
INTRODUCTION

Current issues in ecological systems modeling: from stability theory to the digital practice of recovery

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It is now widely recognized that ecological modeling is rapidly evolving from an academic field into an applied instrument of global security and sustainable development. Accelerating climate change, the depletion of natural capital, and the rising frequency of extreme events of diverse nature and scale make the development of precise and reproducible models a shared priority for all states. The theory of ecosystem stability and resilience provides the conceptual framework for assessing permissible ranges of variation and the risks of shifts to undesirable states. In the twenty-first century, this framework is complemented by a digital practice of recovery, in which decisions are informed by data from satellites, sensor networks, unmanned systems, and geoinformation platforms.

The monograph advances an interdisciplinary integration of ecological-economic models, optimization methods, and contemporary ICTs, deliberately marrying academic rigor with managerial applicability. For countries at different income levels, comparability of indicators and transparency of methods are essential; these are ensured through standardized metrics and verification procedures. In the domain of climate adaptation for transport systems, cost and vulnerability models enable accurate attribution of climate-related expenditures and guide investment planning toward sustainable development objectives. At the agroecosystem level, the integration of field protocols, microbiological markers, and remote sensing makes evidence-based land-use and soil restoration decisions possible.

For aquatic ecosystems and broader environmental security, digital twins and robotic platforms are gaining prominence by ensuring continuity of observations and rapid response. Post-conflict and post-disaster territories require scenario-based remediation management, wherein models guide the transition from emergency sanitation to long-term recovery and revitalization. In such contexts, multi-criteria assessment, probabilistic modeling, and sensitivity analysis substantially enhance

decision quality under high uncertainty. Environmental indicators aggregated at community and regional scales enable the construction of hot-spot maps to prioritize the allocation of scarce resources. A critical direction, moreover, is coupling models with policy, translating quantitative analyses into regulatory norms, adaptation strategies, and investment plans.

Contemporary approaches call for end-to-end digital pipelines – "data → analytics → decision → contract → pay-for-results" – that ensure controllability and accountability. The synergy of ESG frameworks, legal technologies, and decision-support systems makes it possible to measure the effects of environmental projects while reducing investor risk. The circular-economy paradigm and shared mobility illustrate how models of demand, emissions, and resource savings can steer local initiatives with scalable impact. In parallel, models for the development of "green" skills are being designed to align education policy, business needs, and regional employment trajectories. A key challenge lies in bridging spatial and temporal scales, where local processes directly shape national and global outcomes.

In budget-constrained settings, methods that rapidly identify high-return leverage points and optimize portfolios of conservation projects are especially valuable. In this context, digital models for integrated governance of green remediation and the revitalization of post-war territories – drawing on social-entrepreneurship instruments, modern DSS, and LegalTech platforms are of particular importance. The growing availability of open data and computational power makes replication of the models proposed in this monograph, and their adaptation to local conditions, practically feasible for most countries. Taken together, these developments provide the foundation for evidence-informed policy and help to balance ecological limits with socio-economic objectives.

Accordingly, the studies presented in this monograph on ecological systems modeling transcend disciplinary boundaries, becoming the core of strategic risk governance and sustainable development. Collectively, they set the agenda for a scholarly and practical dialogue in which sustainability is treated as a computable property, and recovery – as a reproducible digital practice.