CRITICAL ECOSYSTEM PARTNERSHIP FUND

Climate Change Portfolio Review

Summary of Findings

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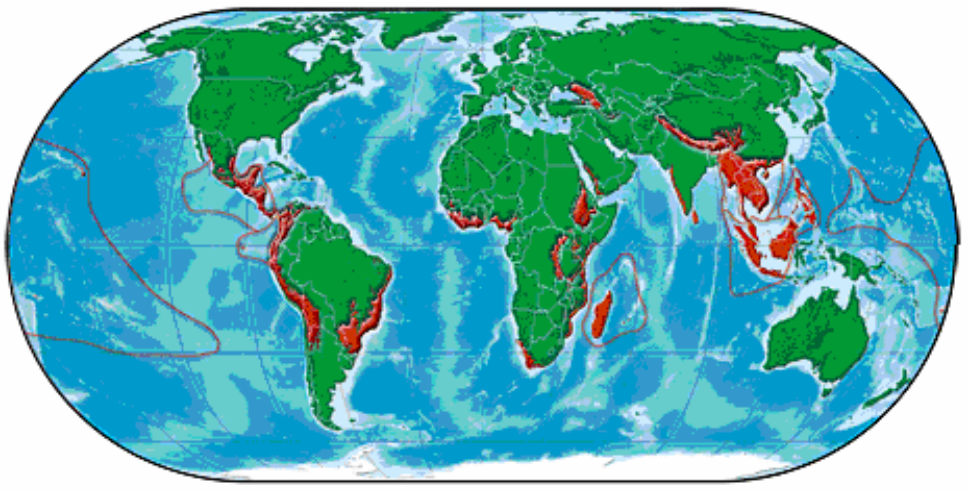


Introduction

The vulnerability of regions, ecosystems, and species to climate change is difficult to asses in absolute terms given the tremendous uncertainties in emissions scenarios and the lack of agreement among models about the spatial and temporal distribution of climate changes. The difficulty of linking specific climatic variables to population dynamics, as well as the likely importance of changing species interactions further precludes an unambiguous assessment of impacts on ecosystems. However, it is possible to look across emissions scenarios and climate models to determine coarse-grained regions of the globe that are likely to be more impacted than others even ignoring species interactive effects and complex dependencies on higher-order changes in climate processes. Similar analyses only considering biodiversity hotspots allows the identification of the most vulnerable hotspots with respect to climate change[1]. Additionally, vulnerable ecosystem types as well as landforms that are associated with climate change vulnerability can be inferred from existing studies. There is also emerging consensus about the species traits that are associated with climate change vulnerability. Thus, by jointly considering broad regional patterns of vulnerability, hotspot prioritization with respect to climate change, presence of vulnerable ecosystems or landforms, and the presence of species with traits that contribute to climate change vulnerability, projects can be scored to determine the extent to which they address climate change vulnerability.

The promotion of resilience is important independent of the relative vulnerability of the target, as all regions, ecosystems, and species are expected to experience some impacts of climate change. Actions that promote resilience can broadly be categorized according to whether they protect appropriate places, limit non-climatic stressors, or manage adaptively. It is important to note that many actions that are beneficial for conservation irrespective of climate change will be increasingly important when considering climate change. In addition to these general actions, there are also more climate change-tailored actions to protect appropriate places and manage adaptively. While limiting non-climatic stressors is always generally applicable, some stressors are known or suspected to act synergistically with

[1] Malcolm, J. R., Liu, C., Neilson, R. P., Hansen, L. & Hannah, L. E. E. Global Warming and Extinctions of Endemic Species from Biodiversity Hotspots. Conservation Biology 20, 538-548 (2006)

climate change while others do not have currently identified mechanistic interactions with climate processes. Thus, by jointly considering whether projects include actions to protect appropriate places, limit non-climatic stressors, or manage adaptively, as well as the climate change-specificity of those actions, projects can be scored to determine the extent to which they promote resilience to climate change.

The relevance of the CEPF project portfolio under climate change is a function of whether it targets regions, ecosystems, and species likely to be vulnerable to climate change in addition to how well it supports actions that promote ecosystem resilience to climate change. For the purpose of this assessment, vulnerability is considered separately from the promotion of resilience to climate change and together they form axes along which to judge the relevance of individual projects. The relevance of the CEPF portfolio as a whole depends on the distribution of projects along these axes. After considering some general issues in the next section, the distribution of projects along the vulnerability and resilience promotion axes are discussed, followed by some broad conclusions about the climate change relevance of the CEPF portfolio.

General considerations

Much can be learned about the climate relevance of the CEPF portfolio without reference to specific projects. By focusing on biodiversity hotspots, the CEPF portfolio necessarily excludes some regions and biomes that are projected to be particularly vulnerable to climate change. For example, polar regions, sea ice biomes, and tundra are all projected to be significantly impacted but are not represented by any designated hotspot as are parts of the southeastern United states and eastern Amazonia. While hotspots do not encompass all regions expected to be particularly vulnerable, many are located in regions predicted to be strongly impacted by climate change (see Table 1).

