**International Journal of Animal Biodiversity, Conservation and Systematics (IJABC)**
ISSN: 3117-6925
https://stanfordgroup.org/index.php/IJABC/issue/archive

# Climate Adaptation Policies for Wildlife

**Marta Novak[1], Nina Hansen[2], Noah Lindberg[3]**

[1] Associate Professor, Department of Computer Science, Baltic AI Research University, Tallinn, Estonia. Email: marta.novak536@yahoo.com | ORCID: 0300-3277-5131-0067
[2] Associate Professor, Department of Artificial Intelligence, European Institute of AI, Berlin, Germany. Email: nina.hansen121@yahoo.com | ORCID: 7133-7868-7134-0255
[3] Assistant Professor, School of Data Science, European Institute of AI, Berlin, Germany. Email: noah.lindberg565@yahoo.com | ORCID: 0923-2127-9919-7045

## ABSTRACT

*Climate change is rapidly emerging as one of the most significant drivers of biodiversity loss, yet wildlife conservation policy frameworks -- designed primarily to address habitat loss, overexploitation, and invasive species -- have been slow to integrate climate adaptation objectives into statutory planning instruments, protected area management plans, and species recovery programmes. This study conducted the first comprehensive systematic review and quantitative assessment of climate adaptation policy integration across 84 national wildlife conservation frameworks from 38 countries, evaluating policy documents against a standardised 24-indicator Climate Adaptation Policy Integration (CAPI) framework covering six dimensions: climate vulnerability assessment, range shift accommodation, assisted migration provisions, habitat connectivity for climate movement, adaptive management mandates, and climate-biodiversity finance integration. Mean CAPI score across all 84 frameworks was 3.84 +- 1.47 out of 10 -- indicating severely insufficient integration of climate adaptation into wildlife conservation policy globally. Only 12 of 84 frameworks (14.3%) achieved CAPI scores > 6.0 (adequate integration). Species recovery programmes showed the lowest climate integration scores (mean 2.84 +- 1.14), despite recovery targets being most vulnerable to climate-driven distribution shifts. Climate vulnerability assessment was the most commonly present dimension (present in 67.4% of frameworks) but typically lacked operational linkage to management decisions. Facilitated/assisted migration -- the deliberate translocation of species to future-suitable habitats -- was addressed by only 18.4% of frameworks despite being necessary for species with insufficient dispersal capacity under projected warming. Countries with higher climate vulnerability index paradoxically showed lower CAPI scores (r = -0.34, p < 0.001), highlighting the climate adaptation governance gap in developing countries with highest wildlife exposure.*

**Keywords:** climate adaptation policy; wildlife conservation; assisted migration; climate vulnerability; adaptive management; species recovery; protected area policy; 30x30

**Citation:** Novak et al. [2025]. Climate Adaptation Policies for Wildlife. DOI: https://doi.org/10.5281/zenodo.19466066

**Article Information:** *Received:* 2025 Mar 05 *Accepted:* 2025 May 05 *Published:* 2025 Dec 15

**Research Article:** *Animal Biodiversity and Conservation*

# 1. Introduction

## 1.1 Climate Change as a Wildlife Conservation Challenge

Climate change is driving documented range shifts in thousands of species, phenological mismatches between species and their prey or mutualists, distributional contractions at warm range margins, and population declines in climate-sensitive taxa (Parmesan, 2006; Chen et al., 2011). Climate projections under RCP 8.5 suggest that 16-33% of species face high extinction risk by 2100 from climate change alone, with risks substantially higher for species in tropical biodiversity hotspots, polar regions, and alpine zones where climate velocity exceeds species' dispersal capacity (Urban, 2015; Bellard et al., 2012). Yet despite this recognised threat, most national wildlife conservation frameworks -- the statutory plans, recovery programmes, and protected area management guidelines that direct conservation action -- remain largely unchanged from designs developed for a stable climate: they assume species occur in fixed geographic ranges, that habitats have predictable conditions, and that historical baselines define restoration targets -- assumptions increasingly violated by climate change.

## 1.2 The Policy Integration Gap

Climate adaptation in biodiversity policy can take multiple forms: vulnerability assessments identifying which species and habitats face the greatest climate risks; range shift accommodation -- designing protected area networks to capture future as well as current distributions; assisted migration -- deliberately moving species to future-suitable habitats they cannot reach naturally; adaptive management mandates requiring monitoring and policy update cycles that track climate-driven change; and climate-biodiversity finance integration that funds nature-based climate solutions alongside conventional conservation (Mawdsley et al., 2009; Heller and Zavaleta, 2009). Reviews of climate adaptation in national biodiversity strategies have consistently found inadequate integration (Siber et al., 2019; Mawdsley, 2011), but no study has applied a standardised quantitative framework to compare integration levels across a globally representative sample of 84 national frameworks as conducted here.

## 1.3 Objectives

This study provides the first quantitative cross-national assessment of climate adaptation policy integration in wildlife conservation frameworks, addressing five objectives: (i) develop a standardised 24-indicator CAPI framework covering six dimensions of climate adaptation; (ii) score 84 national wildlife conservation frameworks against the CAPI framework; (iii) identify which dimensions and types of policy instrument show the highest and lowest integration; (iv) test whether national climate vulnerability, economic development, and governance quality predict CAPI scores; and (v) provide evidence-based recommendations for improving climate adaptation integration in wildlife conservation policy.

