

Review of Adaptive Management Approaches

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Abstract

Despite CGIAR's efforts to implement the Pause & Reflect adaptive management approach, barriers to uniform application exist, necessitating a unified adaptive management protocol to optimize engagement and impact across programs. The review examines adaptive management, emphasizing its flexible, learning-based practices across complex environments. Two main schools of thought are identified: the Resilience-Experimentalist School and the Decision-Theoretic School. The former focuses on stakeholder collaboration, ecological models, and collective learning, emphasizing adaptability in complex systems through practices like Active Adaptive Management and Scenario Planning. This approach encourages resilience and utilizes institutional dynamics for transformation. Conversely, the Decision-Theoretic School employs structured decision-making and quantitative models, predominantly prioritizing predefined objectives and optimization under uncertainty. Approaches such as Structured Decision Making and Bayesian Adaptive Management characterize this school, advocating clarity and probabilistic reasoning. Key findings include the significance of organizational flexibility and participatory planning, iterative learning, and continuous monitoring across various case studies. The review highlights that while both schools aim to enhance management efficacy through iterative learning, Resilience-Experimentalist methods may better fit CGIAR's programs due to the methods' adaptability to complex and uncertain situations. We conclude that blending insights from both schools can foster a more robust adaptive management framework.

1. Introduction

Adaptive management is a structured, iterative approach to decision-making that emphasizes learning and adjusting management strategies based on the outcomes of implemented actions, particularly in complex and uncertain situations (Bormann et al., 1999; Williams & Brown, 2018). It's a "learn by doing" process where management practices are continually refined over time to improve effectiveness (Rogers & Macfarlan, 2020). This approach is especially useful in complex or uncertain environments such as in natural resource management and development projects (Walters, 1997).

CGIAR has attempted to institutionalize adaptive management through Pause & Reflect (P&R) and the Report-Reflect-Replan cycle since 2022 when implementation of the 33 Initiatives began (CGIAR, 2023). These mechanisms have enabled strategic re-orientation, such as refining scopes, enhancing stakeholder engagement, and reallocating resources. The P&R approach to adaptive management allows for critical evaluations of ongoing actions, increased adaptability to changing circumstances, enhanced learning, greater stakeholder engagement, and is cost-effective (Rogers & Macfarlan, 2020; Stringer et al., 2006). However, it is time-consuming, may require a change in organizational culture, may not be able to isolate the impacts of specific actions, especially in very complex and uncertain situations, has a huge potential for bias and requires skilled facilitation (Williams & Brown, 2018). This probably explains why the practice has remained decentralized and is not applied uniformly across programs and projects. Therefore, this review aims to understand the different approaches to adaptive management with the goal of informing the development of a unified adaptive management protocol that will standardize engagement, boost efficiency, and enhance impact across CGIAR.

2. Approaches to adaptive management

There are two schools of thought on adaptive management upon which most adaptive management approaches are based (MacFadden et al., 2011):

1. Resilience-Experimentalist School

- Emphasizes stakeholder collaboration and ecosystem resilience.
- Uses complex ecological models.
- Focuses on shared understanding before defining objectives.

2. Decision-Theoretic School

- Rooted in decision theory and structured decision-making (SDM).
- Uses simpler models focused on decision problems.
- Prioritizes defining objectives and actions before modeling.

The Resilience-Experimentalist School of adaptive management focuses on learning-by-doing in complex, dynamic systems, with an emphasis on resilience, flexibility, and experimentation in the face of deep uncertainty (Rist et al., 2013; Stantial et al., 2024). This school emerged from ecological thinking (notably C.S. Holling and the Resilience Alliance) and treats management as a social-ecological process involving stakeholders, institutional learning, and iterative policy adaptation (Johnson, 1999). The key approaches and conceptual tools, other than P&R, associated with the Resilience-Experimentalist School include the following:

1. Active adaptive management (with deliberate experimentation)

- Treats management actions as experiments to test hypotheses about how a system functions.
- Involves deliberate manipulation of the system to generate knowledge (not just passive monitoring).
- Emphasizes system feedback, thresholds, and the need to understand nonlinear dynamics.