Also, high endemic species richness, a criterion for hotspot designation, and vulnerability to climate change are both correlated with particular geographic features or landforms, such as mountainous terrain and oceanic islands. Thus, numerous hotspots are likely to be vulnerable to climate change by this shared association (see Table 1). It is also notable that 4 of the 34 global hotspots are dominated by Mediterranean-type ecosystems, which have been identified as being particularly sensitive to climate change. Additionally,

species characteristics associated with climate change vulnerability, such as narrow environmental tolerances, tight habitat associations, limited dispersal ability, and tight inter-specific associations are also correlated with endemism. Thus hotspots are likely to contain many species vulnerable to climate change. Considering just biodiversity hotspots, Malcolm et al.[2] identified a total of 12 priority hotspots particularly vulnerable to climate change. Of these, 4 hotspots were identified as vulnerable based on both the required migration rates for biomes within the hotspot (and presumably associated species) to establish in areas of future climatic suitability and the predicted species extinctions due to climate induced biome loss. The remaining 8 hotspots were identified as vulnerable based on species loss or required migration rates alone.

Table 1 – Hotspots characteristics in relation to climate change

Hotspot	Region	Land-form	Med.-type ecosys	Most Vul.	CEPF*
North and Central America					
California Floristic Province	n	n	**y**	**y**	n
Caribbean Islands	n	**y**	n	**y**	**p**
Madrean Pine-Oak Woodlands	n	n	n	n	n
Mesoamerica	**y**	n	n	n	**y**
South America					
Atlantic Forest	n	n	n	n	**y**
Cerrado	**y**	n	n	n	n
Chilean Winter Rainfall-Valdivian Forests	**y**	n	n	n	n
Tumbes-Chocó-Magdalena	n	n	n	n	**y**
Tropical Andes	n	**y**	n	**y**	**y**
Europe and Central Asia					
Caucasus	n	**y**	n	n	**y**
Irano-Anatolian	n	n	n	n	n
Mediterranean Basin	n	n	**y**	**y**	**p**
Mountains of Central Asia	n	**y**	n	n	n
Africa					
Cape Floristic Province	**y**	n	**y**	**y**	**y**
Coastal Forests of Eastern Africa	**y**	n	n	n	**y**
Eastern Afromontane	**y**	**y**	n	n	**y**
Guinean Forests of West Africa	**y**	n	n	n	**y**
Horn of Africa	**y**	n	n	n	n
Madagascar and the Indian Ocean Islands	n	**y**	n	n	**y**
Maputaland-Pondoland-Albany	**y**	n	n	n	**p**

[2] ibid

Hotspot	Region	Land-form	Med.-type ecosys	Most Vul.	CEPF*
Succulent Karoo	**y**	n	n	**y**	**y**
Asia-Pacific					
East Melanesian Islands	n	**y**	n	n	**p**
Himalaya	**y**	**y**	n	n	**y**
Indo-Burma	**y**	**y**	n	**y**	**p**
Japan	n	**y**	n	n	n
Mountains of Southwest China	n	**y**	n	**y**	**y**
New Caledonia	n	**y**	n	**y**	n
New Zealand	n	**y**	n	**y**	n
Philippines	n	**y**	n	n	**y**
Polynesia-Micronesia	n	**y**	n	**y**	**p**
Southwest Australia	**y**	n	**y**	**y**	n
Sundaland	n	**y**	n	n	**y**
Wallacea	n	**y**	n	n	n
Western Ghats and Sri Lanka	**y**	**y**	n	n	**p**
totals	**14**	**18**	**4**	**12**	**22**

* Planned, **p** indicates a hotspot were CEPF has not yet invested but plans to do so in the near future.

Given the discussion above, one might expect that a hotspot-based conservation approach would be relevant to climate change by serendipitously targeting climate change-sensitive regions, landforms, ecosystems, and species. While the CEPF focuses on hotspots, it does not have active programs in all of them. Of the 15 hotspots that have already received CEPF investment, 13 are located in climate change-sensitive regions or are dominated by landforms that contribute to climate change sensitivity (the two exceptions are the Atlantic Forest and the Tumbes-Chocó-Magdalena, both in South America). However, only 4 of the most climate change-vulnerable hotspots have received CEPF investment. Looking at a sample of the individual projects supported by CEPF to date, 88% of them (615 / 697) are in hotspots in sensitive regions or are dominated by sensitive landforms. However, only 31% of projects (218 / 697) are in the most climate change vulnerable hotspots.

All of the hotspots included in the planned CEPF expansion are located in climate change-sensitive regions or are dominated by landforms that contribute to climate change sensitivity. With the planned expansion, CEPF will target 8 of the 12 most climate change vulnerable hotspots.

