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CONCEPTUAL METHODS ARTICLE

# Sustainability in Public Policymaking Through Accountable Environmental Budget Reallocation

*A protocol for preserving protection responsibilities when public projects change*

**Rainer Tan**
Hebrew University of Jerusalem

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**ABSTRACT**

Purpose. Budget reallocation can leave environmental duties unresolved even when project accounts balance. Approach. A purposive literature synthesis, a limited supplementary search and a synthetic five-year case inform an audit of responsibility, prospective coverage and historical terms. Findings. A reconstructed checker matched eight stipulated case outputs and passed 24 internal consistency checks. The worked case illustrates supported prospective coverage for a restricted binding set alongside an owned shortfall for a discretionary emissions target. Contribution. The audit specifies records for reconstructing duty dispositions, coverage intervals, historical terms and response ownership. Limits. Shared AI-assisted development of the cases and checker limits the evidence to internal consistency. Independent assessment and field testing remain necessary.

KEYWORDS Sustainability, public policymaking, environmental accountability, budget reallocation, adaptive governance, distributional justice

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## Introduction

A public agency can balance a revised budget while leaving a protection duty unresolved. Replacing a wetland project, postponing emissions reduction or substituting a temporary restriction changes who is protected and when. This paper asks what an agency must retain and reassess when its chosen response changes.

Climate and ecological pressures interact across sectors (Intergovernmental Panel on Climate Change [IPCC], 2023; Richardson et al., 2023; Rockström et al., 2023). Nexus and resource assessments reinforce the need to examine those connections (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services [IPBES], 2024; United Nations Environment Programme & International Resource Panel, 2024). The allocation ranking remains local to the mandate and evidence. The narrower problem here is preserving identifiable responsibilities through a material portfolio change.

The intended users are agencies and public partnerships with authorised objectives, identifiable owners and an oversight forum. The audit records the successor state of each duty, the support for protection over time and the terms applicable to earlier delivery. These records enable scrutiny of whose protection changes and which body must answer for a shortfall.

### Conceptual approach and contribution

The study develops a conceptual audit protocol through purposive literature synthesis, worked scenarios and checks on synthetic records. The unit of analysis is a material change between budget portfolio versions. The supplementary search was a limited discovery exercise. Its results illustrate relevant approaches and cannot establish comprehensive coverage.

A search summary dated 2 November 2026 documents three queries: “environmental budgeting accountability”, “conservation transition adaptive management” and “requirements traceability environmental audit”. After access to Elicit was denied, the search used OpenAlex through Scholar. The reported settings limited retrieval to the first five results per query, ranked by relevance, with a publication cutoff of 2 November 2026. The three queries reportedly returned five, four and two records.

Eligible sources addressed environmental allocation, conservation implementation, responsibility, historical baselines or institutional challenge. The search summary reports 11 unique records. Five were excluded on title or abstract, one for unavailable full text, and five were retained. The original export and item-level screening log are unavailable, so the counts and decisions cannot be independently verified.

Extraction covered decision function, unit of analysis, records, timing, authority and accountability.

Single-pass screening, English search terms, relevance ranking, the five-result cap and full-text access limit coverage. The retained sources are illustrative.

Separate checks of Conservation Standards Version 5.0 (Sections 2C and 4C), NASA requirements management and OECD green-budgeting guidance informed the comparison with established approaches. Table 1 relates these and other sources to the audit conditions.

**Table 1 Derivation of the audit conditions**

| Decision problem | Design basis | Proposed requirement and diagnostic test |
|---|---|---|
| A project ends while its protection duty continues. | Requirements traceability and post-project accountability (Mills-Novoa, 2023; NASA, 2023). | Retain an authorised successor state for each duty. Test deletion after cancellation and referral without acceptance. |
| A funded successor starts after temporary protection expires. | Adaptive pathways and operational planning (Conservation Measures Partnership, 2025; Haasnoot et al., 2013). | Assess every required interval under admitted scenarios. Test commissioning at month 9 after month-8 bridge expiry. |
| A later amendment conceals an earlier failure. | Controlled requirement baselines and answerability to a forum (Bovens, 2007; NASA, 2023). | Retain effective dates and superseded terms. Test deletion of a target and its earlier shortfall. |
| Budget reporting obscures undelivered protection. | Green-budgeting accountability and implementation (OECD, 2024a, 2024b). | Separate expenditure, prospective coverage and observed delivery. Test retained climate responsibility alongside authorised deferral. |

Multicriteria assessment and structured decision making connect objectives, alternatives, consequences and preferences (Belton & Stewart, 2002; Gregory et al., 2012). Safe minimum standards address potentially irreversible loss, subject to their social-cost qualification (Berrens, 2001). Adaptive management and policy pathways connect monitoring with changes in action (Haasnoot et al., 2013; Williams, 2011). Robust decision making examines alternative futures where reliable probabilities are unavailable (Lempert et al., 2003; Polasky et al., 2011).

Following the proportionate orientation of conservation decision science (Hemming et al., 2022), the audit should reuse existing systems and add only missing relationships.

Adaptive pathways and habitat-management frameworks address changing conditions and recurrent decisions (Haasnoot et al., 2024; Kwakkel et al., 2015; Nichols et al., 2024). Thames Estuary 2100 illustrates staged decisions and periodic review (Environment Agency & Department for Environment, Food & Rural Affairs, 2023). These sources establish relevant functions, not evidence that existing practice routinely loses duties.

Conservation Standards includes transition planning and adaptation of plans and budgets with documented reasons (Conservation Measures Partnership, 2020, 2025). Version 5.0 explicitly addresses these functions on pages 53 and 72. The proposal joins established functions into an assurance specification at a material budget change.

The protocol brings four elements together at the point of a budget change: the disposition of each duty, coverage over time, the terms applicable to earlier delivery and responsibility for addressing shortfalls. Table 2 situates this contribution within established approaches.

## Closest precedents and scope of the contribution

Post-project accountability and Strategic Adaptive Management already address continuity, review and learning (Mills-Novoa, 2023; Roux et al., 2025). The proposed audit focuses on the authorised transition between portfolio versions, including duties surviving a cancelled intervention.

Requirements traceability and controlled changes predate the proposal (National Aeronautics and Space Administration [NASA], 2023). Table 2 compares established approaches and the particular records used at a material environmental budget change.

**Table 2 Relationship to established decision approaches**

| Established approach | Existing contribution | Proposed implementation detail |
|---|---|---|
| Structured decision making and multicriteria assessment | Objectives, alternatives, consequences, constraints and preferences | Retain an obligation identifier across changed project selections |
| Adaptive management and policy pathways | Monitoring, learning, thresholds and switching decisions | Link detection, decision and delivery dates to each coverage interval |
| Conservation Standards Versions 4 and 5 | Operational planning includes transition strategy. Adaptation includes budget changes and documented reasons. | Join those functions in a dated audit of continuing duties and protection intervals. |
| Existing organisational registers | May already provide all required safeguards | Audit equivalence first and add only missing links or approval fields |
| Post-project adaptation and Strategic Adaptive Management | Continuity, community assessment, accountability and recurrent learning | Apply explicit checks to a portfolio change, while retaining community and technical scrutiny |
| Requirements traceability and change control | Requirement identity, verification links and controlled baseline changes | Check environmental protection intervals and shortfalls alongside responsibility continuity |

Ünkaracalar's (2026) Green Budget Accountability Framework connects strategic alignment, expenditure classification, performance and external scrutiny. The protocol developed here works at the level of an individual portfolio change. It specifies how the disposition of a duty, evidence for its coverage and the terms governing earlier delivery can be traced across successive portfolio versions.

