Climate change vulnerability assessment to greater one-horned rhinoceros (*Rhinoceros unicornis*) in Nepal

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Abstract

CLIMATE CHANGE VULNERABILITY ASSESSMENT TO GREATER ONE-HORNED RHINOCEROS (*RHINOCEROS UNICORNIS*) IN NEPAL

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Climate change has been emerging as a severe threat to biodiversity conservation over the last few decades. Nepal is among countries that are vulnerable to climate change and has limited capacity to deal with its adverse impacts. Nepal is exceptionally rich in biological diversity and has demonstrated remarkable success in conserving it. The greater one-horned rhinoceros (*Rhinoceros unicornis*) is one of the iconic wildlife species, the population trend of which reflects the history of conservation in Nepal. In fact, rhinoceros in Nepal was brought back from the brink of extinction during the 1960s. In recent years, effective antipoaching strategies have contributed to an increase in the population of this megaherbivore in Nepal. On the other hand, the rhinoceros population is likely to be affected by climate change such as a spatial shift in and degradation of suitable habitats. However, the likely impacts of climate change have not been incorporated into the management plans prepared for the conservation of rhinoceros in Nepal. Thus, there is a need to know the extent of climate vulnerability facing the rhinoceros in order to facilitate the long-term survival of this species. In this context, we developed vulnerability indicators and assessed the climate change vulnerability to rhinoceros in Nepal through key informant interviews, site visits and consultation with experts and stakeholders. Our findings suggest that rhinoceros in Nepal is likely to be moderately vulnerable in the face of likely impacts of climate change. In addition, we have identified some of the key factors that are likely to make rhinoceros more vulnerable and the possible adaptation measures for enhancing the resilience of the species.

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Presentation outline

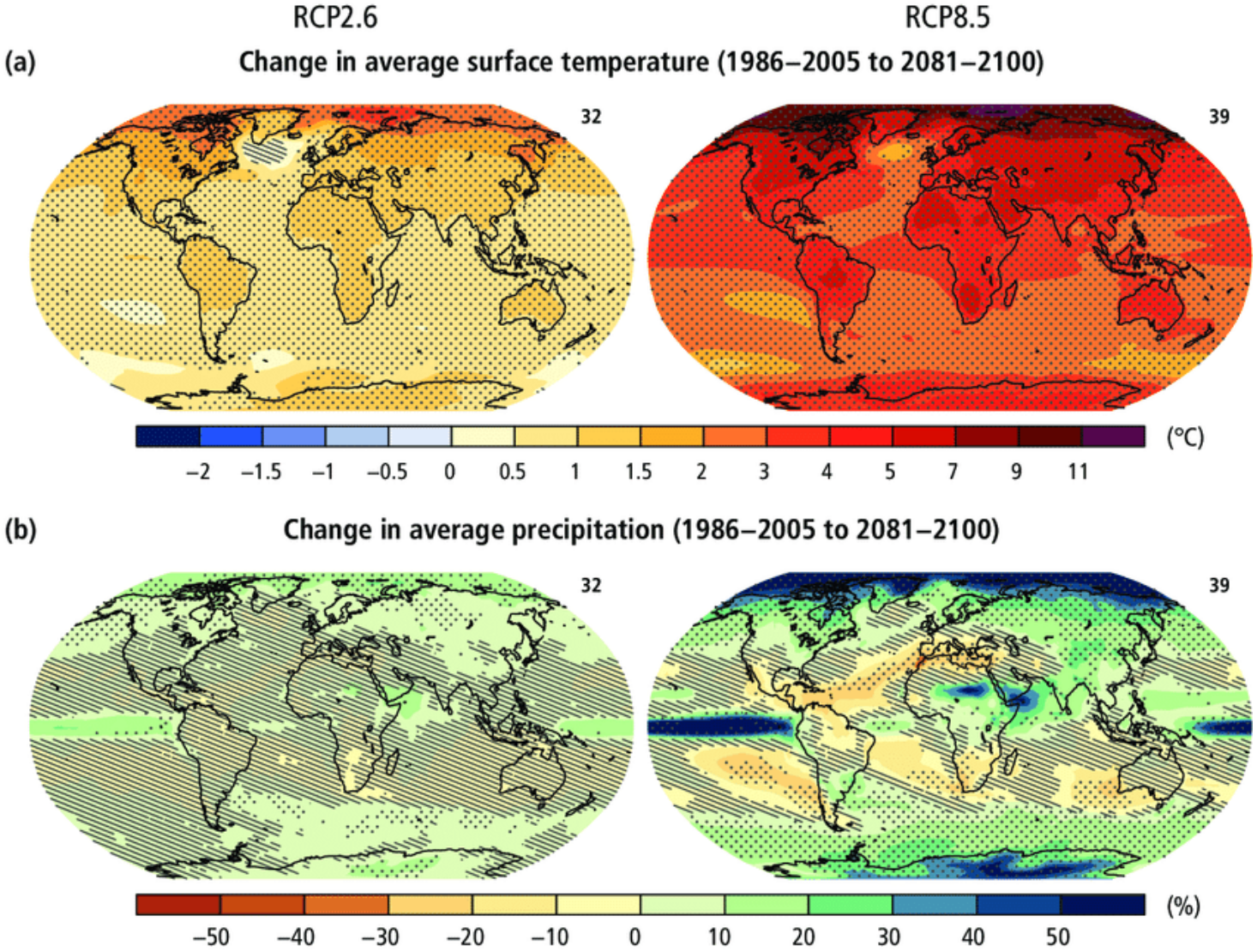
1. Introduction
2. Aim and objectives
3. Research framework
4. Materials and methods
5. Key findings
6. Conclusion
7. Acknowledgements

Global climate change

Observed Change

Global mean temperatur e increase **0.74°C** over the last 100 years

(IPCC 2014)