Detailed Analysis of CEPF Portfolio

More specific conclusions about the climate relevance of the CEPF portfolio can be drawn by considering the composition and details of projects supported by CEPF. A total of 697 projects from the 15 hotspots that have received CEPF investment to date (see Table 1) were evaluated by CEPF staff and scored in different aspects of climate change vulnerability and resilience promotion. The sub-scores were combined and normalized to determine an overall vulnerability score and an overall resilience promotion score for each project. Each project evaluated is represented by a circle in the project evaluation matrix (Figure 1), the centroid of which is located at the intersection of its overall vulnerability score along the x-axis and its overall resilience promotion score along the y-axis; the size of each circle is proportional to the project budget. Details on the evaluation and scoring protocol are provided in the Appendix; additional background information and references motivating the evaluation matrix is provided in[3].

While the number of projects presented in Figure 1 makes it difficult to immediately discern general patterns, it is clear that the CEPF portfolio contains a broad spectrum of projects ranging from those that both address vulnerable areas and promote resilience (quadrant II) to those that do neither (quadrant III). There are also significant numbers of projects that address vulnerable areas but do not promote resilience (quadrant IV) and fewer projects that successfully promote resilience but do not target known climate change vulnerabilities (quadrant I).

Examining the proportion of projects (Figure 2, left panel) or expenditures (Figure 2, right panel) in each quadrant of the evaluation matrix brings the picture into sharper relief. Nearly 46% of all CEPF supported projects (42% of expenditures) have minimal climate change relevance (quadrant III), approximately 38% of projects (32% of expenditures) have moderate climate change relevance (quadrants I and IV), and only 16% of projects (26% of expenditures) have high relevance to climate change. It is also evident that the CEPF portfolio as a whole is better at addressing vulnerability than promoting resilience. The mean

[3] Al-Khafaji, K. 2008. Climate Change Portfolio Review: Literature Review and Evaluation Matrix. Technical Report commissioned by CI-CABS.

vulnerability score of all projects evaluated is 0.42±0.01 (mean ±SE) while the mean resilience promotion score is only 0.29±0.01 (mean ±SE). Accordingly, the marginal distribution of resilience promotion scores has greater density at lower values than does the marginal distribution of vulnerability scores (see Figure 3). Interestingly, they both have similar densities of projects at the high end of the distribution and differ primarily because the vulnerability distribution has higher density at intermediate values while the resilience promotion distribution has higher density at low values.

Conclusions

A significant proportion (16%) of CEPF projects are highly relevant to climate change while an additional 38% are moderately relevant. Proportionally more projects successfully address known vulnerabilities to climate change than promote resilience. This is not surprising given the general correlation between hotspots and various factors associated with climate change vulnerability, such as mountainous terrain or species attributes like narrow environmental requirements. An expansion of the CEPF authorization to include additional hotspots that have been recognized as more vulnerable to climate change could further increase the relevance of the CEPF portfolio with respect to climate change. Similarly, more strategic emphasis on vulnerable ecosystems within hotspots could also improve targeting of known climate change vulnerabilities. As an example, mangroves and other coastal wetlands are known to be vulnerable to climate change but are specifically mentioned in less than 3% of project descriptions.

While the CEPF does relatively less well at promoting resilience than it does at addressing known climate change vulnerabilities, it is perhaps surprising that a significant number of projects (nearly 25%) have high resilience promotion scores even though there has been no explicit focus on climate change. Only 4 projects evaluated specifically mentioned climate change (3 in the Succulent Karoo and 1 in Mesoamerica) and only 10% (69 / 697) included resilience promotion actions tailored to climate change. Thus, the resilience promotion score in most cases is driven by more generally relevant conservation actions that are also likely to be beneficial in accommodating climate change impacts.

It is worth noting that a criterion for hotspot designation is significant habitat loss, and, unsurprisingly, many projects (38%; 265 / 697) aim to increase the amount of protected

area, which is also an important strategy to promote resilience to climate change. Similarly, CEPF has established a corridor framework to guide conservation activities in many regions, further enhancing the climate change relevance of its projects by facilitating climate-induced migrations. The corridor framework could be extended to formally incorporate climate change by considering likely climate-induced migration routes and species range shifts, although appropriate data may be lacking for some regions. Perhaps most striking with respect to resilience promotion is that 69% (482 / 697) of projects incorporate actions related to improving management activities, including public outreach and education. Outreach and advocacy campaigns could incorporate climate change impacts and the previous development of networks and capacity could be crucial in adapting conservation strategies to accommodate the novel threats posed by climate change.

While not focused on climate change impacts, the CEPF portfolio has attained a reasonable relevance to climate change by focusing on hotspots and sound conservation principles. It cannot be assumed, however, that business as usual will continue to assure climate change relevance given the rapidly accruing warning signs about the severity and surprising nature of climate change impacts on ecosystems and the services they provide. Rather, the existing suite of targets and actions promoted in the CEPF portfolio provide a strong foundation for incorporating additional climate change relevant approaches, without completely abandoning the existing strategies.

