Table S1: Modeling Studies Reviewed

ID	Citation
1	Sakamoto, T. 2016. Computational Research on Mobile Pastoralism Using Agent-Based Modeling and Satellite Imagery. PLoS ONE 11 (3):e0151157.
2	Dressler, G. et al. 2019a. Implications of behavioral change for the resilience of pastoral systems—Lessons from an agent-based model. Ecological Complexity 40 (2019):100710.
3	Fust, P., and E. Schlecht. 2018. Integrating spatio-temporal variation in resource availability and herbivore movements into rangeland management: RaMDry—An agent-based model on livestock feeding ecology in a dynamic, heterogeneous, semi-arid environment. Ecological Modelling 369:13-41.
4	Moritz, M. et al. 2015. Simple Movement Rules Result in Ideal Free Distribution of Mobile Pastoralists. Ecological Modelling 305:54-63.
5	Milner-Gulland, E.J. et al. 2006. A Multi-Agent System Model of Pastoralist Behavior in Kazakhstan. Ecological Complexity 3:23-36.
6	Bah, A. et al. 2006. An Agent Based Model to understand the multiple uses of Land and Resources around drillings in Sahel. Mathematical and Computer Modelling 44:513-534.
7	Boone, R. et al 2011. Using Coupled Simulation Models to Link Pastoral Decision Making and Ecosystem Services. Ecology and Society 16(2):6.
8	Okayasu, T. 2010. An intrinsic mechanism for the co-existence of different survival strategies within mobile pastoralist communities. Agricultural Systems 103:180-186.
9	Boone, R. and C. Lesorogol. 2016. Modeling Coupled Human-Natural Systems of Pastoralism in East Africa. In Building Resilience of Human-Natural Systems of Pastoralism in the Developing World, edited by S. Dong, K. Kassam, J. Tourrand, and R. Boone, pp. 251-280. Springer, New York.
10	Dressler, G. et al. 2019b. Polarization in (post)nomadic resource use in Eastern Morocco: insights using a multi-agent simulation model. Regional Environmental Change 19:489-500.
11	Rouchier, J. et al. 2001. A multi-agent model for describing transhumance in North Cameroon: Comparison of different rationality to develop a routine. Journal of Economic Dynamics and Control 25:527-559.
12	Cioffi-Revilla, C. et al. 2010. The MASON HouseholdsWorld Model of Pastoral Nomad Societies. In Simulating Interacting Agents and Social Phenomena: The Second World Congress, edited by Keiki Takadama, Claudio Cioffi-Revilla, and Guillaume Deffuant, pp. 193-204. Springer, New York.
13	Hailegiorgis, A. et al. 2010. An Agent Based Model of Climate Change and Conflict Among Pastoralists in East Africa. Proceedings of the International Congress on Environmental Modeling and Software. Ottawa, Ontario, Canada.
14	Hailegiorgis, A. et al. 2018. An Agent-Based Model of Rural Households' Adaptation to Climate Change. Journal of Artificial Societies and Social Simulation 21(4):4.
15	Rogers, J. D. et al. 2015. The Sustainability of Wealth among Nomads: An Agent-Based Approach. In Mathematics and Archaeology, edited by J. A. Barcelo and I. Bogdanovic: CRC Press.
16	Rogers, J. D. et al. 2012. Modeling scale and variability in human–environmental interactions in Inner Asia. Ecological Modelling 241:5-14.
17	Yu, R. et al. 2019. An agent-based model for assessing grazing strategies and institutional arrangements in Zeku, China. Agricultural Systems 171:135-142.

18	Martin, R. et al. 2014. Livelihood security in face of drought e Assessing the vulnerability of pastoral households. Environmental Modelling and Software 75(2016):1-10.
19	Kariuki, R. et al. 2018. Rangeland Livelihood Strategies under Varying Climate Regimes: Model Insights from Southern Kenya. Land 7(47):1-22.
20	Kuznar, L. and R. Sedlmeyer. 2005. Collective Violence in Darfur: An Agent-Based Model of Pastoral Nomad/Sedentary Peasant Interaction. Mathematical Theory and Cultural Anthropology 1(4):1-22.
21	Joyce, J. and P. Verhagen. 2014. Simulating the Farm: Computational Modelling of Cattle and Sheep Herd Dynamics for the Analysis of Past Animal Husbandry Practices. LAC 2014 proceedings (xxx): 1-17
22	Moritz, M. et al. 2017. No Magic Number: An Examination of the Herd-Size Threshold in Pastoral Systems Using Agent-Based Modeling. Human Ecology 45:525-532.
23	Aktipis, A. et al. 2011. Risk-Pooling and Herd Survival: An Agent-Based Model of a Maasai Gift-Giving System. Human Ecology 39(2):131-140.
24	Aktipis, A. et al. 2016. Cooperation in an Uncertain World: For the Maasai of East Africa, Need-Based Transfers Outperform Account-Keeping in Volatile Environments. Human Ecology 44:353-364.
25	Clark, J. and S. Crabtree. 2015. Examining Social Adaptations in a Volatile Landscape in Northern Mongolia via the Agent-Based Model Ger Grouper. Land 4:157-181.
26	Rasch, S. et al. 2017. Multi-scale resilience of a communal rangeland system in South Africa. Ecological Economics 131:129-138.
27	John, F. et al. 2019. Ecological Vulnerability Through Insurance? Potential Unintended Consequences of Livestock Drought Insurance. Ecological Economics 157:357-368.
28	Angourakis, A. et al. 2014. Land Use Patterns in Central Asia. Step 1: The Musical Chairs Model. Journal of Archaeological Methods and Theory 21:405-425.
29	Angourakis, A. et al. 2017. The Nice Musical Chairs Model: Exploring the Role of Competition and Cooperation Between Farming and Herding in the Formation of Land Use Patterns in Arid Afro-Eurasia. Journal of Archaeological Method and Theory 24:1177-1202.
30	Kato, S. 2014. Quantitative Predictions for Ecological and Economic Sustainability in Mongolian Pastoralist Systems. In Social-Ecological Systems in Transition, edited by S. Sakai and C. Umetsu. Springer, Tokyo.
31	Macopiyo, L. 2005. Spatially Explicit, Individual-Based Modelling of Pastoralists' Mobility in the Rangelands of East Africa. Unpublished Dissertation, Department of Rangeland Ecology and Management. Texas A&M University.
32	Janssen, M. et al. 2000. An Adaptive Agent Model for Analysing co-evolution of management and policies in a complex rangeland system. Ecological Modelling 131:249-268.
33	Günther,G., et al. 2021. Of Animal Husbandry and Food Production—A First Step towards a Modular Agent-Based Modelling Platform for Socio-Ecological Dynamics. *Land. 10:* 1366.
34	Guerrin, François. 2020. Agent-Based Modelling of a Simple Synthetic Rangeland Ecosystem. In Landscape Modelling and Decision Support.
35	Traore, Cheick Amed Diloma Gabriel, et al. 2023. Agent-Based Modeling of the Spatio-temporal Distribution of Sahelian Transhumant Herds. In Arai, K. (eds) Intelligent Systems and Applications. IntelliSys 2022. Lecture Notes in Networks and Systems, 543. Springer, Cham.

