Appendix 1. Classifications of reviewed models

This document is listed as online resource for the publication:

Title: Agent-based modeling of environment-migration linkages: a review

Journal name: Ecology & Society

This document contains the classifications of the reviewed agent-based models. This includes the diagrams drafted based on the conceptual framework as well as the filled out standardized protocols for each of the reviewed agent-based models.

Berman et al. 2004

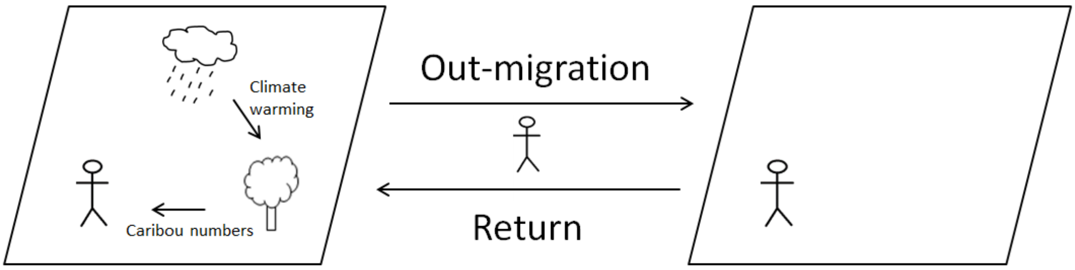

Fig. A1.1 *Diagram drafted for the ABM described by Berman et al. (2004)*

Table A1.1 *Standardized protocol for the ABM described by Berman et al. (2004)*

General
Reference(s): Berman, M., C. Nicolson, G. Kofinas, J. Tetlichi, and S. Martin. 2004. Adaptation and sustainability in a small Arctic community: results of an agent-based simulation model. *Arctic* 57(4):401-414.

Purpose of the study	**Case study**
1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	[Y]es/[N]o/[C]ontext-specific conceptual model (for most of model processes; only hunting and harvesting are based on geographic data) Western Arctic Canadian community of Old Crow, Yukon

Spatial scale	**Temporal scale**
Based on the distance a hunter can travel in one day	40 years with 5 seasons per year (hunting takes place 5 times a year, migration once every 5 years)

Migration process		
Migration flow 1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system	**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both

Migration decision			
Number of environmental influence factors: 2	**Which factor:** Climate warming, caribou numbers	**Type** 1. Abiotic (climate warming) 2. Biotic (caribou numbers)	**Direct/indirect** 1. Direct 2. Indirect (via hunting success)

<table>
<tr><td>Other influence factors
1. Economic
2. Social
3. Both</td><td>Which factor:
Earnings, household type, age, education, sex</td><td>Social network
1. Yes
2. No</td><td>How:
Sharing of hunting gear and harvest sharing occur throughout the community</td></tr>
<tr><td colspan="4">Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization</td></tr>
<tr><td colspan="4">Social-ecological feedbacks</td></tr>
<tr><td colspan="4">Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages</td></tr>
<tr><td colspan="4">Other decision processes (besides migration)</td></tr>
<tr><td colspan="2">Object of decision making
1. Cropping
2. Livestock
3. Hunting
4. Other
5. None</td><td colspan="2">Other
Wage employment and hunting</td></tr>
<tr><td colspan="4">Comment: “One-way linkage” is chosen as type of coupling because the ABM does not contain a direct link to caribou population. Caribou numbers are an input to the ABM and are modelled by a caribou population model, which considers total harvest by all communities including the study community.</td></tr>
</table>

Hadzibeganovic & Xia 2016

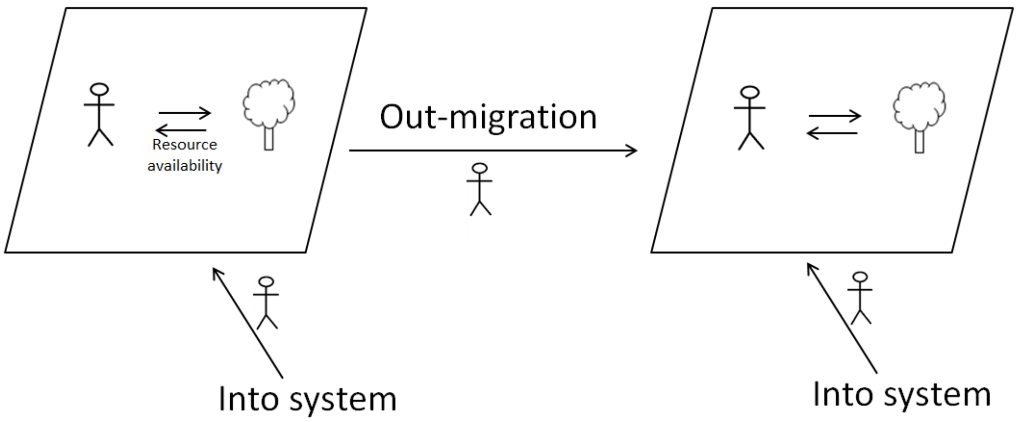

Fig. A1.2 *Diagram drafted for the ABM described by Hadzibeganovic & Xia (2016); the model includes two types of migration decision („reproduction-based“ and „payoff-based“) of which one is with knowledge of the destination system (i.e. emptiness of a node) and one is not; the case with knowledge of the destination system is illustrated here*

Table A1.2 *Standardized protocol for the ABM described by Hadzibeganovic & Xia (2016)*

General
Reference(s): Hadzibeganovic, T., and C. Xia. 2016. Cooperation and strategy coexistence in a tag-based multi-agent system with contingent mobility. *Knowledge-Based Systems* 112:1-13.