When expanding the CEPF program, the most climate change vulnerable hotspots could be selected as could hotspots with greater proportional representation of vulnerable species, ecosystem types, and landforms. Additionally, climate change sensitive regions that are not represented by hotspots could also be considered for investment. Without adjusting the authorization for investments, larger portions of the grant-making budget could be earmarked for the most climate change vulnerable hotspots and regions. Given broad geographic regions targeted by CEPF (and budgetary allocations), the climate change relevance of the CEPF portfolio could additionally be enhanced by focusing on the broad categories of action that promote resilience to climate change: protecting appropriate places, limiting non-climatic stressors, and managing adaptively. For example, site selection algorithms could be implemented to incorporate projected future species and biome ranges as well as their likely migration routes. Additionally, climatic refugia, outlier populations and

biomes, and upland areas for wetland migration could be preferentially targeted. Other factors for selecting places to protect, such as network redundancy and representation of heterogeneity (topographic, environmental, microclimatic, genetic, etc.), could also increase the climate relevance[4] of CEPF projects. With respect to limiting non-climatic stressors, greater emphasis could be placed on stressors known to act in concert with changing climatic processes, such as water withdrawals and habitat fragmentation[5]. There are numerous management actions that could be incorporated into projects to enhance their climate change relevance[6]. These range from pedestrian options (e.g., managing the matrix around reserves or restoring habitat) to more exotic tactics (e.g., species translocations, conservation call options, novel habitat creation); however, it is essential that management activities anticipate and plan for a changing climate.

[4] See Al-Khafaji (2008) for further discussion.

[5] See Al-Khafaji (2008) for further discussion.

[6] See Al-Khafaji (2008) for further discussion.

Figure 1 – Project Evaluation Matrix

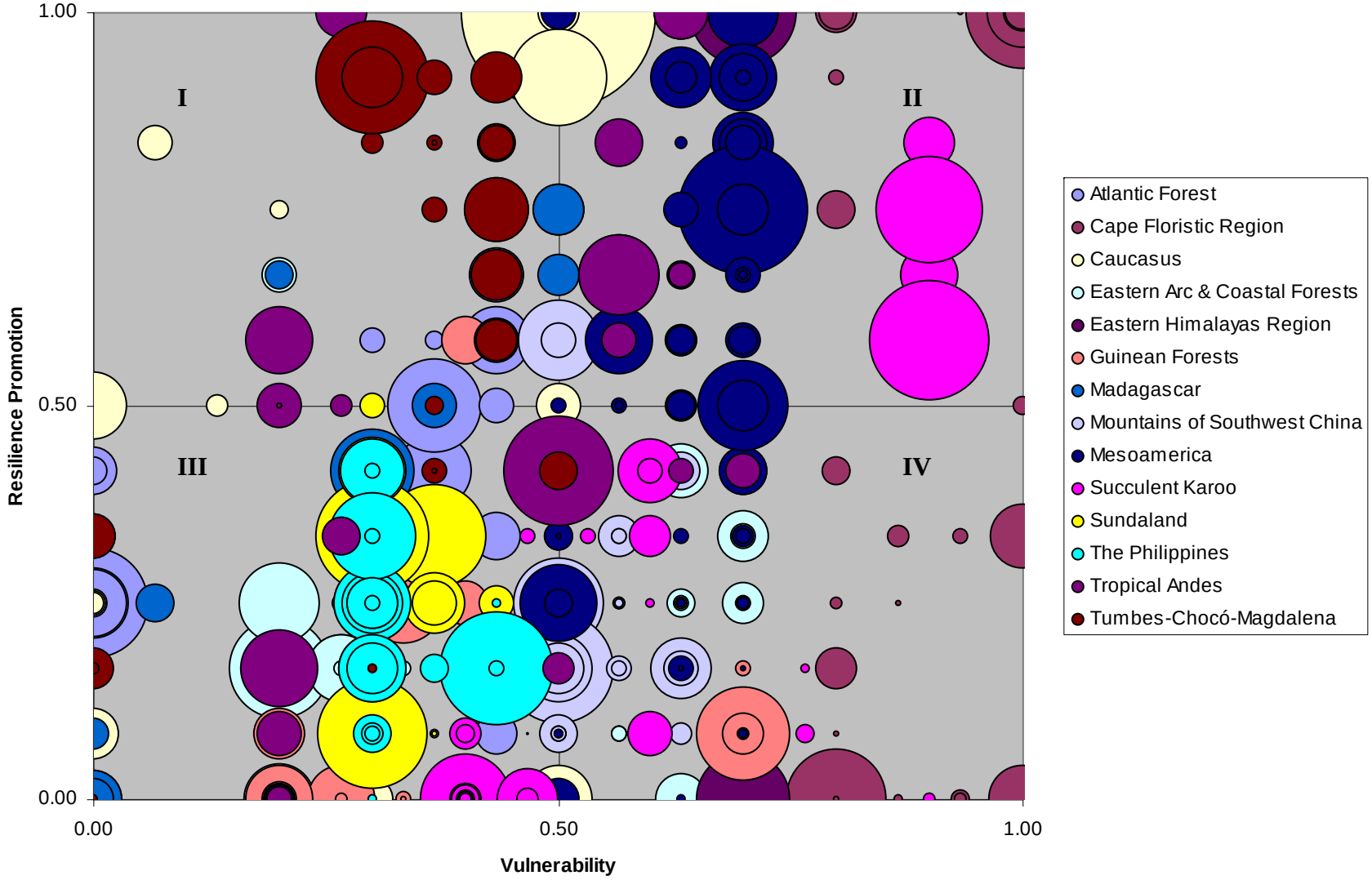


Figure 2 – Distribution of projects and expenditures among quadrants of the project evaluation matrix.