Table S2: Model Implementation, Documentation, and Dissemination

	Modeling Study	Model availability	ODD	Programming language	Existing model
1	Sakamoto (2016)	1	0	Python	0
2	Dressler et al. (2019a)	1	1	NetLogo	0
3	Fust and Schlecht (2018)	1	1	NetLogo	0
4	Moritz et al. (2015)	1	1	NetLogo	0
5	Milner-Gulland et al. (2006)	0	0	?	0
6	Bah et al. (2006)	0	0	CORMAS	0
7	Boone et al. (2011)	0	1	FORTRAN 95	1
8	Okayasu et al. (2010)	0	0	?	1
9	Boone and Lesorogol (2016)	0	0	FORTRAN 95	1
10	Dressler et al. (2019b)	0	1	C++	1
11	Rouchier et al. (2001)	0	0	?	0
12	Cioffi-Revilla et al. (2010)	0	0	MASON	0
13	Hailegiorgis et al. (2010)	0	0	MASON	1
14	Hailegiorgis et al. (2018)	1	1	MASON	1
15	Rogers et al. (2015)	0	0	MASON	1
16	Rogers et al. (2012)	0	0	MASON	1
17	Yu et al. (2019)	0	1	?	0
18	Martin et al. (2014)	0	1	?	0
19	Kariuki et al. (2018)	0	1	NetLogo	0
20	Kuznar and Sedlmeyer (2005)	0	0	SWARM	1
21	Joyce and Verhagen (2014)	1	1	NetLogo	0
22	Moritz et al. (2017)	1	1	NetLogo	0
23	Aktipis et al. (2011)	0	1	NetLogo	0
24	Aktipis et al. (2016)	0	1	NetLogo	1
25	Clark and Crabtree (2015)	0	0	NetLogo	0
26	Rasch et al. (2017)	0	1	REPAST	1
27	John et al. (2019)	1	1	NetLogo	0
28	Angourakis et al. (2014)	0	1	NetLogo	0
29	Angourakis et al. (2017)	0	0	NetLogo	1
30	Kato (2014)	0	0	?	0
31	MacOpiyo (2005)	0	0	Java	1
32	Janssen et al. (2000)	0	0	?	0
33	Günther et al. (2021)	1	1	Julia	0
34	Guerrin (2020)	0	1	NetLogo	0
35	Traore et al. (2023)	0	1	?	0

Table S3: Focal system

	Source	Specific (1), Generic (0)	Focal system
1	Sakamoto (2016)	1	Mobile pastoralists in the semi-arid rangelands of Northeast Nigeria
2	Dressler et al. (2019a)	0	African pastoralists
3	Fust and Schlecht (2018)	1	Mobile pastoralists in southwest Madagascar
4	Moritz et al. (2015)	1	Mobile pastoralists in the Logone floodplain of Cameroon
5	Milner-Gulland et al. (2006)	1	Pastoralists in the semi-arid rangelands of Kazakhstan
6	Bah et al. (2006)	1	Farmers and herders in the Sahel of Senegal
7	Boone et al. (2011)	1	Agropastoral Maasai in Southwestern Kenya
8	Okayasu et al. (2010)	1	Pastoralists in Mongolia
9	Boone and Lesorogol (2016)	1	Samburu pastoralists in Kenya
10	Dressler et al. (2019b)	1	Mobile pastoralists of the High plateau of Eastern Morocco
11	Rouchier et al. (2001)	1	Mobile pastoralists in North Cameroon
12	Cioffi-Revilla et al. (2010)	0	Asian pastoralists
13	Hailegiorgis et al. (2010)	1	Herding groups of the Mandera Triangle in East Africa
14	Hailegiorgis et al. (2018)	1	Agropastoralists and pastoralists in the South Omo zone of Ethiopia
15	Rogers et al. (2015)	0	Prehistoric pastoralists in Mongolia
16	Rogers et al. (2012)	0	Prehistoric pastoralists of Inner Asia
17	Yu et al. (2019)	1	Semi-arid terrestrial grasslands of China
18	Martin et al. (2014)	1	Transhumant pastoralists of the High Atlas Mountains of Morocco
19	Kariuki et al. (2018)	1	Ecosystems in southern Kenya
20	Kuznar and Sedlmeyer (2005)	1	Pastoral nomads and peasant farmers in Darfur, Sudan
21	Joyce and Verhagen (2014)	1	Prehistoric farmers in the lower Rhine region of the Netherlands
22	Moritz et al. (2017)	0	African pastoralists
23	Aktipis et al. (2011)	1	Maasai pastoralists of East Africa
24	Aktipis et al. (2016)	1	Maasai pastoralists of East Africa
25	Clark and Crabtree (2015)	1	Mobile pastoralists in Northern Mongolia
26	Rasch et al. (2017)	1	Village community of Sediba in South Africa
27	John et al. (2019)	0	African pastoralists
28	Angourakis et al. (2014)	0	Prehistoric pastoralists and farmers in Central Asia
29	Angourakis et al. (2017)	0	Herding and farming groups in arid Afro-Eurasia
30	Kato (2014)	1	Pastoralists in Mongolia
31	MacOpiyo (2005)	1	Semi-arid region of Southern Ethiopia and Northern Kenya
32	Janssen et al. (2000)	0	Australian pastoralists.
33	Günther et al. (2021)	1	Transhumant pre-industrial Turkish pastoralists
34	Guerrin (2020)	0	Generic rangeland system
35	Traore et al. (2023)	1	Mobile pastoralists in Senegal