Purpose of the study		**Case study**
1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches)	5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	[Y]es/[N]o/[C]ontext-specific conceptual model

Spatial scale	**Temporal scale**
System size 10000 nodes	Model runs until equilibrium was reached; mostly after 5000 steps

Migration process			
Migration flow 1. Out-migration 2. Direct return 3. Indirect return	 4. Out of system 5. Into system	**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both

Migration decision

Number of environmental influence factors: 1	**Which factor:** Resource availability (food source)	**Type** 1. Abiotic 2. Biotic	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Average fitness of neighbors	**Social network** 1. Yes 2. No	**How:**

Methodology

1. Probability function
2. Decision theory
3. Heuristic
4. Optimization

Social-ecological feedbacks

Type of coupling

1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages

Other decision processes (besides migration)

Object of decision making 1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	**Other** Prisoner's dilemma games

Hassani-Mahmooei & Parris 2012

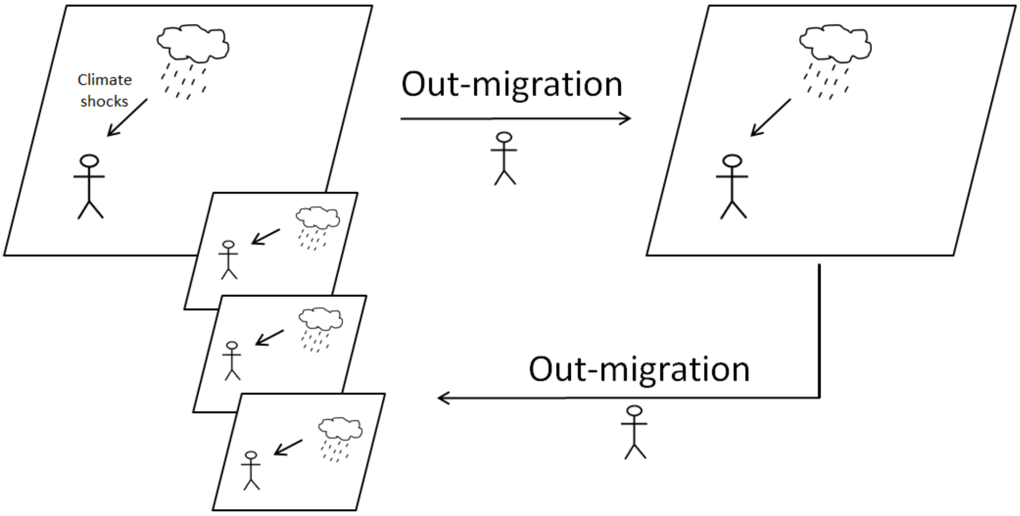

Fig. A1.3 *Diagram drafted for the ABM described by Hassani-Mahmooei & Parris (2012); agents do not make explicit return decisions, but migrate from region to region and can thereby visit a region again at some point in the future*

Table A1.3 *Standardized protocol for the ABM described by Hassani-Mahmooei & Parris (2012)*

General
Reference(s): Hassani-Mahmooei, B., and B. W. Parris. 2012. Climate change and internal migration patterns in Bangladesh: an agent-based model. *Environment and Development Economics* 17:763-780.

Purpose of the study		**Case study**
1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches)	5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	[Y]es/[N]o/[C]ontext-specific conceptual model Bangladesh

Spatial scale	**Temporal scale**
Bangladesh divided in 64 districts	50 years in monthly time steps

Migration process			
Migration flow		**Agents know situation at destination**	**Duration**
1. Out-migration 2. Direct return 3. Indirect return	5. Out of system 6. Into system	1. Yes 2. No	1. Seasonal 2. Permanent 3. Both

Migration decision			
Number of environmental influence factors: 4 combined in one	**Which factor:** Climate shock represented by combination of droughts, floods, cyclones and sea level rise	**Type** 1. Abiotic 2. Biotic	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Intervening factors: household ownership, land ownership, employment Pull factors: socioeconomic conditions of the potential destinations (economic variable, education, ethnic composition, infrastructure, health, mutual distance) Push factors: poverty level, local government development expenditures and unemployment rate	**Social network** 1. Yes 2. No	**How:**
Methodology 1. Probability function 2. Decision theory 3. Heuristic 4. Optimization			
Social-ecological feedbacks			
Type of coupling 1. One-way linkage 2. Partly integrated linkages 3. Fully integrated two-way linkages			
Other decision processes (besides migration)			
Object of decision making 1. Cropping 2. Livestock 3. Hunting 4. Other 5. None		**Other**	

Janssen 2010

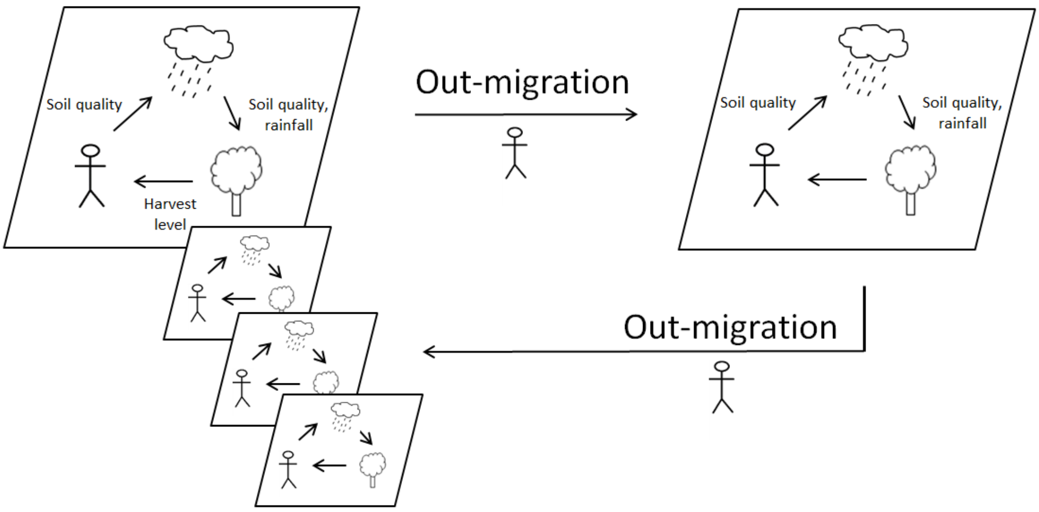

Fig. A1.4 *Diagram drafted for the ABM described by Janssen (2010); agents do not make explicit return decisions, but migrate from region to region and can thereby visit a region again at some point in the future*

