APPLICATION OF THE CLIMATE VULNERABILITY INDEX FOR ALDABRA ATOLL

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Climate Vulnerability Index
Technical Memorandum Series

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Scott F. Heron, Jon C. Day, Nancy Bunbury, Luke A'Bear, Anna Koester, Christina Quanz, Veronique Banane, Jeremy Raguain, Cheyenne Chang-Yunn, Corianna Julie and Frauke Fleischer-Dogley

aldabra atoll

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CVI

VALUES-BASED | SCIENCE-DRIVEN | COMMUNITY-FOCUSED

APPLICATION OF THE CLIMATE VULNERABILITY INDEX FOR ALDABRA ATOLL

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Published: December 2021

ISBN: 978-0-6455878-2-1

Suggested citation: Heron SF, Day JC, Bunbury N, A'Bear L, Koester A, Quanz C, Banane V, Raguain J, Chang-Yunn C, Julie C, Fleischer-Dogley F (2021). *Application of the Climate Vulnerability Index for Aldabra Atoll*. Climate Vulnerability Index Technical Memorandum Series No. 5, Townsville, Australia.

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EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

Climate change is the fastest growing global threat to World Heritage. Many World Heritage properties around the world have already experienced significant negative impacts, damage and degradation. These and many other significant heritage areas are vulnerable to impacts from climate stressors such as rising temperatures, sea level rise and drought. Recently observed trends are expected to continue and accelerate as climate change intensifies.

The Aldabra Atoll World Heritage property is among the largest atolls in the world and its remote location has resulted in a high level of biodiversity and endemism. Aldabra Atoll was inscribed on the UNESCO World Heritage List in 1982, in recognition of its Outstanding Universal Value (OUV).

This report describes outcomes from an application of Phase 1 of the Climate Vulnerability Index (CVI) for Aldabra Atoll, conducted with staff of the Seychelles Islands Foundation, the agency responsible for the management of the property. The CVI process is a methodology to rapidly assess vulnerability through expert appraisal of the best-available climate science, applicable to all types of World Heritage properties (natural, cultural or mixed). The analysis was conducted during three online sessions across several weeks in November and December 2021. Using the CVI Snapshot rapid assessment approach, the first phase of the CVI assessed the OUV Vulnerability. The Snapshot is the most abbreviated delivery mode for the CVI process.

Through examination of the key World Heritage values, participants identified the three key climate stressors likely to impact the OUV of Aldabra Atoll as:

- Extreme temperature events;
- Drought (severity, duration, frequency); and
- Storm intensity and frequency.

Considering a high-emissions climate scenario (RCP8.5) and a timeframe for the analysis of ca. 2050, OUV Vulnerability was assessed as Moderate (on a three-point scale from Low to High). There is potential for some loss or alteration of some attributes that convey the OUV.

Various opportunities were discussed to strategically mitigate the potential impacts from the key climate stressors. These were prioritised based on feasibility and considering the current preference for “hands-off” management activities to support future resourcing for their implementation.

This rapid Snapshot assessment provides a useful and informative initial analysis of climate vulnerability for Aldabra Atoll. A full CVI Workshop analysis is recommended to draw upon the expertise of a broader range of experiences; to align with other CVI assessments of World Heritage properties; and, importantly, to assess the vulnerability of the associated community (local, national and international).

INTRODUCTION

SECTION 1. INTRODUCTION

1.1 Background

Climate change is the fastest growing global threat to World Heritage properties (Osipova et al. 2017, 2020), many of which are already being impacted. Like many other World Heritage properties, Aldabra Atoll is vulnerable to impacts of climate change. The severity of current climate impacts on individual World Heritage properties varies, as do the range of climate drivers causing those impacts and the rate at which they are occurring. In most cases, climate change impacts result in a degradation of the attributes that collectively convey the Outstanding Universal Value (OUV). OUV is the central concept for World Heritage properties and the basis for inscription on the World Heritage List.

1.2 Overview of the Climate Vulnerability Index (CVI)

The Climate Vulnerability Index (CVI) is a systematic and rapid assessment tool that is values-based, science-driven and community-focused. It was developed to assess the impacts of climate change upon all types of World Heritage (WH) areas – natural, cultural, and mixed. The CVI is comprised of two phases assessing:

- **OUV Vulnerability** - this assesses the exposure, sensitivity, and adaptive capacity of the key values of the property (i.e., the World Heritage attributes that convey the OUV), assessing how they will be impacted by the three key climate stressors chosen to be the most relevant for that property; and
- **Community Vulnerability** based on the economic, social, and cultural connections of the community associated with the World Heritage property, the dependency of the community upon the property, and the capacity of the community to adapt to climate change. The Community Vulnerability assesses the extent to which the community may be able to adapt, an aspect rarely considered in most vulnerability assessments.

At the time of this report, applications of the CVI have occurred in natural WH properties (including Shark Bay, Western Australia; and Wadden Sea, which spans Germany, Netherlands and Denmark) and in an array of diverse cultural WH properties – a small archaeological site (Heart of Neolithic Orkney, Scotland); a major urban city (Old and New Towns of Edinburgh, Scotland), two very diverse cultural landscapes (Vega Archipelago in Norway, and Sukur Cultural Landscape in Nigeria) and in a village with coastal fortifications (Kilwa Kisiwani in Tanzania). The CVI was also the focus of a recent major online training course in Africa (see: *cvi-africa.org*).

1.3 Why was Aldabra Atoll chosen for a CVI application?

Seychelles Islands Foundation (SIF) was awarded funding by the Rosa Luxemburg Foundation (Rosa Luxemburg Stiftung) to undertake the project "*Climate vulnerability assessment and justice for Aldabra*". SIF approached the CVI developers regarding the potential for a CVI application within this project. Through a series of video conference meetings, it was agreed that an abbreviated mode of the CVI – the CVI Snapshot – would be appropriate given the scope and timing for the project. This delivery mode assesses only the Phase 1 of the CVI (OUV Vulnerability) in consultation with a small group of representatives from the property (which can mean as few as one or two key people). It was also noted that this application could benefit by considering UNESCO reports of climate change impacts on World Heritage coral reefs (Heron et al. 2017, 2018) and from an earlier CVI application at one of those properties (Shark Bay, Western Australia). With the on-going pandemic, the CVI Snapshot was conducted via video conference.

ALDABRA ATOLL WORLD HERITAGE PROPERTY

SECTION 2. ALDABRA ATOLL WORLD HERITAGE PROPERTY

2.1 Location and description

Aldabra Atoll is a raised coral atoll in the western Indian Ocean near 46.3°E, 9.4°S. It is one of the world's largest atolls and is situated in the Aldabra Group of islands that are part of the outer Islands of the Seychelles. Aldabra Atoll is around 1100 km southwest of the Seychelles capital, Victoria, north of Madagascar and east of Tanzania (Figure 2.1).