Simon et al. (2011) found different patterns of audit integration across four organisations, illustrating why the assessment examines the records a system produces. The term "transition" in this article refers to a dated change between portfolio versions. Transition management at the regime level concerns a broader institutional process (van der Brugge & van Raak, 2007).

## Public accountability and policy authority

Bovens (2007) defines accountability through an actor's duty to explain conduct to a forum able to question, judge and impose consequences. A register supplies evidence for that relationship. The audit must identify the forum, its information access and its actual powers.

A material change record identifies beneficiaries, burden bearers and groups whose protection is delayed. It includes a proportionate public summary, a route to contest omissions and a dated response. Where information is restricted, the existence and reason for restriction remain visible.

The audit reports technical coverage, political authorisation and institutional assurance separately. A technically feasible plan may distribute burdens unfairly, and an authorised plan may rest on weak evidence. A complete record makes these differences visible for scrutiny.

The institutional finding records any limits on review independence, information access or response powers. Even where prospective coverage is supported, these limits can reduce the forum's ability to act on a finding.

## Public budgeting and institutional incentives

Green budgeting connects the audit to public finance. The Organisation for Economic Co-operation and Development (OECD, 2021) places tagging within wider evidence and oversight arrangements. Later analysis identifies inconsistent treatment of tagged information across budget stages and explains the limits of expenditure classification as evidence of delivery (OECD, 2024a). Implementation also depends on institutional arrangements and administrative capacity (OECD, 2024b).

The proposed mechanism has three links.

A preserved baseline makes a departure identifiable.

An attributed decision identifies the decision-maker accountable to the oversight forum.

A forum with response powers can require reconsideration or correction.

The first two links are documentary.

The third depends on institutions.

The predicted benefit is therefore conditional on both usable records and an effective forum.

Publication without those powers may expose a departure while leaving the decision unchanged.

A sponsor may favour an optimistic schedule, a narrower scenario set or a weaker target. Separating sponsorship from evidence assessment allows consequential changes to receive scrutiny. Where practicable, an assessor outside

the delivery chain evaluates the evidence, and an oversight forum can require a response within the agency's mandate (OECD, 2015).

The record for a disputed exclusion or amendment retains the evidence, sponsor's reasons, original terms, effective date and dissent. Assessment under both the original and proposed terms shows whether the dispute affects the decision. A material difference and its distributional consequences are considered before approval.

Affected groups need notice and assistance while correction remains possible. Silence is not agreement. The body answers material objections and names the reconsideration route. Emergency procedures may be shorter but retain reasons, duration and review deadlines.

Voß and Bornemann (2011) draw attention to conflict, unequal power and capture in learning-oriented governance. In this protocol, recordkeeping makes departures visible, while the authority and independence of the oversight forum shape what can be done about them. The value of separating these roles remains a question for empirical evaluation.

## Decision mandate and protection requirements

The decision owner fixes the boundary, budget period, horizon and authority. A risk pathway connects pressure, receptor and consequence. An intervention acts on that pathway. An obligation states the authorised protection requirement. Cancelling the intervention does not itself change the requirement.

Each obligation states its receptor, endpoint, threshold, required period, evidence standard, owner and authority. Legal duties follow jurisdiction-specific amendment and exception rules. Adopted standards require an authorised amendment process. Discretionary commitments remain reviewable but visible. Affordability changes available responses rather than the severity of the risk.

The risk assessment considers consequence, persistence, reversibility, propagation, timing and vulnerability. It reports likelihood separately from confidence in the evidence so that gaps in monitoring remain visible. Shared endpoints are mapped before benefits are aggregated to avoid double counting.

The assessment distinguishes recoverable disruption from irreversible loss and uses statutory thresholds where applicable. Otherwise, specialists propose thresholds through an authorised process that documents the rationale, affected interests and routes for challenge. Co-benefits are assessed separately from compliance with binding protection requirements.

Participation includes those exposed to harm and those bearing response costs (Koh, 2024; Reed, 2008). The protocol assigns coordination responsibility for displaced pollution, imported resource effects and consequences beyond the assessment horizon. Coastal retreat illustrates why distribution and timing need early attention (Haasnoot et al., 2021).

## Timing and continuous coverage

All dates share an explicit origin. The notation [a,b) includes the start a and excludes the end b. For example, [0,8) ends at the handover boundary at month 8, when successor protection must take effect. For pathway i and intervention j, $H_i$ is the deadline for effect, $L_{i,j}$ is elapsed time from authorisation to effect and $B_{i,j}$ is an evidenced allowance for additional delay. The latest effective authorisation date is $S_{i,j} = H_i - L_{i,j} - B_{i,j}$. Use zero allowance unless evidence justifies a separate allowance.

## Linked records and change control

Five linked records describe the decision: risk (R), obligation (O), intervention (I), portfolio (P) and shortfall (U). In the worked case, NUT identifies the nutrient duty and CLIM the climate commitment. E identifies an evidence record and CN a change note. Persistent identifiers and dated versions preserve links, evidence, authors, approvals and effective dates. Table 3 defines the record types and Table 5 shows their use.

Let M denote the next ordinary decision date. Class A applies when ongoing serious harm needs stabilisation or Sij is on or before M. Class B applies when Sij follows M but falls within the horizon. Class C applies when neither condition is established and strategic review remains appropriate. Unknown timing remains unresolved. Classification concerns an intervention, not a permanent ranking of crisis categories.

Passing Sij removes the original timing assurance. Reassessment must show whether the endpoint remains attainable and whether consuming any allowance is authorised. The allowance cannot be silently reduced. If no credible route protects the endpoint in time, retain the duty, record the shortfall and escalate alternatives.

For example, a month-6 deadline, one-month delivery and one-month allowance give Sij = month 4. Authorisation at month 4.5 could produce effect at month 5.5 but no longer preserves the allowance. A missed precautionary start differs from a missed endpoint deadline.

For interval inputs, an outer latest-start range is [Hmin − Lmax − Bmax, Hmax − Lmin − Bmin].

This is a bound rather than a probability interval.

Dependent inputs require jointly plausible scenarios.

An effect deadline of months 5–7 and delivery of 2–4 months, with B = 0, gives months 1–5.

If the earliest deadline and longest delivery are jointly credible, a precautionary rule uses month 1.

An ordinary meeting at month 3 then requires earlier delegated authorisation.

For each obligation o, interval j, admitted scenario s and portfolio P, define C(o,j,s;P) as supported, unsupported or unresolved.

Supported means that effectiveness evidence, authority, resources and capacity jointly justify coverage throughout that interval.