Table A1.4 *Standardized protocol for the ABM described by Janssen (2010)*

General		
Reference(s): Janssen, M. A. 2010. Population aggregation in ancient arid environments. *Ecology and Society* 15(2):19.		
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model American Southwest	
Spatial scale 20*20 cells with 10*10km	**Temporal scale** Yearly time steps for 10000 years	
Migration process		
Migration flow 1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system	**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both

Migration decision

Number of environmental influence factors: 3	Which factor: Rainfall, soil quality depletion and recovery, harvest level	Type 1. Abiotic (rain) 2. Biotic (soil quality, harvest)	Direct/indirect 1. Direct (Harvest) 2. Indirect (Soil quality, rainfall)
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Population level & experience & required proportion of productivity in current cell (to consider moving costs) & storage	**Social network** 1. Yes 2. No	**How:**

Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization

Social-ecological feedbacks

Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages

Other decision processes (besides migration)

Object of decision making	Other
1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	Sharing of food and exchange between settlements

Kniveton et al. 2011; Kniveton et al. 2012

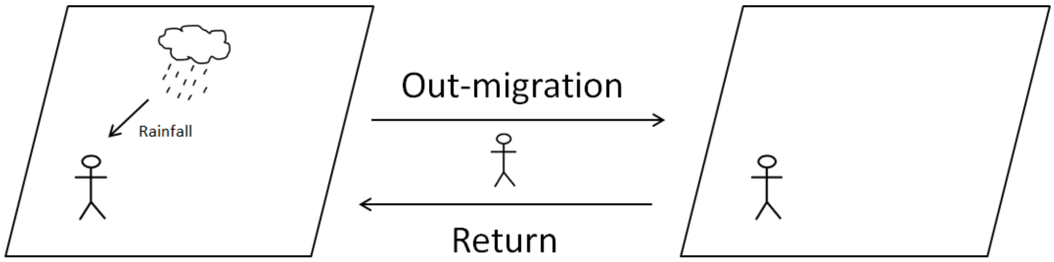

Fig. A1.5 *Diagram drafted for the ABM described by Kniveton et al. (2011; 2012); the destination system is also influenced by rainfall, but as the return decision is not influenced by rainfall it is not depicted visually in the destination system*

Table A1.5 *Standardized protocol for the ABM described by Kniveton et al. (2011; 2012)*

General	
Reference(s): Kniveton, D. R., C. D. Smith, and R. Black. 2012. Emerging migration flows in a changing climate in dryland Africa. *Nature Climate Change* 2:444-447. Kniveton, D. R., C. D. Smith, and S. Wood. 2011. Agent-based model simulations of future changes in migration flows for Burkina Faso. *Global Environmental Change* 21:S34-S40.	
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model Burkina Faso
Spatial scale Burkina Faso divided into 5 regions	**Temporal scale** Validation: 1970 to 2000, scenarios: to 2060. Daily time steps, but birth, ageing, marriage and death events on monthly basis, migration yearly decision

Migration process		
Migration flow 1. Out-migration 2. Direct return 3. Indirect return 5. Out of system 6. Into system	**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both

Migration decision			
Number of environmental influence factors: 1	**Which factor:** Rainfall	**Type** 1. Abiotic 2. Biotic	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** age, gender, marital status, assets, experience, behavior of peers	**Social network** 1. Yes 2. No	**How:** Fixed network for information exchange; each agent randomly linked to 50 others at initialization
Methodology 1. Probability function 2. Decision theory 3. Heuristic 4. Optimization			
Social-ecological feedbacks			
Type of coupling 1. One-way linkage 2. Partly integrated linkages 3. Fully integrated two-way linkages			
Other decision processes (besides migration)			
Object of decision making 1. Cropping 2. Livestock 3. Hunting 4. Other 5. None		**Other**	

Magallanes et al. 2014

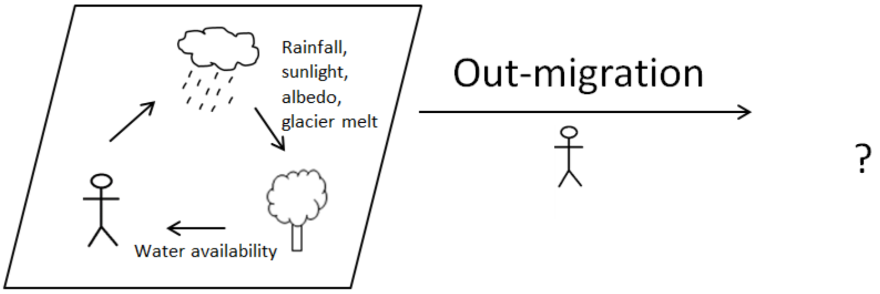

Fig. A1.6 *Diagram drafted for the ABM described by Magallanes et al. (2014)*

Table A1.6 *Standardized protocol for the ABM described by Magallanes et al. (2014)*

General
Reference(s): Magallanes, J. M., A. Burger, and C. Cioffi-Revilla. 2014. Understanding migration induced by climate change in the Central Andes of Peru via agent-based computational modeling. In J. Sichman, E. MacKerrow, F. Squazzoni, and T. Terano, editors. Proceedings of the 5th World Congress on Social Simulation. Sao Paolo, Brazil.