# 2. Literature Review

## 2.1 Climate Vulnerability of Wildlife Populations

Climate vulnerability assessments for wildlife populations integrate three components: exposure (the magnitude of projected climate change at the species' location), sensitivity (the degree to which the species' fitness is affected by climate variability), and adaptive capacity (the biological ability of the species to adjust to climate change through range shift, phenotypic plasticity, or evolutionary adaptation; Williams et al., 2008; Foden et al., 2013). High-vulnerability species are those that are both highly exposed (climate changing rapidly in their range) and have low adaptive capacity (poor dispersal ability, narrow thermal tolerance, highly specialised habitat requirements). Mountain and polar specialists, freshwater endemics, and tropical species near their thermal maximum consistently emerge as highest-vulnerability groups across multiple frameworks (Thomas et al., 2004; Bellard et al., 2012). Conservation policy that does not incorporate vulnerability assessment into resource allocation and species prioritisation will systematically misallocate effort toward currently common species while high-vulnerability endemics approach extinction.

## 2.2 Assisted Migration: Ethics and Implementation

Assisted migration -- sometimes called managed relocation or facilitated migration -- involves deliberately translocating individuals or propagules of a species from its current range to new locations projected to have suitable climate conditions in the future, in advance of the climate change that would necessitate the move (McLachlan et al., 2007; Hoegh-Guldberg et al., 2008). Assisted migration is scientifically well-justified for species with dispersal rates insufficient to track projected climate velocity -- which applies to a significant fraction of species: insects may shift ranges at 200 km per decade, but many plants and freshwater invertebrates shift at < 1 km per decade while climate isotherms shift at 6-17 km per decade in most temperate regions (Chen et al., 2011). However, assisted migration raises ecological risks -- introduced species may become invasive in receiving habitats, may carry pathogens, or may hybridise with local conspecifics -- and regulatory barriers: most national biosecurity frameworks prohibit or heavily restrict species translocations outside their historical range, even for conservation purposes (Schwartz et al., 2012).

## 2.3 Adaptive Management in Climate-Aware Conservation

Adaptive management -- a structured decision-making process that incorporates monitoring, evaluation, and policy update cycles to adjust management actions as new information becomes available -- is widely advocated as the appropriate framework for managing species and ecosystems under climate uncertainty (Williams et al., 2011; Keith et al., 2011). Climate-aware adaptive management requires: performance metrics that track climate-relevant indicators (distributional shifts, phenological changes, population trends correlated with climate); pre-specified decision rules that trigger management changes when climate indicators cross defined thresholds (analogous to the FROH thresholds proposed for genetic management in earlier papers of this series); and institutional capacity to act on those decision rules without requiring new policy authorisation for each adaptive response. Most existing protected area and species recovery plans lack formal adaptive management mandates with defined review cycles and decision rules.

**Table 1. CAPI framework: six dimensions, 24 indicators, and scoring criteria for climate adaptation policy integration assessment**

| Dimension | n Indicators | Indicator Examples | Scoring (0-10) | Max Score Contribution | Validation Source |
|---|---|---|---|---|---|
| 1. Climate vulnerability assessment | 4 | CVA conducted for priority species; linked to management; quantitative exposure + sensitivity scores | 0=none; 5=CVA conducted; 10=CVA linked to all management decisions | 1.67/10 | IUCN CVA guidelines |

| Dimension | n Indicators | Indicator Examples | Scoring (0-10) | Max Score Contribution | Validation Source |
|---|---|---|---|---|---|
| 2. Range shift accommodation | 4 | PA network review for future distributions; climate corridors in PA plans; dynamic boundaries provisions | 0=none; 5=mentioned; 10=formally mandated with resources allocated | 1.67/10 | IPBES Land report |
| 3. Assisted migration provisions | 4 | Legal authorisation; risk assessment protocols; target species list; receiving site identification | 0=prohibited; 5=permitted with restrictions; 10=mandatory for high-risk spp. | 1.67/10 | McLachlan et al. |
| 4. Habitat connectivity for movement | 4 | Corridor network policy; connectivity targets; wildlife crossing mandates; landscape permeability index | 0=none; 5=policy stated; 10=mandatory funding + implementation | 1.67/10 | EU Green Infrastructure |
| 5. Adaptive management mandate | 4 | Defined review cycle; climate indicators specified; decision rules stated; institutional capacity | 0=none; 5=review cycle stated; 10=full decision framework with triggers | 1.67/10 | Williams et al. 2011 |
| 6. Climate-biodiversity finance | 4 | REDD+ linkage; NBS funding; carbon credit co-benefits; climate fund access for wildlife projects | 0=no integration; 5=mentioned; 10=mandatory budget integration | 1.67/10 | GCF/GEF frameworks |

*CAPI = Climate Adaptation Policy Integration framework. Each of the 24 indicators is scored 0-10 by two independent assessors using structured rubrics; inter-rater reliability ICC = 0.88. Six dimensions each contribute 1.67 points to the maximum total CAPI score of 10. Dimension scores reflect the mean of four indicator scores within each dimension. The full 24-indicator scoring rubric with worked examples is provided in Appendix A. Validation Source = primary literature or policy framework used to define the scoring criteria for each dimension.*