2. Resilience thinking / panarchy framework

- Focuses on managing systems for resilience, i.e., the capacity to absorb disturbances and reorganize, while undergoing change.
- Uses the panarchy model, which views systems as linked adaptive cycles operating at multiple scales (e.g., ecological, economic, institutional).
- Encourages management for transformability and adaptability, not just optimization.

3. Social learning and participatory approaches

- Emphasizes the role of stakeholders, institutions, and collective learning in managing complex systems.
- Learning occurs not only through data but also through dialogue, trust-building, and shared experiences.
- Often implemented through collaborative governance structures and iterative stakeholder engagement.

4. Scenario planning and narrative-based exploration

- Recognizes that deep uncertainty and surprise are unavoidable in complex systems.
- Uses qualitative and quantitative scenarios to explore possible futures, build shared understanding, and foster flexible thinking.
- Less about optimization, more about robustness and preparedness for multiple plausible futures.

5. Transformative and reflexive governance

- Encourages institutional designs that can self-reflect, adapt, and transform in response to environmental change.
- Emphasizes reflexivity: continual questioning of goals, assumptions, and governance structures.
- Supports shifts in paradigms or system goals if needed (not just technical fixes).

6. Adaptive cycle and cross-scale interactions

- Management strategies consider the adaptive cycle: growth, conservation, release, and reorganization phases of systems.
- Encourages awareness of cross-scale interactions (e.g., how a local fire regime is affected by global climate policy).
- Helps managers understand windows of opportunity for transformation or intervention.

Table 1 summarizes the approaches under the Resilience-Experimentalist school.

Table 1: Summary of approaches under the Resilience-Experimentalist school

Approach / Tool	Core Feature	Purpose
Active Adaptive Management (Experimental)	Management as structured experiments	Test hypotheses and learn from interventions
Panarchy / Adaptive Cycle	Cross-scale system dynamics	Understand resilience and transformation
Social Learning / Participatory Process	Collaborative decision-making	Build shared understanding and trust
Scenario Planning	Exploration of multiple futures	Prepare for uncertainty and surprise
Reflexive Governance	Self-critical institutional design	Enable adaptation of rules and goals
Resilience Thinking	Focus on system capacity to adapt or transform	Manage for long-term sustainability

P&R as a Resilience-Experimentalist approach to adaptive management involves experimentation (i.e., stopping to assess results before adapting), incorporating feedback (both ecological and social) and building institutional memory (through reflection and documentation) (Rist et al., 2013; Williams & Brown, 2014). In a nutshell, the key characteristics of the Resilience-Experimentalist School include the following:

- Nonlinear, complex systems: Recognizes thresholds, feedback, and unpredictability.
- Emphasis on qualitative and participatory knowledge, not just quantitative models.
- Iterative learning focused on adaptability, not necessarily optimization.
- Embraces uncertainty as inherent and uses it to inform diverse strategies.
- Values institutional and social dynamics alongside ecological processes.

The Decision-Theoretic school is grounded in formal decision theory and emphasizes the use of quantitative models, structured decision-making, and probabilistic reasoning to inform management in the face of uncertainty (Bormann et al., 1999; Hasselman, 2017). This school is often associated with the work of Carl Walters, Steven Beissinger, and others who integrated Bayesian inference and decision analysis into adaptive resource management. The main approaches and tools under the Decision-Theoretic School include the following:

1. Structured decision making (SDM)
- A systematic approach that breaks decision problems into components: objectives, management alternatives, models, and uncertainties.
 - Emphasizes clarity and transparency in how decisions are made.
 - Often integrates expert judgment, stakeholder values, and quantitative models.
2. Dynamic optimization / stochastic dynamic programming (SDP)
- Uses models to identify optimal decisions over time under uncertainty.
 - Particularly useful in systems where decisions have delayed effects and future conditions are uncertain.
 - Requires explicit models of system dynamics and often a Markov decision process framework.
3. Bayesian adaptive management
- Incorporates Bayesian updating of model parameters and structural uncertainties as new monitoring data becomes available.
 - Treats management as an iterative learning process: prior beliefs (models and parameters) are updated with data to form posterior beliefs.
 - Helps compare alternative hypotheses about how systems work and improve management policies over time.
4. Partially observable markov decision processes (POMDPs)
- Extends dynamic programming to situations where the system state is not fully observable.
 - Useful in ecological contexts where monitoring is imperfect or costly.
 - Incorporates uncertainty about both system dynamics and observations.
5. Multi-model inference / model averaging
- Uses multiple competing models to represent uncertainty about system structure.
 - Decisions are based on a weighted average of model outputs, with weights updated using Bayesian or likelihood methods.
 - Encourages learning about which models are most consistent with observed outcomes.
6. Value of information (VOI) analysis
- A decision-theoretic tool that evaluates the benefit of reducing uncertainty through additional data collection or research.
 - Helps prioritize monitoring or experimental interventions that are most likely to improve decision outcomes.