Table S4: Purpose

	Source	Purpose
1	Sakamoto (2016)	Demonstrate the analytical potential of combining satellite images and agent-based modeling to examine pastoral resource access in drylands with unpredictable ecological dynamics.
2	Dressler et al. (2019a)	Assess the consequences of scenarios of behavioral and demographic change, and in particular how changes in stocking strategies affect livestock numbers, pasture conditions, and livelihoods.
3	Fust and Schlecht (2018)	Understand the parameters for a sustainable use of rangelands within a semi-arid environment and how management and/or environmental changes affect the herbivore-grassland-system.
4	Moritz et al. (2015)	Examine whether and how pastoralists in a floodplain achieve ideal free distribution (IFD) and whether this system is adaptive in the long term.
5	Milner-Gulland et al. (2006)	To study the dynamics of the rangeland system in Kazakhstan through decision-making of pastoralists and whether they invest in stock or capital.
6	Bah et al. (2006)	Examine the interactions between the biophysics dynamics of the natural resources and the socio-economic factors driving the land-use dynamics around well drilling in the Sahel.
7	Boone et al. (2011)	Examine how the decision making and behaviors of the households in response to changes in ecosystem services affects in the well-being of households.
8	Okayasu et al. (2010)	Examine how survival strategies of pastoralists change in response to different costs of flock movement.
9	Boone and Lesorogol (2016)	Examine changes in a coupled human-natural system in response to drought and changes in wildlife populations.
10	Dressler et al. (2019b)	Examine the economic, ecological, climatic, and demographic factors driving this polarization or emergence of two distinct socio-economic groups in terms of livestock and capital.
11	Rouchier et al. (2001)	Examine whether and how herders' relationships with farmers leads to rangelands systems that are efficient and sustainable.
12	Cioffi-Revilla et al. (2010)	Gain a better understanding of pastoral nomadic dynamics, including human and societal adaptive behavior to long-term climate and environmental change.
13	Hailegiorgis et al. (2010)	To examine how climatic variability and environmental stress affects conflicts between herders and farmers.
14	Hailegiorgis et al. (2018)	Examine the adaptive capacity of rural households in the South Omo zone of Ethiopia in response to variation in climate, socioeconomic factors, and land-use at the local level.
15	Rogers et al. (2015)	Study why and how wealth differentials and associated social inequalities are generated and sustained over multiple generations of pastoral nomads.
16	Rogers et al. (2012)	Assess the interaction between slow and fast processes and examine how interpretations of adaptive capacity and system resilience are affected by the scale at which observations are made.
17	Yu et al. (2019)	Assess grassland status under different combination of individual grazing strategies and institutional arrangements.

18	Martin et al. (2014)	Assess the relevance of drought as a driving force for losses of livelihood security leading to a specific systemic change, i.e., households abandoning transhumant pastoralism.
19	Kariuki et al. (2018)	Investigate the impact of land use change decisions, by pastoralists in southern Kenya rangelands, on human well-being and animal densities.
20	Kuznar and Sedlmeyer (2005)	Demonstrate how individual family responses to ecological phenomena can produce conflict on a regional scale.
21	Joyce and Verhagen (2014)	Investigate changes in pastoral production as a result of differing population dynamics of sheep and cattle herds subjected to different animal husbandry practices.
22	Moritz et al. (2017)	Explore the concept of a herd-size threshold by examining the role of scale and stochasticity in family herd dynamics.
23	Aktipis et al. (2011)	Explore whether livestock exchanges among Maasai increase the viability of herds by comparing herd survivorship and stability.
24	Aktipis et al. (2016)	Examine whether and how two different types of livestock transfer found among Maasai pastoralists lead to more risk-pooling and more effective risk management than others.
25	Clark and Crabtree (2015)	Examine how households mitigate risks of winter storms and how different sharing strategies impact the survivability of mobile pastoralist groups.
26	Rasch et al. (2017)	Assess the impacts of shocks, stressors and policy interventions on the resilience of rangeland systems on different ecological and social scales.
27	John et al. (2019)	To study the long-term effects of index-based drought insurance on livestock and pasture development and especially potential unintended side-effects.
28	Angourakis et al. (2014)	Explore the evolutionary processes of Central Asian oases, considered as ecosystems where sedentary agriculture and mobile livestock breeding interact to produce specific land use patterns
29	Angourakis et al. (2017)	Examine how farmers and herders may interact, through different mechanisms and under various conditions, to contribute to the long-term formation of land use patterns.
30	Kato (2014)	Analyze how mobility and grazing pressure impacts grazing lands and sustainability of pastoral system in Mongolia.
31	MacOpiyo (2005)	Examine how pastoralists adapt their livestock movements to the spatial heterogeneity of their environment.
32	Janssen et al. (2000)	Examine how different policy and institutional regimes affect pastoralists decision-making and how this affects the ecological system.
33	Günther et al. (2021)	Examine the herd requirements of pre-industrial pastoral communities to meet their caloric needs and also how disruptions to environmental processes may impact this ability
34	Guerrin (2020)	Find a balance between healthy herbivores and vegetation, guaranteeing sustainability; Evaluate ecological hypotheses like Ideal-Free Distribution
35	Traore et al. (2023)	Model the spatio-temporal distribution of Sahelian transhumant practices and vegetation cover.