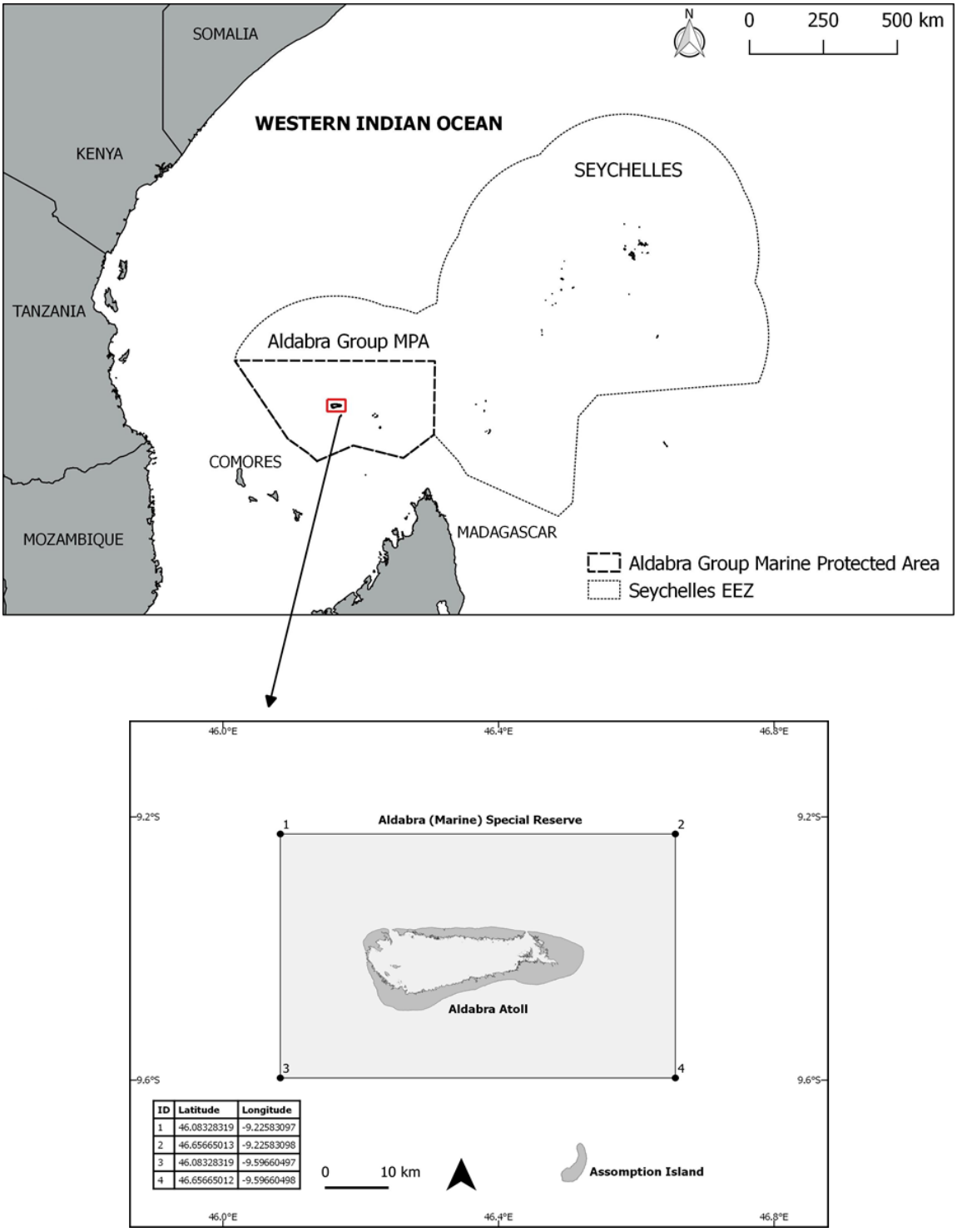

Figure 2.1 Location and detail of Aldabra Atoll. (upper) Western Indian Ocean showing the location of the Aldabra Group Marine Protected Area (MPA) within the the Seychelles Exclusive Economic Zone (EEZ). (lower) Aldabra Atoll is located within the Aldabra Marine Special Reserve.

The property was inscribed on the World Heritage List in 1982, with the retrospective Statement of Outstanding Universal Value (SOUV, the foundational document for World Heritage) adopted in 2010 (see Appendix 1).

The values and attributes described in the SOUV were recognised by UNESCO as meeting three of the natural criteria for World Heritage: Criterion (vii), relating to natural phenomena and aesthetic importance; Criterion (ix), relating to ecological and biological processes; and Criterion (x), relating to biological diversity and related habitat. Habitats include islands, coral reefs, seagrass beds and mangrove mudflats that support a diverse array of terrestrial and marine species. These include the giant tortoise, land and sea birds and endemic flora. Due to the level of remoteness and inaccessibility, these have experienced minimal human impact, allowing the evolution of numerous endemic species.

Within the UNESCO World Heritage reporting framework, there have been five principal reports[§]:

- in 1986, a State of Conservation report was submitted that included a request for funding to support consultant services regarding the eradication of feral goats in Aldabra Atoll and equipment;
- in 2001, a management plan for Aldabra Atoll developed in 1998 and covering the period 1998-2005 was submitted as part of the Periodic Report;
- in 2008, a periodic report was submitted to World Heritage Convention as part of the periodic cycle reporting;
- in 20014, a periodic report was submitted to World Heritage Convention as part of the periodic cycle reporting; and
- in 2020, a periodic report was submitted to World Heritage Convention as part of the periodic cycle reporting

In addition to the removal of goats, substantial efforts have been made to prepare for the eradication of rats and cats. It is of note that the 1998 management plan identified sea-level rise, ocean warming and drought as key climate-related threats; and mentioned the potential reduction in WH values that could results from events such as the coral bleaching and mortality of 1998.

2.2 Identifying and assessing the key values of the World Heritage property

A WH property is inscribed because it has values that have been recognised as being of international significance. Those values are underpinned by attributes (tangible or intangible characteristics) at which level management typically occurs. While some property values are described within the SOUV (the WH values), there can also be property values that are not included, or not entirely outlined, in the SOUV but which are important at a local, national or even international level. In the CVI process, values in this second group are referred to as other Significant Property Values (SPVs). A hierarchy of these is often helpful to distinguish into which category each of these should be placed (Figure 2.2). While these SPVs may also experience impacts from climate change, the CVI analysis focuses solely on the values and attributes outlined within the SOUV.

Analysis of the SOUV to determine key values of the property is a foundational component of the CVI process. Excerpts from the SOUV were identified and grouped into common themes as a list of 'key values'. This was initially undertaken by the CVI developers and submitted to SIF for review (and subsequent improvement). The final list of key values is summarised in Table 2.1 (see also Annex 1 for the full SOUV). In addition, a list of other SPVs was also compiled by SIF staff (see Appendix 2).

Participants in the CVI Snapshot assessed the current condition and recent trend (since inscription) of the key values (Table 2.1, legend on page 13).