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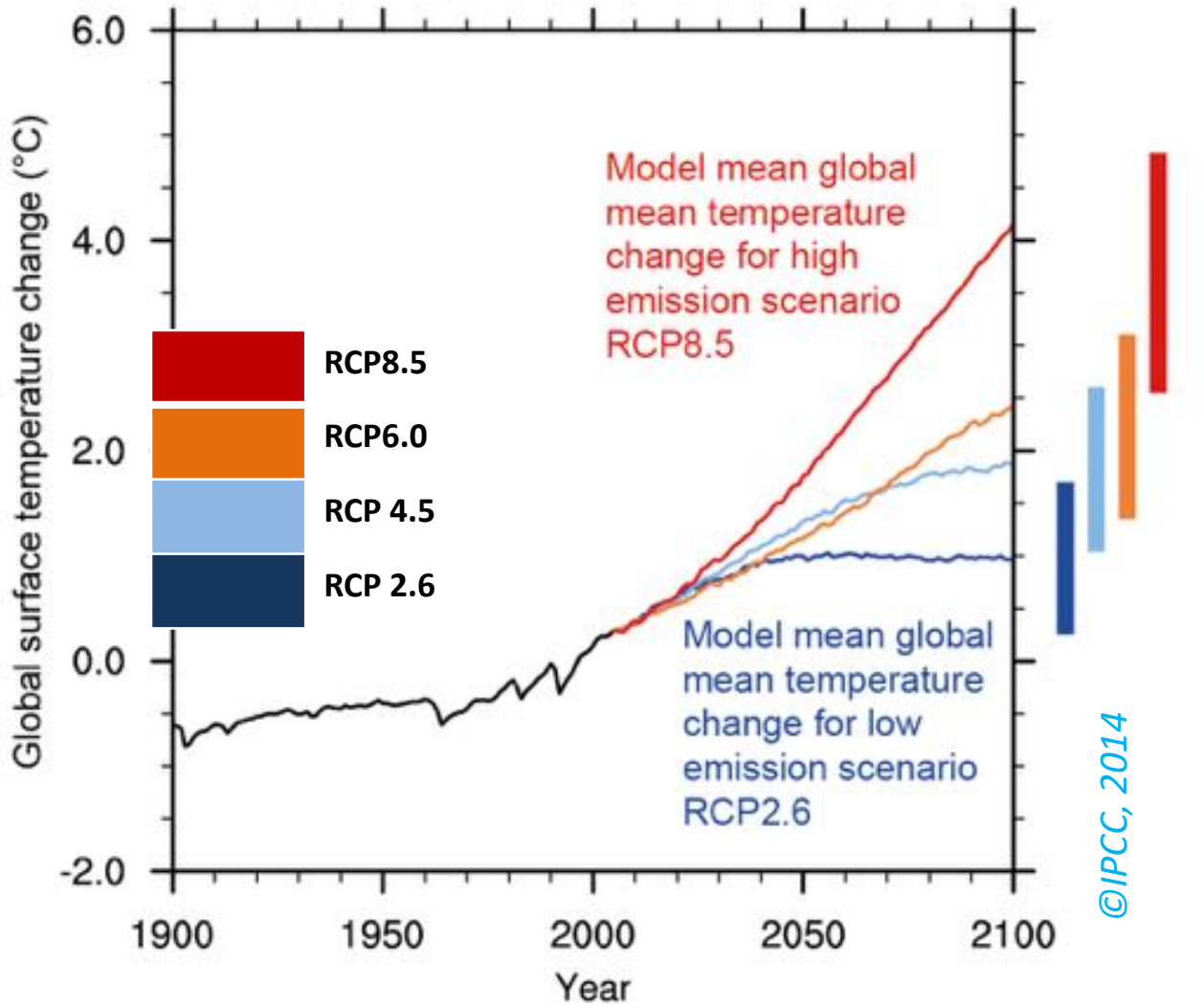
Projected Change

Global mean temperature will increase by **4.3 ± 0.7°C** by 2100

(IPCC 2014)

Global climate change projection



Global mean surface temperature change by the end of the 21st century compared to 1986-2005

- **1.7°C** under **RCP2.6**
- **2.6°C** under **RCP4.5**
- **3.1°C** under **RCP6.0**
- **4.8°C** under **RCP8.5**

(IPCC 2014)

Biodiversity-related impacts of climate change

- Shift in species distribution (Parmesan 2006; Thuiller et al. 2011)
- Change in timing of life history events (Charmantier et al. 2008)
- Reduction in population size (Gedir et al. 2015; Selwood et al. 2015)
- Increased fire frequency (Flannigan et al. 2000)
- Increased spread of wildlife diseases (Harvell et al. 2009)
- Increased spread of invasive species (Hellman et al. 2008)
- Loss of habitat (Leadley 2010)
- Species extinction (Thomas et al. 2004)

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Bramble cay melomys (*Melomys rubicola*) (Fulton 2017)

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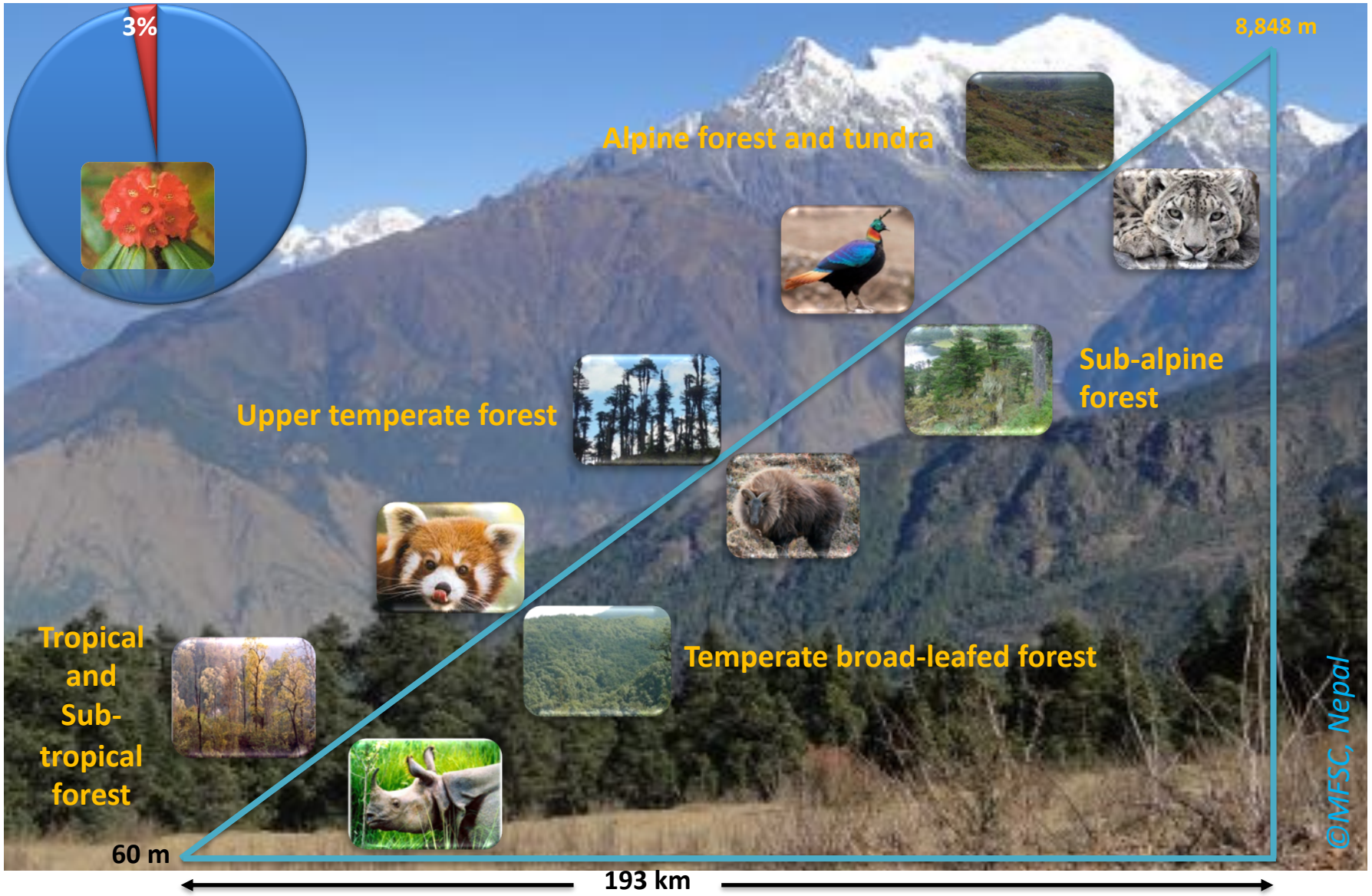
Malagasy baobab (*Adansonia suarezensis*) in Madagascar is likely to go extinct before 2080 (Vieilledent et al. 2013)