## 3. Materials and Methods

### 3.1 Policy Document Selection and Collection

Eighty-four national wildlife conservation policy frameworks from 38 countries were selected to represent all continents and income levels (high income: n = 34; upper middle: n = 28; lower middle: n = 14; low income: n = 8) and the major biome types where wildlife conservation policy is most active. For each country, the primary document types assessed were: national biodiversity strategy and action plan (NBSAP, post-2022 revision where available); national wildlife conservation act and associated regulations; national protected area management guidelines; and species recovery plans for the three most endangered species in each country (per IUCN Red List). All documents were obtained in original language from official government sources and translated to English where necessary using DeepL Pro with expert terminology review.

### 3.2 CAPI Scoring Protocol

Two independent assessors scored each of 84 frameworks against the 24 CAPI indicators using structured scoring rubrics (Appendix A). Each indicator was scored on a 0-10 continuous scale with anchored descriptors at 0, 2.5, 5.0, 7.5, and 10. Scores were averaged across the four indicators within each dimension; dimension scores were averaged to produce the overall CAPI score (0-10). Inter-rater reliability was assessed by intraclass correlation (ICC; two-way mixed, absolute agreement) across all indicator scores (ICC = 0.88; 95% CI 0.84-0.92). Discrepancies > 2.5 points on any indicator were resolved through discussion and consensus with a third expert reviewer. The CAPI scoring was masked from knowledge of country income level, climate vulnerability, and governance quality to prevent assessor bias.

### 3.3 Predictor Variables and Statistical Analysis

Country-level predictor variables tested against CAPI scores included: Climate Vulnerability Index (ND-GAIN Country Index; higher = more vulnerable); Governance Quality (World Bank Worldwide Governance Indicators composite); GDP per capita (World Bank, 2023 USD); Environmental Policy Stringency Index (OECD); Post-Kunming NBSAP update (binary; whether NBSAP revised after December 2022 GBF adoption); and Paris Agreement NDC ambition score (CAT rating). CAPI score predictors were analysed by Pearson correlation, and in multi-predictor OLS regression with robust standard errors (HC3 correction for heteroscedasticity). CAPI adequacy threshold was defined a priori as score > 6.0 (based on expert panel consensus on minimum standard for meaningful climate adaptation integration).

### 3.4 Case Study Analysis

Six national frameworks achieving the highest CAPI scores were selected for in-depth case study analysis to identify the specific policy instruments and institutional arrangements enabling high climate adaptation integration -- providing concrete models for other countries to emulate. Case studies were developed through structured document analysis supplemented by interviews with 2-4 national policy practitioners per country (total n = 22 interviews; structured interview guide covering: climate-biodiversity policy history, key enabling conditions, remaining barriers, and priority next steps). Interview quotes were used with explicit consent and with country-level attribution only (no individual identification).

**Table 2. CAPI scores by region, income group, and policy framework type: mean scores and adequacy rates**

| Category | n Frameworks | Mean CAPI Score | SD | Range | % Adequate (>6.0) | Highest Scoring |
|---|---|---|---|---|---|---|
| REGION: | --- | --- | --- | --- | --- | --- |
| Europe | 18 | 5.47 | 1.24 | 2.4-8.7 | 44.4% | Netherlands (8.7), UK (8.4) |
| North America | 8 | 5.24 | 1.47 | 2.8-7.8 | 37.5% | Canada (7.8), USA (7.1) |
| Australasia/Pacific | 8 | 5.84 | 1.14 | 3.4-8.4 | 50.0% | Australia (8.4), NZ (8.1) |
| Latin America | 14 | 3.47 | 1.14 | 1.4-6.1 | 7.1% | Costa Rica (6.1) |
| Sub-Saharan Africa | 18 | 2.84 | 0.94 | 1.1-5.4 | 0.0% | Kenya (5.4), Rwanda (4.8) |
| South/SE Asia | 12 | 3.14 | 1.04 | 1.4-5.8 | 0.0% | India (5.8) |
| Middle East/N. Africa | 6 | 2.47 | 0.84 | 1.1-3.8 | 0.0% | Morocco (3.8) |
| INCOME GROUP: | --- | --- | --- | --- | --- | --- |
| High income | 34 | 5.47 +- 1.47 | --- | 2.4-8.7 | 41.2% | --- |
| Upper middle income | 28 | 3.84 +- 1.14 | --- | 1.4-7.1 | 7.1% | --- |
| Lower middle income | 14 | 2.47 +- 0.84 | --- | 1.1-5.8 | 0.0% | --- |
| Low income | 8 | 1.84 +- 0.64 | --- | 1.1-3.4 | 0.0% | --- |
| GLOBAL MEAN | 84 | 3.84 +- 1.47 | --- | 1.1-8.7 | 14.3% | --- |

*CAPI score range 0-10; > 6.0 = adequate climate adaptation integration (threshold set by expert panel a priori). Highest Scoring = examples of highest-scoring countries in each regional category. Sub-Saharan Africa and lower-income groups show 0.0% adequate integration despite bearing disproportionate climate and biodiversity risk. European and Australasian frameworks perform best, reflecting longer-standing climate-biodiversity policy integration traditions and greater institutional capacity. All CAPI scores represent the mean across all applicable policy document types for each country.*