[§] https://whc.unesco.org/en/list/185/

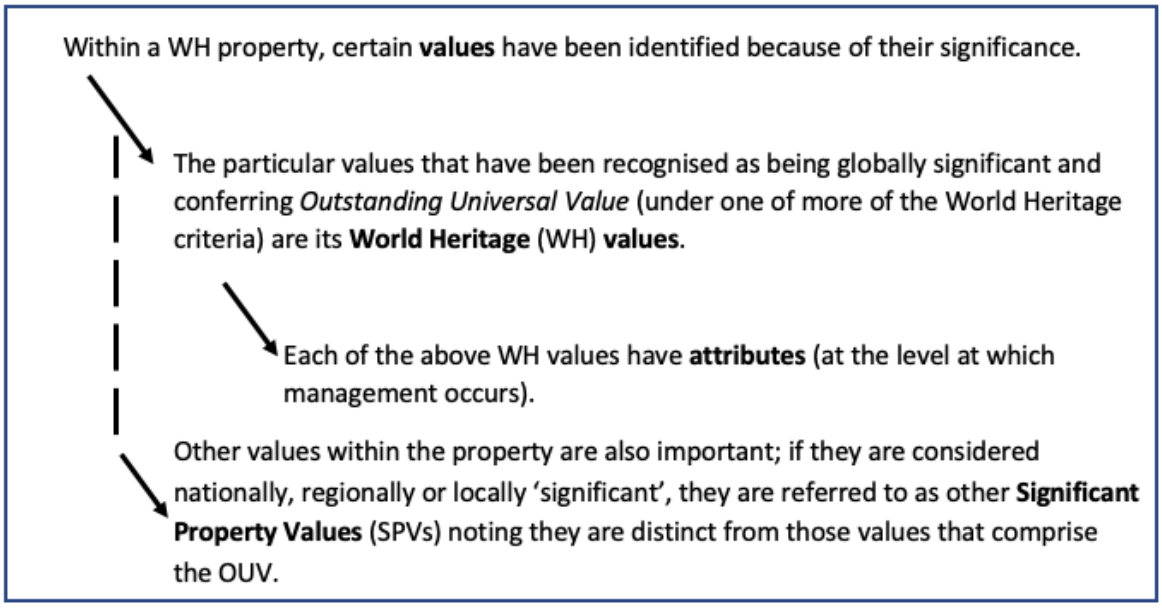

Figure 2.2 Hierarchy of World Heritage terminology. *(adapted from Heron et al. 2020)*

Table 2.1 Key values for Aldabra Atoll derived from the Statement of Outstanding Universal Value, together with the assessed current condition and recent trend since inscription (legend on page 10).

Key values	Excerpts taken directly from the Statement of OUV	Attributes (at the level at which management is undertaken) for each key value	Assessment of current condition and recent trend (since 1982)
1. Outstanding example of raised coral atoll	outstanding example of a raised coral atoll.	*Tangible attributes* • *size of atoll* • *raised coral atoll* • *large shallow lagoon* • *islands /islets* *Intangible attributes* • *intactness*	
	one of the largest atolls in the world,		
	Aldabra Atoll consists of four main islands of coral limestone separated by narrow passes and enclosing a large shallow lagoon		
	Includes the four main islands which form the atoll plus numerous islets and the surrounding marine area.		
2. Marine habitats with minimal human impact	…atoll is comprised of four large coral islands which enclose a shallow lagoon; the group of islands is itself surrounded by a coral reef	*Tangible attributes* • *coral reef system (fringing & lagoon)* • *seagrass beds* • *mangrove mudflats* • *abundance/size of reef species* • *minimal human impact* *Intangible attributes* • *pristine reef system* • *reef ecosystem health* • *intactness*	
	Marine habitats range from coral reefs to seagrass beds and mangrove mudflats with minimal human impact.		
	The pristine fringing reef system and coral habitat are in excellent health and distinguished by their intactness and the sheer abundance and size of species contained within them.		
	The lagoon contains many smaller islands and the entire atoll is surrounded by an outer fringing reef		

3. A remote, isolated, almost intact ecosystem with high endemism	Due to difficulties of access and the atoll's isolation, Aldabra has been protected from human influence Due to its remoteness and inaccessibility, the atoll has remained largely untouched by humans for the majority of its existence. The remoteness and inaccessibility of the atoll limit extensive human interference which could otherwise jeopardize ongoing processes. As such, Aldabra displays an almost intact ecosystem… …protection and management need to address the constant threats posed by invasive alien species, climate change and oil spills the property displays an almost intact ecosystem The atoll's isolation has also allowed the evolution of endemic flora and fauna. a relatively rich biota for an oceanic island and a high degree of endemism permitted the development of a variety of discrete insular communities with a high incidence of endemicity among the constituent species The atoll constitutes a refuge for over 400 endemic species and subspecies (including vertebrates, invertebrates and plants).	*Tangible attributes* • *naturally viable populations of all key species* • *limited human influence* • *remoteness and inaccessibility* • *endemic flora* • *endemic fauna (vertebrates & invertebrates)* • *high degree of endemism* *Intangible attributes* • *untouched, intact ecosystem* • *remoteness* • *minimal intervention* • *rich biota*	
4. Geomorph-ology	Geomorphologic processes have produced a rugged topography, which supports a variety of habitats Most of the land surface comprises ancient coral reef (~125,000 years old) which has been repeatedly raised above sea level. The size and morphological diversity of the atoll	*Tangible attributes* • *rugged topography* • *ancient coral reef* • *variety of habitats* *Intangible attributes* • *geomorphic processes* • *morphological diversity*	

CURRENT CONDITION

Rating	Criteria
Good	The site's values are in good condition and are likely to be maintained for the foreseeable future, provided that current conservation measures are maintained.
Good with some concerns	While some concerns exist, with minor additional conservation measures the site's values are likely to be essentially maintained over the long-term.
Significant Concern	The site's values are threatened and/or may be showing signs of deterioration. Significant additional conservation measures are needed to maintain and/or restore values over the medium to long-term.
Critical	The site's values are severely threatened and/or deteriorating. Immediate large-scale additional conservation measures are needed to maintain and/or restore the site's values over the short to medium-term or the values may be lost.