Table S5: Main Topic(s) of the Modeling Studies

	Source	Main topic(s)	Categories	Number of Submodels
1	Sakamoto (2016)	Mobility	Mobility	5
2	Dressler et al. (2019a)	Sustainability	Sustainability	7
3	Fust and Schlecht (2018)	Sustainability	Sustainability	7
4	Moritz et al. (2015)	Mobility, sustainability	Mobility	5
5	Milner-Gulland et al. (2006)	Decision-making, sustainability	Sustainability	8
6	Bah et al. (2006)	Resource management	Resource management	7
7	Boone et al. (2011)	Decision-making, sustainability	Sustainability	9
8	Okayasu et al. (2010)	Wealth dynamics	Wealth dynamics	6
9	Boone and Lesorogol (2016)	Wealth dynamics, system dynamics	Wealth dynamics	11
10	Dressler et al. (2019b)	Wealth dynamics	Wealth dynamics	8
11	Rouchier et al. (2001)	Resource management	Resource management	6
12	Cioffi-Revilla et al. (2010)	Climate change, adaptation	Adaptation	9
13	Hailegiorgis et al. (2010)	Climate change, conflict	Conflict	10
14	Hailegiorgis et al. (2018)	Climate change, adaptation	Adaptation	8
15	Rogers et al. (2015)	Wealth dynamics	Wealth dynamics	8
16	Rogers et al. (2012)	Climate change, adaptation	Adaptation	8
17	Yu et al. (2019)	Resource management	Resource management	4
18	Martin et al. (2014)	Wealth dynamics	Wealth dynamics	8
19	Kariuki et al. (2018)	Resource management	Resource management	7
20	Kuznar and Sedlmeyer (2005)	Conflict	Conflict	10
21	Joyce and Verhagen (2014)	Herd demography	Herd demography	2
22	Moritz et al. (2017)	Herd demography	Herd demography	3
23	Aktipis et al. (2011)	Herd demography and exchange	Herd demography	6
24	Aktipis et al. (2016)	Herd demography and exchange	Herd demography	6
25	Clark and Crabtree (2015)	Herd demography and exchange	Herd demography	7
26	Rasch et al. (2017)	Resilience	Sustainability	9
27	John et al. (2019)	Wealth dynamics, system dynamics	Wealth dynamics	8
28	Angourakis et al. (2014)	Resource management, land use	Resource management	3
29	Angourakis et al. (2017)	Conflict	Conflict	3
30	Kato (2014)	Mobility, sustainability	Mobility	8
31	MacOpiyo (2005)	Climate change, adaptation	Adaptation	7
32	Janssen et al. (2000)	Resource management	Resource management	9
33	Günther et al. (2021)	System dynamics, sustainability	Herd demography	7
34	Guerrin (2020)	Mobility, resource management	Mobility	4
35	Traore et al. (2023)	Mobility, resource management	Mobility	5

Table S6: Submodels

	Code	Code description	Number of studies
1	Herd manager	Are decisions by herd manager modeled, for example, about movements, following rules, selling animals?	28
2	Vegetation-Quant	Are the dynamics of the vegetation modeled? Does the quantity of vegetation change intra-annually or inter-annually?	30
3	Herd grazing	is there a model that describes how animals consume forage, reduce resources, and gain energy?	29
4	Herd demography	Are the demographics of the herd modeled (e.g., fertility, mortality)?	28
5	Climate	Is the climate modeled? Does rainfall change from year to year?	26
6	Herd movement	Are herds moving and is there a model that guides herd movements	25
7	Household	Are the demographics of the household modeled? Are household consuming resources and/or providing labor?	22
8	Institutions	Are institutions modeled that govern the movement of herds or the use of and access to pastures and other resources?	15
9	Vegetation-Qual	Does vegetation change in composition, for example, from grass to trees, over the years?	9
10	Market	Do pastoralists sell livestock at the market or buy supplementary feed at the market?	9
11	Social dynamics	Are pastoralists interacting with other pastoralists, for example, by exchanging animals?	9
12	Outside world	Do the pastoralists interact with other members of society (e.g., conflicts with farmers) or are only pastoralists modeled?	8

Table S7: Agents

	Source	Type of agents	Number of agents	Agent collectives	Agent interactions
1	Sakamoto (2016)	individuals	50	-	-
2	Dressler et al. (2019a)	households	20 to 100	-	-
3	Fust and Schlecht (2018)	herds	variable	-	-
4	Moritz et al. (2015)	camps	50	-	-
5	Milner-Gulland et al. (2006)	households	5 to 30	-	-
6	Bah et al. (2006)	individuals	70	-	-
7	Boone et al. (2011)	households	3,280	-	Information
8	Okayasu et al. (2010)	households	50	-	-
9	Boone and Lesorogol (2016)	households	240 to 370	-	Cooperation
10	Dressler et al. (2019b)	households	18	-	-
11	Rouchier et al. (2001)	individuals	104	Farmers and chiefs	Negotiation
12	Cioffi-Revilla et al. (2010)	households	100	Clans and camps	Information, avoidance
13	Hailegiorgis et al. (2010)	households	300	Tribes	Cooperation or conflict
14	Hailegiorgis et al. (2018)	households	50,000	-	Information
15	Rogers et al. (2015)	households	-	Clans and camps	Information, avoidance
16	Rogers et al. (2012)	households	-	Clans and camps	Information, avoidance
17	Yu et al. (2019)	herds	-	-	-
18	Martin et al. (2014)	herds	-	-	-
19	Kariuki et al. (2018)	pasture	-	-	-
20	Kuznar and Sedlmeyer (2005)	households	-	-	Conflict
21	Joyce and Verhagen (2014)	herds	1	-	-
22	Moritz et al. (2017)	herds	1	-	-
23	Aktipis et al. (2011)	households	2	-	Cooperation
24	Aktipis et al. (2016)	households	2	-	Cooperation
25	Clark and Crabtree (2015)	households	20	Networks	Cooperation
26	Rasch et al. (2017)	households	-	-	Sanctioning
27	John et al. (2019)	households	10	-	-
28	Angourakis et al. (2014)	pasture	-	Herders or Farmers	Conflict
29	Angourakis et al. (2017)	pasture	-	Herders or Farmers	Conflict
30	Kato (2014)	individuals	-	-	-
31	MacOpiyo (2005)	individuals	-	Ethnic groups	-
32	Janssen et al. (2000)	individuals	100	-	-
33	Günther et al. (2021)	Individuals	304	Settlement, population	Cooperating
34	Guerrin (2020)	Individuals	1225	-	-
35	Traore et al. (2023)	individuals	200+	Herd, Social Network	Cooperating