Biological diversity in Nepal



0.1% Area vs. 25th Rank in biodiversity wealth

Climate change vulnerability in Nepal

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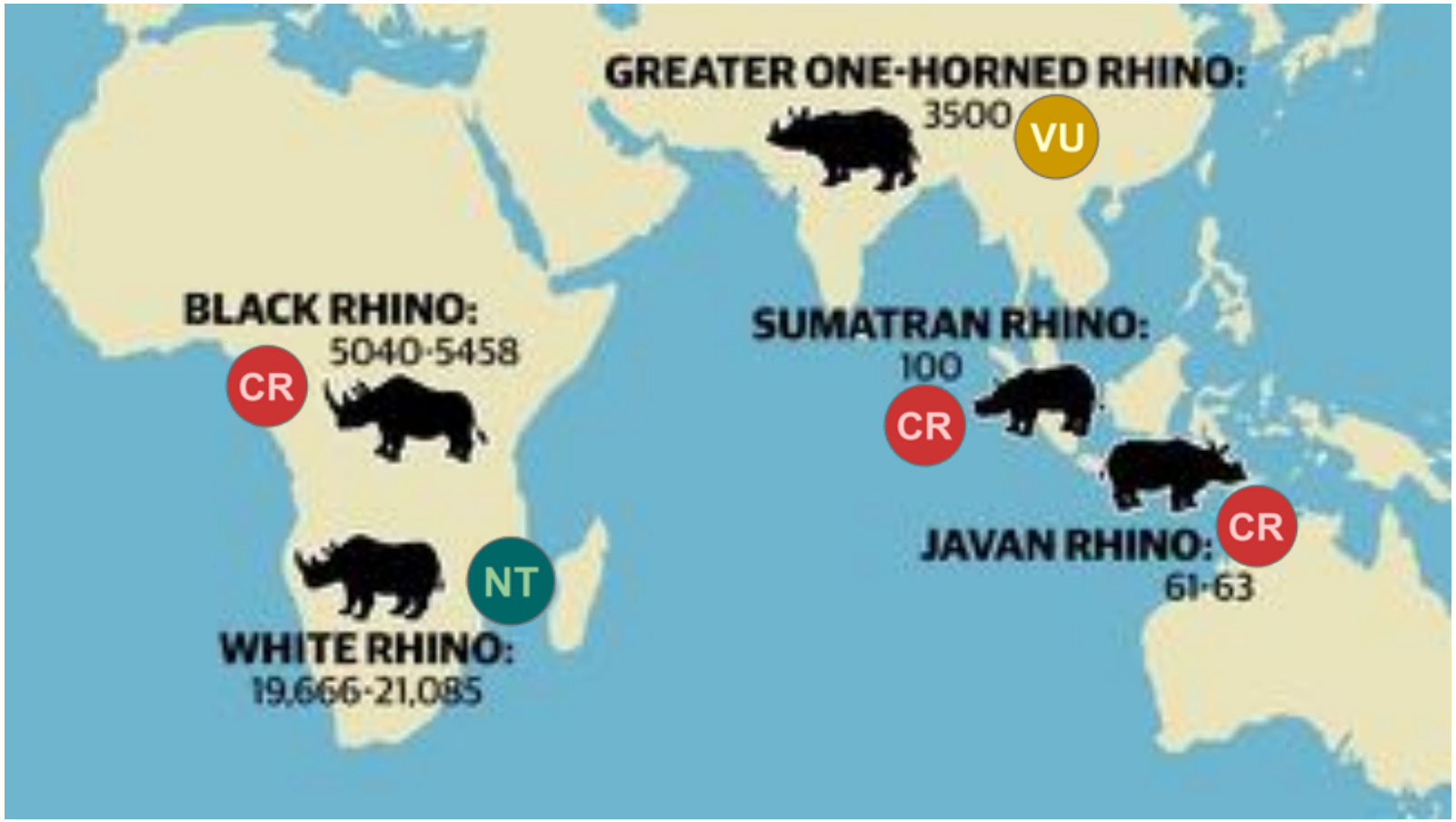
Global vs. Nepal

- **0.07°C** per decade globally (IPCC 2007)
- **0.6°C** per decade in Nepal (Shrestha et al. 1999)

Nepal is the fourth most vulnerable country in the world due to climate change (MOE 2010; Maplecroft 2011; MFSC 2014)