TREND *(since inscription in 1982)*

— **STABLE** ↗ **IMPROVED** ↘ **DETERIORATED** ? **UNKNOWN**

5. Evolutionary and Ecological Processes	outstanding example of an oceanic island ecosystem in which evolutionary processes are active within a rich biota. It is sufficiently large to support all ongoing biological and ecological processes essential for ensuring continued evolution in the atoll. While the remoteness of the property has limited human interference, thus contributing for the protection of the biological and ecological processes all the elements of its [giant tortoise's] intricate interrelationship with the natural environment are evident plants which have evolved in response to [giant tortoise] grazing patterns. contains one of the most important natural habitats for studying evolutionary and ecological processes The atoll's isolation has also allowed the evolution of endemic flora and fauna.	*Tangible attributes* • *rich biota* *Intangible attributes* • *active evolutionary processes* • *ongoing biological and ecological processes (leading to continued evolution)* • *intricate relationship between tortoise and environment*	
6. Giant tortoises	retains some 152,000 giant tortoises, the world's largest population of this reptile. It is home to the largest giant tortoise population in the world. The top of the terrestrial food chain is, unusually, occupied by an herbivore: the giant tortoise. The tortoises feed on grasses and shrubbery, including plants which have evolved in response to its grazing patterns These include a population of over 100,000 Aldabra Giant Tortoise. The tortoises are the last survivors of a life form once found on other Indian Ocean islands and Aldabra is now their only remaining habitat The tortoise population is the largest in the world and is entirely self-sustaining:	*Tangible attributes* • *size of Aldabra giant tortoise population (largest in world)* • *food-plants and habitats for tortoise* • *self-sustaining population of tortoise* *Intangible attributes* • *historical significance of tortoises*	
7. Other key fauna	There are also globally important breeding populations of endangered green turtles, and critically endangered hawksbill turtles are also present. The property is a significant natural habitat for birds, with two recorded endemic species (Aldabra Brush Warbler and Aldabra Drongo), and another eleven birds which have distinct subspecies, amongst which is the White-throated Rail, the last remaining flightless bird of the Western Indian Ocean. vast waterbird colonies including the second largest frigatebird colonies in the world One of the world's only two oceanic flamingo populations sustaining naturally viable populations of all key species.	*Tangible attributes* • *green turtles* • *hawksbill turtles* • *Aldabra brush warbler* • *Aldabra drongo* • *White-throated rail* • *other 11 landbird species* • *second largest frigatebird colonies* • *one of only two oceanic flamingo populations* • *vast waterbird colonies* • *endemic species*	  warbler  drongo  landbirds   
8. Superb aesthetics	The richness and diversity of the ocean and landscapes result in an array of colours and formations that contribute to the atoll's scenic and aesthetic appeal. providing a superlative spectacle of natural phenomena	*Intangible attributes* • *aesthetic appeal* • *superb spectacle* • *richness and diversity of ocean & landscapes*	 
9. Outstanding natural laboratory	Aldabra provides an outstanding natural laboratory for scientific research and discovery. Due to minimal human interference, these ecological processes can be clearly observed in their full complexity.	*Intangible attributes* • *outstanding natural laboratory* • *scientific research & discovery*	

ALDABRA ATOLL WORLD HERITAGE PROPERTY

SECTION 3. APPLYING THE CLIMATE VULNERABILITY INDEX (CVI) TO ALDABRA ATOLL

The Climate Vulnerability Index (CVI) is a rapid assessment tool that was specifically developed for application to World Heritage properties. The CVI framework builds upon the vulnerability framework approach described in the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007). Vulnerability of OUV is determined by assessing the exposure, sensitivity and adaptive capacity with respect to determined climate stressors. The OUV Vulnerability becomes the exposure term to assess the vulnerability of the community associated with the property, combining with assessments of economic-social-cultural dependency (sensitivity) and adaptive capacity (Figure 3.1). A customised spreadsheet-based worksheet is used to determine outcomes based on user inputs. A more detailed outline of the CVI methodology is provided by *Day et al.* (2020).

For Aldabra Atoll, Phase 1 of the CVI process – to assess OUV Vulnerability – was undertaken as a CVI Snapshot. Two one-hour introductory and coordination meetings of SIF staff and the CVI developers were held in July and August 2021 to ensure the required outcomes of the project would be achieved and to arrange logistics. The Phase 1 analysis was conducted in three Snapshot sessions (totalling approximately six hours) over a four-week period in November and December 2021. Between sessions during this period, SIF staff undertook a review and revision of the key values.

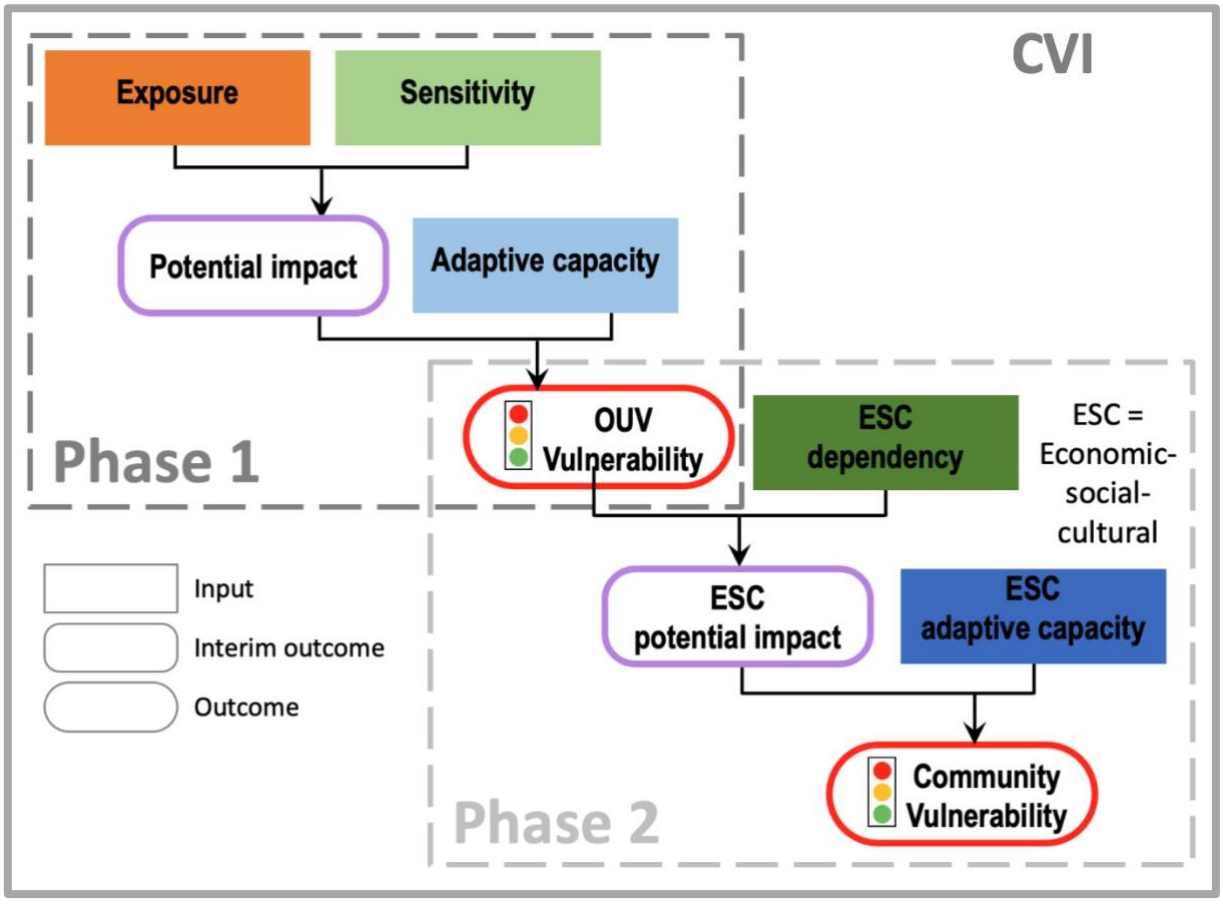

Figure 3.1 The CVI framework to undertake rapid assessment of climate change vulnerability of World Heritage properties and associated communities. Phase 1 was assessed for Aldabra Atoll.