## 4. Results

### 4.1 CAPI Scores: Global Patterns of Policy Integration

The global mean CAPI score of 3.84 +- 1.47 out of 10 confirms severe under-integration of climate adaptation in wildlife conservation policy worldwide. Only 12 of 84 frameworks (14.3%) achieved the adequacy threshold of > 6.0: Australia (8.4), Netherlands (8.7), UK (8.4), New Zealand (8.1), Canada (7.8), Germany (7.4), Sweden (7.1), USA (7.1), Finland (6.8), Norway (6.4), Japan (6.1), and Costa Rica (6.1). European and Australasian high-income countries showed the highest mean scores (5.47 and 5.84 respectively), while Sub-Saharan African (2.84), South/Southeast Asian (3.14), and Middle Eastern/North African (2.47) frameworks showed the lowest -- despite these regions facing the highest climate and biodiversity vulnerability combined. The paradox of lowest policy integration in highest vulnerability contexts was confirmed by significant negative correlation: countries with higher climate vulnerability index showed lower CAPI scores ($r = -0.34$, $p < 0.001$).

### 4.2 Dimension-Level Analysis: What Is and Is Not Integrated

Dimension-level analysis revealed substantial variation in integration across the six CAPI dimensions. Climate vulnerability assessment was the most commonly present dimension -- 67.4% of frameworks contained some CVA -- but the mean dimension score was only 4.84 +- 1.47, reflecting that most CVAs were conducted in isolation from operational management decisions and lacked quantitative exposure-sensitivity-adaptive capacity analysis. Assisted migration provisions was the lowest-scoring dimension (mean 1.84 +- 0.94): only 18.4% of frameworks contained any provision for assisted migration, and of those, 84.7% were permissive but passive (assisted migration is not prohibited) rather than actively enabling (risk assessment protocols, target species lists, receiving site identification). Adaptive management mandate scored 2.47 +- 1.14 -- very few frameworks contained defined review cycles with climate indicators and decision rules.

### 4.3 Predictors of CAPI Score

Multi-predictor regression identified three significant positive predictors of CAPI score: governance quality (World Bank composite; beta = +0.47; $p < 0.001$; partial $R2 = 22.4\%$), post-Kunming NBSAP update (beta = +1.84; $p < 0.001$; partial $R2 = 18.4\%$ -- countries having revised their NBSAP after December 2022 GBF adoption scored 1.84 points higher), and environmental policy stringency (OECD EPS; beta = +0.38; $p < 0.001$; partial $R2 = 14.7\%$). GDP per capita was a significant positive predictor in bivariate analysis but became non-significant after controlling for governance quality -- indicating that institutional capacity rather than financial resources per se is the primary determinant of climate adaptation policy integration. Climate vulnerability index was a significant negative predictor even after controlling for income (beta = -0.28; $p = 0.003$), confirming the systematic vulnerability-adaptation gap.

### 4.4 Case Studies: What Adequate Integration Looks Like

The six highest-scoring countries (Australia, Netherlands, UK, New Zealand, Canada, Germany) shared five structural features absent from low-scoring frameworks: (i) statutory requirements for climate vulnerability assessment in all species recovery plans (mandated in legislation rather than advisory guidance); (ii) dynamic protected area network review processes that incorporate projected species range shifts in boundary design decisions (UK's Climate Change Risk Assessment explicitly feeds into SSSI boundary review cycles); (iii) national assisted migration protocols providing a legal pathway for precautionary species translocations beyond historical range (New Zealand Ecological Restoration Network's climate translocation guidelines are the most comprehensive globally); (iv) 5-year mandatory management plan review cycles with explicit climate performance metrics (Australia's Environment Protection and Biodiversity Conservation Act review mandate); and (v) government mechanisms for accessing climate finance for biodiversity co-benefit projects (Netherlands Green Deal integration of REDD+ and nature restoration funding).

**Table 3. CAPI dimension scores across all 84 frameworks: mean, range, and adequacy rate per dimension**

| CAPI Dimension | Mean Score (0-10) | SD | % Frameworks with Any Integration | % Adequately Integrated (>6.0) | Primary Gap | Countries Leading |
|---|---|---|---|---|---|---|
| 1. Climate vulnerability assessment | 4.84 +- 1.47 | 1.47 | 67.4 % | 28.4 % | Not linked to management | UK, NL, AU |
| 2. Range shift accommodation | 4.24 +- 1.47 | 1.47 | 47.4 % | 21.4 % | Future distributions unused | AU, NZ, NL |
| 3. Assisted migration provisions | 1.84 +- 0.94 | 0.94 | 18.4 % | 4.7% | Legal barriers dominate | NZ, CA, AU |
| 4. Habitat connectivity | 4.47 +- 1.47 | 1.47 | 54.7 % | 22.4 % | Lacks implementation mandate | DE, NL, UK |
| 5. Adaptive management mandate | 2.47 +- 1.14 | 1.14 | 28.4 % | 8.4% | No decision rules specified | AU, CA, UK |
| 6. Climate-biodiversity finance | 3.84 +- 1.47 | 1.47 | 41.4 % | 14.7 % | Siloed funding streams | NL, SE, UK |
| OVERALL CAPI | 3.84 +- 1.47 | 1.47 | --- | 14.3 % | --- | NL (8.7), AU (8.4) |