Global distribution and status of rhinoceros



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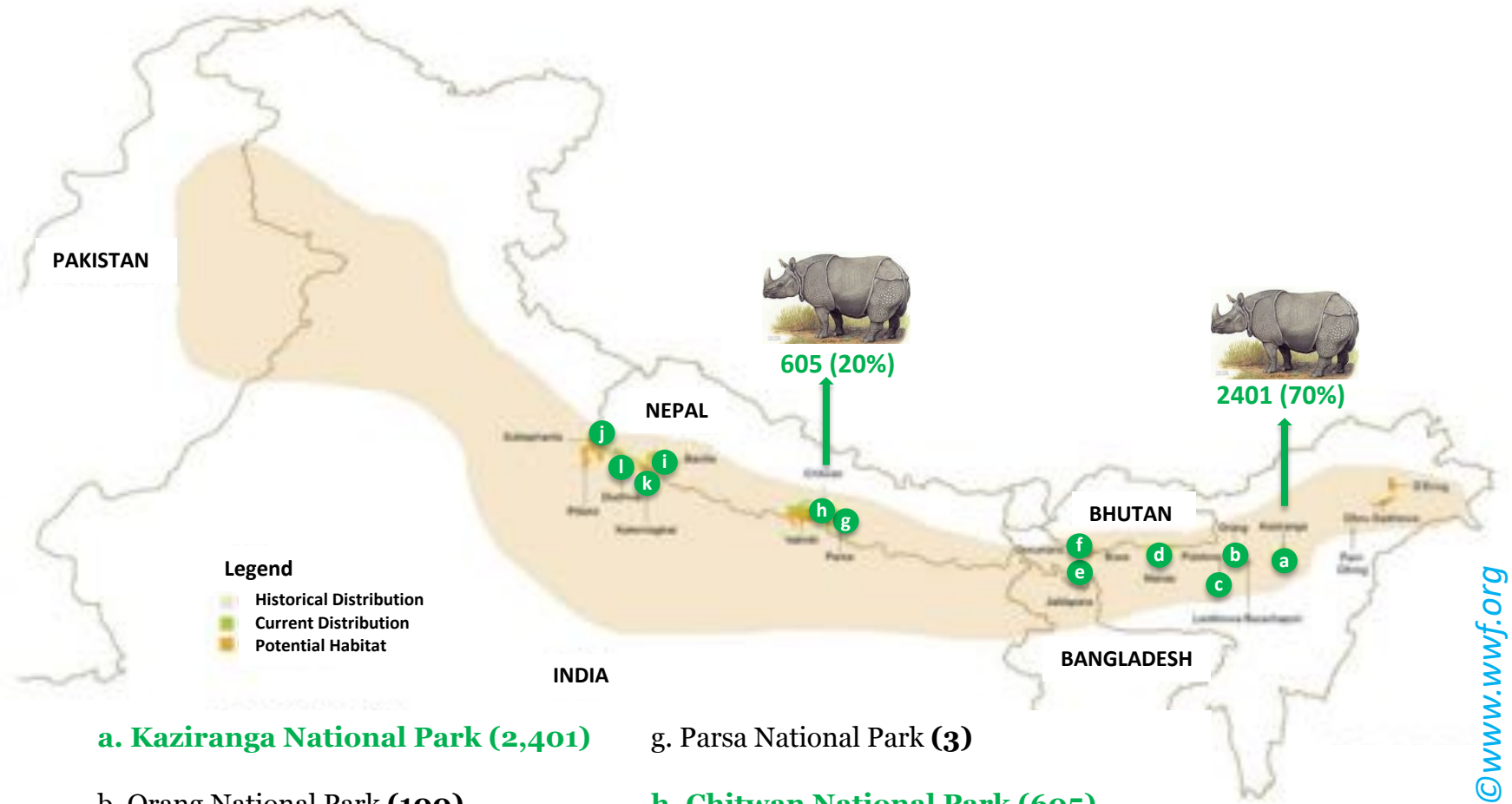
Key Threats
- Habitat loss
- Poaching

(DNPWC 2017; WWF 2018)

Distribution of greater one-horned rhinoceros



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Historical Distribution
1. Bangladesh
2. Bhutan
3. India
4. Nepal
5. Pakistan

Current Distribution
1. India
2. Nepal

a. Kaziranga National Park (2,401)

b. Orang National Park **(100)**

c. Pobitora Wildlife Sanctuary **(92)**

d. Manas National Park **(32)**

e. Jaldapara National Park **(200)**

f. Gorumara National Park **(50)**

g. Parsa National Park **(3)**

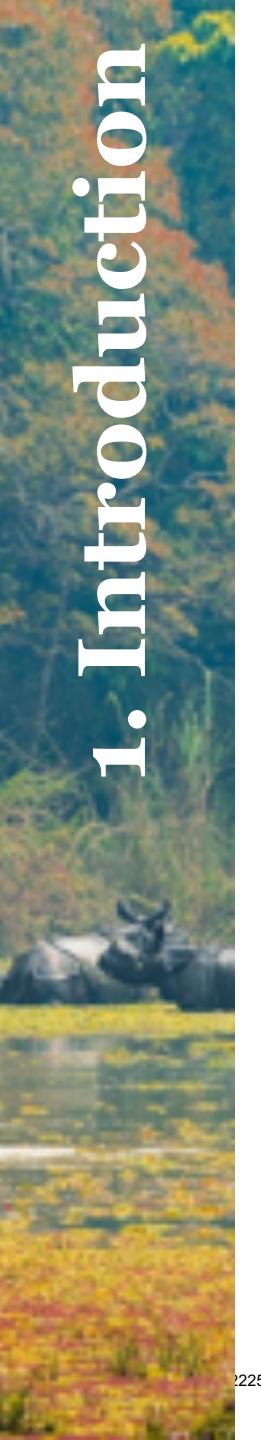
h. Chitwan National Park (605)