3.1 Selection of key climate stressors

A list of 15 climate stressors considered likely to impact a broad range of WH properties was provided as part of the CVI process. Definitions of these were clarified during the Snapshot sessions, including the characterisation of each as either 'chronic' (i.e., acting over years-to-decades, also known as trend or press stressors) or 'acute' (i.e., acting over a shorter periods of days-to-weeks, also known as event or pulse stressors). There is also scope within the process to nominate a climate stressor that is particularly relevant to the specific property but not featured in the standard list; however, this was not deemed necessary for Aldabra Atoll.

The Snapshot participants considered the appropriate time scale within which to consider impacts was ca. 2050. The participants also decided to conduct the assessment considering a high-emissions scenario (Representative Concentration Pathway, RCP8.5), noting that future climate change progression until 2050 is anticipated to be fairly similar under other RCPs (e.g., stabilisation scenario, RCP4.5) due to committed warming from historical greenhouse gas emissions.

For each of the identified key values from the SOUV, the participants analysed which climate stressors would be likely to have the greatest impact. The climate stressors appearing in the top three for each value (including equal-third) were used to rank the stressors (Table 3.1, Figure 3.2).

Implicit within the methodology used to determine the three key climate stressors is an equal weighting across all key values of OUV. Workshop participants considered which of the key values of OUV may be of greater importance or priority than others. Marine habitats with minimal human impact; A remote, isolated, almost intact ecosystem with high endemism; and Evolutionary and ecological processes were collectively considered foundational to the other attributes and therefore of higher priority in evaluating climate vulnerability. When considering the comparative importance of key values, participants confirmed the three stressors identified using the selection process as the most appropriate for the CVI analysis. The three climate stressors likely to have greatest impact on the OUV for ca. 2050 were determined as:

- Extreme temperature events;
- Drought; and
- Storm intensity and frequency.

Table 3.1 Climate stressors identified as likely to have the greatest impact for each of nine key values of OUV. Marked cells indicate that the climate stressor was in the top three responses for each key value. Stressor impacts were assessed for 2050 under a high-emissions scenario.

	Temperature trend (air and/or water)	Extreme temperature events	Precipitation trend	Intense precipitation events	Flooding (fluvial, pluvial)	Drought (severity, duration, frequency)	Mean wind trend	Storm intensity and frequency	Sea level rise (trend)	Coastal flood	Storm surge	Coastal erosion	Changing currents
Key values of OUV	Climate stressors												
Outstanding example of raised coral atoll	X	X							X				
Marine habitats with minimal human impact	X	X	X					X					
A remote, isolated, almost intact ecosystem with high endemism		X				X		X					
Geomorphology								X	X			X	
Evolutionary and ecological processes		X	X			X							
Giant tortoises	X					X			X				
Other key fauna		X				X		X					
Superb aesthetics		X				X	X	X					
Outstanding natural laboratory			X			X		X					
Total	3	6	3	0	0	6	1	6	3	0	0	1	0

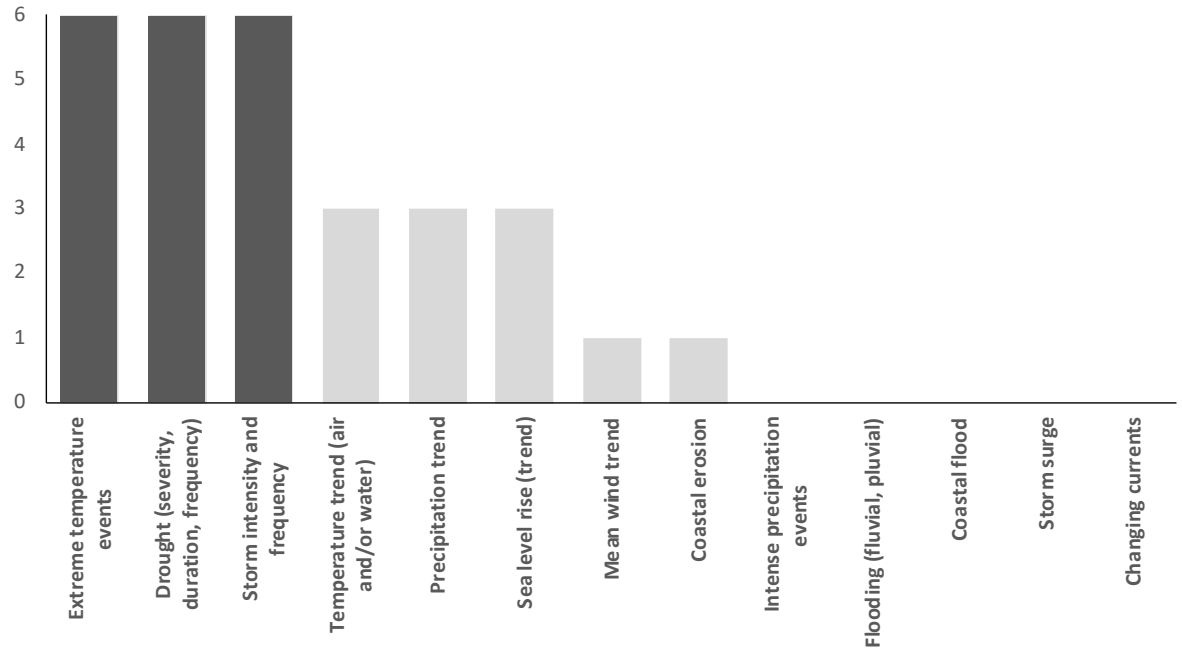

Figure 3.2 Histogram of impacts on nine key values of OUV from 15 climate stressors whose impacts were assessed for ca. 2050 under a high-emissions climate scenario.

Examples of impacts identified from these stressors were: coral bleaching and mortality, loss of habitat and fauna (Extreme temperature events); impacts on evolutionary and ecological processes, and terrestrial flora and fauna (Drought); and impacts on birds and their habitat/feeding grounds, tortoises, corals and turtle nesting (Storm intensity and frequency).

As previously noted, in addition to the values within the OUV, there are other values of local, national or international significance. Between sessions, participants identified a list of other SPVs that were compiled for future consideration and reference (Appendix 2). While these values were not included in the Snapshot analysis, which focused only on the key values, the climate stressors identified may also affect these other SPVs.