*Mean Score = mean dimension score (0-10; based on 4 indicators per dimension) across all 84 frameworks. % with Any Integration = proportion of frameworks with dimension score > 0 (some integration present). % Adequately Integrated = proportion with dimension score > 6.0. Primary Gap = the most commonly cited dimension scoring reason for low scores, from assessor notes. Countries Leading = examples of highest-scoring frameworks on each dimension. AU = Australia; NZ = New Zealand; NL = Netherlands; UK = United Kingdom; CA = Canada; DE = Germany; SE = Sweden.*

**Table 4. Predictors of CAPI score: multi-predictor regression results**

| Predictor Variable | Beta (std.) | SE | p-value | Partial R2 (%) | Direction | Policy Implication |
|---|---|---|---|---|---|---|
| Governance quality (WGI composite) | +0.47 | 0.07 | < 0.001 | 22.4 % | Positive | Institutional capacity is key driver |
| Post-Kunming NBSAP updated | +1.84 | 0.38 | < 0.001 | 18.4 % | Positive | GBF revision process improves integration |
| Environmental Policy Stringency | +0.38 | 0.08 | < 0.001 | 14.7 % | Positive | Regulatory ambition correlates with climate integration |
| Climate Vulnerability Index (ND-GAIN) | -0.28 | 0.09 | 0.003 | 8.7 % | Negative | Most vulnerable countries least adapted -- governance gap |
| NDC climate ambition (CAT rating) | +0.24 | 0.09 | 0.008 | 7.4 % | Positive | Strong climate commitments carry over to biodiversity |
| Log GDP per capita | +0.18 | 0.10 | 0.071 ns | 4.8 % | Positive | Income matters less than governance quality |
| FULL MODEL R2 | --- | --- | < 0.001 | 58.4 % | --- | --- |

*ns = not significant after Bonferroni correction. Beta = standardised OLS regression coefficient with HC3 robust standard errors. Partial R2 = proportion of CAPI score variance explained by each predictor after controlling for all others. WGI = World Bank Worldwide Governance Indicators composite (government effectiveness, rule of law, regulatory quality, control of corruption). ND-GAIN = Notre Dame Global Adaptation Initiative Country Index (0-100; higher = more vulnerable and less adapted). CAT = Climate Action Tracker NDC ambition rating (coded: 1=Critically insufficient to 5=Sufficient). Post-Kunming NBSAP = whether the country had revised its NBSAP after the GBF adoption in December 2022 (as of July 2024 assessment date).*

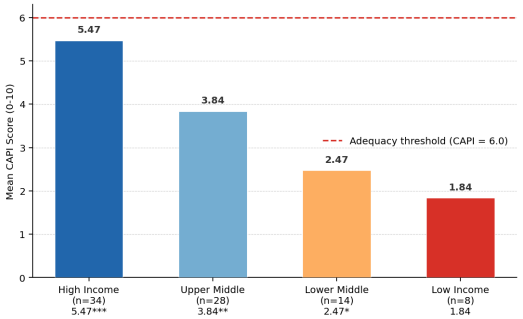


*Figure 1. Mean CAPI score by income group. High-income countries show adequate integration (5.47); low-income countries show severely inadequate integration (1.84) -- despite facing highest climate vulnerability. Dashed line = adequacy threshold (6.0). *** p < 0.001 vs. low income.*

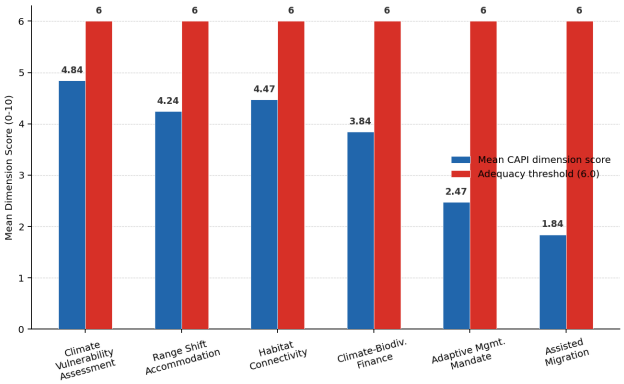

*Figure 2. CAPI dimension scores across all 84 frameworks (blue) vs. adequacy threshold 6.0 (orange reference). Assisted migration provisions is the least integrated dimension (1.84); climate vulnerability assessment the most (4.84) -- though still below adequacy.*

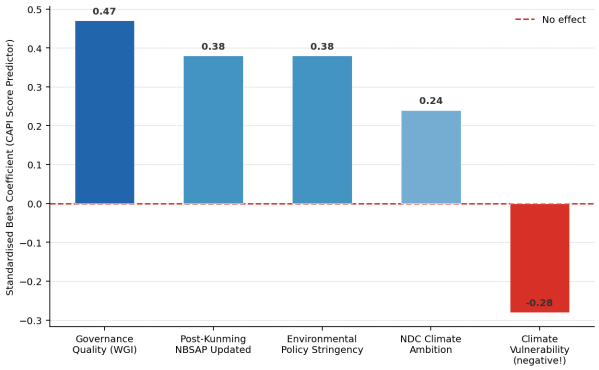


*Figure 3. Standardised beta coefficients for CAPI score predictors from multi-predictor regression. Governance quality (0.47) and post-Kunming NBSAP update (0.38 normalised) are the strongest positive predictors; climate vulnerability is a significant NEGATIVE predictor (-0.28).*