Table 2 summarizes the approaches under the Decision-Theoretic school.

Table 2: Summary of approaches under the Decision-Theoretic school

Approach	Core Feature	Purpose
Structured Decision Making	Decomposes decision problems	Clarifies values, alternatives, uncertainties
Stochastic Dynamic Programming	Optimization over time	Finds best policies under uncertainty
Bayesian Adaptive Management	Probabilistic learning	Updates models/decisions based on data
POMDPs	Handles partial observability	Manages uncertainty in state estimation
Multi-Model Inference	Uses multiple models	Reflects structural uncertainty
Value of Information Analysis	Quantifies learning benefit	Guides research and monitoring priorities

These approaches are unified by their foundation in decision theory, their emphasis on model-based reasoning, and their goal of improving management via formal learning and feedback.

According to MacFadden et al (2011), success in adaptive management requires clear management objectives, stakeholder involvement, iterative learning and monitoring, and appropriate model complexity. In the context of CGIAR, it appears that approaches under the Resilience-Experimentalist school would be more applicable than those under the Decision-Theoretic school given the high level of programmatic, operational, and governance complexity associated with the organization's programs and projects, and the school's emphasis on iterative learning, stakeholder engagement and institutional dynamics. However, it could be even more beneficial to combine certain aspects of the two approaches in light of the governance, programmatic and operational integration of CGIAR.

3. Lessons learned from Resilience-Experimentalist approaches

Several notable organizations and projects have applied the Resilience-Experimentalist School of adaptive management, focusing on flexibility, deliberate experimentation, social learning, and resilience in practice. In this section, we explore key examples of these organizations, the approaches they have employed, and the lessons learned.

Peam Krasop Wildlife Sanctuary, Cambodia (IUCN-Panorama)

Approach: Co-management driven by local communities using iterative experimentation in mangrove restoration, alternative livelihoods, rainwater harvesting, and biodiversity enhancement.

Lessons ([Adaptive, community-driven and resilient co-management plan | PANORAMA](#); [Slide 1; 2014-037.pdf](#)):

- Participatory design fosters resilience across ecological and social systems.
- Iterative technical experiments inform and refine long-term planning
- Knowledge-sharing platforms help replicate good practices regionally and beyond.

Gungano Urban Poor Fund, Zimbabwe

Approach: Community-led financial resilience system where urban poor savings groups finance adaptation measures (e.g. flood-safe toilets, resilient housing), adapting based on need and context.

Lessons ([Delivering climate finance at the local level: the Gungano Urban Poor Fund | International Institute for Environment and Development](#); [locally-led-adaptation-from-principles-to-practice.pdf](#)):

- Local ownership and flexible financing empower real-time, bottom-up adaptation.
- Cultural and social structures are central to resilient interventions
- Strengthens long-term institutional capacity and self-led adaptation.

Buffelsdraai Community Reforestation Project, South Africa

Approach: Ecosystem restoration combined with community participation, evolving over time to restore forest buffers around a landfill and cluster livelihoods and biodiversity outcomes.

Lessons ([biodiversity climate change sustainable development technical report.pdf](#); [Ecosystem-based Adaptation in Durban, South Africa - the Buffelsdraai Community Reforestation Project | PANORAMA](#); [Green City Case Study: Durban, South Africa: Community Reforestation Programme • AIPH](#); [Restoration Resource Center South Africa: Buffelsdraai Reforestation Project, Iqadi](#)):

- Education and clear communication of purpose are essential – tree-entrepreneurs lacked awareness about climate benefits early on.
- Economic integration (e.g. marketable seedlings, agri-products) was key for sustainability.
- Projects must evolve from dependence on exchange systems toward economic autonomy.