Table S8: Spatial units, spatial resolution, and size of the system

	Source	Number of spatial units	Size spatial unit in hectares	Size of the system in hectares
1	Sakamoto (2016)	90,000	100	9,000,000
2	Dressler et al. (2019a)	10,000	1	1,000
3	Fust and Schlecht (2018)	12,321	0.8	10,000
4	Moritz et al. (2015)	900	100	90,000
5	Milner-Gulland et al. (2006)	-	-	25,000
6	Bah et al. (2006)	900	9	9
7	Boone et al. (2011)	10,677	625	1,074,600
8	Okayasu et al. (2010)	-	-	6,000
9	Boone and Lesorogol (2016)	-	4	-
10	Dressler et al. (2019b)	-	400	-
11	Rouchier et al. (2001)	-	-	-
12	Cioffi-Revilla et al. (2010)	-	-	1,000,000
13	Hailegiorgis et al. (2010)	22,500	100	225,0000
14	Hailegiorgis et al. (2018)	329,634,900	1	3,296,349
15	Rogers et al. (2015)	10,000	100	1,000,000
16	Rogers et al. (2012)	-	-	100,000
17	Yu et al. (2019)	-	21	-
18	Martin et al. (2014)	-	300	-
19	Kariuki et al. (2018)	-	100	-
20	Kuznar and Sedlmeyer (2005)	-	-	-
21	Joyce and Verhagen (2014)	-	-	-
22	Moritz et al. (2017)	-	-	-
23	Aktipis et al. (2011)	-	-	-
24	Aktipis et al. (2016)	-	-	-
25	Clark and Crabtree (2015)	1,600	-	-
26	Rasch et al. (2017)	-	-	-
27	John et al. (2019)	-	100	-
28	Angourakis et al. (2014)	-	-	-
29	Angourakis et al. (2017)	500	-	-
30	Kato (2014)	14,400	25	36,0000
31	MacOpiyo (2005)	11,735	2,100	24,644,800
32	Janssen et al. (2000)	100	-	-
33	Günther et al. (2021)	46,010	2,660	2,660
34	Guerrin (2020)	1,225	100,000	12,250,000
35	Traore et al. (2023)	-	-	12,108,472

Table S9: Temporal Resolution and Simulation Duration

	Source	Temporal resolution	in days	Duration in years	and in generations
1	Sakamoto (2016)	month	30	20,000	800
2	Dressler et al. (2019a)	year	365	100	4
3	Fust and Schlecht (2018)	day	1	20	1
4	Moritz et al. (2015)	day	1	10	0
5	Milner-Gulland et al. (2006)	day	1	100	4
6	Bah et al. (2006)	month	30	30	1
7	Boone et al. (2011)	week	7	24	1
8	Okayasu et al. (2010)	day	1	5	0
9	Boone and Lesorogol (2016)	week	7	20	1
10	Dressler et al. (2019b)	year	365	200	10
11	Rouchier et al. (2001)	-	-	-	-
12	Cioffi-Revilla et al. (2010)	day	1	5	0
13	Hailegiorgis et al. (2010)	day	1	100	4
14	Hailegiorgis et al. (2018)	day	1	50	2
15	Rogers et al. (2015)	day	1	500	20
16	Rogers et al. (2012)	day	1	1,000	40
17	Yu et al. (2019)	week	7	1	0
18	Martin et al. (2014)	season	180	30	1
19	Kariuki et al. (2018)	year	365	200	8
20	Kuznar and Sedlmeyer (2005)	season	180	70	3
21	Joyce and Verhagen (2014)	year	365	100	4
22	Moritz et al. (2017)	season	180	100	4
23	Aktipis et al. (2011)	year	365	10,000	400
24	Aktipis et al. (2016)	year	365	100	4
25	Clark and Crabtree (2015)	season	180	250	10
26	Rasch et al. (2017)	day	1	100	4
27	John et al. (2019)	season	180	1,000	40
28	Angourakis et al. (2014)	season	180	300	12
29	Angourakis et al. (2017)	season	180	250	10
30	Kato (2014)	week	7	30	1
31	MacOpiyo (2005)	week	7	8	0
32	Janssen et al. (2000)	-	-	200	8
33	Günther et al. (2021)	¼ day	0.25	50	2
34	Guerrin (2020)	day	1	100	4
35	Traore et al. (2023)	year	330	33	16.5

Table S10: Agent objectives

	Source	Objective	Maximize (1 = yes, 0 = no)	Focus on
1	Sakamoto (2016)	maximize access to forage	1	Forage
2	Dressler et al. (2019a)	maximize access to forage / maintain environment	1, 0	Forage, environment
3	Fust and Schlecht (2018)	maximize access to forage	1	Forage
4	Moritz et al. (2015)	maximize access to forage	1	Forage
5	Milner-Gulland et al. (2006)	maximize access to forage	1	Forage
6	Bah et al. (2006)	-		-
7	Boone et al. (2011)	maximize herd growth	1	Herd
8	Okayasu et al. (2010)	maximize herd growth	1	Herd
9	Boone and Lesorogol (2016)	maximize herd growth	1	Herd
10	Dressler et al. (2019b)	maintain herd growth	0	Herd
11	Rouchier et al. (2001)	maximize access to forage	1	Forage
12	Cioffi-Revilla et al. (2010)	maintain access to forage	0	Forage
13	Hailegiorgis et al. (2010)	maximize access to forage	1	Forage
14	Hailegiorgis et al. (2018)	maintain herd growth	0	Herd
15	Rogers et al. (2015)	maintain access to forage	0	Forage
16	Rogers et al. (2012)	maintain access to forage	0	Forage
17	Yu et al. (2019)	maintain herd growth	0	Herd
18	Martin et al. (2014)	maximize access to forage	1	Forage
19	Kariuki et al. (2018)	maximize herd growth	1	Herd
20	Kuznar and Sedlmeyer (2005)	maintain herd growth	0	Herd
21	Joyce and Verhagen (2014)	maintain herd growth	0	Herd
22	Moritz et al. (2017)	maintain herd growth	0	Herd
23	Aktipis et al. (2011)	maintain herd growth	0	Herd
24	Aktipis et al. (2016)	maintain herd growth	0	Herd
25	Clark and Crabtree (2015)	maintain herd growth	0	Herd
26	Rasch et al. (2017)	maximize utility	1	-
27	John et al. (2019)	maximize access to forage	1	Forage
28	Angourakis et al. (2014)	maintain access to forage	0	Forage
29	Angourakis et al. (2017)	maintain access to forage	0	Forage
30	Kato (2014)	maximize access to forage	1	Forage
31	MacOpiyo (2005)	maximize access to forage	1	Forage
32	Janssen et al. (2000)	maintain environment	0	Environment
33	Günther et al. (2021)	meet human subsistence needs	0	Subsistence
34	Guerrin (2020)	maintain environment	0	Environment
35	Traore et al. (2023)	maintain access to forage	0	Forage