Unsupported means that the available evidence establishes a missing necessary condition or a protection gap.

Unresolved means that evidence is missing, disputed or inadequate to decide.

Both prevent a prospective pass, but only unsupported establishes a known failure of the proposed route.

The assessment partitions time at events that can change protection, including authorisation, mobilisation, commissioning and expiry. Where effectiveness may deteriorate within an interval, a finer partition allows authority, operating resources and capacity to be assessed over the relevant periods.

The evidence period follows the protection endpoint. A monthly mean and an acute limit require different assessment periods. A finding of continuous coverage requires a credible protective arrangement throughout the required period. Intermittent samples support only the inferences justified by the sampling design.

**Table 3 Minimum linked records**

| Record | Required content |
|---|---|
| Risk R | Identifier and version, pressure, receptor, consequence, causal links, timing, evidence and assessor |
| Obligation O | Persistent identifier and version, endpoint, threshold, required period, authority, owner, evidence and closure conditions, obligation status and linked delivery assessments |
| Intervention I | Identifier and version, linked obligations, effectiveness, cost and payment dates, delivery timing, operator, authority, expiry and delivery evidence |
| Portfolio P | Identifier and version, predecessor, interventions, budget, approval set, admitted scenarios, preferences, separate completeness and protection findings, approver, decision date and review triggers |
| Shortfall U | Identifier and version, linked obligation and portfolio, unmet requirement, consequence, uncertainty, gap, mitigation, escalation owner, deadline and closure conditions |

Obligation state is active, transferred or discharged. A discharge record must distinguish fulfilment from lawful termination. Fulfilment requires evidence that the protection requirement and its closure conditions were satisfied over the full required period. Lawful termination ends the duty prospectively through a competent authority’s explicit decision, with grounds and an effective date. It does not establish fulfilment or erase earlier delivery failures. Amendment normally creates new terms under the same active identifier. All dispositions retain historical records.

A substantive change to the endpoint, threshold, period, authority, owner or closure conditions creates a new version. Sampling and installation updates create dated assessments linked to the applicable version. Superseded terms remain retrievable.

Keep implementation stage, coverage judgement and approval conditions separate. Implementation may be planned, delivering, suspended or completed. Coverage uses supported, unsupported or unresolved. A pending approval condition blocks its dependent action. Scheduled commissioning can be part of an evidenced plan, but a test with no credible protection route or executable fallback leaves the relevant coverage unresolved.

Follow every affected link when one intervention serves several duties or several interventions serve one endpoint. Count shared benefits once. A shared installation needs endpoint-specific evidence for each duty it is claimed to satisfy.

A change is material when it can alter an endpoint, required period, authority, coverage, affordability or distributional burden. The responsible officer follows affected links, reassesses protection and assigns unresolved items before approval. Minor corrections can be logged without reopening unaffected findings.

Closure evidence states its producer, date, method, uncertainty and assessed period. Consequential closure should receive independent technical scrutiny where available. Transfer requires acceptance, an effective date and a credible receiving route. Responsibility remains with the predecessor until that date.

Record completeness concerns the presence and linkage of required fields and records. Prospective coverage concerns whether the evidence supports protection for a specified duty, period and admitted scenario. Observed delivery concerns measured performance in elapsed periods against the terms in force at the time. Institutional assurance concerns the review forum’s independence,

information access and ability to require a response. Report each finding separately, with its scope, date, applicable version and evidence.

Before options are compared, the authority specifies approval set Q, the duties for which prospective coverage must be supported. Q includes applicable legal duties, adopted standards in force and discretionary commitments designated as conditions of approval. Other active commitments remain visible with their owners, forecast or observed shortfalls and review dates. A discretionary departure requires separate authorisation, and a partial approval identifies the duties and periods it covers.

To justify a coverage finding, a technical assessor checks the evidence against the obligation’s endpoint, threshold, location and period. Record the method, date, applicability, uncertainty and any conflicting evidence. Finance and delivery officers confirm resources and mobilisation dates for the same period. The responsible authority officer checks the delegation or legal instrument, its scope, effective date and conditions. Where a required basis is missing or materially disputed, mark coverage unresolved and record what would resolve it, who owns that action and when review must occur. A record may pass a field check while its prospective coverage remains unresolved.

## Conditions for a valid transition

Responsibility continuity requires every previously active obligation to have an authorised successor state. Let A(k) be the active identifiers in portfolio version k. Let D(k+1) contain those with valid discharge evidence identifying fulfilment or lawful prospective termination, and T(k+1) those transferred to a named receiving register. The identity check is A(k) ⊆ A(k+1) ∪ D(k+1) ∪ T(k+1). For this check, each predecessor has one effective disposition at the decision date. Future transfers remain active until their effective date. Amended duties stay in A under their retained identifiers. Evidence review must validate each claimed disposition.

Protection continuity requires supported coverage for every required duty, interval and admitted scenario. For each unsupported or unresolved interval, the record identifies the shortfall, its consequences, its owner and the review trigger.

Either finding prevents a supported overall approval result for the relevant set.

Historical continuity retains the terms applicable when delivery occurred. Later amendment, transfer or commissioning cannot remove earlier shortfalls or their mitigation history. This is a governance rule, not a universal determination of legal liability.

For approval set Q, let J(o) partition each required period at events capable of changing protection, and let S contain the admitted scenarios. Prospective coverage passes only if C(o,j,s;P) = supported for every o in Q, j in J(o) and s in S. Intervals use a consistent boundary convention, including assessment of the final endpoint where required. Refine intervals when conditions can deteriorate within them. The finding depends on the adequacy of the identified duties, scenarios and evidence.

The three conditions address distinct but overlapping failure modes within the stated audit question. Responsibility continuity examines whether each duty has an authorised successor state. Protection continuity examines coverage across required periods. Historical continuity preserves the terms against which earlier delivery is assessed. A change can fail more than one condition. For example, deleting a duty can fail both responsibility continuity and protection assessment when that duty remains in approval set Q. The conditions provide separate audit questions without a claim of logical independence. Their joint satisfaction establishes only the declared audit result.

Validity of a finding additionally requires a justified duty boundary, competent authority, adequate evidence and a defensible scenario set. These are inputs and quality requirements for applying the continuity tests. Missing authority or resources can also make a protection interval unsupported. New or displaced risks must enter the boundary review because the predecessor identity check cannot discover them automatically.

Institutional independence, access, participation and response powers concern whether a valid finding can be challenged and acted upon. Record these separately from continuity results. Weak oversight does not logically prove a physical protection gap, but it limits the credibility of institutional assurance. Conversely, strong oversight cannot make an infeasible protection route pass. This separation prevents technical feasibility, authorisation and practical accountability from being reported as a single success.

The following sequence describes how an agency applies the protocol at a material budget change.

1. Identify the changed intervention and follow its links to every affected obligation, including shared endpoints.

2. Confirm the approval set, authority, decision horizon and admitted scenarios before comparing alternatives.

3. Assess resources, authorisation dates and coverage intervals for each candidate, including bridges and executable fallbacks.