Purpose of the study	**Case study**
1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	[Y]es/[N]o/[C]ontext-specific conceptual model Huancayo region, Peru

Spatial scale	**Temporal scale**
A region covering appox. 400km² subdivided into 5 regions	Monthly time steps, total extent not stated

Migration process		
Migration flow	**Agents know situation at destination**	**Duration**
1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system	1. Yes 2. No	1. Seasonal 2. Permanent 3. Both

Migration decision			
Number of environmental influence factors: 5	**Which factor:** Water availability, seasonal rainfall, glacier melt affected by sunlight luminosity and glacier albedo	**Type** 1. Abiotic 2. Biotic	**Direct/indirect** 1. Direct 2. Indirect

Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Education, economic level, belonging to a family, success in trading, number of neighbors	**Social network** 1. Yes 2. No	**How:**
Methodology 1. Probability function 2. Decision theory 3. Heuristic 4. Optimization			
Social-ecological feedbacks			
Type of coupling 1. One-way linkage 2. Partly integrated linkages 3. Fully integrated two-way linkages			
Other decision processes (besides migration)			
Object of decision making 1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	**Other**		

Mena et al. 2011

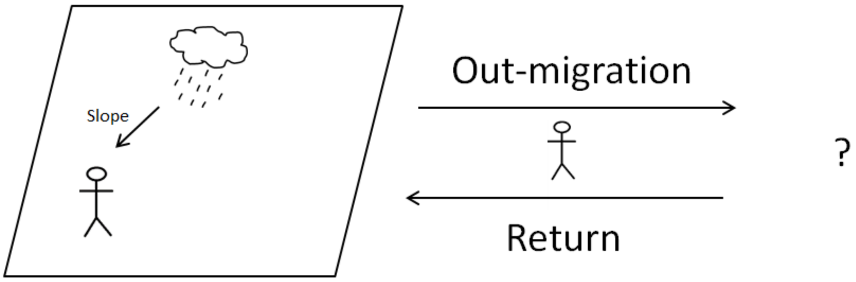

Fig. A1.7 *Diagram drafted for the ABM described by Mena et al. (2011)*

Table A1.7 *Standardized protocol for the ABM described by Mena et al. (2011)*

General			
Reference(s): Mena, C. F., S. J. Walsh, B. G. Frizzelle, Y. Xiaozheng, and G. P. Malanson. 2011. Land use change on household farms in the Ecuadorian Amazon: design and implementation of an agent-based model. *Applied Geography* 31(1):210-222.			
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*			**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model Northern Ecuadorian Amazon
Spatial scale approx. 20,000km², size of all farms is 50ha		**Temporal scale** 25 years in annual time steps	
Migration process			
Migration flow 1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system		**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both
Migration decision			
Number of environmental influence factors: 1	**Which factor:** Slope	**Type** 1. Abiotic 2. Biotic	**Direct/indirect** 1. Direct 2. Indirect

Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Assets (influenced by market prices & maintenance costs), age; gender; number of persons in household; engagement in farm work; household's head education; number of previous out-migrants in the household; population density at the farm; walking distance to the nearest road; distance to nearest market; land use change in crops, pasture and forest from 1990 to 1999	**Social network** 1. Yes 2. No	**How:**
Methodology 1. Probability function 2. Decision theory 3. Heuristic 4. Optimization			
Social-ecological feedbacks			
Type of coupling 1. One-way linkage 2. Partly integrated linkages 3. Fully integrated two-way linkages			
Other decision processes (besides migration)			
Object of decision making 1. Cropping 2. Livestock 3. Hunting 4. Other 5. None		**Other**	

Naivinit et al. 2010

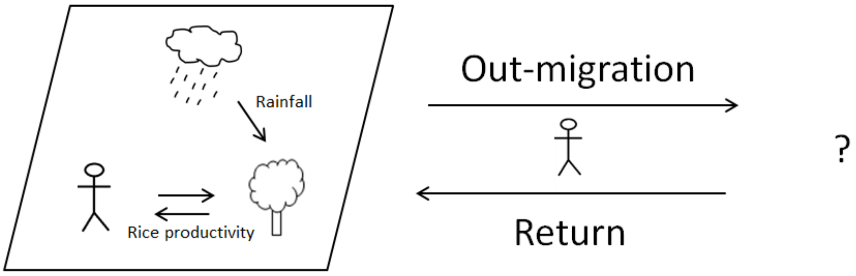

Fig. A1.8 *Diagram drafted for the ABM described by Naivinit et al. (2010)*

Table A1.8 *Standardized protocol for the ABM described by Naivinit et al. (2010)*

General	
Reference(s): Naivinit, W., C. Le Page, G. Trébuil, and N. Gajaseni. 2010. Participatory agent-based modeling and simulation of rice production and labor migrations in northeast Thailand. *Environmental Modelling & Software* 25(11):1345-1358.	
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model Ban Mak Mai village, Northeast Thailand
Spatial scale Local (one village); 4 households (2*3.6ha and 2*7ha); resolution 0.04ha; abstract landscape setting	**Temporal scale** 10 years; daily time steps; migration decision only once a year

Migration process		
Migration flow 1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system	**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both

Migration decision			
Number of environmental influence factors: 2	**Which factor:** Rainfall, Rice productivity	**Type** 1. Abiotic (rain) 2. Biotic (rice productivity)	**Direct/indirect** 1. Direct 2. Indirect

<table>
<tr><td>Other influence factors
1. Economic
2. Social
3. Both</td><td>Which factor:
Age, gender, marital status, migration experience, income at household level, dependent at home</td><td>Social network
1. Yes
2. No</td><td>How:
Individuals belong to households; dependents in household influence migration decisions</td></tr>
<tr><td colspan="4">Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization</td></tr>
<tr><td colspan="4">Social-ecological feedbacks</td></tr>
<tr><td colspan="4">Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages</td></tr>
<tr><td colspan="4">Other decision processes (besides migration)</td></tr>
<tr><td colspan="2">Object of decision making
1. Cropping
2. Livestock
3. Hunting
4. Other
5. None</td><td colspan="2">Other</td></tr>
</table>