Table S11: Type of study and results from simulations

	Source	Explanatory study	Result from simulations
1	Sakamoto (2016)	0	Simulations show that seasonality in resource distributions as well as tsetse fly and cropland distributions result in the heterogenous mobility responses of pastoralists.
2	Dressler et al. (2019a)	0	Simulations show that maximizing strategies are not sustainable and that household stocking decisions have a major impact on sustainable use of rangelands.
3	Fust and Schlecht (2018)	0	Simulations show that shorter growing seasons (due to climate change), energy costs of moving, and vegetation dynamics all affect rangeland productivity, i.e., rangeland carrying capacity.
4	Moritz et al. (2015)	1	Simulations show that pastoralists with freedom to move and knowledge of resource distribution distribute themselves in an ideal free distribution.
5	Milner-Gulland et al. (2006)	0	Simulations show that winter forage is the limiting factor and that wealthier pastoralists with more animals and capital can move to more distant pastures.
6	Bah et al. (2006)	0	Simulations show that rainfall has a major impact on agriculture and pastoralism and that in scenarios with good rainfall, agriculture will expand at the expense of pastoralism.
7	Boone et al. (2011)	0	Simulations show that when pastoralists lose access to rangelands, they suffer more than those farther away. Compensating pastoralists for losses limits the impacts of loss of access.
8	Okayasu et al. (2010)	1	Simulations show that when moving costs are low, poor and wealthy pastoralists graze in the same areas, but when moving costs increase there is a spatial differentiation.
9	Boone and Lesorogol (2016)	1	Simulations show that even a modest drought has a significant impact on household livestock holdings and well-being. Also, income from wildlife does not compensate for loss of productivity.
10	Dressler et al. (2019b)	0	Simulations show that differentiation among pastoral households results from climate, and economic factors because of scale and stochasticity have a negative effect on poor households.
11	Rouchier et al. (2001)	0	Simulations show that pastoralists negotiating access to resources are more effective when they use a friendship rule, rather than a cost-minimizing rule.
12	Cioffi-Revilla et al. (2010)	0	The distribution of wealth among households and the seasonal movements resemble those observed in the real world.
13	Hailegiorgis et al. (2010)	1	Simulations show that droughts have a greater impact on household survival than expected, and that conflict and cooperation decrease with droughts but increase with recovery from drought.
14	Hailegiorgis et al. (2018)	0	Simulations show that increasing climate variability results in substantial reduction of crop and livestock assets and this forces households to leave for the city.
15	Rogers et al. (2015)	1	Simulations show that household's freedom to move and livestock exchange system increases lineage longevity, but herd size surprisingly had little effect on lineage longevity.
16	Rogers et al. (2012)	0	Simulations show that larger herd size allows households to recover more easily from droughts and other disasters, but factors, like household autonomy and freedom to move matter also.
17	Yu et al. (2019)	1	Simulations show that rotational grazing systems perform better in terms of pasture conditions than continuous grazing systems.
18	Martin et al. (2014)	1	Simulations show that droughts threaten the livelihoods of pastoral households that are more vulnerable, but that vulnerability is driven by multiple, other factors.

19	Kariuki et al. (2018)	0	Simulations show that higher rainfall and private land ownership lead to the growth of agriculture and lower rainfall and conservation subsidies lead to growth of pastoralism.
20	Kuznar and Sedlmeyer (2005)	1	Simulations show that seasonal resource scarcity is associated with incidents of herders raiding farmers, while drought conditions lead to widespread raiding by herders.
21	Joyce and Verhagen (2014)	0	Simulations show that production strategies that focus on livestock products from living animals, lead to greater herd growth but require more land and labor than strategies focused on meat.
22	Moritz et al. (2017)	1	Scale and stochasticity matter in herd growth – smaller herds have a greater chance of "dying" – and livestock sales significantly limit herd growth.
23	Aktipis et al. (2011)	1	Simulations show that traditional livestock exchange system increases herd longevity among Maasai pastoralists.
24	Aktipis et al. (2016)	0	Simulations show that need-based livestock exchange systems outperform systems in which pastoralists keep accounts in terms of herd longevity and equality.
25	Clark and Crabtree (2015)	1	Simulations show that limited sharing of resources to cope with environmental shocks is more efficient in the long-term than sharing everything or nothing.
26	Rasch et al. (2017)	1	Simulations show that drought and overstocking lead to greater economic inequality among households, and that policy interventions may reduce some of these effects.
27	John et al. (2019)	1	Simulations show that livestock insurance helps households rebuild herds after drought but interferes with rangeland recovery and reduce long-term carrying capacity.
28	Angourakis et al. (2014)	0	Simulations show the emergence of specialization in either agriculture or pastoralism, but little agropastoralism. Farmers have a competitive advantage over herders when it comes to land use.
29	Angourakis et al. (2017)	1	Linkages between herders and farmers do not prevent the emergence of specialization in either agriculture or pastoralism, but herder territoriality does prevent farmers from taking over land.
30	Kato (2014)	1	Simulations with higher mobility and lower livestock numbers were sustainable, whereas simulations with no mobility and higher livestock numbers were unsustainable.
31	MacOpiyo (2005)	0	Simulated mobility patterns match observed modality patterns. Experiments indicate that increasing availability of water and forages leads to less mobility.
32	Janssen et al. (2000)	0	Different policies have different economic and ecological outcomes. Most productive is a system that follows the ecological dynamics. Least productive is a strategy aimed at conservation.
33	Günther et al. (2021)	0	There was little difference in herd population dynamics between the average and high requirement experiments, suggesting relatively stable processes.
34	Guerrin (2020)	0	Sustainable outcomes in terms of herds and rangelands were achieved with local foraging, short movements, and anticipation of resource exhaustion.
35	Traore et al. (2023)	1	Simulations show that transhumant herds are widely distributed and have little impact on vegetation. Also, herds are widely distributed across the region independent of rainfall.