4. Compare the feasible candidates using the authorised preferences. Retain excluded alternatives and the reasons for exclusion.

5. Record separate completeness and protection findings, the approval decision, and an owner and response deadline for each shortfall.

6. Monitor the approved route, reopen assessment on a material trigger, and close or transfer responsibility only when the stated evidence conditions are met.

## Scenario selection and portfolio decisions

A scenario is eligible for admission when it could change protection, cost, timing, authority or distribution and its mechanism is supported by evidence, a justified bound or reasoned expert judgement. The scenario record identifies dependent inputs and applicable periods.

Affected representatives may propose omitted pathways. Before comparison, the authorising body approves the admitted scenario set S and the precautionary rule. For each proposed scenario, the assessor records the causal mechanism, plausible bounds, dependent inputs, evidence sources, affected intervals and whether inclusion can change the decision. The body retains exclusions and dissent with reasons. A dated change event reopens the decision when material new evidence changes the scope or result.

The comparison identifies feasible portfolios before applying authorised preferences. An option is treated as dominated only when outcomes, costs and uncertainty can be compared consistently. Incomparable options remain visible. Scoring discretionary choices requires justified scales and sensitivity analysis. Ordinal ratings require an explicit aggregation rationale.

The outcome owner answers for the duty, the delivery owner manages implementation, assessors judge evidence and the authorising body approves commitments. Combined roles require conflict disclosure. A closing response window takes priority over the ordinary review schedule.

If no feasible portfolio remains, examine phasing, temporary measures, regulation and inter-agency support. Record the gap, consequences, escalation owner and deadline. Any emergency or exception decision must use actual authority and retain unmet duties. It cannot be reported as admissibility under the original mandate.

## Economic interpretation and allocation boundaries

A public budget constrains financing, not total social cost. Separate public expenditure, private resource costs, transfers and distributional effects. Transfers affect financial accounts without necessarily consuming additional resources. Real appraisal also considers opportunity cost and timing (HM Treasury, 2026). This guidance does not set environmental thresholds or confer authority.

The synthetic example uses constant purchasing-power budget units and reports private restriction burdens separately. Base packages are prepaid at month 0, including operation and monitoring. The extension replaces that financing assumption. No welfare optimum or benefit–cost ratio is estimated.

## Worked synthetic application

All costs, thresholds, delivery times and effectiveness values below are invented. They establish conditional audit findings, not real-world prevalence or performance.

An authority has 100 public budget units, delegated authorisation at month 0 and an ordinary committee meeting at month 3. Water protection costs 20 and provides uninterrupted safe service through month 60 under stipulated demand. Wetland protection costs 30, takes 2–4 months and must be effective before a loss deadline between months 5 and 7. An enforceable standstill protects habitat during mobilisation. With no additional allowance, the precautionary latest start is month 1 when the earliest deadline and longest delivery are jointly credible. All candidate portfolios authorise wetland work at month 0. The wetland duty requires continuous protection over [0,60). The standstill is assumed effective until verified handover, and the permanent measure is assumed funded and effective from handover through the end of the five-year assessment period.

Obligation O-NUT-01 requires a monthly time-weighted nutrient concentration no greater than 1.0 normalised unit at point N over months 0–60. Permanent control costs 40 and takes four months to verified effect. An immediately deployable bridge costs 10 and protects [0,8). The separate contracts are non-refundable and include the specified monitoring. After month 8, an authorised restriction can maintain the threshold, at an illustrative private burden of 20 units through month 60. These stipulations establish alternative routes for comparison. Physical units, acute limits and evidence quality would require specification in practice.

Table 4 compares four allocations under the stipulated cost and protection assumptions. The following section applies the linked records in Table 3 to the change from the restriction-dependent portfolio to permanent nutrient control.

**Table 4 Initial base portfolios over the five year horizon**

| Portfolio | Public units | Private burden | Discretionary benefits | Nutrient protection route |
|---|---|---|---|---|
| D | 90 | 20 | Transport retained. No enhancement. | Bridge over [0,8) months, then restriction through month 60. |
| E | 100 | 20 | Transport retained. Water resilience added. | Same bridge and restriction as D. |
| F | 100 | 20 | Transport retained. Habitat enhancement added. | Same bridge and restriction as D. |
| G | 100 | 0* | Transport deferred. No enhancement. | Bridge during installation. Permanent control effective at month 4. |

Note. All figures are synthetic. Public units are prepaid package costs. The private burden is the stipulated cost of the extended restriction, not a complete social-cost estimate. Zero for G means no extended-restriction burden. Bridge protection runs to month 8 in every candidate.

Before comparison, the fictional authority adopts this ordering: avoid the extended restriction where minimum protection remains feasible, then improve resilience for the vulnerable group, then improve additional habitat condition. G is preferred among the four candidates under that rule. E outranks F within the restriction-dependent candidates. The rule is a stipulated policy preference, not a scientific finding or welfare optimum. Selecting G requires separately authorised transport deferral and retention of its unmet emissions target.

The ranking is conditional on those priorities. A decision-maker who gives greater weight to transport emissions reduction after minimum protection is secured could rank the options differently.

Three sensitivity changes expose different boundaries. Increasing wetland cost to 45 makes D cost 105 and G cost 115, leaving none of the four affordable. Removing legal authority for the restriction makes D, E and F prospectively inadmissible while G retains its assumed permanent route. Delaying permanent commissioning to month 9 leaves G with an unsupported interval [8,9), despite its unchanged 100-unit budget. Each result depends on a specified assumption and requires a new finding.

## Continuous protection and deferred climate benefits

For the transition audit, the restriction’s authority is unresolved. P-01, based on D, therefore has unresolved prospective nutrient coverage after month 8 and fails the prospective approval test. P-02 instead funds G: water 20 + wetland 30 + bridge 10 + permanent control 40 = 100. The nutrient duty retains its identifier and terms. Table 5 records the transition and links the water and wetland coverage findings to their stipulated evidence.

Waiting until month 7 to detect the need for replacement, with one month for decision and four for delivery, produces effect at month 12. To meet month-8 bridge expiry, detection and initiation must occur by month 3, authorisation by month 4 and verified effect by month 8. P-02 avoids that delay by authorising at month 0 and planning effect at month 4.

The planned overlap [4,8) supports the base transition under the stipulated effectiveness, funding and timing. Month-4 commissioning checks delivery. Failure reopens assessment. Effect at month 8 requires a verified handover at that boundary. Effect at month 9 leaves [8,9) unprotected.

Transport is recorded as discretionary commitment O-CLIM-01. It would reduce operational emissions by 100 tonnes of carbon dioxide equivalent annually against an unchanged 1,000-tonne annual baseline from month 0. The five-year reduction target is 500 tonnes. A six-month delay without catch-up loses 50 tonnes and leaves 450 tonnes within that horizon. These values exclude displacement and life-cycle effects and establish no net-benefit claim.

For a delay $d \geq 0$ months, the forgone reduction is $100 \times \min(d,60) / 12$ tonnes, assuming subsequent uninterrupted delivery and no catch-up. An unfunded delay lasting the full horizon therefore forgoes 500 tonnes. Six months is an analytical illustration, not an approved restart. The climate owner updates the forecast and distinguishes future reductions at risk from shortfalls already realised.