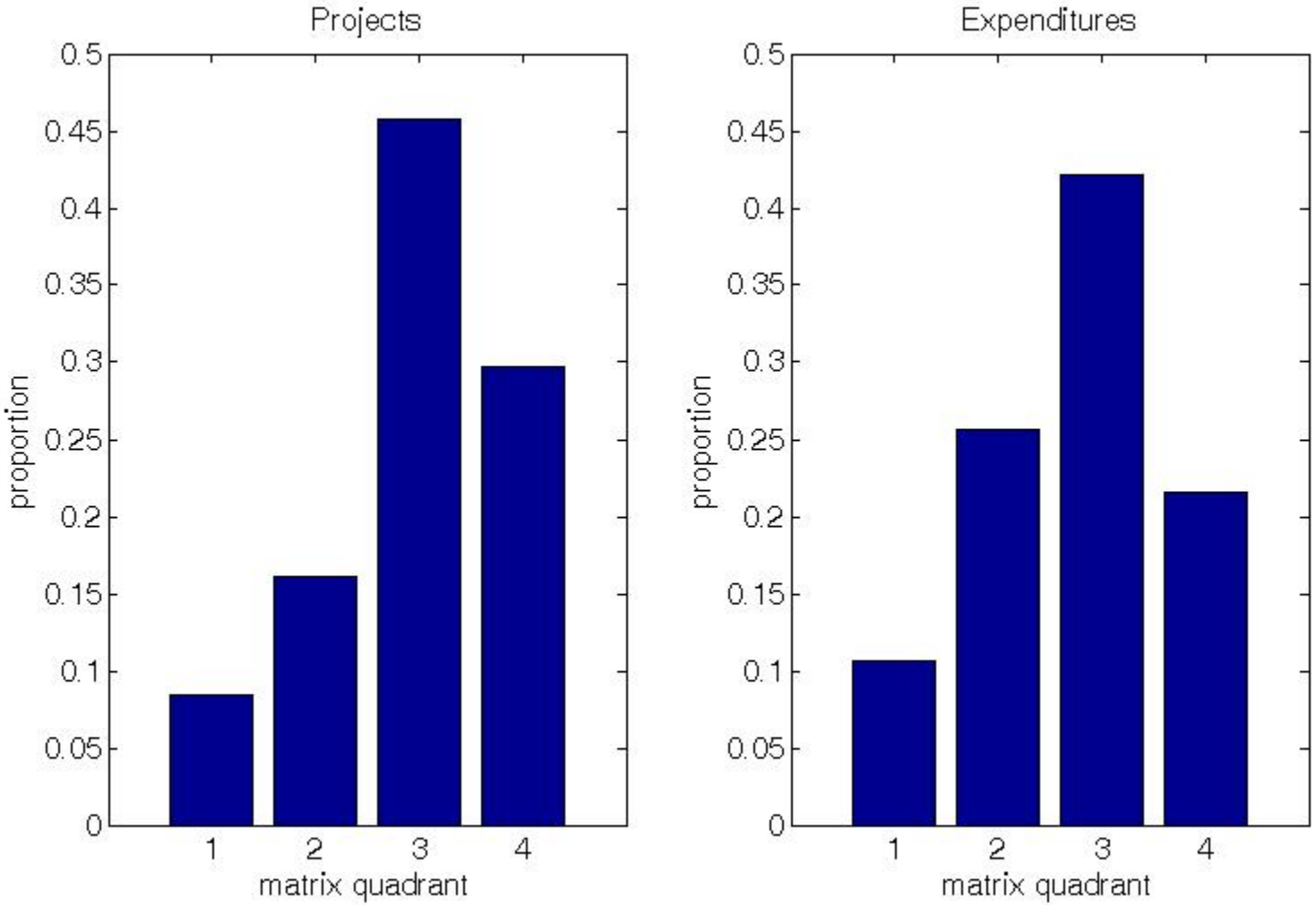
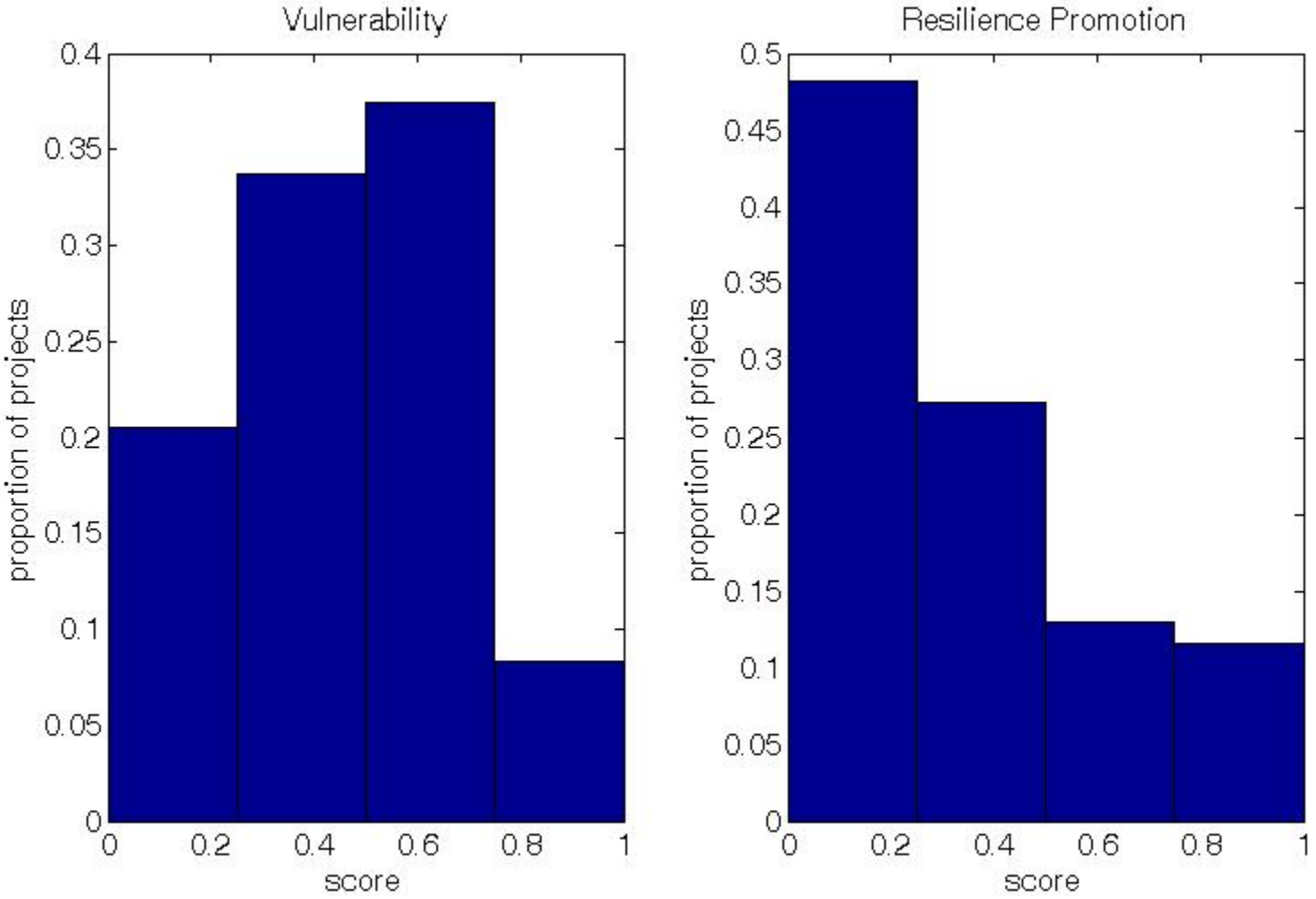