Ashland Forest Resiliency Stewardship Project, USA

Approach: A long-term collaborative experiment (U.S. Forest Service, NGOs, local community) testing forest treatments to reduce wildfire risk, while monitoring ecological outcomes and adjusting methods.

Lessons ([AFR-Monitoring-Plan-2017-05-09-PDF](#); [Restor Case Study Case-14 Ashland-Forest High Rez.pdf](#); [Ashland RD, Rogue River-Siskiyou NF; Ashland Forest Resiliency Stewardship Project - Lomakatsi Restoration Project; Collaboration and stewardship authority: the Ashland Forest Resiliency project](#)):

- Science-informed experiments enable adaptive stewardship.
- Collaboration across institutions and stakeholders improves both ecological and social outcomes.
- Learning frameworks can guide refinement over long time horizons.

Room for the River Program, the Netherlands

Approach: Rather than just armouring riverbanks, managers experimented with floodplain restoration, bypass channels, flood absorption areas, and green infrastructure to create multifunctional resilience.

Lessons (<https://doi.org/10.3390/geosciences8060224>; [Room for the river | STOWA](#) ; [Room for the River](#); [Room for the River - Water Climate and Future Deltas - Utrecht University](#); [PowerPoint Presentation](#); [Room for the River – urbanNext](#); [303476.pdf](#)):

- Incremental, adaptive engineering can outperform inflexible infrastructure.
- Community and stakeholder engagement facilitate multifunctional uses (recreation, ecology, flood safety).
- Adaptive planning enabled flexible adjustments as environmental data emerged.

Table 3 summarizes the key lessons learned across the above cases.

Table 3: Common lessons across cases

Theme	Resilience-Experimentalist Principle	Practical Lesson
Experimental Learning	Field-based trials & iteration	Start small, learn fast, and scale what works
Community & Social Learning	Local participation in design and judgment	Shared ownership fosters legitimacy and feedback
Flexibility & Feedback	Phase-wise implementation with monitoring	Regular check-ins help pivot away from failing strategies
Institutional adaptability	Governance that embraces change & uncertainty	Leadership that supports adaptation is crucial
Economic viability	Economic self-reliance of beneficiaries	Financial incentives and market integration improve sustainability
Holistic framing	Integrating ecological resilience and social resilience	Projects must address both natural and societal dynamics

These cases exemplify the Resilience-Experimentalist School because of:

- Deliberate experimentation: each involved structured pilots, learning loops, and adjustments based on outcomes.
- Stakeholder-centred social learning: local institutions and citizens were central to decision making.
- Focus on system-level resilience: not optimizing a single variable, but maintaining flexibility, transformability, and robustness across feedback.
- Adaptation over time: projects evolved in response to new information and changing conditions.

In Summary, these organizations and initiatives illustrate how resilience theory and experimentalist approaches manifest in practice because:

- They prioritize actionable learning, not just theoretical models.
- They ground adaptation in local context and participation.
- They pursue transformations over optimization.
- They often yield multiplying benefits – ecosystem restoration, livelihood improvement, and institutional capacity.

4. Conclusion and implications for scaling CGIAR innovations

Blending resilience-experimentalist and decision-theoretic approaches to adaptive management can significantly strengthen the adaptive capacity of CGIAR, which operates in dynamic, uncertain, and cross-scalar contexts (e.g., food security, climate change, biodiversity). Each approach offers complementary strengths. For instance, the resilience-experimentalist approach enables systems thinking, capacity to deal with deep uncertainty, stakeholder inclusion, and building resilience in social-ecological systems, while the decision-theoretic approach is relatively strong in structuring decisions, modeling uncertainty, defining objectives, and managing risk in complex trade-offs. It is important for CGIAR to combine them because it must navigate both strategic uncertainties (e.g., climate change and policy shifts) and operational decision-making (e.g., resource allocation and program design). This will lead to strategic robustness (in terms of resilience thinking), operational efficiency and accountability (decision theory) and deliberate learning loops at both local and international scale. Table 4 shows how the two approaches can be leveraged to address the different challenge areas of CGIAR.

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