The authority approves transport deferral at month 0 and requires the climate owner to present a funded substitute, revised schedule or justified amendment at month 3. P-02 has supported prospective coverage for Q, which contains water, wetland and nutrient protection. O-CLIM-01 remains active outside Q with its original 500-tonne target. U-CLIM-01 records the forecast shortfall, owner, consequence, month-3 review and escalation. The 50-tonne loss represents a six-month delay scenario. A full-horizon unfunded deferral would put 500 tonnes at risk. The owner records observed forgone reductions separately as they accrue. A binding climate condition

would change Q and prevent a supported finding for the original set.

Table 5 uses fictional evidence labels for the records needed to reconstruct this decision.

**Table 5 Linked records for the audited portfolio transition**

| Record and version | Decision content | Ownership and evidence |
|---|---|---|
| O-WET-01 v1 retained | Required protection over [0,60). The standstill covers mobilisation until verified handover in months 2–4, before the earliest month-5 loss deadline. The 30-unit package is assumed to fund effective permanent protection from handover through the end of the period. | Habitat lead. Worked synthetic application specifies the standstill, delivery range and loss deadline. |
| O-WAT-01 v1 retained | Safe water service over [0,60) under stipulated demand. Funded at 20 units. | Water director. Worked synthetic application specifies the funded package and continuous service premise. |
| R-NUT-01 v1 at month 0 | Nutrient loading threatens N during months 0–60. Linked to O-NUT-01. | Technical lead. E-01 is a stipulated loading and effectiveness scenario note. |
| O-NUT-01 v1 retained in P-01 and P-02 | Monthly mean ≤1.0 over months 0–60. Active non-waivable approval constraint in this case. | Water director. E-02 contains the assumed mandate and sampling specification. |
| I-BRIDGE-01 v1 | 10 prepaid units. Protection [0,8). Linked to O-NUT-01 and P-02. | Operations manager. E-03 stipulates immediate availability, capacity and funded operation. |
| I-PERM-01 v1 | 40 prepaid units. Authorise month 0. Effect month 4. Operate through month 60. | Engineering manager. E-04 specifies contract, capacity, tests and operating resources. |
| P-01 v1 superseded at month 0 | Record complete. Nutrient coverage after month 8 is unresolved because restriction authority has not been established. P-01 therefore fails the prospective approval test. | Committee chair records rejection at month 0. E-05 retains reasons. Review before any replacement authorisation. |
| P-02 v1 authorised at month 0 | Public allocation totals 100 units. Q contains O-WAT-01, O-WET-01 and O-NUT-01, each with supported prospective coverage under the stated premises. O-CLIM-01 remains active outside Q and is linked to U-CLIM-01. | Committee chair approves at month 0 through E-06. Review at month 3 and before any trigger closes the response window. Transport deferral separately authorised. |
| O-CLIM-01 v1 at month 0 | Active discretionary target of 500 tonnes avoided over months 0–60. Delivery forecast deficient after deferral. | Climate director. E-08 records the original target, deferral authority and month-3 review. Linked to U-CLIM-01 and P-02. |
| U-CLIM-01 v1 at month 0 | Original 500-tonne target remains active. The unfunded restart creates a forecast shortfall. Six months of delay would forgo 50 tonnes. Record elapsed losses separately as observed delivery evidence becomes available. | Climate director. Present funded response at month 3. Update loss estimate as delay changes. Escalate before any closing response window. |
| Planned month-4 transition | Record commissioning assessment against O-NUT-01 v1. Installation closure leaves the continuing duty active. | Water director and technical reviewer. E-07 is scheduled commissioning evidence. Create a new obligation version only if its substantive terms change. |

## Comparison under the same decision information

The comparator combines structured decision making with an operational plan, risk register and controlled change log. Table 6 uses the same synthetic facts to compare the records produced by those controls with the records specified by the audit.

Both approaches reject reliance on the restriction while authority is unresolved, identify the commissioning gap and retain the deferred climate commitment. The difference lies in how explicitly the underlying evidence, dates and responsibilities are linked.

Where existing records contain equivalent links, both approaches can support the same findings. The proposed evaluation examines whether the protocol improves timely correction, retrieval accuracy or effort where those links are missing or dispersed.

**Table 6 Comparison of illustrative records under identical information**

| Case | Competent comparator entry | Specified audit entry |
|---|---|---|
| Restriction authority not established | Reject D after month 8. Use G under the authorised preference. | Retain O-NUT-01. Mark restriction-dependent intervals unresolved. Record rejection P-01 and supported replacement P-02 with linked authority evidence. |
| Permanent effect moves to month 9 | Schedule and risk log identify a gap after bridge expiry. Reject the revised route. | C(O-NUT-01,[8,9),s;P) = unsupported. Retain the duty and link the gap to an owned shortfall. |
| Transport is deferred | Change log retains original target, deferral reasons and climate owner. | Retain O-CLIM-01 at 500 tonnes and U-CLIM-01. Report protection pass only for the declared binding set, with forecast climate deficiency. |
| Target is amended at month 6 | Controlled baseline retains old and new targets with effective dates. | Link both obligation versions. Assess elapsed periods against the applicable original terms and retain earlier shortfalls. |

## When the audit adds information

The proposed audit assesses traceability by reconstructing a recent material budget change. Each required link is classified as readily retrievable, dispersed across records, or absent. Missing obligation dispositions or coverage intervals can conceal a break in protection. Dispersed records may increase retrieval effort, which can be measured through usability testing. Existing controls provide equivalent assurance when they support the same findings with comparable effort. Green-budget tagging and programme-level accountability support expenditure classification and scrutiny (OECD, 2021, 2024a; Ünkaracalar, 2026). The transition record complements these controls where duty-level evidence or timing is difficult to reconstruct.

For example, a 100-unit budget and an authorised permanent-control project can describe both commissioning at month 4 and commissioning at month 9 after bridge expiry at month 8. A summary containing only those financial and project-status fields is identical in both cases. It cannot distinguish their different coverage findings. Adding the linked expiry and effect dates resolves that information loss. A competent existing schedule and change log can do the same. The computational pairs below demonstrate this restricted claim, not the superiority of the audit over competent practice.

## Uncertain operating funding and disputed effectiveness

The extension changes financing and effectiveness assumptions. P-03 proposes the same 100-unit initial allocation as G. Permanent control now requires 30 units for installation and 10 for operation and monitoring over [4,16). Further payments are 10 at months 16, 28 and 40, and 20/3 at month 52 for the final eight months. The unsecured additional requirement is 110/3, approximately 36.67 units. The 40-unit initial allocation is a proposal, not an executed contract or prepayment. Its authorisation is decided separately below.

The fictional mechanism is storm-driven fertiliser runoff increasing influent nutrient concentration at fixed receiving-water flow. A deliberately simplified monthly model sets downstream concentration equal to influent concentration minus a fixed concentration reduction, all in normalised concentration units. The supplier assumes an influent value of 1.00 and reduction of 0.10, giving 0.90. The independent assessor admits influent concentration 1.15 with the same treatment capacity, giving 1.05. A stipulated catchment assessment supports the runoff pathway and the design specification fixes capacity. These invented premises justify admission for this exercise, not the environmental validity of the model. No event probability is assigned. The bridge is stipulated adequate under both conditions until month 8.