Figure 3 – Marginal distribution of Vulnerability and Resilience Promotion Scores.



Appendix – Project Evaluation Methodology

The climate relevance of projects can be assessed by asking whether they address climate change vulnerabilities in ways that promote resilience and adaptation. Breaking this question into its two fundamental components, vulnerability and promotion of resilience, suggests axes along which to evaluate projects. Aspects of vulnerability can be divided into 1) geographical and ecosystem factors and 2) species factors, as discussed in[i]. Projects can be scored according to whether they address vulnerable areas, vulnerable, hotspots or vulnerable ecosystems. The scores for each of these aspects of vulnerability are summed and normalized by the maximum possible to determine the vulnerability score for geographical and ecosystem factors (details for scoring are provide in Table A2). Likewise, projects can be scored according to the numbers of species vulnerable to climate change, as inferred from the traits discussed above, that they address and normalized by the maximum possible points to determine the vulnerability score for species factors(details for scoring are provide in Table A2). The overall score for how well a project addresses known vulnerabilities is a weighted average of its geographical and ecosystem factor sub-score and its species factors sub-score. Geographical and ecosystem factors are relatively unambiguous to assess and the data is more readily available than is species information, therefore the geographical and ecosystem factor sub-score is weighted to account for 80% of the total vulnerability score while the species factor sub-score is weighted to account for 20%.

