Hybrid Agent-based Modeling of Land-use Changes in the Soyang River Basin

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Problem Statement

Many factors such as climate change, new regulations, or local development plans can affect land-use decision-making processes in the Soyang River Basin. However, it is difficult to represent these factors in a model and to reflect the complexity of decision-making processes of land-users (Parker et al., 2003). In this situation, agent-based modeling (ABM) approaches can be useful to consider such diverse factors and emergent aspects in agent decision-making processes. Simulation of land use and cover changes based on the ABM approach can be effective to prepare land use and cover scenarios for support of future policy-making (Le, et al., 2008).

Research Objective

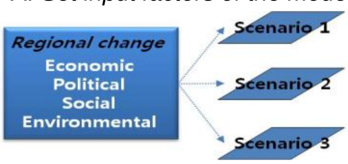
To develop a model that provides insight into critical agents' land-use decision-making and the emergent community-landscape transitions that result from policy change

Research Methods

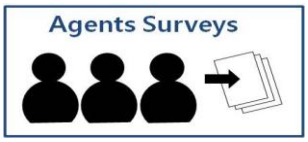
- Study Area: Soyang River Basin area, South Korea
- Data: Spatial data, statistical data, spatially-explicit survey data
- Methods: Interviews and surveys with stakeholders, logistic regressions, NetLogo programming of ABM (including nested cellular automata)

Model Description and Procedures

A. Set input factors of the model

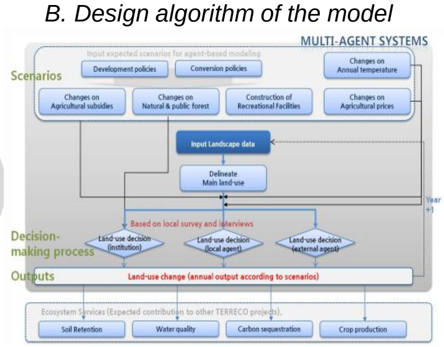


▲ Set Possible Scenarios



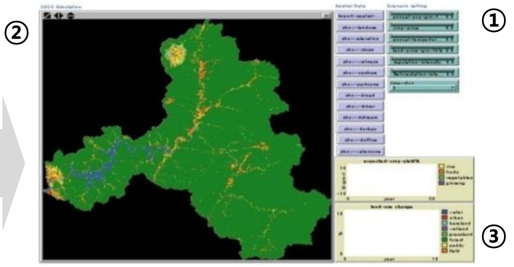
▲ Set Characteristics of Agents

B. Design algorithm of the model



▲ Conceptual algorithm of the model

C. Visualize model using NetLogo



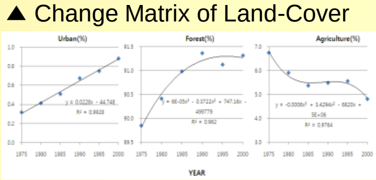
▲ Interface of the model
① Input Scenario Parameters
② Output map of expected land-use changes
③ Output graphs for temporal changes

Preliminary Results

A. Patterns of land-use changes

		Land-cover 2000				
		Other	Urban	Forest	Agri-culture	Sum
Land-cover 1990	Other	1730 (25.45%)	718 (10.56%)	2134 (31.39%)	2216 (32.60%)	6798
	Urban	170 (4.66%)	1766 (48.38%)	473 (12.96%)	1241 (34.00%)	3650
	Forest	1510 (0.22%)	717 (0.11%)	665242 (98.34%)	8970 (1.33%)	676439
	Agri-culture	1799 (5.25%)	2276 (6.64%)	11561 (33.73%)	18641 (54.38%)	34277
	Sum	5209	5477	679410	31068	