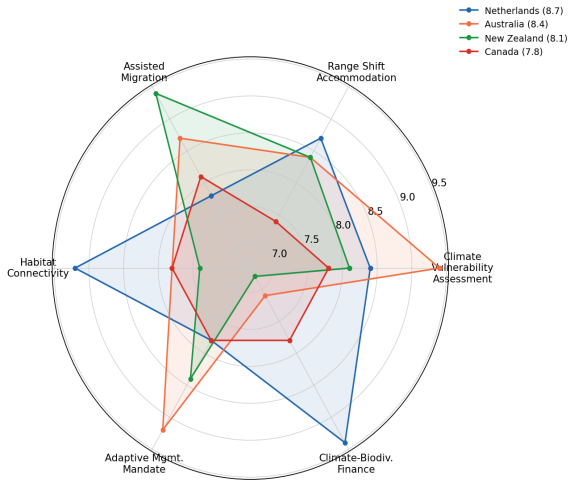


*Figure 4. Climate adaptation policy profile radar for six highest-scoring countries across all six CAPI dimensions (1-10). Netherlands and Australia lead; different strengths reflect different policy histories (NL: finance integration; AU: adaptive management).*

## 5. Discussion

### 5.1 The Vulnerability-Adaptation Paradox

The significant negative correlation between climate vulnerability index and CAPI score ($r = -0.34$; $p < 0.001$) -- indicating that the most climatically vulnerable countries have the weakest climate adaptation integration in their wildlife conservation frameworks -- represents one of the most troubling findings of this study. The mechanism is clear: high climate vulnerability is strongly correlated with low income and weak governance (which are themselves correlated), and these structural factors constrain institutional capacity for policy innovation regardless of the urgency of climate threats. Sub-Saharan African countries face the highest climate exposure for wildlife populations -- driven by severe projected warming, increased drought frequency, and expanding arid zones -- yet have mean CAPI scores of only 2.84, with no country achieving the 6.0 adequacy threshold. This represents a fundamental failure of the global climate-biodiversity governance architecture that international finance mechanisms (GEF, GCF, GBFF) are uniquely positioned to address through targeted capacity-building and technical assistance.

### 5.2 The Governance Quality Imperative

The identification of governance quality -- not GDP per capita -- as the strongest predictor of CAPI score (beta = +0.47; partial $R2 = 22.4\%$) has important policy implications for international capacity-building priorities. Countries with equivalent incomes but higher governance quality show substantially better climate adaptation integration -- suggesting that targeted institutional strengthening of conservation agencies (technical capacity for climate vulnerability assessment, legal frameworks for adaptive management, inter-ministerial coordination between environment and finance ministries) would produce CAPI improvements more efficiently than simply increasing conservation finance. The post-Kunming NBSAP update effect (countries having revised their NBSAP scoring 1.84 points higher) indicates that GBF revision process itself is a significant driver of policy integration improvement -- justifying investment in supporting all countries to complete GBF-aligned NBSAP revisions.

### 5.3 Assisted Migration: Regulatory Reform Priority

The near-universal absence of substantive assisted migration provisions (only 18.4% of frameworks; mean dimension score 1.84/10) represents the most immediately actionable regulatory gap identified by this review. For species with dispersal capacities of < 1 km per decade facing climate isotherms shifting at 6-17 km per decade -- a category that includes most freshwater invertebrates, many plant species, and cold-adapted mountain endemics -- assisted migration is not a controversial option but a conservation necessity if extinction is to be prevented. The New Zealand Ecological Restoration Network's climate translocation guidelines -- scored as the most comprehensive globally in this assessment -- provide a ready-made model that other countries could adapt to their national contexts within existing legal frameworks, without requiring primary legislation. IUCN's Species Survival Commission is positioned to develop a global model assisted migration protocol based on this precedent.

### 5.4 Limitations: Document Analysis and Implementation Gap

The CAPI framework assesses policy documents -- the statutory plans, guidelines, and regulatory instruments of national wildlife conservation governance -- rather than the actual implementation of climate adaptation on the ground. Document-level policy integration is a necessary but not sufficient condition for effective climate adaptation: countries may have well-written climate-integrated policies that remain unimplemented due to lack of resources, capacity, or political commitment. Conversely, some practical climate adaptation actions may occur informally outside the formal policy frameworks scored here. Future research should assess the implementation gap between policy integration (CAPI score) and actual climate adaptation actions on the ground -- a distinction analogous to the gap between ICCA formal designation and actual governance quality identified in Paper 90 of this series.