Naqvi & Rehm 2014

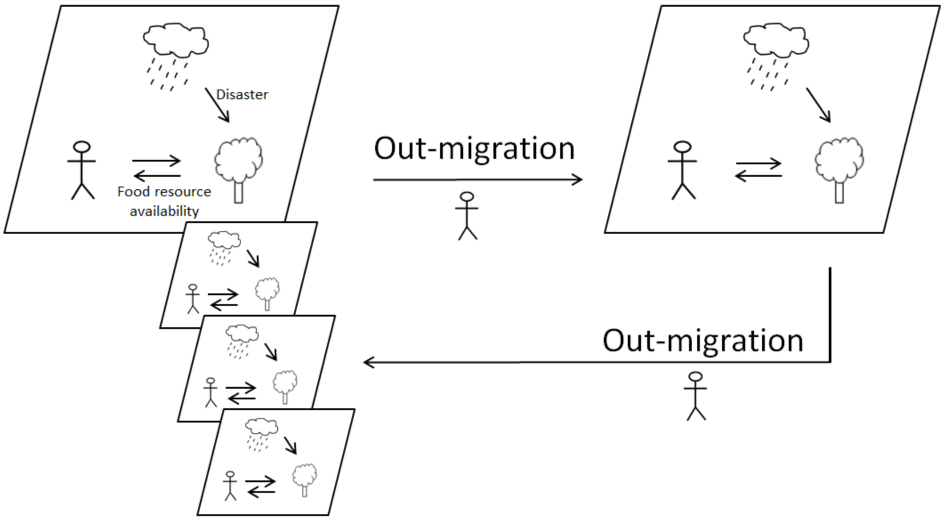

Fig. A1.9 Diagram drafted for the ABM described by Naqvi & Rehm (2014); agents do not make explicit return decisions, but migrate from region to region and can thereby visit a region again at some point in the future

Table A1.9 Standardized protocol for the ABM described by Naqvi & Rehm (2014)

General	
Reference(s): Naqvi, A. A., and M. Rehm. 2014. A multi-agent model of a low income economy: simulating the distributional effects of natural disasters. *Journal of Economic Interaction and Coordination* 9(2):275-309.	
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model Punjab region in rural Pakistan
Spatial scale 9 villages and 3 cities linked through a road network	**Temporal scale** 1 time step is 1 day, simulation results are presented for 3 years in total

Migration process

Migration flow		**Agents know situation at destination**	**Duration**
1. Out-migration 2. Direct return 3. Indirect return	4. Out of system 5. Into system	1. Yes 2. No	1. Seasonal 2. Permanent 3. Both

Migration decision

Number of environmental influence factors: 2	**Which factor:** abstract disaster interpreted as flooding, but not modeled explicitly, food resource availability	**Type** 1. Abiotic (disaster) 2. Biotic (food production)	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Distance, income	**Social network** 1. Yes 2. No	**How:**

Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization

Social-ecological feedbacks

Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages

Other decision processes (besides migration)

Object of decision making	**Other**
1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	Related to economic interactions (hiring workers, selling and buying goods)

Rogers et al. 2011

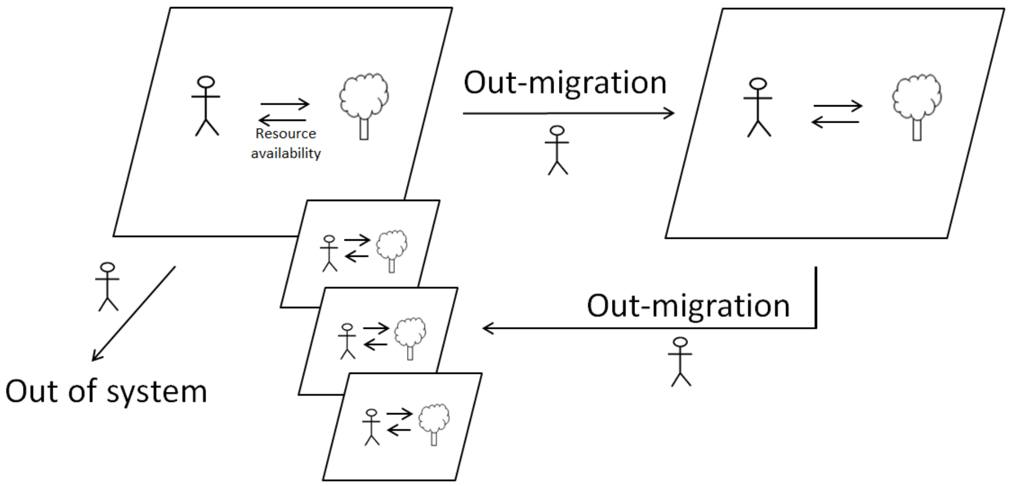

Fig. A1.10 *Diagram drafted for the ABM described by Rogers et al. (2011); agents do not make explicit return decisions, but migrate from region to region and can thereby visit a region again at some point in the future; migration out of the system is possible from all subsystems, but for simplicity reasons it is only visualized for the origin system; the situation in the destination system does not influence the migration decision, but as agents interact with the environment in all visited systems these factors are visualized*

Table A1.10 *Standardized protocol for the ABM described by Rogers et al. (2011)*

General	
Reference(s): Rogers, D. S., O. Deshpande, and M. W. Feldman. 2011. The spread of inequality. *PLoS ONE* 6(9):e24683.	
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model

Spatial scale	Temporal scale
100 sites with same size	Yearly time steps for 2000 years

Migration process

Migration flow	Agents know situation at destination	Duration
1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system	1. Yes 2. No	1. Seasonal 2. Permanent 3. Both

Migration decision

Number of environmental influence factors: 1	**Which factor:** Resource availability	**Type** 1. Abiotic 2. Biotic	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Population decline	**Social network** 1. Yes 2. No	**How:**

Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization

Social-ecological feedbacks

Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages

Other decision processes (besides migration)

Object of decision making	Other
1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	

Smajgl & Bohensky 2013; Smajgl et al. 2009

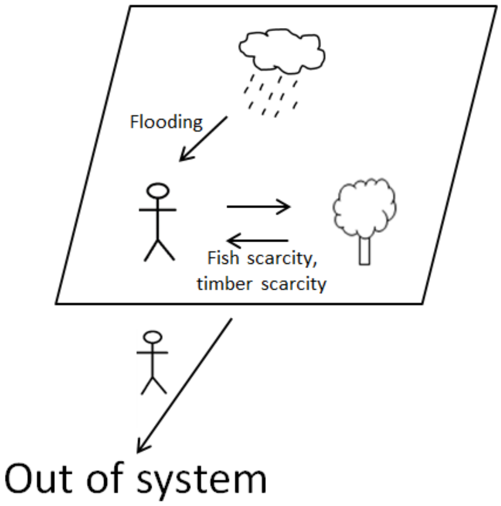

Fig. A1.11 *Diagram drafted for the ABM described by Smajgl & Bohensky (2013) and Smajgl et al. (2009)*