▲ Change Matrix of Land-Cover



▲ Temporal Land-use Changes

B. Factors of land-cover changes and parameterization of cellular automata sub-model

Logistic Regression

- Urban changes

Variable	Model1: Urban to others Coefficient (B)	Model1: P-value	Model2: Urban to Forest Coefficient (B)	Model2: P-value	Model3: Urban to Agriculture Coefficient (B)	Model3: P-value
Rainfall	.002	.000**	.008	.000**	.002	.000**
Elevation	-.002	.000**	-.001	.004**	-.002	.000**
Aspect	.000	.744	.000	.096	.001	.000**
Slope	-.025	.000**	-.032	.000**	-.061	.000**
Upslope	.048	.527	.292	.000**	.042	.399
Wetness	.019	.001**	.007	.141	-.011	.005**
D_Stream	.001	.000**	.000	.448	.000	.000
N_Other	.024	.000**	.018	.000**	.009	.001**
N_Urban	-.024	.000**	-.018	.000**	-.020	.000**
N_Forest	.027	.000	.058	.000**	.033	.000**
N_Farm	-.014	.000**	.024	.000**	.023	.000**
R_park=0	-.378	.327	-.856	.005**	-.535	.071
R_park=1						
R_water=0	.628	.319	-.996	.079	-.585	.040
R_water=1						
Constant	-4.391	.000	-14.340	.000	-3.250	.000

- Forest changes

Variable	Model1: Forest to others Coefficient (B)	Model1: P-value	Model2: Forest to Urban Coefficient (B)	Model2: P-value	Model3: Forest to Agriculture Coefficient (B)	Model3: P-value
Rainfall	-.002	.001**	-.002	.021*	-.001	.059
Elevation	-.003	.000**	.000	.311	-.003	.000**
Aspect	.001	.001**	.002	.000**	.001	.000**
Slope	-.051	.000**	-.064	.000**	-.044	.000**
Upslope	.203	.000**	-.041	.660	.121	.000**
Wetness	-.016	.058	-.014	.227	-.017	.001**
D_Stream	.001	.000**	-.002	.000**	-.001	.000**
N_Forest	-.055	.000**	-.062	.000**	-.040	.000**
N_Farm	-.015	.000**	-.011	.006**	.007	.000**
R_park=0	-.503	.002	-1.158	.000**	-.278	.003
R_park=1						
R_water=0	-.195	.636	-1.064	.013	-.564	.012
R_water=1						
Constant	4.779	.000	6.078	.000	3.953	.000

- Agricultural changes

Variable	Model1: Agriculture to others Coefficient (B)	Model1: P-value	Model2: Agriculture to Urban Coefficient (B)	Model2: P-value	Model3: Agriculture to Forest Coefficient (B)	Model3: P-value
Rainfall	.002	.001**	.000	.961	-.007	.000
Elevation	-.003	.000**	-001	.000**	.000	.000**
Aspect	.000	.085	.001	.000**	.000	.000**
Slope	.009	.000**	-.021	.000**	.024	.000**
Upslope	.074	.001**	.046	.063	.100	.000**
Wetness	.008	.001**	-.018	.000**	.007	.000**
D-Urban	.000	.000	-.002	.000**	.001	.000
D_Stream	.001	.000**	-.001	.000**	-.001	.000**
N_Forest	-.012	.000**	-.020	.000**	.031	.000**
N_Farm	-.020	.000**	-.025	.000*	.002	.001**
R_park=0	-.658	.000**	-.144	.266	.119	.070
R_park=1						
R_water=0	-.288	.636	-.318	.049	.060	.569
R_water=1						
Constant	-3.478	.000**	.239	.457	-10.940	.000

Expected Outputs

① **Calibrated cellular automata sub-model of land cover (broad type) transition at watershed level**
② **Calibrated sub-model of agents' decisions and their effect on agricultural land use**
③ **Landscape agent-based model that couples (1) and (2)**
④ **Informed scenarios on future land-use change across the study watershed**

Contribution to TERRECO

- Reliable land-use maps to allow estimation of future potential changes in ecological processes and ecosystem services
- Definition of scenarios for land-use change in relation to possible changes in policy and climate

Reference

Le, Q.B., Park, S.J., Vlek, P. L.G., and Cremers, A. B., 2008, Land-Use Dynamic Simulator(LUDAS): A multi-agent system model for simulating spatio-temporal dynamics of coupled human-landscape system. I. Structure and theoretical specification, *Ecological Informatics*, 3, 135-153.
Parker, D.C., Manson, S.M., Janssen, M.A., Hoffmann, M.J., and Deadman, P., 2003, Multi-Agent Systems for the Simulation of Land-Use and Land-Cover Change: A Review, *Annals of the Association of American Geographers*, 93(2), 315-337