i. Bardia National Park **(29)**

j. Shuklaphanta National Park **(8)**

k. Katerniaghat Wildlife Sanctuary **(2)**

l. Dudhwa National Park **(32)**

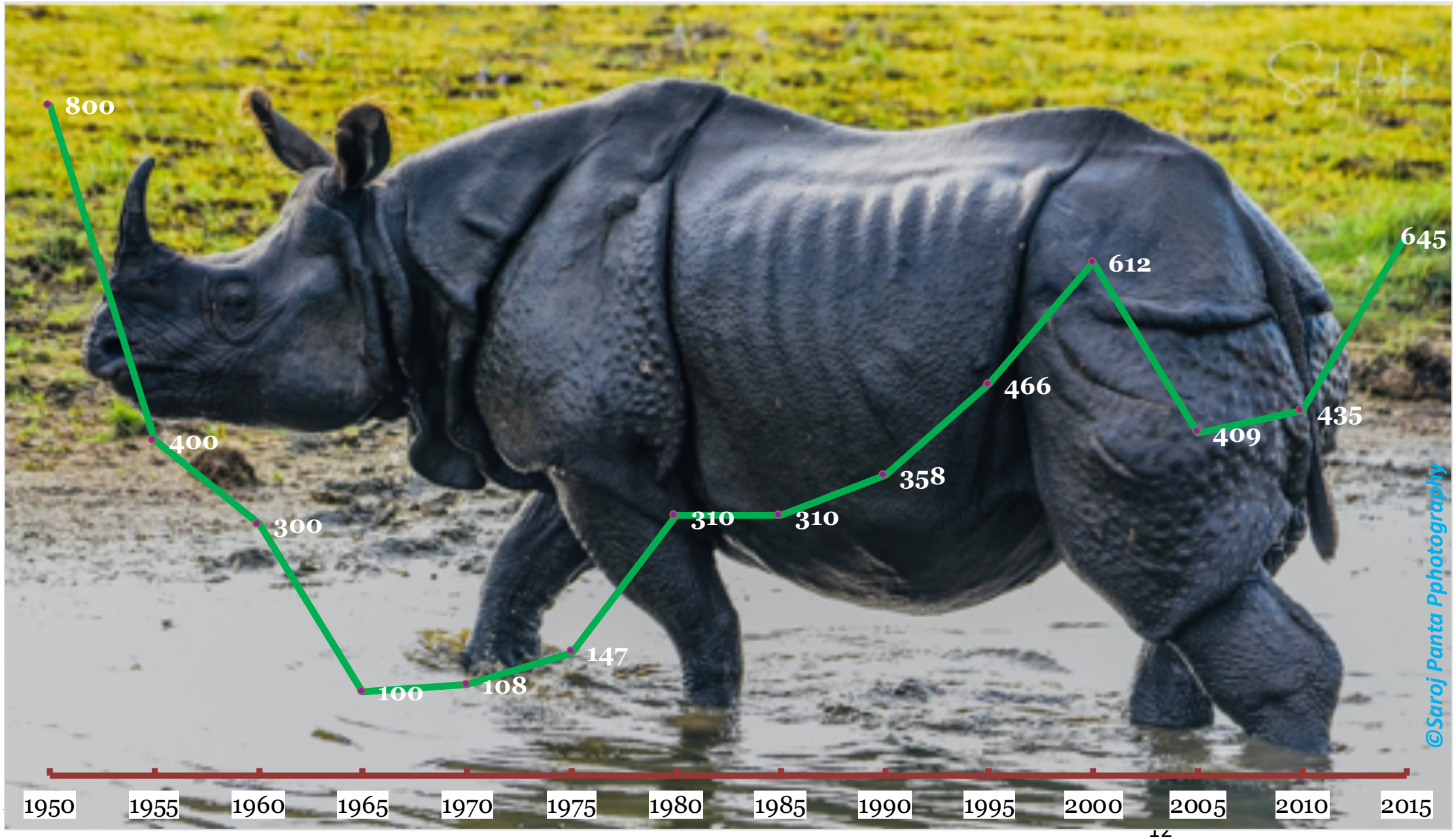


Salient features of greater one-horned rhinoceros

- Megaherbivore having life expectancy of 40 years (DNPWC 2017)
- Highly k-selected species: large body size, lowest reproductive rate, large home range (Poudyal et al. 2009)
- Specialist in terms of habitat and food requirements (Dinerstein 2003)
- Umbrella species (Amin et al. 2006) , Flagship species (Subedi 2012; Cedric et al 2016)
- Vulnerable species on IUCN Red list (Talukdar et al. 2008)
- Iconic species for conservation and tourism promotion (DNPWC 2017)

Traits that make species vulnerable to climate change are **limited dispersal ability, slow reproductive rate, specialised habitat and dietary requirements, restricted distribution, rarity and narrow physiological tolerances** (Pacifici et al. 2015)

Population trend of rhinoceros in Nepal



Aim

To assess the climate change vulnerability and develop adaptation measures for greater one-horned rhinoceros in Nepal

Objectives

2.1. To develop climate change vulnerability indictors following participatory approach **- Developing vulnerability indicators**

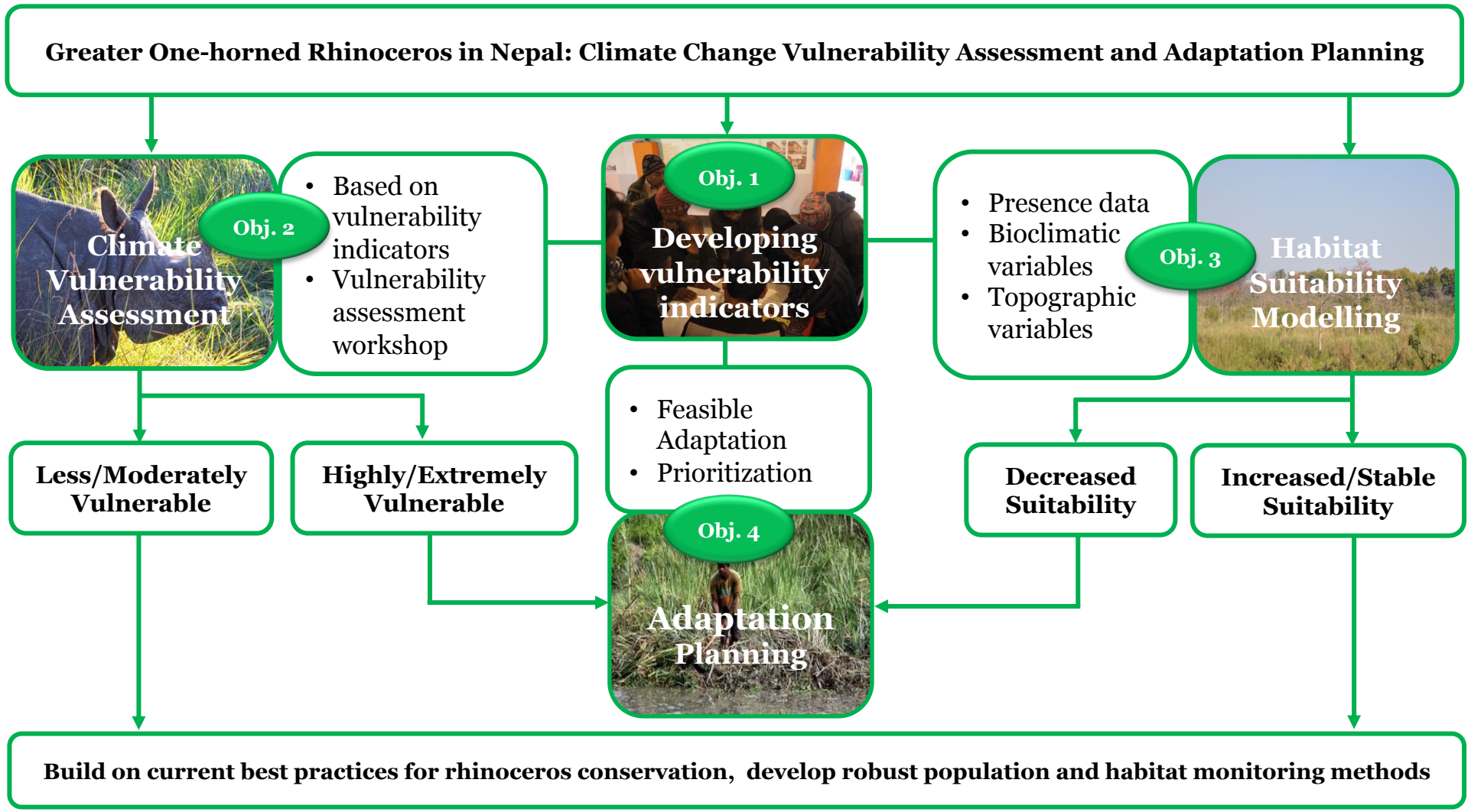
2.2. To assess the extent of climate change vulnerability **- Climate change vulnerability assessment (CCVA)**

