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Methodological Abilities of Integrated Models to Support Agricultural Landscape Resilience: Current Status and Research Perspectives

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Abstract: It is important to increase the resilience of rural landscapes in the face of global changes. It is widely recognized that integrated modeling is often a methodological choice to study landscape resilience because the task is often beyond the ability of direct, empirical studies. However, so far there has not yet been a systemized, critical review on methodological abilities current modeling approaches can have for supporting management for agricultural landscape resilience. This review study (i) highlighted the methodological abilities of integrated system modeling ideally needed for agricultural landscape management for resilience, (ii) reviewed strengths and weakness of common integrated modeling methods with respects to these required methodological abilities, and (iii) discussed perspectives of modeling research toward meeting these abilities. Based on common frameworks of socio-ecological systems, we identified nine methodological abilities that would be ideally needed for integrated modeling for supporting agricultural landscape resilience: (1) representing social-ecological complementariness, (2) anticipating multiple performances in a distributed way, (3) explaining behavioral change of multiple human actors, (4) representing flexible, multi-scale feedbacks, (5) capturing intra- and inter-farm heterogeneity, (6) explaining farm's structural changes, (7) being sensitive to key drivers, (8) managing uncertainty, and (9) mediating effective participation. Seven common integrated modeling approaches selected for our review are: (a) material flow analysis, (b) system dynamics, (c) Bayesian network, (d) bio-economic optimization, (e) coupled components, (f) cellular automata, and (g) multi-agent systems (agent-based model). The results are the matrices of concise narrative assessments with references to published examples, rather than abstract scores, of each modeling approach against the nine methodological criteria. The matrices can serve as methodological maps that help citizen scientists, with own context, to position themselves and wherefrom identify relevant modeling directions towards meeting the required methodological criteria better. We demonstrated the potential usage of the reviewed matrices with different typical use cases.

Keywords: agricultural landscape, integrated modeling, methodological abilities, review, socio-ecological resilience, sustainability