Table A1.11 *Standardized protocol for the ABM described by Smajgl & Bohensky (2013) and Smajgl et al. (2009)*

<table>
<tr><td colspan="3">General</td></tr>
<tr><td colspan="3">Reference(s):
Smajgl, A., and E. Bohensky. 2013. Behaviour and space in agent-based modelling: poverty patterns in East Kalimantan, Indonesia. Environmental Modelling & Software 45:8-14.
Smajgl, A., G. Carlin, A. House, J. Butler, E. Bohensky, A. S. Kurnia, C. Sugiyanto, and M. Hodgen. 2009. Design document for agent-based model SimPaSI Jawa Tengah. Simulating pathways to sustainability in Indonesia. CSIRO, Townsville, Australia.</td></tr>
<tr><td colspan="2">Purpose of the study
1. System understanding
2. Prediction (quantitative)
3. Management or decision support
4. Communication (participatory approaches)
5. Theory development
6. Hypothesis testing
7. Not clearly stated
multiple criteria possible</td><td>Case study
[Y]es/[N]o/[C]ontext-specific conceptual model
East Kalimantan, Indonesia</td></tr>
<tr><td>Spatial scale
study area consists of six southern districts of</td><td colspan="2">Temporal scale
Combination of daily (environment) and weekly</td></tr>
</table>

<table>
<tr><td colspan="2">East Kalimantan (approx. 220.400km^2)</td><td colspan="2">(households) time steps, 2006 to 2013</td></tr>
<tr><td colspan="4">Migration process</td></tr>
<tr><td colspan="2">Migration flow
1. Out-migration
2. Direct return
3. Indirect return
4. Out of system
5. Into system</td><td>Agents know situation at destination
1. Yes
2. No</td><td>Duration
1. Seasonal
2. Permanent
3. Both</td></tr>
<tr><td colspan="4">Migration decision</td></tr>
<tr><td>Number of environmental influence factors: 3</td><td>Which factor:
Flooding, timber, fish scarcity</td><td>Type
1. Abiotic (flooding)
2. Biotic (fish scarcity and timber)</td><td>Direct/indirect
1. Direct
2. Indirect (timber affects forest economy)</td></tr>
<tr><td>Other influence factors
1. Economic
2. Social
3. Both</td><td>Which factor:
Fuel price, groundwater price, electricity price, kerosene price</td><td>Social network
1. Yes
2. No</td><td>How:</td></tr>
<tr><td colspan="4">Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization</td></tr>
<tr><td colspan="4">Social-ecological feedbacks</td></tr>
<tr><td colspan="4">Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages</td></tr>
<tr><td colspan="4">Other decision processes (besides migration)</td></tr>
<tr><td colspan="2">Object of decision making
1. Cropping
2. Livestock
3. Hunting
4. Other
5. None</td><td colspan="2">Other
use of different natural resources (fish, timber)</td></tr>
</table>

Smajgl et al. 2013; Smajgl et al. 2015a; Smajgl et al. 2015b

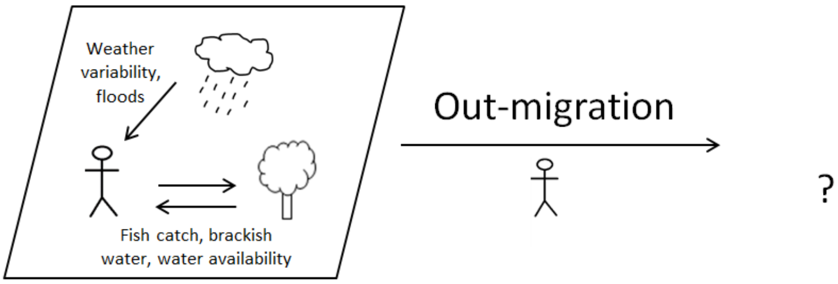

Fig. A1.12 *Diagram drafted for the ABM described by Smajgl et al. (2013; 2015a; 2015b)*

Table A1.12 *Standardized protocol for the ABM described by Smajgl et al. (2013; 2015a; 2015b)*

General		
Reference(s): Smajgl, A., S. Egan, M. Kirby, M. Mainuddin, J. Ward, and F. Kroon. 2013. *The Mekong Region simulation (Mersim) model - design document.* CSIRO Climate Adaptation Flagship, Townsville, Australia. Smajgl, A., J. Xu, S. Egan, Z.-F. Yi, J. Ward, and Y. Su. 2015*a*. Assessing the effectiveness of payments for ecosystem services for diversifying rubber in Yunnan, China. *Environmental Modelling & Software* 69:187-195. Smajgl, A., J. R. Ward, T. Foran, J. Dore, and S. Larson. 2015*b*. Visions, beliefs, and transformation: exploring cross-sector and transboundary dynamics in the wider Mekong region. *Ecology and Society* 20(2):15.		
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches)	5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*	**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model Mekong region (Laos, Cambodia, Yunnan Province China, Thailand, Vietnam)
Spatial scale Extent: Greater Mekong Subregion Resolution: Irregular polygons derived from overlapping various GIS layers (incl. elevation and land cover).	**Temporal scale** Daily time steps; scenarios up to 2029	

Migration process

Migration flow 1. Out-migration 2. Direct return 3. Indirect return 4. Out of system 5. Into system	**Agents know situation at destination** 1. Yes 2. No	**Duration** 1. Seasonal 2. Permanent 3. Both

Migration decision

Number of environmental influence factors: 5	**Which factor:** Loss of fish catch, increasing weather variability, water availability, more brackish water, small floods	**Type** 1. Abiotic (weather variability, water availability, floods) 2. Biotic (fish catch, brackish water)	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Income changes, industry employment conditions, market access, irrigation scheme, competition among water users, rubber tree replacement	**Social network** 1. Yes 2. No	**How:**