2.3. To develop habitat suitability models **- Habitat suitability modelling**

2.4. To identify feasible adaptation measures **- Adaptation planning**

3. Research framework

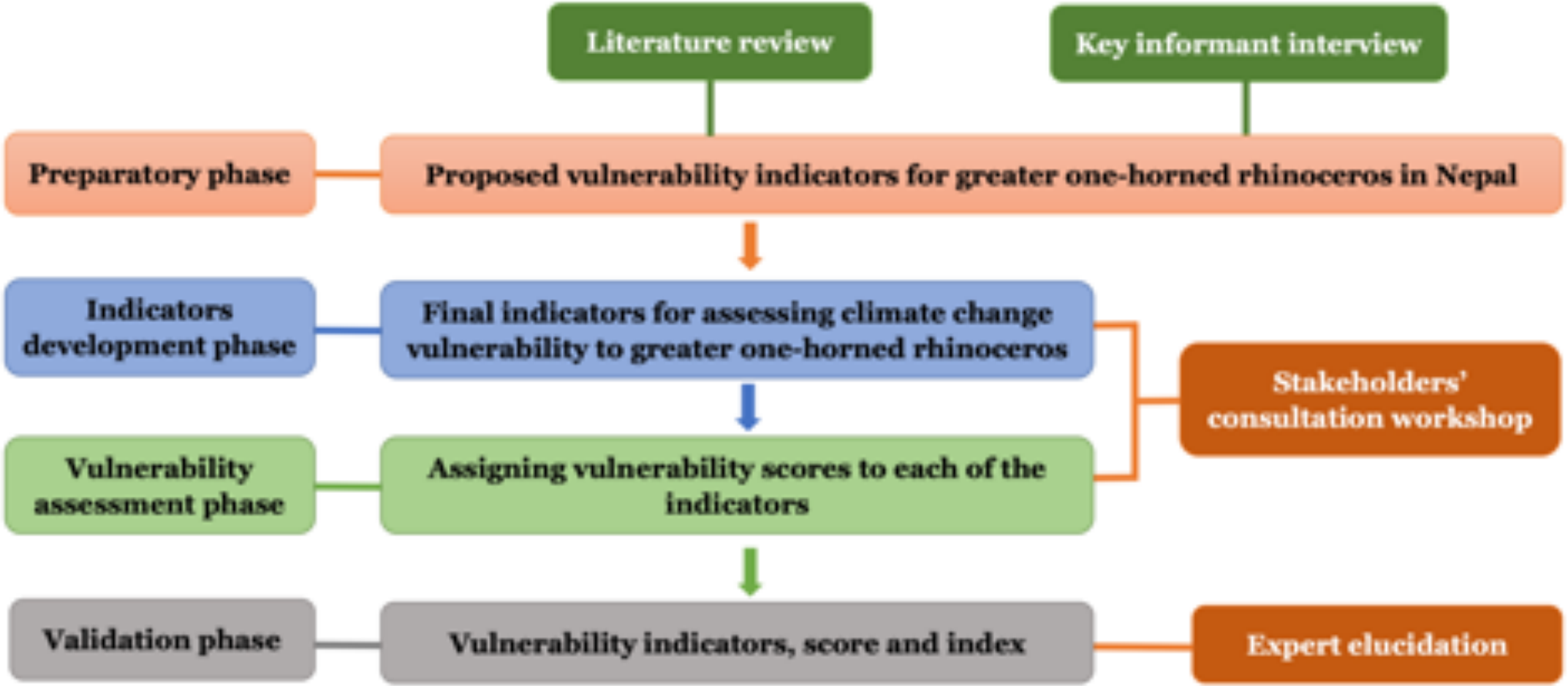
Conceptual framework of the research



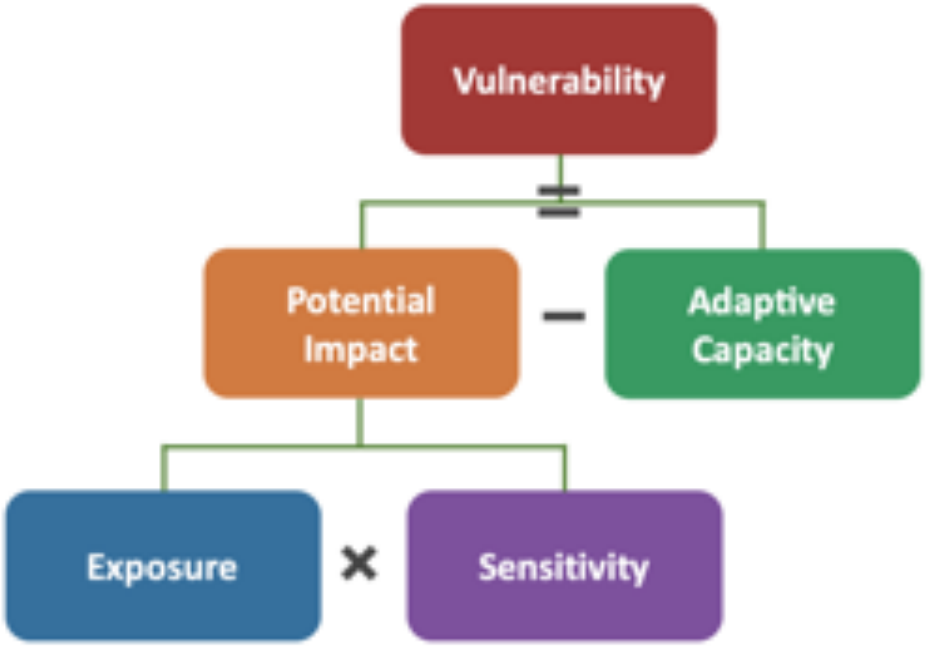
Study area

(Source of the shape file: UNEP-WCMC & IUCN, https://www.protectedplanet.net/country/NP)