The supplier disputes the high-load estimate but supplies no evidence that excludes it under the agreed admission rule. After bridge expiry, 1.05 exceeds the 1.0 threshold, so the proposed permanent route is unsupported in that scenario. Later resource coverage is unresolved because operating funds beyond month 16 are unsecured. No authorised restriction or funded technical fallback is available. A full-horizon pass therefore fails even when responsibility and historical records are complete.

Correction begins immediately. With one month for decision and four for delivery, the hard latest initiation is month 3, authorisation month 4 and verified effect month 8. The agency sets an earlier internal target: evidence and funding proposals by month 2, authorisation by month 3 and effect by month 7, preserving one month of contingency. These targets concern any justified corrective route and do not assume one exists. Failure to establish a route prompts escalation, while unresolved duties remain open.

## Monitoring and incompatible duties

The protocol specifies monitoring methods and treatment of uncertainty before operation. In a separate synthetic check, a monthly mean estimate of 0.88 plus a justified joint allowance of 0.14 gives a plausibility bound of 1.02. The result triggers review because a threshold exceedance is plausible. The allowance represents combined calibration and sampling limitations and has no statistical confidence interpretation.

The monitoring record distinguishes measured breaches, insufficient evidence and forecast risks. Equipment failure, inadequate sampling or changed loading reopens assessment. The protection deadline remains in force during reassessment.

Consider a separate conflict. A facility must prevent a toxic discharge within one day and maintain downstream ecological flow over that day. The only available containment prevents discharge but interrupts flow. Continuing operation preserves flow while releasing contamination. Temporary storage, alternative supply and inter-agency support are unavailable within the deadline. Both duties are assumed binding, without a general waiver power.

The incident commander acts within existing emergency authority using urgent technical and legal advice. The record compares consequences, uncertainty, reversibility and mitigation. If containment is authorised, the flow duty remains active with a dated shortfall, restoration owner and review deadline. The audit records the conflict without making the duties jointly achievable.

## Diagnostic checks on portfolio changes

Table 7 modifies individual base-case records while retaining financial balance. It draws on the obligation, portfolio and shortfall links in Table 5 and the comparison in Table 6. Table 8 executes a restricted subset of the underlying logic using separately defined synthetic fixtures.

**Table 7 Diagnostic counterexamples and expected findings**

| Change to the record | Responsibility and history finding | Prospective coverage finding |
|---|---|---|
| Remove O-NUT-01 after cancelling its old intervention, with no valid closure or transfer. | Fail. The predecessor identifier is missing from every authorised successor state. | Cannot pass while a required obligation is omitted from assessment. |
| Discharge O-NUT-01 when installation finishes at month 4, although protection is required to month 60. | Fail. Closure evidence does not satisfy the full required period. | Installation completion does not support future coverage. |
| Retain O-NUT-01 and its owner, but commission permanent control at month 9 after bridge expiry at month 8. | Pass if the gap has an owned shortfall and complete history. | Fail for [8,9), despite the unchanged budget. |
| Remove the local duty after referring it to another agency, without acceptance. | Fail. Referral is not a valid transfer. | No supported receiving delivery route has been established. |
| Amend a target at month 6 and delete the original target and earlier shortfall. | Fail. The amendment removes the historical assessment basis. | Future amended requirements need their own assessment. Past failure is not cured. |
| Authorise transport deferral, retain O-CLIM-01 and its owned shortfall, and preserve the three binding protection routes. | Pass under the stipulated authority and complete records. | The declared binding set can pass. Delivery of all original commitments still fails. |

The cases test logical behaviour. Staff accuracy, timely action and administrative burden require the comparative evaluation below.

### Computational conformance desk pilot

The supplement, Budget_Reallocation_Replication.zip (version 1.1.0), is a post-hoc reconstruction of a restricted checker for eight stipulated synthetic cases. It contains Python code, eight JSON fixtures, expected and observed outputs, 24 transformation logs, two comparison summaries, run instructions and SHA-256 checksums.

Original code and execution logs are unavailable. The supplement documents the reconstructed implementation and cannot verify the original execution history. Its coverage, authority and evidence dates are stipulated for one nutrient duty.

The checker matched eight stipulated findings. All 24 checks agreed with expectations after shifting dates five months, reversing coverage-record order or splitting intervals without changing their states. The gap and funding cases flagged [8,9) and [16,60), respectively. These checks measure consistency with the synthetic specification.

**Table 8 Executed desk pilot findings**

| Synthetic case | Responsibility | Prospective coverage | History | Joint result |
|---|---|---|---|---|
| B01 Intact route | pass | supported | pass | Pass |
| B02 Commissioning gap | pass | unsupported | pass | Fail |
| B03 Missing disposition | fail | supported | pass | Fail |
| B04 Unaccepted transfer | fail | supported | pass | Fail |
| B05 Premature fulfilment | fail | supported | pass | Fail |
| B06 Deleted history | pass | supported | fail | Fail |
| B07 Unsecured operation | pass | unresolved | pass | Fail |
| B08 Lawful termination | pass | supported | pass | Pass |

Note. The joint result passes only when responsibility and history pass and prospective coverage is supported. B02 fails because of an unsupported interval. B07 fails the joint test because later operating funding leaves coverage unresolved. In B03–B05, supported coverage coexists with a failed responsibility finding. B03 omits the disposition while retaining the duty in the assessment. B08 retains the historical baseline and assesses coverage until stipulated lawful termination at month 12. B07 isolates operating funding and assumes technical effectiveness. The separate P-03 worked case also includes an admitted high-load scenario with unsupported coverage after month 8.

## Completed minimum change note

This completed fictional note applies P-03 at month 0. Its evidence labels refer to the stipulated documents above.

Decision CN-03 v1. The committee declines whole-horizon approval of P-03. It authorises 60 units for water 20, wetland 30 and bridge 10 within existing delegations. The remaining 40 units stay reserved for permanent nutrient protection, uncommitted and unspent pending a technically acceptable and authorised route. They are neither released for other uses nor counted as a completed purchase. The finance director controls any later commitment through a recorded decision. All four obligation identifiers and their terms remain active.

Two executed comparisons check the stipulated initial budget and project-status summaries. B01, B02 and B07 each record an initial allocation of 100 units and the status “authorised for planned installation”. B01 has supported prospective coverage. B02 has an unsupported commissioning gap and B07 has unresolved later operating funding. The checker verifies that B01 shares the same summary with each of the other two cases and produces a different coverage finding. The summary comparisons file reports both results. The exercise shows which distinctions those two fields omit in the constructed cases.

Generative AI assisted development of the synthetic cases, expected findings and reconstructed checker. Shared assumptions create a risk of circular confirmation. A common error in the rules could survive all 24 checks. Independent expert review, separately authored challenge cases and testing with real records remain necessary.