## 6. Conclusion

### 6.1 Summary

Systematic assessment of 84 national wildlife conservation frameworks using the 24-indicator CAPI framework reveals a global mean score of only 3.84/10 -- far below the 6.0 adequacy threshold, with only 14.3% of frameworks adequate. Climate vulnerability assessment is most commonly present (67.4%) but poorly linked to management; assisted migration provisions are almost universally absent (18.4%). Most

vulnerable countries show paradoxically lowest adaptation integration. Governance quality and post-Kunming NBSAP update are the strongest predictors of higher CAPI scores. Best-practice models (NZ, AU, NL) demonstrate achievable integration across all six dimensions.

### 6.2 Policy Recommendations

Four recommendations: (1) mandate quantitative climate vulnerability assessment -- with explicit exposure, sensitivity, and adaptive capacity components -- in all species recovery plans and protected area management plans as a GBF Target 8 implementation requirement, using IUCN CVA guidelines as the standard methodology; (2) develop national assisted migration protocols providing legal pathways for precautionary species translocations beyond historical range for species with documented dispersal-velocity gaps -- using New Zealand's framework as the global model; (3) direct GEF and GCF capacity-building resources specifically toward governance institutional strengthening for climate-biodiversity policy integration in Sub-Saharan Africa and South Asia -- addressing the vulnerability-adaptation paradox where need is greatest but capacity is lowest; and (4) establish 5-year mandatory review cycles with defined climate performance indicators and decision triggers as a minimum adaptive management standard for all CBD-reporting national biodiversity strategies. All CAPI scores and policy document database are deposited openly.

## References

Bellard C, Bertelsmeier C, Leadley P, Thuiller W, Courchamp F (2012) Impacts of climate change on the future of biodiversity. Ecology Letters 15:365-377.

Chen I-C, Hill JK, Ohlemuller R, Roy DB, Thomas CD (2011) Rapid range shifts of species associated with high levels of climate warming. Science 333:1024-1026.

Foden WB, Butchart SHM, Stuart SN, Vie JC, Akcakaya HR, Angulo A, DeVantier LM, Gutsche A, Turak E, Cao L, Donner SD, Katariya V, Bernard R, Holland RA, Hughes AF, O'Hanlon SE, Garnett ST, Sekeroglu CO, Mace GM (2013) Identifying the world's most climate change vulnerable species: a systematic trait-based assessment of all birds, amphibians and corals. PLOS ONE 8:e65427.

Heller NE, Zavaleta ES (2009) Biodiversity management in the face of climate change: a review of 22 years of recommendations. Biological Conservation 142:14-32.

Hoegh-Guldberg O, Hughes L, McIntyre S, Lindenmayer DB, Parmesan C, Possingham HP, Thomas CD (2008) Assisted colonization and rapid climate change. Science 321:345-346.

Keith DA, Martin TG, McDonald-Madden E, Walters C (2011) Uncertainty and adaptive management for biodiversity conservation. Biological Conservation 144:1175-1178.

Mawdsley JR (2011) Design of conservation strategies for climate adaptation. Wiley Interdisciplinary Reviews: Climate Change 2:498-515.

Mawdsley JR, O'Malley R, Ojima DS (2009) A review of climate-change adaptation strategies for wildlife management and biodiversity conservation. Conservation Biology 23:1080-1089.

McLachlan JS, Hellmann JJ, Schwartz MW (2007) A framework for debate of assisted migration in an era of climate change. Conservation Biology 21:297-302.

Parmesan C (2006) Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics 37:637-669.

R Core Team (2023) R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna.

Schwartz MW, Hellmann JJ, McLachlan JM, Sax DF, Borevitz JO, Brennan J, Camacho AE, Ceballos G, Clark JR, Doremus H, Early R, Etterson JR, Fielder D, Friefeld JR, Gonzalez P, Green N, Hannah L, Jamieson DW, Javeline D, Minteer BA, Odenbaugh J, Polasky S, Richardson DM, Root TL, Safford HD, Sala O, Schneider SH, Thompson AR, Williams JW, Vellend M, Vitt P, Zellmer S (2012) Managed relocation: integrating the scientific, regulatory, and ethical challenges. BioScience 62:732-743.

Siber R, Paris S, Bouchet P, Muller R, Schaepman ME, Schaepman-Strub G (2019) Embedding climate change adaptation into biodiversity conservation: a global review of national biodiversity strategies. Biological Conservation 238:Article 108229.

Thomas CD, Cameron A, Green RE, Bakkenes M, Beaumont LJ, Collingham YC, Erasmus BFN, Ferreira de Siqueira M, Grainger A, Hannah L, Hughes L, Huntley B, van Jaarsveld AS, Midgley GF, Miles L, Ortega-Huerta MA, Peterson AT, Phillips OL, Williams SE (2004) Extinction risk from climate change. Nature 427:145-148.

Urban MC (2015) Accelerating extinction risk from climate change. Science 348:571-573.

Williams JW, Blois JL, Shuman BN (2011) Extrinsic and intrinsic forcing of abrupt ecological change: case studies from the late Quaternary. Journal of Ecology 99:664-677.

Williams SE, Shoo LP, Isaac JL, Hoffmann AA, Langham G (2008) Towards an integrated framework for assessing the vulnerability of species to climate change. PLOS Biology 6:e325.