3.2 Assessing OUV Vulnerability

For the identified three key climate stressors, assessments of **exposure** and **sensitivity** of the entire OUV system to each stressor were undertaken using a five-point categorical scale, adapted from categories used by IPCC and IUCN analyses (see Day et al. 2020 for details). These assessments were undertaken in discussions involving all participants. Exposure to all three key climate stressors was determined as very likely (>90%). Sensitivity of OUV to Extreme temperature events and Drought were each determined as high, indicating potential for loss or alteration of many key WH values, whilst sensitivity to Storm intensity and frequency was determined as moderate, indicating some loss or alteration of some key WH values will occur. Notably, the sensitivity of OUV with respect to Air Temperature Change was increased from the initial assessment (moderate) to the final assessment (high) through application of the modifiers (Table 3.2).

The **potential impact** on the OUV, derived from exposure and sensitivity, was determined as extreme (the highest on a four-point scale, low to extreme) for Extreme temperature events and Drought; and as high for Storm intensity and frequency (Table 3.2).

The capacity of a system to adapt to stress can mitigate (i.e., reduce) the potential impacts of that stress. The **adaptive capacity** of the OUV system was assessed for each key climate stressor by considering the levels of local management response and scientific/ technical support (four-point scale), as well as the effectiveness of these to address impacts from each stressor (four-point scale).

In preparation for these assessments, participants were asked to brainstorm potential adaptive capacity options to mitigate climate impacts and to identify associated key values (

Table 3.3). These were subsequently prioritised by the level of feasibility and likelihood of undertaking. The prioritisations were categorised as High (for strategies already being considered), Potential (for those feasible but not yet in consideration) and Low (not currently feasible). Importantly, it was noted that there is a strong leaning toward "hands-off" management approaches on Aldabra Atoll – and therefore a cautious and tentative disposition to undertake dramatic interventions – which was included in the prioritisations in the Low category. The assessments of adaptive capacity were informed by these adaptive strategies, principally by those in the High category.

For each key climate stressor, the adaptive capacity was determined to be moderate (four-point scale, very low to high; Table 3.2). Based on these assessments, the OUV Vulnerability (three-point scale, low to high) was determined to be moderate for all three key climate stressors. The combined **OUV Vulnerability** for Aldabra Atoll was therefore determined to be Moderate (Table 3.2).

It is important to acknowledge that the assessed Moderate level of OUV Vulnerability is contingent upon the implementation of identified adaptive capacity strategies. In the absence of these, the property would likely be subject to the full effect of the assessed potential impact, which was at the highest level (extreme) with respect to two of the key climate stressors and at the second-highest level (high) for the third (Storm intensity and frequency).

Table 3.2 CVI Snapshot rapid assessment of OUV Vulnerability to the identified three key climate stressors. Assessed values of exposure, sensitivity and adaptive capacity contribute to derived outcomes for potential impact and OUV Vulnerability. Colours refer to the elements of the CVI framework (Figure 3.1).

Key Climate Stressors:	Extreme temperature events	Drought (severity, duration, frequency)	Storm intensity and frequency
Exposure	**Very likely**	**Very likely**	**Very likely**
Sensitivity	**High**	**High**	**Moderate**
Potential impact	**Extreme**	**Extreme**	**High**
Local management response	Low/Moderate	Moderate	Moderate
Scientific/technical support	Moderate	Moderate/High	Low
Effectiveness	Low/Moderate	Low/Moderate	Moderate
Adaptive capacity	**Moderate**	**Moderate**	**Moderate**
OUV Vulnerability	**Moderate**	**Moderate**	**Moderate**
Combined OUV Vulnerability	**Moderate**		

Table 3.3 Strategies considered in the assessment of adaptive capacity, prioritised into categories (see text), noting the relevant key climate stressors (ETE=Extreme temperature events; D=Drought; SI&F=Storm intensity & frequency) and key values for each (numbered in Table 2.1).

Feasibility/ likelihood	Adaptive strategy	Relevant key climate stressors			Relevant key values								
		ETE	D	SI&F	1	2	3	4	5	6	7	8	9
High	Rat & cat eradication	X	X	X									
	Build reservoirs, water storage		X										
	Rebuild research station away from coast			X									
Potential	Species translocation to provide buffer populations		X	X									
	Captive breeding (e.g., banded snail)		X	X									
Low	Plant restoration	X	X	X									
	Implement shading	X											
	Coral restoration	X											
	Support tortoise hatchlings		X										
	Mangrove nursery, seed collection & propagation		X										
	Create a turtle nursery			X									
	Replace *Casuarina* with natural vegetation			X									

CONCLUSION

SECTION 4. CONCLUSION

4.1 CVI Snapshot outcomes

Using the CVI Snapshot rapid assessment, the Aldabra Atoll World Heritage property was assessed to have a Moderate level of OUV Vulnerability (on a three-point scale from Low to High). This outcome was with respect to the ca. 2050 under a high-emission scenario (RCP8.5) and considered the three key climate stressors identified by the participants: Extreme temperature events, Drought and Storm intensity and frequency. There is potential for extreme impacts from climate change upon the World Heritage values, which may be mitigated by naturally-occurring and/or management-led strategies, as noted in the adaptive capacity assessment.

In addition to the assessed OUV Vulnerability, outcomes from the workshop included insights from this analysis towards a full CVI Workshop (see below), including analysis of Community Vulnerability; and the discussion of a variety of scientific studies that could be undertaken, potentially as collaborative projects by SIF and CVI. These included:

- analysis of historical meteorological records for past heatwave events;
- comparisons of historical satellite and in situ ocean temperature data to provide better guidance for localised conditions from satellite monitoring products;
- analysis of subsurface ocean temperature data to provide information on the likelihood and effects of upwelling and internal wave events
- a further study on the 2015/16 heat stress and coral bleaching event, particularly noting the spatial variation between eastern and western ocean-facing reefs and within the lagoon.

4.2 Future CVI analysis

The CVI Snapshot delivery mode provides a rapid assessment of climate vulnerability from a small group of participants, typically (including for Aldabra) comprised of property managers. In contrast, the full CVI Workshop includes a diverse array of representatives of management, policy, academic, business and community representatives, in which different perspectives are brought together. In addition, the broader CVI Workshop mode uses breakout groups (with diverse make-up) to foster input from across all areas of expertise for inclusion in the analysis, which also provides the potential for a range of responses that are discussed in synthesis sessions. Finally, there are additional assessments of 'modifiers' to the exposure and sensitivity analyses that are incorporated in a Workshop.

Building from the assessment of OUV Vulnerability, applying Phase 2 of the CVI process would provide an assessment of Community Vulnerability for Aldabra Atoll. This assessment would consider economic, social, and cultural connections with the property to evaluate the effects on the community from a loss of World Heritage values due to climate change. While assessments of Community Vulnerability often prioritise the 'local' community (over national and international considerations) in terms of potential impacts, this would very likely not be the case for Aldabra Atoll given the small number of local residents. However, given the high level of national and international interest in Aldabra, assessing the Community Vulnerability would complete the CVI process and may provide useful information to SIF. In addition, undertaking Phase 2 for such a remote location would be novel for the CVI and would provide a first exemplar for other similarly-remote World Heritage properties.