Promotion of resilience can divided into actions that 1) protect appropriate places, 2) limit non-climatic stressors, or 3) manage adaptively, as discussed in[ii]. Within these broad categories, a gradient from general to specific factors can be considered. Similar to the procedure for vulnerability score, a project is assigned a score for each aspect of resilience promotion with general and climate change specific actions considered separately (details for scoring are provide in Table A3). The scores for general actions in each of the resilience promotion categories are summed and normalized to determine a general resilience promotion score. It is unrealistic to expect that a single project would effectively be able to

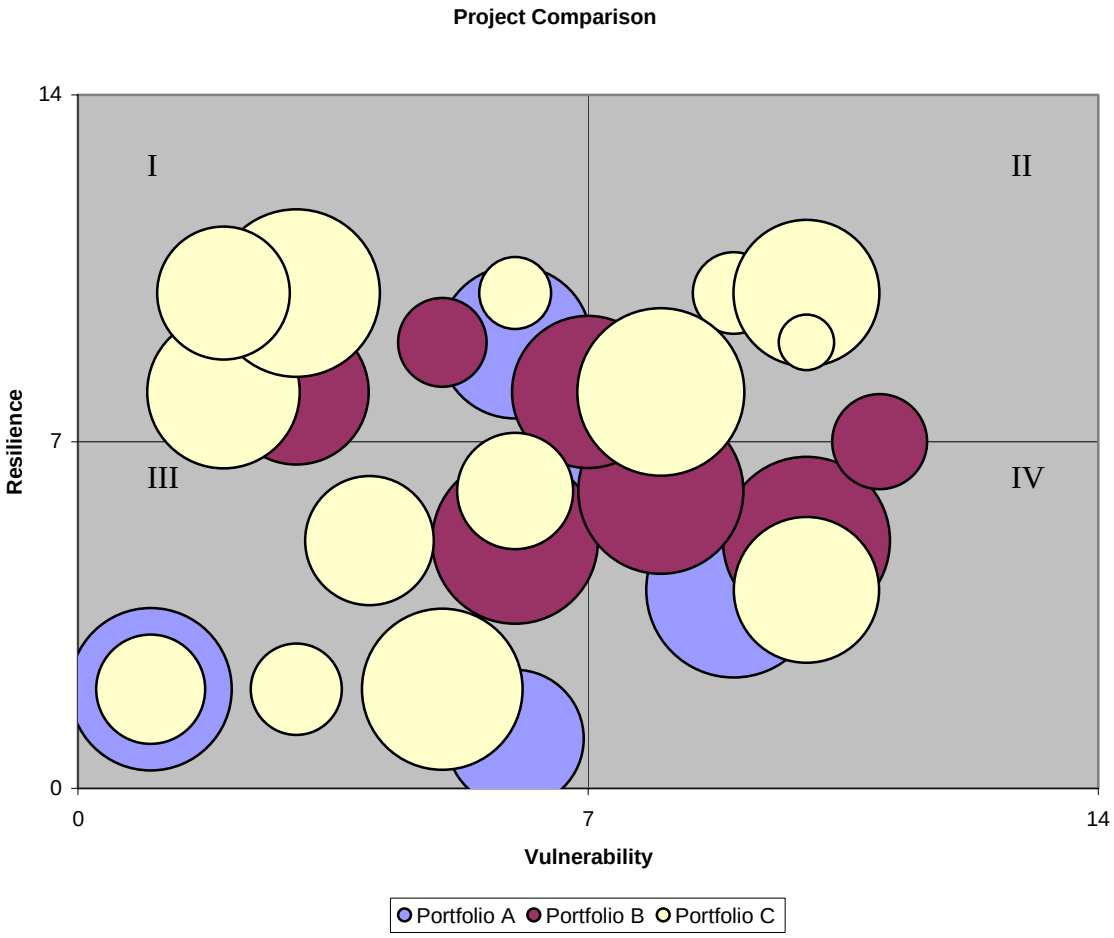
[i] Al-Khafaji, K. 2008. Climate Change Portfolio Review: Literature Review and Evaluation Matrix. Technical Report commissioned by CI-CABS.

[ii] Ibid.

simultaneously protect appropriate places, limit non-climatic stressors, and manage adaptively; therefore, the general resilience promotion score was normalized by factor equal to the maximum score considering just 2 of the 3 categories. In an analogous fashion, a specific resilience promotion score can be determined for each project (details for scoring are provide in Table A3) and similarly normalized. The overall score for how well a project promotes resilience is a weighted average of its general and specific resilience promotion sub-scores; the sub-scores are equally weighted.

A sample project evaluation form illustrating this sort of evaluation is shown in Table A1, with the details for the column headings and scoring given in Tables A2 and A3. A sample project evaluation matrix displaying the vulnerability and resilience scores and the relative budget of the project is given in Figure A1. Note that quadrant II contains highly climate relevant projects, quadrant III contains projects with limited relevance, while quadrants I and II contain projects of moderate relevance that either promote resilience effectively or target vulnerabilities, respectively, but not both.