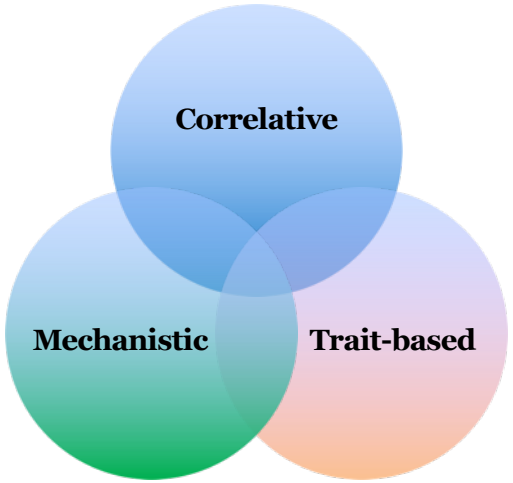
Flowchart of the research methods



4.1. Review of literature



Species' vulnerability is the function of exposure sensitivity, and adaptive capacity (Williams et al. 2008; Glick et al. 2011; Foden et al. 2013)

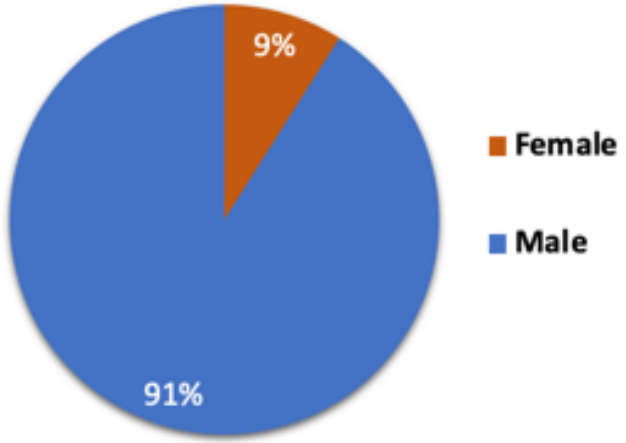


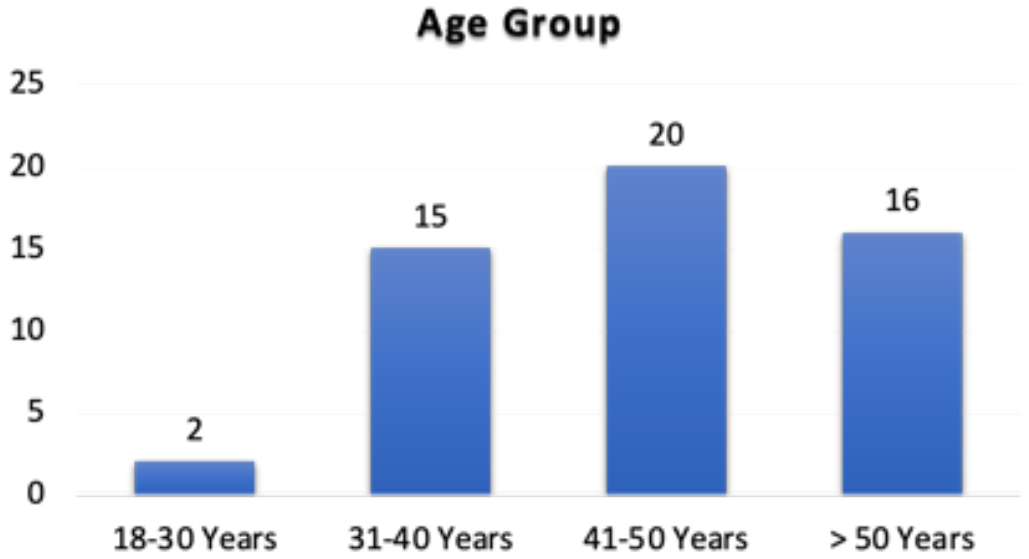
(Foden & Young 2016)

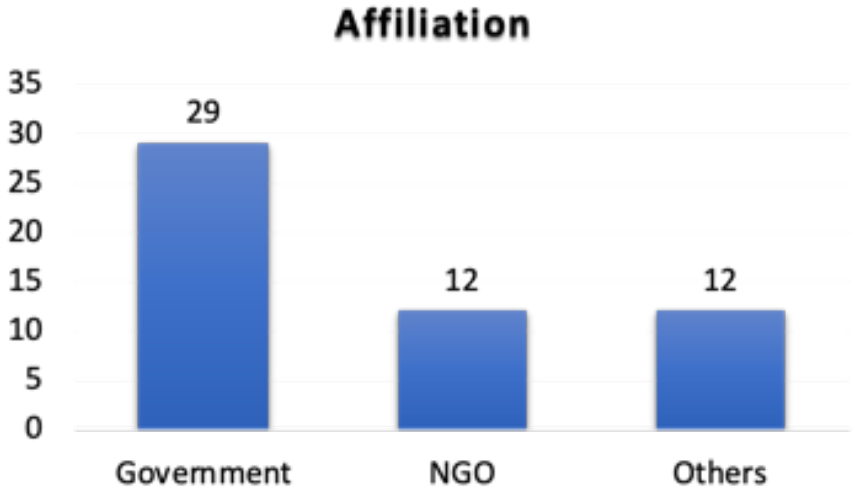
Trait-based approach is commendable for CCVA of species (Foden et al. 2013)

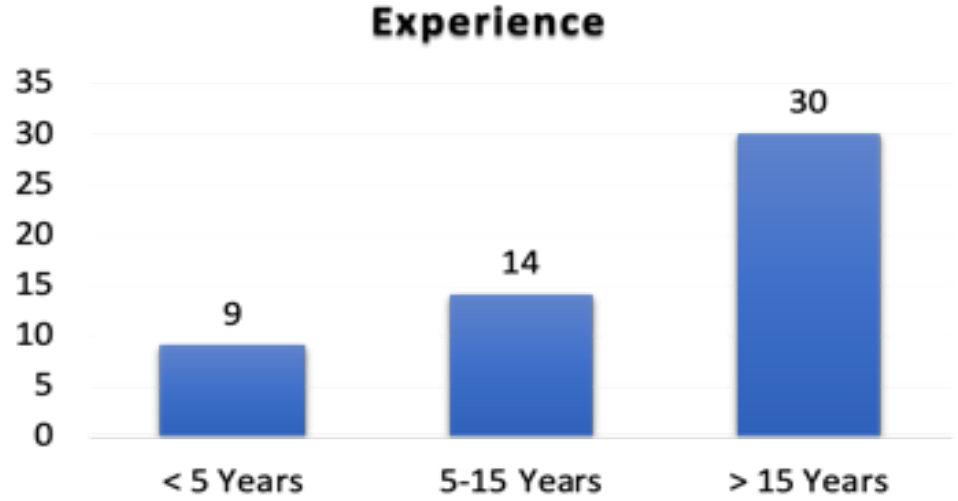
Vulnerability assessment is a theoretical concept, and needs indicators for measuring (Hinkel 2011; Tonmoy et al. 2014)