Table S12: Keywords

	Source	Keywords
1	Sakamoto (2016)	Land use, grazing, livestock, seasons, tsetse fly, agent-based modeling, theoretical ecology, grasslands
2	Dressler et al. (2019a)	Multi-agent simulation, social-ecological model, decision theory, social norms, common property, income diversification
3	Fust and Schlecht (2018)	Energy maximization, rangeland productivity, ruminant foraging simulation, model description, model validation
4	Moritz et al. (2015)	Complex adaptive systems, common-pool resources, emergent commons pastoralism, ideal free distribution, agent-based model
5	Milner-Gulland et al. (2006)	Decision-making, movement, soviet, livestock, migration
6	Bah et al. (2006)	Sahel, integrated natural resource management, grazing, agent-based modelling, Senegal
7	Boone et al. (2011)	Agent-based modeling, DECUMA household model, ecosystem services, livestock, Maasai, mobility, pastoral decision making, SAVANNA ecosystem model
8	Okayasu et al. (2010)	Mobile pastoralism, mobility herders' strategy, multi-agent model, Mongolia, co-existence mechanism
9	Boone and Lesorogol (2016)	-
10	Dressler et al. (2019b)	Agent-based model, social-ecological system, common property resource, pastoralism, global change, poverty trap
11	Rouchier et al. (2001)	Exchanges, modeling, pastoralism, familiarity, economics
12	Cioffi-Revilla et al. (2010)	Social simulation, agent-based modeling, computational social science, pastoral, nomads, inner Asia, Mongolia, mason toolkit, coupled socio-natural systems, climate change, social complexity.
13	Hailegiorgis et al. (2010)	Agent-based model, conflict, climate change, pastoral
14	Hailegiorgis et al. (2018)	Climate change adaptation, agent-based modeling, socio-cognitive behavior
15	Rogers et al. (2015)	-
16	Rogers et al. (2012)	Complexity, pastoralism, inner Asia, weather, agent-based modeling, simulations
17	Yu et al. (2019)	Grassland degradation, grazing systems, leaf area index, global environmental change, natural resources management
18	Martin et al. (2014)	Social-ecological system, simulation model, semi-arid rangeland, transhumant pastoralism, morocco, global change

19	Kariuki et al. (2018)	Agent-based-model, climate change, conservation, grazing, pastoralists, precipitation, savannahs, social-ecological systems
20	Kuznar and Sedlmeyer (2005)	Darfur, genocide, agent-based modeling, conflict, pastoralism
21	Joyce and Verhagen (2014)	Dutch roman limes, system dynamics, zooarchaeology, roman agriculture
22	Moritz et al. (2017)	Agent-based model, demography, threshold, family herds, African pastoral systems
23	Aktipis et al. (2011)	Risk-pooling, reciprocity, cooperation, norms, pastoralism, Maasai
24	Aktipis et al. (2016)	Need-based transfers, account-keeping transfers, risk pooling, herd survival outcomes, Maasai, East Africa
25	Clark and Crabtree (2015)	Archaeology, agent-based modeling, Mongolia, risk-management, cooperation
26	Rasch et al. (2017)	Socio-ecological system, resilience, agent-based model, rangeland systems, south Africa development
27	John et al. (2019)	Index-based insurance, risk-coping strategies, pastoralism, grazing, East Africa
28	Angourakis et al. (2014)	Land use, Central Asia, agent-based modeling, coevolution, herding and farming
29	Angourakis et al. (2017)	Agent-based model, competition, cooperation, herder-farmer relationship, land use, pastoral systems
30	Kato (2014)	Nomadic grazing, scenario comparison, sedentary grazing, simulation, spatially explicit agent-based model
31	MacOpiyo (2005)	-
32	Janssen et al. (2000)	Complex adaptive systems, ecosystem management, rangelands, adaptive agents
33	Günther et al. (2021)	Multi-agent Simulation, pastoralism, human impact, grazing, landscape
34	Guerrin (2020)	Agent-based modelling, landscape simulation, grazing ecosystem, grazing lawns, ideal free distribution
35	Traore et al. (2023)	Extensive livestock farming, agro-pastoral ecosystem, Sub-Saharan Africa, agent-based system, distributed artificial intelligence

Table S13: Codebook

Code Category	Code	Code Descriptions
ID	ID	Unique ID
SOURCE	Citation	Citation
SOURCE	Year of publication	Year of publication
SOURCE	Number of citations	Web of science
SOURCE	Keywords	What are the keywords used in the article?
FOCAL SYSTEM	Focal system	Type of pastoralism, location, ecoclimate, type of livestock, mean annual precipitation, percentage of woody cover, …
PROJECT	Goal	What is the goal of the modeling study?
PROJECT	Approach	Do the researchers use an explanatory or exploratory approach, i.e., do they start with hypotheses or not?
CONCEPTUAL MODEL	Conceptual model	What are the assumptions about entities and processes of the focal system? How do they conceptualize pastoral systems?
CONCEPTUAL MODEL	Decision-making	Do the researchers explain their decisions on what to include in the model and what to leave out?
CONCEPTUAL MODEL	Demographic dynamics	Do the researchers model demographic dynamics, i.e., do agents die and/or reproduce?
CONCEPTUAL MODEL	Ecological dynamics	Do the researchers model ecological dynamics, i.e., does the species composition change over time?
CONCEPTUAL MODEL	Social dynamics	Do the researchers model social dynamics, i.e., do agents influence the behavior of other agents directly?
CONCEPTUAL MODEL	autonomous	Are agents autonomous and only influence each other's behavior indirectly?
CONCEPTUAL MODEL	Political dynamics	Do the researchers model political dynamics, i.e., do agents use power to forcefully change the behavior of other agents?
CONCEPTUAL MODEL	Level of abstraction	What is the level of abstraction on a scale of 5? 1= simple, theoretical model, 5 = more realistic model.
PROGRAM	Programming framework	What software or programming language is used to build the agent-based model?
PROGRAM	Model availability	Is the model published and if so where?
PROGRAM	Existing model	Do the researchers use an existing model? If so, which one?
PROGRAM	Modifications to existing model	What modifications do researchers make to an existing model?
TEAM	Researchers	What is the composition of the research team? It is one researcher or an interdisciplinary team?