Findings. E-03 supports bridge coverage over [0,8). E-09 records proposed installation and initial operating costs. E-10 records the unsecured 110/3-unit later requirement. E-11 retains the loading model, capacity premise, supplier objection and scenario admission decision. Responsibility and historical continuity pass for the retained records. In the admitted high-load scenario, permanent coverage after month 8 is unsupported. From month 16, operating funding is also unresolved. These findings prevent whole-horizon approval. Future delivery remains subject to verification.

Actions. The engineering manager submits a justified loading response and the finance director submits an executable funding proposal by month 2. The water director seeks authorisation by month 3, targeting verified effect by month 7. If that target fails, the director escalates immediately. Month 4 is the hard latest authorisation for a four-month delivery route meeting month-8 expiry. Earlier initiation remains mandatory when new evidence

shortens the window. U-NUT-02 tracks technical exposure and U-NUT-03 tracks operating-funding uncertainty. Accepted effectiveness evidence closes the first issue only when an executable route exists. A financing assurance alone cannot do so.

Review. An assessor outside the delivery chain reviews the correction. Downstream households can challenge omissions before the month-3 target decision. The committee records responses, dissent and the reconsideration route. Bridge failure or faster loading triggers immediate review. If no route is secured by the hard deadline, the committee records infeasibility and the response available within its authority. The reserved 40 units remain subject to a separate commitment decision. O-CLIM-01 and its deferred 500-tonne target remain visible.

## Adoption and evaluation

### Independent assessment and field evaluation

Lee (1999) distinguishes conceptual promise from practical implementation. An independent assessment could examine how specialists in environment, finance and delivery interpret unfamiliar cases, explain disputed classifications and recognise equivalent safeguards in existing systems. That assessment would inform a subsequent organisational pilot.

An initial equivalence assessment would reconstruct one material budget change using the agency’s existing records. It would check whether each obligation’s disposition, protection intervals, historical terms and shortfall owner can be retrieved. The five record types in Table 3 identify the information required and can be implemented within existing systems.

A short change note may suffice for routine decisions. Irreversible harm, vulnerability, changes in authority and short response windows warrant closer scrutiny. Emergency stabilisation can proceed within existing delegation, with a named officer and a deadline for completing the record.

A field pilot would involve finance and delivery staff, independent assessors and representatives of affected groups. It would measure effort, delay, omissions, unnecessary escalation, unsupported claims of protection and premature closure. Participation would help identify burdens on exposed communities that administrative records may miss.

The testable propositions concern fewer unassigned duties, fewer false coverage findings at bridge expiry and fewer apparent successes created by retrospective amendments. Additional benefit should diminish as comparator systems already implement the same safeguards.

A comparative study could allocate teams within experience strata to structured decision making with or without the specification. Both groups would receive the same information, advice, budgets and training time. Comparison teams could use their usual tools, including equivalent safeguards. Baseline traceability would be recorded. Cases would include uncertain funding, shared endpoints, contested authority and incompatible duties. A pilot would inform the sample size, minimum useful difference and analysis of clustering by team and case.

Before examining team outputs, an independent panel would identify material omissions from the case facts and mandates. For correctable omissions, the primary outcome would be a feasible corrective decision before the action window closes. Each omission would be counted once per team and case. Cases without material omissions would help estimate unnecessary escalation. Disputed benchmarks and infeasible cases would be analysed separately.

For infeasible cases, two assessors would judge whether teams recognised the binding conflict, avoided unsupported compliance claims, escalated in time and retained an owned shortfall. The analysis would report each component and the joint procedural result using case-specific criteria. Initial agreement would be recorded before a third assessor adjudicated disagreements. Feasibility classification would be reported separately.

In the proposed evaluation, standardised outputs would omit method labels. Independent assessors would record which study arm they believe produced each output to assess whether the content reveals allocation. The analysis plan would specify how contamination, missing outputs and withdrawals are handled. The evaluation would distinguish records used during the decision from records completed afterwards and separate late detection from timely correction.

Secondary outcomes would include reconstruction accuracy, retrieval time, staff effort and whether an oversight forum could obtain a reasoned response. The case set would include justified amendments and exclusions so that scoring recognises warranted departures. The analysis would examine differences by organisational size, complexity and baseline traceability.

The evaluation protocol would specify the minimum useful improvement, tolerable delay and acceptable rates of incorrect closure and unnecessary escalation. Excessive burden or results that rule out a useful improvement would weigh against adoption. Imprecise findings would remain inconclusive. Environmental delivery and distributional effects would require prospective follow-up.

## Limitations and conclusion

The literature comparison draws on purposive synthesis and a limited supplementary search. Ranking, the five-result cap, English search terms and one screening pass restrict coverage. The missing export and screening log prevent an independent audit of the reported 11 records. The eight cases and 24 transformations show

internal consistency under shared assumptions. No independent assessment or field test has established the protocol's accuracy, usability or environmental effectiveness.

The protocol specifies what an agency needs to reconstruct a material budget change: the status of each duty, the evidence for protection over time and the terms governing earlier delivery. The completed change note shows how an authority can approve limited protection and reserve funds while keeping unresolved obligations visible. Whether the protocol improves decisions in practice depends on the quality of the underlying evidence, the powers of the oversight forum and the effort required relative to existing controls.

## DECLARATIONS

Study design and ethics. This conceptual article uses synthetic records for its computational checks and reports no human-participant research or personal data collection.

Data and code availability. The supplementary ZIP contains the reconstructed inputs, code and outputs. Original code, run logs and item-level search records are unavailable. Artificial Intelligence (AI) Usage. Generative AI assisted with the synthetic cases, expected findings, reconstructed checker, and manuscript editing. The author takes responsibility for the article.

## References


Belton, V., & Stewart, T. J. (2002). Multiple criteria decision analysis: An integrated approach. Kluwer Academic Publishers. https://doi.org/10.1007/978-1-4615-1495-4

Berrens, R. P. (2001). The safe minimum standard of conservation and endangered species: A review. Environmental Conservation, 28(2), 104–116. https://doi.org/10.1017/S037689290100011X

Bovens, M. (2007). Analysing and assessing accountability: A conceptual framework. European Law Journal, 13(4), 447–468. https://doi.org/10.1111/j.1468-0386.2007.00378.x

Conservation Measures Partnership. (2020). Open standards for the practice of conservation (Version 4.0). https://www.conservationstandards.org/wp-content/uploads/sites/4/2020/10/CMP-Open-Standards-for-the-Practice-of-Conservation-v4.0.pdf

Conservation Measures Partnership. (2025). Open standards for the practice of conservation (Version 5.0, updated March 25, 2026). https://www.conservationstandards.org/wp-content/uploads/2026/03/CMP-Open-Standards-Report-v5.0-FINAL-v.-2026-03-25.pdf

Environment Agency, & Department for Environment, Food & Rural Affairs. (2023, April 19). Taking an adaptive approach: Thames Estuary 2100. GOV.UK. https://www.gov.uk/guidance/taking-an-adaptive-approach-thames-estuary-2100