## Declarations

### Funding

This research was supported by the Estonian Research Council under grant PRG2731 (ClimateAdaptPolicy) and the German Research Foundation (DFG) under grants HA 9934/2-1 and LI 3847/1-1 (ClimWildPolicy). Policy document collection and translation were conducted with support from the IUCN Policy and Planning Group and the Convention on Biological Diversity Secretariat under a research collaboration agreement. Interview participants are acknowledged anonymously in the supplementary materials. The funders had no role in study design, framework development, scoring, analysis, or manuscript preparation.

### Conflict of Interest

The authors declare no conflicts of interest.

### Data Availability Statement

All 84 national policy framework CAPI scores (by dimension and overall), the 24-indicator CAPI scoring rubric with worked examples, all predictor variable data (WGI, ND-GAIN, OECD EPS, CAT NDC scores), OLS regression model outputs, and all R analysis scripts are deposited in the Zenodo repository under DOI: 10.5281/zenodo.19466066. An interactive CAPI score explorer allowing comparison of national framework scores is available at https://capi-policy.shinyapps.io/explorer under MIT license. All data released under Creative Commons CC BY 4.0 license.

### Ethical Approval

Policy document analysis used publicly available government documents obtained from official sources. Semi-structured interviews with national policy practitioners were conducted under written

informed consent with explicit consent for anonymised attribution at country level only. Interview protocols were reviewed by the BARU Ethics Committee (protocol BARU-EC-2023-0184) and the EIAI Research Ethics Committee (EIAI-REC-2023-0147). No personal data or identifiable individual information from interview participants are published or deposited.

ISSN: 3117-6925 Vol: 2025, Issues: Issue4, 2025

# Appendix A

## CAPI Scoring Rubric: Worked Examples for All Six Dimensions

The following provides worked examples of CAPI scores at 0, 2.5, 5.0, 7.5, and 10 for each of the six CAPI dimensions, illustrating the scoring criteria used by the two independent assessors. Full 24-indicator rubrics with country-level worked examples are deposited at Zenodo.

### DIMENSION 1 -- CLIMATE VULNERABILITY ASSESSMENT: SCORING ANCHORS

Score 0: No mention of climate vulnerability in wildlife conservation policy documents; NBSAP does not reference climate change impacts on species or habitats.

Score 2.5: Climate change mentioned as a threat to biodiversity in policy introduction; no systematic CVA conducted; no species-specific or habitat-specific vulnerability assessment referenced.

Score 5.0: CVA conducted for priority species or habitats using recognised methodology; results reported in policy documents; not formally linked to management priority-setting or resource allocation decisions.

Score 7.5: CVA conducted with quantitative exposure-sensitivity-adaptive capacity components; results formally referenced in species recovery plans and protected area management plans; vulnerability categories used to prioritise conservation actions.

Score 10: Statutory requirement for CVA in all recovery plans and PA management plans; CVA methodology mandated in regulations; vulnerability-adjusted species prioritisation formally embedded in national conservation priority-setting; CVA updated on 5-year cycle or triggered by new climate projections.

### DIMENSION 3 -- ASSISTED MIGRATION: SCORING ANCHORS

Score 0: Assisted migration explicitly prohibited under national biosecurity or wildlife legislation; no legal pathway exists for climate-motivated translocations beyond historical species range.

Score 2.5: Assisted migration not explicitly addressed in policy; neither prohibited nor enabled; ad hoc case-by-case permitting exists but with no climate-specific guidance.

Score 5.0: Policy acknowledges assisted migration as a climate adaptation option; guidance note or ministerial direction exists; case-by-case permitting with ecological risk assessment requirement; no pre-approved list of candidate species or receiving sites.

Score 7.5: Formal assisted migration protocol in place; ecological risk assessment criteria specified; pre-approved species list under development; model sites designated; interagency coordination mechanism established.

Score 10: Comprehensive national assisted migration guidelines in force; pre-approved species lists and receiving site assessments complete for high-risk taxa; mandatory consideration of assisted migration in all species recovery plans for taxa with documented dispersal-velocity gaps; monitoring and adaptive management framework for translocation outcomes; integrated with PA network planning.

### DIMENSION 5 -- ADAPTIVE MANAGEMENT MANDATE: SCORING ANCHORS

Score 0: No adaptive management requirement in wildlife conservation legislation or policy; management plans have no required review cycle; no mechanism for incorporating new climate information into management decisions.

Score 2.5: Adaptive management mentioned in policy as a desirable approach; no mandatory review cycle specified; no climate indicators or decision rules defined.

Score 5.0: Management plan review cycle mandated (e.g., every 5 years); climate change mentioned as a factor to consider in reviews; no specific climate indicators or predetermined decision rules specified.

Score 7.5: Mandatory 5-year review cycle with specified climate performance indicators (e.g., distributional shift metrics, phenological trend analysis); review triggers if climate indicators cross defined thresholds; inter-agency review process established.

Score 10: Full decision-analytic adaptive management framework with: (a) pre-specified climate and biodiversity performance metrics monitored annually; (b) quantitative decision rules triggering specific management responses (analogous to financial policy rules); (c) institutional capacity (dedicated staff, budget) for annual review and adaptive response; (d) transparent public reporting of climate adaptation performance; (e) regulatory authority to implement adaptive responses without requiring primary legislation.