Figure A1 - Sample project evaluation matrix.



Colored circles indicate illustrative project distribution. Projects are plotted in Vulnerability-Resilience space according to qualitative scores determined in the project evaluation matrix. Each circle corresponds to a project, the size of the circle is proportional to a projects budget. Different colors represent different portfolios.

Table A1 - Project evaluation worksheet

Project		Vulnerability					Resilience promotion							
		Geographic/Ecosystems				Species	Area		Non-climate threats		Management			
		General --> Specific												
Name	Budget		Region	Hotspot	Ecosystems & landforms	Climate sensitive	General	Specific	General	Synergistic	General	Specific	Scaled Vulnerability score	Scaled Resilience score
Bladen Nature Reserve Protection Program		--	2		3				2		1		0.50	0.25
Infrastucture Integration and Biodiversity Conservation in Mesoamerica		--	2						1		3		0.20	0.33
Baviaanskloof Mega-Reserve Project: Mega-Reserve Vision and 5-Year Development and Management Plan		--	2	3	3						3		0.80	0.25
Co-authorship of a Book Entitled: East of the Cape - Conserving Eden		--	2								1		0.20	0.08
Framework for Eco-Historical Tourism in the Sierra Madre Biodiversity Corridor		--			3						2		0.30	0.17
Building Partnerships for Sustainable Management of Critical Watersheds in the Sierra Madre's PMMR, Nueva Vizcaya, Northeastern Luzon, Philippines		--			3						3		0.30	0.25

Table A2 - Description of vulnerability score assignment.

Vulnerability	**Geographic/Ecosystems**	General --> Specific	Region	Far Northern latitudes Eastern Amazonia Mesoamerica Central Africa Southern India Himalayan region South Africa Australia Southeast USA Southwestern South America	Assign 2 points
			Hotspot Tier 1	California Floristic Province Cape Floristic Region Polynesia and Micronesia Southwest Australia	Assign 3 points
			Hotspot Tier 2	Caribbean Indo-Burma Mediterranean Basin New Caledonia New Zealand Mountains of South Central China Succulent Karoo Tropical Andes	Assign 2 points
			Ecosystems & landforms	Sea-ice biomes tundra tropical cloud forest tropical dry forest mountainous areas Mediterranean-type ecosystems coastal wetlands (mangroves, salt marshes, mudflats) river deltas oceanic islands	Assign 3 points
	Species		Climate change sensitive species	Narrow habitat requirements or tight association with particular habitats Narrow thermal range, moisture ranges, O2 ranges, etc. Or low thresholds beyond which physiological function rapidly breaks down. Dependence on environmental triggers for life-cycle events (e.g. migration, spring emergence, breeding, etc.) Only consider cues likely to be affected by climate change (e.g. temperature or rainfall, not day length or lunar cycle). Tight dependence on interspecific interactions, e.g. sybionts, specialized pollinators/seed dispersers, host plants, narrow prey/resource range Limited ability to disperse and colonize new areas. May consider extrensic limitations to dispersal, such as geographic features (large mountain ranges, oceans) or anthropogenic transformation of migration routes	Assign 0-3 points based on relative numbers of sentsitive species as well as their vulnerability to climate change. Do not consider general risk factors like current IUCN classification or endemism

Table A3 - Description of resilience promotion score assignment

Resilience promotion	Area	General	Additional area Part of regional network Increases connectivity Buffer zones Corridors Redundancy Representation of heterogeneity (topographic, microhabitat, genetic)	Assign 0-3 points. Consider number of qualifying actions, their efficacy, and any other relevant factors
		Specific	Moveable reserves Areas chosen for future climate Corridors planned for future climate Climatic refugia Outlier populations Upland areas for wetland migration	Assign 0-3 points. Consider number of qualifying actions, their efficacy, and any other relevant factors
	Non-climate threats	General	Pollution Exploitation, harvesting	Assign 0-3 points. Consider number of qualifying actions, their efficacy, and any other relevant factors
		Synergistic	Invasive species Anthropogenic disturbance Disease & Parasites Habitat loss, fragmentation Water diversions and withdrawals	Assign 0-3 points. Consider number of qualifying actions, their efficacy, and any other relevant factors
	Management	General	Regional & trans-jurisdictional planning, coordination, & cooperation Adaptive management procedures, monitoring, and evaluation Matrix management (incentive or regulation based) Outreach and engagement with communities Habitat restoration Enhancement, replacement, or focused maintenance of ecosystem services (e.g. pollination, seed dispersal, pest control) Species reintroductions Ex situ management (captive breeding)	Assign 0-3 points. Consider number of qualifying actions, their efficacy, and any other relevant factors
		Specific	Species translocations (assisted migration) Habitat creation Manipulation of disturbance regimes (e.g. fuel reduction and fire suppression to prevent forest conversion) Conservation call options	Assign 0-3 points. Consider number of qualifying actions, their efficacy, and any other relevant factors