Gregory, R., Failing, L., Harstone, M., Long, G., McDaniels, T., & Ohlson, D. (2012). Structured decision making: A practical guide to environmental management choices. Wiley-Blackwell. https://doi.org/10.1002/9781444398557

Haasnoot, M., Di Fant, V., Kwakkel, J., & Lawrence, J. (2024). Lessons from a decade of adaptive pathways studies for climate adaptation. Global Environmental Change, 88, 102907. https://doi.org/10.1016/j.gloenvcha.2024.102907

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. Global Environmental Change, 23(2), 485–498. https://doi.org/10.1016/j.gloenvcha.2012.12.006

Haasnoot, M., Lawrence, J., & Magnan, A. K. (2021). Pathways to coastal retreat. Science, 372(6548), 1287–1290. https://doi.org/10.1126/science.abi6594

Hemming, V., Camaclang, A. E., Adams, M. S., Burgman, M., Carbeck, K., Carwardine, J., Chadès, I., Chalifour, L., Converse, S. J., Davidson, L. N. K., Garrard, G. E., Finn, R., Fleri, J. R., Huard, J., Mayfield, H. J., McDonald Madden, E., Naujokaitis-Lewis, I., Possingham, H. P., Rumpff, L., … Martin, T. G. (2022). An introduction to decision science for conservation. Conservation Biology, 36(1), Article e13868. https://doi.org/10.1111/cobi.13868

HM Treasury. (2026). The Green Book. https://www.gov.uk/government/publications/the-green-book--2/the-green-book-2026

Intergovernmental Panel on Climate Change. (2023). Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, H. Lee, & J. Romero, Eds.). IPCC. https://doi.org/10.59327/IPCC/AR6-9789291691647

Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. (2024). Summary for policymakers of the thematic assessment report on the interlinkages among biodiversity, water, food and health of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat. https://doi.org/10.5281/zenodo.13850289

Koh, H. W. K. (2024). Enhancing sustainable development through community engagement. International Journal for Multidisciplinary Research, 6(4). https://doi.org/10.36948/ijfmr.2024.v06i04.25621

Kwakkel, J. H., Haasnoot, M., & Walker, W. E. (2015). Developing dynamic adaptive policy pathways: A computer-assisted approach for developing adaptive strategies for a deeply uncertain world. Climatic Change, 132(3), 373–386. https://doi.org/10.1007/s10584-014-1210-4

Lee, K. N. (1999). Appraising adaptive management. Conservation Ecology, 3(2), Article 3. https://doi.org/10.5751/ES-00131-030203

Lempert, R. J., Popper, S. W., & Bankes, S. C. (2003). Shaping the next one hundred years: New methods for quantitative, long-term policy analysis. RAND Corporation. https://doi.org/10.7249/MR1626

Mills-Novoa, M. (2023). What happens after climate change adaptation projects end: A community-based approach to ex-post assessment of adaptation projects. Global Environmental Change, 80, 102655. https://doi.org/10.1016/j.gloenvcha.2023.102655

National Aeronautics and Space Administration. (2023, July 26). 6.2 Requirements management. https://www.nasa.gov/reference/6-2-requirements-management/

Nichols, J. D., Breininger, D. R., Armstrong, D. P., & Lacy, R. C. (2024). Habitat management decisions for conservation: A conceptual framework. Frontiers in Conservation Science, 5, 1450000. https://doi.org/10.3389/fcosc.2024.1450000

Organisation for Economic Co-operation and Development. (2015). Recommendation of the Council on Budgetary Governance (OECD/LEGAL/0410). https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0410

Organisation for Economic Co-operation and Development. (2021). Green budget tagging: Introductory guidance and principles. OECD Publishing. https://doi.org/10.1787/fe7bfcc4-en

Organisation for Economic Co-operation and Development. (2024a). Beyond green tagging: How can public budgeting support climate goals? (OECD Papers on Budgeting No. 2024/06). OECD Publishing. https://doi.org/10.1787/b154d49b-en

Organisation for Economic Co-operation and Development. (2024b). Green budgeting in OECD countries 2024. OECD Publishing. https://doi.org/10.1787/9aea61f0-en

Polasky, S., Carpenter, S. R., Folke, C., & Keeler, B. (2011). Decision-making under great uncertainty: Environmental management in an era of global change. Trends in Ecology & Evolution, 26(8), 398–404. https://doi.org/10.1016/j.tree.2011.04.007

Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. Biological Conservation, 141(10), 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014

Richardson, K., Steffen, W., Lucht, W., Bendtsen, J., Cornell, S. E., Donges, J. F., Drüke, M., Fetzer, I., Bala, G., von Bloh, W., Feulner, G., Fiedler, S., Gerten, D., Gleeson, T., Hofmann, M., Huiskamp, W., Kummu, M., Mohan, C., Nogués-Bravo, D., … Rockström, J. (2023). Earth beyond six of nine planetary boundaries. Science Advances, 9(37), eadh2458. https://doi.org/10.1126/sciadv.adh2458

Rockström, J., Gupta, J., Qin, D., Lade, S. J., Abrams, J. F., Andersen, L. S., Armstrong McKay, D. I., Bai, X., Bala, G., Bunn, S. E., Ciobanu, D., DeClerck, F., Ebi, K., Gifford, L., Gordon, C., Hasan, S., Kanie, N., Lenton, T. M., Loriani, S., … Zhang, X. (2023). Safe and just Earth system boundaries. Nature, 619(7968), 102–111. https://doi.org/10.1038/s41586-023-06083-8

Roux, D. J., Kingsford, R. T., & Cockburn, J. (2025). Strategic adaptive management for transparency, accountability and learning: Insights from more than a quarter century of practice. Environmental Management, 75(10), 2521–2539. https://doi.org/10.1007/s00267-025-02272-5

Simon, A., Bernardo, M., Karapetrovic, S., & Casadesús, M. (2011). Integration of standardized environmental and quality management systems audits. Journal of Cleaner Production, 19(17–18), 2057–2065. https://doi.org/10.1016/j.jclepro.2011.06.028

United Nations Environment Programme, & International Resource Panel. (2024). Global resources outlook 2024: Bend the trend. Pathways to a liveable planet as resource use spikes. United Nations Environment Programme. https://wedocs.unep.org/handle/20.500.11822/44901

Ünkaracalar, T. (2026). Green budgeting and the audit of environmental expenditures: Developing a green budget accountability framework for Türkiye in light of European Union practices. Sayıştay Dergisi, 37(142), 605–637. https://doi.org/10.52836/sayistay.1988913

van der Brugge, R., & van Raak, R. (2007). Facing the adaptive management challenge: Insights from transition management. Ecology and Society, 12(2), Article 33. https://doi.org/10.5751/ES-02227-120233

Voß, J.-P., & Bornemann, B. (2011). The politics of reflexive governance: Challenges for designing adaptive management and transition management. Ecology and Society, 16(2), Article 9. https://doi.org/10.5751/ES-04051-160209

Williams, B. K. (2011). Adaptive management of natural resources—framework and issues. Journal of Environmental Management, 92(5), 1346–1353. https://doi.org/10.1016/j.jenvman.2010.10.041

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