ACKNOWLEDGEMENTS

This CVI application for Aldabra Atoll would not have been possible without the funding support to SIF from the Rosa Luxembourg Foundation.

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ACRONYMS and GLOSSARY

ACRONYMS

CVI	*Climate Vulnerability Index*
ESC	*Economic, Social and Cultural*
IPCC	*Intergovernmental Panel on Climate Change*
IUCN	*International Union for Conservation of Nature*
JCU	*James Cook University*
KVs	*Key values*
OUV	*Outstanding Universal Value*
SIF	*Seychelles Islands Foundation*
SPVs	*Significant Property Values*
WH	*World Heritage*

GLOSSARY

Adaptive capacity	The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
Climate	the composite or generally prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years
Climate change	A change in the pattern of weather, and related changes in oceans, land surfaces and ice sheets, occurring over time scales of decades or longer.
Weather	The state of the atmosphere—its temperature, humidity, wind, rainfall and so on—over hours to weeks.

APPENDIX 1: STATEMENT OF OUTSTANDING UNIVERSAL VALUE – ALDABRA ATOLL (1982)

The atoll is comprised of four large coral islands which enclose a shallow lagoon; the group of islands is itself surrounded by a coral reef. Due to difficulties of access and the atoll's isolation, Aldabra has been protected from human influence and thus retains some 152,000 giant tortoises, the world's largest population of this reptile.

Outstanding Universal Value

Brief synthesis

Located in the Indian Ocean, the Aldabra Atoll is an outstanding example of a raised coral atoll. Due to its remoteness and inaccessibility, the atoll has remained largely untouched by humans for the majority of its existence. Aldabra is one of the largest atolls in the world, and contains one of the most important natural habitats for studying evolutionary and ecological processes. It is home to the largest giant tortoise population in the world. The richness and diversity of the ocean and landscapes result in an array of colours and formations that contribute to the atoll's scenic and aesthetic appeal.

Criterion (vii): Aldabra Atoll consists of four main islands of coral limestone separated by narrow passes and enclosing a large shallow lagoon, providing a superlative spectacle of natural phenomena. The lagoon contains many smaller islands and the entire atoll is surrounded by an outer fringing reef. Geomorphologic processes have produced a rugged topography, which supports a variety of habitats with a relatively rich biota for an oceanic island and a high degree of endemism. Marine habitats range from coral reefs to seagrass beds and mangrove mudflats with minimal human impact.

Criterion (ix): The property is an outstanding example of an oceanic island ecosystem in which evolutionary processes are active within a rich biota. Most of the land surface comprises ancient coral reef (~125,000 years old) which has been repeatedly raised above sea level. The size and morphological diversity of the atoll has permitted the development of a variety of discrete insular communities with a high incidence of endemicity among the constituent species. The top of the terrestrial food chain is, unusually, occupied by an herbivore: the giant tortoise. The tortoises feed on grasses and shrubbery, including plants which have evolved in response to its grazing patterns. The atoll's isolation has also allowed the evolution of endemic flora and fauna. Due to minimal human interference, these ecological processes can be clearly observed in their full complexity.

Criterion (x): Aldabra provides an outstanding natural laboratory for scientific research and discovery. The atoll constitutes a refuge for over 400 endemic species and subspecies (including vertebrates, invertebrates and plants). These include a population of over 100,000 Aldabra Giant Tortoise. The tortoises are the last survivors of a life form once found on other Indian Ocean islands and Aldabra is now their only remaining habitat. The tortoise population is the largest in the world and is entirely self-sustaining: all the elements of its intricate interrelationship with the natural environment are evident. There are also globally important breeding populations of endangered green turtles, and critically endangered hawksbill turtles are also present. The property is a significant natural habitat for birds, with two recorded endemic species (Aldabra Brush Warbler and Aldabra Drongo), and another eleven birds which have distinct subspecies, amongst which is the White-throated Rail, the last remaining flightless bird of the Western Indian Ocean. There are vast waterbird colonies including the second largest frigatebird colonies in the world and one of the world's only two oceanic flamingo populations. The pristine fringing reef system and coral habitat are in excellent health and distinguished by their intactness and the sheer abundance and size of species contained within them.

Integrity

The property includes the four main islands which form the atoll plus numerous islets and the surrounding marine area. It is sufficiently large to support all ongoing biological and ecological processes essential for ensuring continued evolution in the atoll. The remoteness and inaccessibility of the atoll limit extensive human interference which could

otherwise jeopardize ongoing processes. As such, Aldabra displays an almost intact ecosystem, sustaining naturally viable populations of all key species.

Protection and management requirements

The property is legally protected under national legislation and is managed by a public trust, the Seychelles Islands Foundation, with daily operations guided by a management plan. Boundaries are ecologically viable but the extension of the seaward boundary some 20 km into the sea would provide additional protection to the marine fauna. While the remoteness of the property has limited human interference, thus contributing for the protection of the biological and ecological processes, it also poses tremendous logistical challenges. Tourism is limited and carefully controlled. Whilst the property displays an almost intact ecosystem, protection and management need to address the constant threats posed by invasive alien species, climate change and oil spills, particularly in the event that oil exploration increases in the wider region.

APPENDIX 2: LIST OF OTHER SIGNIFICANT PROPERTY VALUES (SPVs) THAT ARE LOCALLY, NATIONALLY OR INTERNATIONALLY SIGNIFICANT FOR ALDABRA ATOLL

Broad groupings of SPVs	Key SPVs (listed in a prioritised order based on significance)	Additional justification (Why is the value significant? Locally, regionally or nationally?)
Biological diversity *(e.g., flora, fauna, or habitats of significance not in the SOUV)*	*Madagascar pond-heron*	*The only critically endangered terrestrial species on the atoll, i.e., the most threatened species on the atoll. Aldabra is likely the best protected remaining nesting area for the Madagascar pond-heron.*
	Dugongs	*Once common across the Seychelles, Aldabra is now the only known remaining location where dugongs occur in the country. Potential for the atoll to act as a regional recovery area.*
	Cetaceans	*Aldabra was declared an International Marine Mammal Area in 2020 partly because it is on the migratory route of humpback whales and has a large potentially resident population of spinner dolphins*
	Coconut crabs	*Aldabra's coconut crab population is likely one of the largest populations remaining in the world, certainly the WIO. Become extinct across most of its former range due to human pressure.*
	Aldabra banded snail	*One of the world's rarest snail species, was falsely claimed to be the first species to go extinct due to climate change in early 2000s. Since re-discovered on two separate islands.*
	Sharks and rays	*Aldabra hosts large populations of X shark and Y ray species. Sharks remain the top marine predators around Aldabra and the tropic pyramid is reflective of very healthy marine system. Suspected to be several 'cleaning stations' on Aldabra's reefs frequented by reef mantas.*
	Groupers	*High number of large grouper species that have either disappeared or are in decline and smaller-bodied elsewhere due to fishing pressure.*
	Pelagic fish species	
	Mangrove forests	*The largest remaining tracts of mangrove forests in the Seychelles Aldabra has more mangrove habitat than the rest of Seychelles combined, and recent research indicates that this habitat is increasing.* *Important blue carbon source*
	Seagrass	*Large intact seagrass beds that support myriad species.* *Important blue carbon source*
	Small reptiles	*Endemic and native geckos and skinks*
	Small seabird populations	*Aldabra is an important nesting site for several small seabird species including white terns, brown noddies, red- and white-tailed tropicbirds, tropical shearwaters (possibly endemic subspecies), black-naped terns, Caspian terns, greater crested terns and others. All have the potential to increase substantially after invasive mammal eradication.*
	Paleoecological values	*Aldabra has excellent fossil and sub-fossil deposits from its several emergences and submergences that must be preserved. There is huge potential to build a picture of past climate and species colonisation patterns from paleoecological research. Deposits include extinct species such as crocodiles and birds.*
	Monitoring programme/data and conservation lessons	*Aldabra is the site of many conservation interventions, and monitoring programmes, and holds lessons for other islands. For example, there is a broad*
	Elevated limestone islands in the lagoon, champignon islands	*Iconic view especially at low tide*

