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# Integrating human agency and ecosystem services: an ABM perspective on food

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**Abstract:** Food is a primary provisioning ecosystem service. The concept of ecosystem services only focuses on the flow of services from nature to humans and doesn't consider human flows, which include both the flows from human to nature (i.e. the co-production of ecosystem services or environmental pressures caused by humans) and human to human flows (i.e. social flows). Neglecting human flows is a main issue for modelling food provision within the ecosystem services framework, especially so under a food security perspective, where food access greatly depend on economic entitlements and social networks. We use the example of food security to provide a blueprint for modelling the sustainability of provisioning ecosystem services by incorporating human flows.

We adopt an agent-based perspective that allows not only to capture critical flows between agents, but also to tag social agents with heterogeneous roles and behaviors. In complex coupled human-natural systems individual human behavior affects the emergence of collective outcomes of natural resource management. We conceptually model household behavior in the context of food provision within a rural village by framing it into a social-ecological governance compass based on four cardinal directions: differentiation, conformation, cooperation and competition.

We argue that by acting together towards diet diversity, differentiation and cooperation may stimulate the rise of human flows that make a rural community more food secure. When generalized to the ecosystem services paradigm, the consequences of this study stand out. From a descriptive point of view scientists could draw more informed conclusions on both the environmental and social sustainability of the ecosystem services dynamics. From a normative point of view science could inform policy-making on how to stimulate the human flows that better optimize the flow of benefits from nature to humans.

**Keywords:** agent-based, ecosystem services, social-ecological systems, self-governance, food security, human behaviour, social flows.