TEAM	Related models	Has the researcher or research team published other models? Is the model part of a larger research project?
TEAM	Empirical research	Has the researchers or research team conducted empirical research of the focal system.
ODD	ODD	Do the researchers use the ODD to describe the model?
ODD	Purpose	What is the purpose of the model? What are the research questions asked? What are the hypotheses tested?
ODD	Agents	What is the agent that behaves as a unit and interacts with other agents and/or environment? It is an individual, household, herd of something else?
ODD	Agent number	What is the number of agents in the model? Or what is the range of the number of agents in the experiments?
ODD	Agent attributes	What are the agent attributes, e.g., number of livestock, number of people, age, ethnicity? What is the heterogeneity of the population?
ODD	Temporal resolutions	What are the time steps in the model?
ODD	Duration	How many time steps and/or years does the model run?
ODD	Size of the world	What is the size of the spatial world?
ODD	Spatial units / resolution	What is the size of individual spatial units?
ODD	Attributes of spatial units	What are the attributes of spatial units, e.g., vegetation type, biomass, …
ODD	Global processes	What are the global ecoclimatic processes modeled? What is the variability of these ecoclimatic processes
ODD	Process overview	Who does what, and in what order? When are state variables updated?
ODD	Modeling strategy	Do the researchers use pattern-driven or process-driven modeling strategies?
ODD	DC1: Basic principles	Which general concepts, theories, hypotheses, or modeling approaches are underlying the model's design?
ODD	DC2: Emergence	What key results or outputs of the model are emerging from the adaptive traits, or behaviors, of individuals?
ODD	DC3: Adaptation	What rules do agents have for making decisions or changing behavior in response to changes in themselves or their environment?
ODD	DC4: Objectives	If adaptive traits act to increase some measure of the individual's success at meeting some objective, how is it measured?
ODD	DC5: Learning	Do agents change their adaptive traits over time as a consequence of their experience? If so, how?
ODD	DC6: Prediction	How do agents predict the future conditions they will experience?
ODD	DC7: Sensing	What internal and environmental state variables do agents sense and consider in their decisions?
ODD	DC8: Interactions	What are the direct and/or indirect interactions among agents?

ODD	DC9: Stochasticity	What processes are modeled as random or partly random?
ODD	DC10: Collectives	Do individuals form or belong to aggregations that affect, and are affected by, the individual agents?
ODD	DC11: Observations	What data are collected from the ABM for testing, understanding, and analyzing it, and how and when are they collected?
ODD	Initialization	What is the initial state of the model world? Is initialization always the same, or is it allowed to vary among simulations? If so, how?
ODD	Input data	Does the model use input from external sources such as data files? If so, what data - remote sensing data, ethnographic data?
ODD	Submodels	What, in detail, are the submodels that represent the processes listed in process overview?
ODD submodels	herd manager	Are decisions by herd manager modeled, for example, about movements, following rules, selling animals?
ODD submodels	vegetation-Quant	Are the dynamics of the vegetation modeled? Does vegetation age or dry out?
ODD submodels	vegetation-Qual	Does vegetation change in composition, for example, from grass to trees, over the years?
ODD submodels	herd grazing	is there a model that describes how animals graze the vegetation (reduce resources and gain energy)?
ODD submodels	herd demography	Are the demographics of the herd modeled (e.g., fertility, mortality)?
ODD submodels	climate	Is the climate modeled? Does rainfall change from year to year?
ODD submodels	herd movement	Are herds moving and is there a model that guides herd movements
ODD submodels	household	Are the demographics of the household modeled? Are household consuming resources and/or providing labor?
ODD submodels	institutions	Are there institutions that govern the movement of herds or the use of and access to pastures and other resources?
ODD submodels	market	Do pastoralists sell livestock at the market or buy supplementary feed at the market?
ODD submodels	social dynamics	Are pastoralists interacting with other pastoralists, for example, by exchanging animals?
ODD submodels	outside world	Do the pastoralists interact with other members of society (e.g., conflicts with farmers) or are only pastoralists modeled?
ODD submodels	water	Is access to and use of water modeled? Is water a factor considered in herd movements?
ODD submodels	fire	Is fire modeled? Does it have an impact on vegetation?

SIMULATION	Experiments	What experiments are run? Is the model used to answer multiple questions? If so, what questions?
SIMULATION	Simulation results	How many runs were simulation results based upon?
SIMULATION	Sensitivity analysis	Did the researchers conduct a sensitivity analysis?
SIMULATION	Results sensitivity analysis	What were the results of the sensitivity analysis?
VALIDATION	Validation	How did the researcher(s) validate the results from the simulations? Did they compare results with empirical data?
FINDINGS	Findings	What are the main findings from the simulations? What did the researcher(s) learn about pastoral systems?
FINDINGS	Hypothesis evaluation	If hypotheses were tested, were they confirmed or rejected based upon model results?
FINDINGS	Theoretical implications	Did the researcher(s) learn something new? Or did they confirm existing theoretical understandings?
FINDINGS	Methodological implications	What are the methodological implications of this study? What are the methodological recommendations made by the researcher(s)?
FINDINGS	Practical implications	Do the researcher(s) make any practical recommendation based on their modeling studies? If so, what are the recommendations?
FINDINGS	Disclaimers	Do the researchers identify any limitations of the modeling study? If so, what are the limitations?
FINDINGS	Extrapolation	Do the researchers acknowledge that the results only apply to the type of pastoral system that they model?
ANALYSIS	Implementation	How does the implementation of the conceptual model in computer code change the conceptualization of the focal model?