Methodology

1. Probability function
2. Decision theory
3. Heuristic
4. Optimization

Social-ecological feedbacks

Type of coupling

1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages

Other decision processes (besides migration)

Object of decision making 1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	**Other** Use of different natural resources (fish, timber), get income from livelihood activities, modify livelihood as form of adaptation

Smith 2014

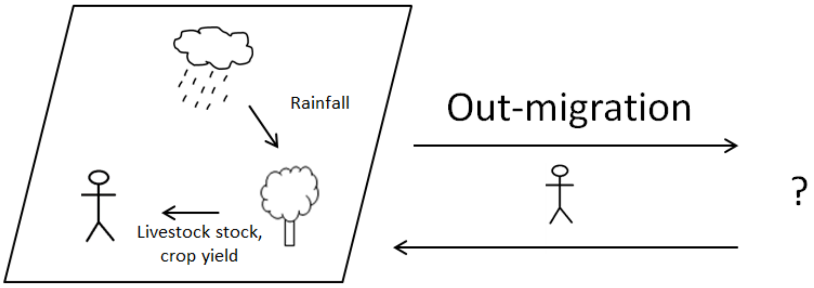

Fig. A1.13 *Diagram drafted for the ABM described by Smith (2014); migrants send remittances back to their household and are therefore not deleted from the system (i.e. this is not „migration out of the system")*

Table A1.13 *Standardized protocol for the ABM described by Smith (2014)*

<table>
<tr><td colspan="3">General</td></tr>
<tr><td colspan="3">Reference(s):
Smith, C. D. 2014. Modelling migration futures: development and testing of the rainfalls agent-based migration model - Tanzania. Climate and Development 6(1):77-91.</td></tr>
<tr><td colspan="2">Purpose of the study
1. System understanding
2. Prediction (quantitative)
3. Management or decision support
4. Communication (participatory approaches)
5. Theory development
6. Hypothesis testing
7. Not clearly stated
multiple criteria possible</td><td>Case study
[Y]es/[N]o/[C]ontext-specific conceptual model
Kilimanjaro Region, Tanzania</td></tr>
<tr><td>Spatial scale
3 villages as 3 entities, not spatially explicit</td><td colspan="2">Temporal scale
Simulation runs from 2015 to 2050, rainfall monthly time steps, human decisions also monthly</td></tr>
<tr><td colspan="3">Migration process</td></tr>
<tr><td>Migration flow
1. Out-migration
2. Direct return
3. Indirect return
4. Out of system
5. Into system</td><td>Agents know situation at destination
1. Yes
2. No</td><td>Duration
1. Seasonal
2. Permanent
3. Both (up to 72 months)</td></tr>
</table>

<table>
<tr><td colspan="4">Migration decision</td></tr>
<tr><td>Number of environmental influence factors: 3</td><td>Which factor:
Rainfall, crop yield, livestock stock</td><td>Type
1. Abiotic (rainfall)
2. Biotic (crop yield, livestock stock)</td><td>Direct/indirect
1. Direct
2. Indirect</td></tr>
<tr><td>Other influence factors
1. Economic
2. Social
3. Both</td><td>Which factor:
individuals (individual propensity of migration): influence of peers (proportion of peers who have already migrated), age, gender, home village households (actual decision how many household members should migrate): income (dependent on rainfall), number of household members</td><td>Social network
1. Yes
2. No</td><td>How:
Households are randomly linked to create a network, different scenarios with different numbers of links per household; migration experience of others is influencing own migration decision</td></tr>
<tr><td colspan="4">Methodology
1. Probability function
2. Decision theory
3. Heuristic
4. Optimization</td></tr>
<tr><td colspan="4">Social-ecological feedbacks</td></tr>
<tr><td colspan="4">Type of coupling
1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages</td></tr>
<tr><td colspan="4">Other decision processes (besides migration)</td></tr>
<tr><td colspan="2">Object of decision making
1. Cropping
2. Livestock
3. Hunting
4. Other
5. None</td><td colspan="2">Other</td></tr>
</table>

Walsh et al. 2013; Entwisle et al. 2008; Entwisle et al. 2016

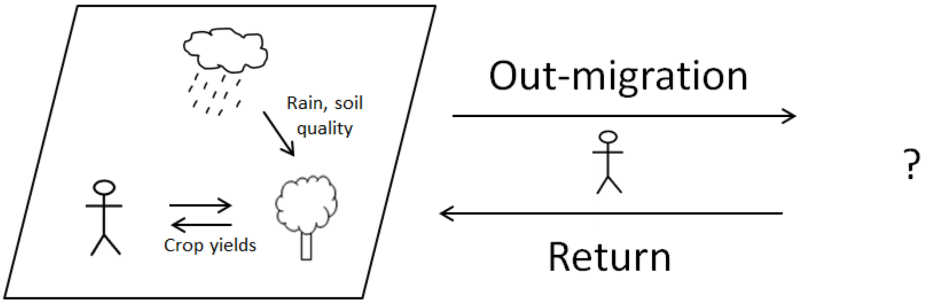

Fig. A1.14 *Diagram drafted for the ABM described by Walsh et al. (2013) and Entwisle et al. (2008; 2016)*

Table A1.14 *Standardized protocol for the ABM described by Walsh et al. (2013) and Entwisle et al. (2008; 2016)*