Broad groupings of SPVs	Key SPVs (listed in a prioritised order based on significance)	Additional justification (Why is the significant? Locally, regionally or nationally?)
Aesthetic values or phenomena *(e.g., any special scenic qualities or phenomena that are significant)*	*Grande Terre*	*Most remote part of Aldabra. Flamingo colony, large tortoise turf (grassland area where they forage) – looks like grass carpet. During rainy season, inland pools are aesthetic value*
	Aerial view of Aldabra	*Extreme tides*
	Marine ecosystems	*Amazing, unique marine ecosystem when diving and complex underwater geomorphology, producing caves, rocky outcrops overhangs*
	Malabar	*Frigatebird colony and turtles in mangroves, beautiful river network when tide comes in.*
Economic values *(e.g., provide income or employment opportunities through tourism, fishing, or other commercial activities, etc.)*	*Tourism*	*Fees*
	Documentary film making	
	Blue carbon	*Mangroves, seagrass etc have potential as economic value for offsets/net zero etc*
	Fish breeding population (MPA benefits)	*Positive effect for the wider region – interlinks to other regions*
	Research	*Fees*
	Source population of coral larvae	*Aldabra shown to be an important regional source of coral, which is spawning other islands in Seychelles and almost certainly other reefs in the WIO, supporting coral recovery and marine ecotourism in other places. Similar for fish – but partially covered above*
Recreational values *(e.g., provide for recreational activities like hiking, camping, wildlife viewing, etc.)*	*Wildlife viewing*	*Tortoises, coral reefs, turtles, sharks, mangroves and seabirds.*
	Diving/snorkelling	*Amazing underwater life*
	Guided tours	
Historic/cultural values *(e.g., features or locations that represent history or enable traditions or ways of life to continue, etc.)*	*Old settlement*	*The old church is on the Seychelles national register of historic buildings. The now collapsed old manager's house was where Mrs Geva Rene, former First Lady of Seychelles, lived as a child. Other buildings include two former jails, an old salted meat store, water reservoirs (still functioning) and several staff houses.*
	Lion's wreck	*The 'SS Glen Lyon' coal supply ship that ran aground in the early 20th century.*
	Tortoise enclosures/exclosures	*Various enclosures scattered around the atoll comprised of dry champignon walls. Structures that seemed to look like old turtle pond (finding wood from old pirog)*
	Turtle/tortoise exploitation	*Significant contributor to turtle/tortoise meat trade in 19th and early 20th centuries.*
	Research station/La Gigi	*Publications from years ago (library). Few foundation stones – old publications suggest it was old mill where they used to grind turtle bone for fertiliser (can be seen when walking along La Gigi).*
	Previous settlements (e.g., Ile Magnan)	*Traces of a potential old settlement*
Learning/ Scientific values *(e.g., opportunities for scientific*	*Living laboratory*	*Relatively intact tropical island ecosystem, providing valuable baselines for the rest of the world. Especially for climate change impacts. Also, a place to study 'evolutionary processes.' Fossil record illustrates the repeated colonisation and evolution of both the tortoises and the flightless rail.*

Broad groupings of SPVs	Key SPVs (listed in a prioritised order based on significance)	Additional justification (Why is the value significant? Locally, regionally or nationally?)
research, nature interpretation, etc.)	*Training arena for young Seychellois scientists and conservationists*	*Aldabra is a site where newly qualified Seychellois graduates, and international volunteers learn on-the-job practical conservation and monitoring skills, and local and international students can conduct meaningful projects*
	Geology and paleo sea level rise	*Repeated submergences by the ocean have created distinct coraline deposits. A recent geology expedition indicates Aldabra has one of the world's best records of recent sea-level rise/change, via the use of fossilised coral formations.*
	Invasive alien species management	*Aldabra included in publication on WH case studies on IAS best practice. SIF has eradicated two invasive landbirds (both world firsts), goats and one plant species, sisal in the last 10 years and pioneering techniques are used by other sites.*
	Biosecurity	*Continued development and improvement of biosecurity measures and processes, acting as a model for other WH sites.*
	Marine plastic	*Aldabra has the highest reported marine plastic accumulation of any island, offering opportunity to study terrestrial and marine impacts and drive move towards plastic reduction, recycling, and circular economy.*
	Ecosystem connectivity	*Coral: Opportunity to study the connectivity in corals (as well as other marine ecosystems) in the region* *Water quality: Connectivity between terrestrial and marine ecosystem which impacts the fish and corals*
Spiritual/ Philosophical fulfilment *(e.g., areas that are sacred, religious, or spiritually significant, etc.)*	*Intact large tropical atoll*	*One of only a handful of large tropical islands where wild processes are allowed to unfold, with little to no intervention undertaken by humans. Thereby an illustration to humanity of 'our' origins and the 'natural state' of the world.*
	Chapel	*Old settlement church*
Health/ therapeutic values *(e.g., areas that enable people to feel better physically or mentally, etc.)*	*Mental health*	*Natural state to get away from real world. All natural sights and sounds, etc., can be very therapeutic* *Blue skies, amazing sunsets, dark skies with no light pollution and incredible nightsky views – sights that have suggested to enhance mental health*
	Fresh, clean air	*Healthier air to breathe in which lack of industrialisation*
	Medicinal plants	*Both marine and terrestrial plants that can be used for extraction and medicine (or have medicinal properties)*
Other/ special places *(if places are special, state reason why)*	*Ile Esprit*	*Oldest champignon, oldest limestone. Very interesting if you look at it from geomorphological and paloeecological perspective (unique features).*
	Sand dunes	*Highest point of Aldabra – amazing view point.*
	Channels	*Channels between islands that is an amazing sight. Spotting of mangroves, etc.*