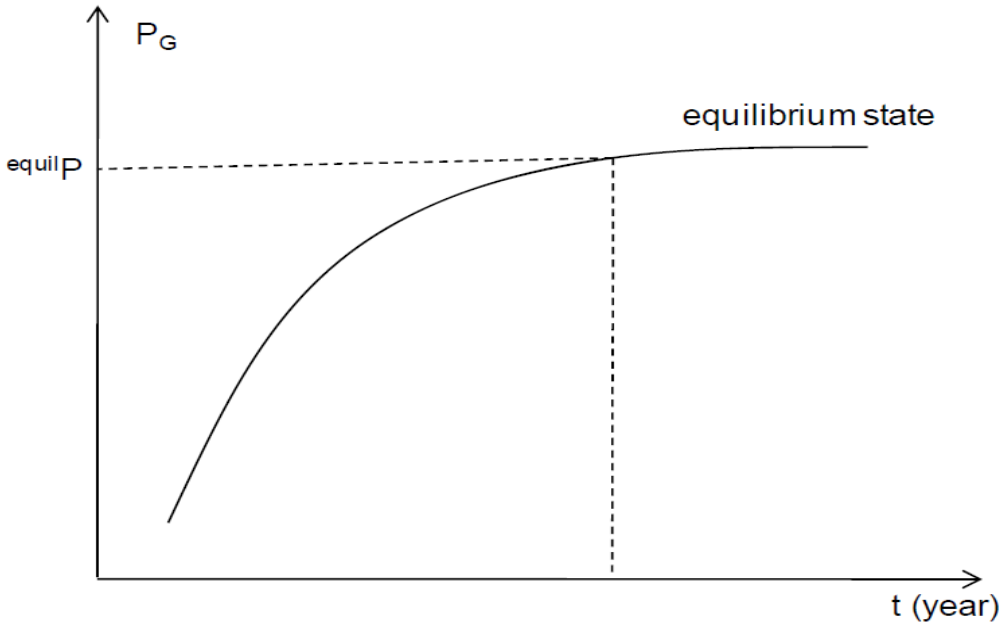
$(^{t-1}P_G + ^{t-1}Z_G)$ represents the natural dynamics of forest.

$G_{removals}$ = the amount of basal area removed from the patch, caused by logging activities of household agents.

Function to calculate Z_G: $Z_G = a(P_G)^{\varepsilon} - b(P_G)$

$^{max}Z_G$ = maximal growth rate of stand basal area (known, fixed)

$^{equil}P_G$ = stand basal area at the equilibrium state of the forest stand (known, fixed)



Function to calculate $G_{removals}$: $G_{removals} = G_{logged} + G_{damage} + G_{mortality}/T$

G_{logged} = the harvested amount, i.e. the basal area logged by human agent(s),

G_{damage} = logging damage, taking place imediately at the time of logging event

$G_{mortality}$ = logging-driven mortality, occuring over some years (T) after the logging event