<table>
<tr><td colspan="4">General</td></tr>
<tr><td colspan="4">Reference(s):
Walsh, S. J., G. P. Malanson, B. Entwisle, R. R. Rindfuss, P. J. Mucha, B. W. Heumann, P. M. McDaniel, B. G. Frizzelle, A. M. Verdery, N. E. Williams, X. Yao, and D. Ding. 2013. Design of an agent-based model to examine population—environment interactions in Nang Rong District, Thailand. Applied Geography 39:183-198.
Entwisle, B., G. Malanson, R. R. Rindfuss, and S. Walsh. 2008. An agent-based model of household dynamics and land use change. Journal of Land Use Science 3(1):73-93.
Entwisle, B., N. E. Williams, A. M. Verdery, R. R. Rindfuss, S. J. Walsh, G. P. Malanson, P. J. Mucha, B. G. Frizzelle, P. M. McDaniel, X. Yao, B. W. Heumann, P. Prasartkul, Y. Sawangdee, and A. Jampaklay. 2016. Climate shocks and migration: an agent-based modeling approach. Population and Environment 38:47-71.</td></tr>
<tr><td colspan="3">Purpose of the study
1. System understanding
2. Prediction (quantitative)
3. Management or decision support
4. Communication (participatory approaches)
5. Theory development
6. Hypothesis testing
7. Not clearly stated
multiple criteria possible</td><td>Case study
[Y]es/[N]o/[C]ontext-specific conceptual model
Nang Rong District, Northeastern Thailand</td></tr>
<tr><td>Spatial scale
1300km^2, 41 villages, 5m spatial resolution</td><td colspan="3">Temporal scale
Annual time steps for 25 years</td></tr>
<tr><td colspan="4">Migration process</td></tr>
<tr><td>Migration flow
1. Out-migration
4. Out of system</td><td colspan="2">Agents know situation at destination</td><td>Duration
1. Seasonal</td></tr>
</table>

2. Direct return 3. Indirect return	5. Into system	1. Yes 2. No	2. Permanent 3. Both
Migration decision			
Number of environmental influence factors: 3	**Which factor:** Rainfall, soil quality & type, crop yields	**Type** 1. Abiotic (rainfall) 2. Biotic (soil quality, crop yields)	**Direct/indirect** 1. Direct 2. Indirect
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Age, population, connectivity of village, migration prevalence, ties to migrants and residents, marital status, percent village has pump, percent village has vehicle, percent village grows cassava, household centrality, gender, kinship dependency, distance to nearest village, percent village has TV, land deed	**Social network** 1. Yes 2. No	**How:** Households are connected in a social network; ties to current migrants, remittances, household centrality, migration prevalence, village connectivity, ties to wealthy households
Methodology 1. Probability function 2. Decision theory 3. Heuristic 4. Optimization			
Social-ecological feedbacks			
Type of coupling 1. One-way linkage 2. Partly integrated linkages 3. Fully integrated two-way linkages			
Other decision processes (besides migration)			
Object of decision making 1. Cropping (land use and fertilizer input) 2. Livestock 3. Hunting 4. Other 5. None		**Other**	

Wu et al. 2011

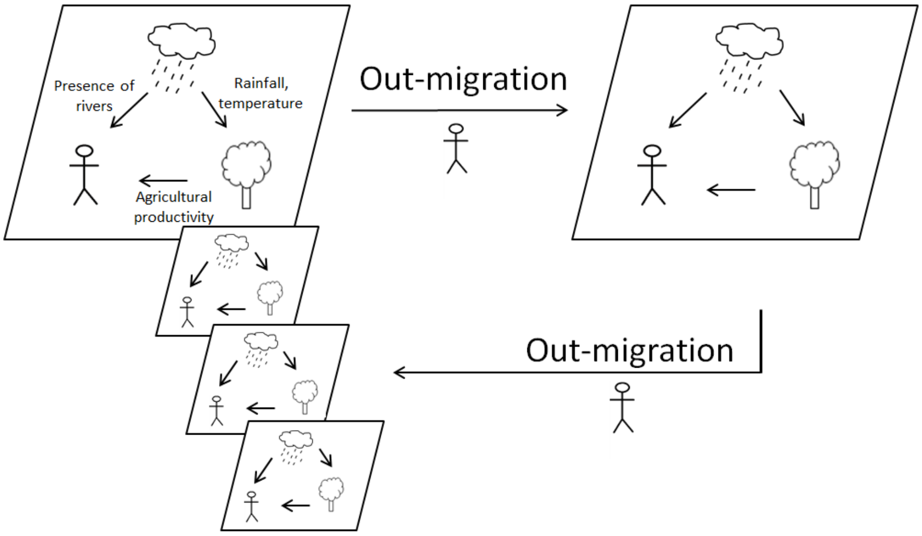

Fig. A1.15 *Diagram drafted for the ABM described by Wu et al. (2011); agents do not make explicit return decisions, but migrate from region to region and can thereby visit a region again at some point in the future*

Table A1.15 *Standardized protocol for the ABM described by Wu et al. (2011)*

General		
Reference(s): Wu, J., R. Mohamed, and Z. Wang. 2011. Agent-based simulation of the spatial evolution of the historical population in China. Journal of Historical Geography 37:12-21.		
Purpose of the study 1. System understanding 2. Prediction (quantitative) 3. Management or decision support 4. Communication (participatory approaches) 5. Theory development 6. Hypothesis testing 7. Not clearly stated *multiple criteria possible*		**Case study** [Y]es/[N]o/[C]ontext-specific conceptual model China
Spatial scale 227*297 cells a 468km^2	**Temporal scale** 2000 years	

Migration process

Migration flow		Agents know situation at destination	Duration
1. Out-migration 2. Direct return 3. Indirect return	4. Out of system 5. Into system	1. Yes 2. No	1. Seasonal 2. Permanent 3. Both

Migration decision

Number of environmental influence factors: 4	**Which factor:** agricultural productivity, annual rainfall, annual average temperature, presence of rivers	**Type** 1. Abiotic (rainfall, temperature, river) 2. Biotic (agricultural productivity)	**Direct/indirect** 1. Direct (agricultural productivity, rivers) 2. Indirect (rainfall, temperature)
Other influence factors 1. Economic 2. Social 3. Both	**Which factor:** Social: Migration rates, existing settlements, population size Accessibility: distance between provinces	**Social network** 1. Yes 2. No	**How:**

Methodology

1. Probability function
2. Decision theory
3. Heuristic
4. Optimization

Social-ecological feedbacks

Type of coupling

1. One-way linkage
2. Partly integrated linkages
3. Fully integrated two-way linkages

Other decision processes (besides migration)

Object of decision making	Other
1. Cropping 2. Livestock 3. Hunting 4. Other 5. None	

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