4.2. Key informant interviews









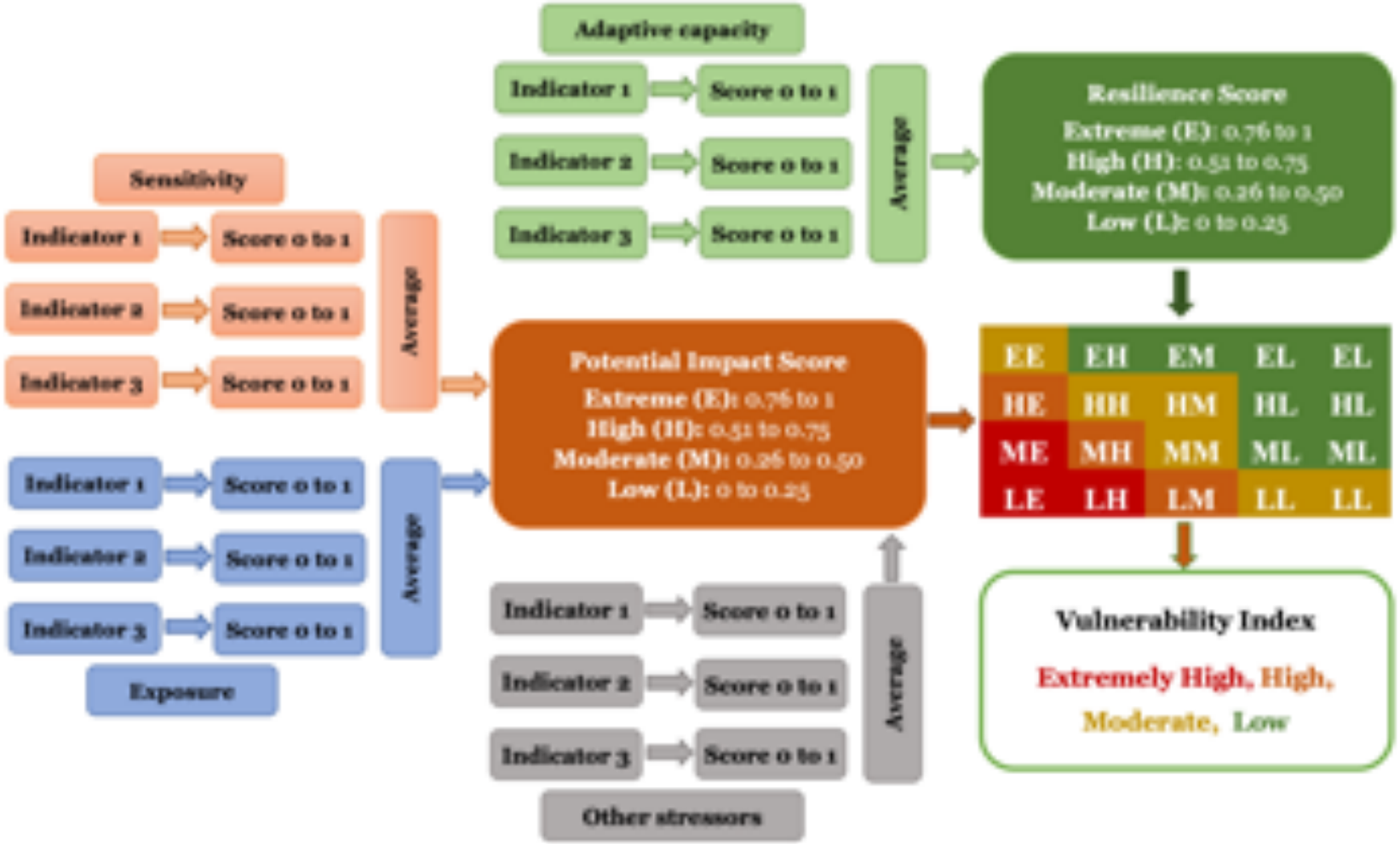
4.3. Stakeholders' consultation workshop

- Two-day workshop in April 2019 in Chitwan National Park, Nepal
- A total of 37 stakeholders participated representing both governmental and non-governmental organizations

4.4 Expert elucidation meeting

- A meeting of experts in Kathmandu, Nepal later in April 2019

4.5. Data analysis



Least Vulnerable (LV)
0 to 0.25
Moderately Vulnerable
(MV) 0.26 to 0.50
Highly Vulnerable (HV)
0.51 to 0.75
Extremely Vulnerable (EV)
0.76 to 1

(NatureServe 2018)

5. Key Findings

5.1. Vulnerability indicators

SN	Indicator	Rationale
Sensitivity		
1	Habitat component – Food	The changing climate is likely to impact the abundance of food resources that will be available for the species.
2	Habitat component – Water	The spatial and temporal availability of water could be affected due to climate change.
3	Special habitat requirements	Rhinoceros requires mud pools for wallowing to maintain its body temperature and the availability of the wallowing sites could be limited due to the effects of climate change.
4	Distribution range	Species with restricted distributions are more likely to be vulnerable to climate change.
5	Population size	Species that can quickly recover from low population numbers may be less vulnerable to climate change.
6	Niche breadth	Species with a narrow physiological niche are likely to be more vulnerable to climate change.
7	Susceptibility to disease	The increased spread of wildlife diseases is a likely impact of climate change.
8	Invasive species	The spread of invasive species is likely to increase due to climate change.

5.1. Vulnerability indicators

SN	Indicator	Rationale
Exposure		
9	Change in temperature	The degree of observed and projected changes in temperature could affect the species and its habitat.
10	Change in precipitation	The degree of observed and projected changes in precipitation pattern could affect the species and its habitat.
11	Floods	Frequent and severe floods will cause habitat destruction and loss or decline in the species population.
12	Droughts	Prolonged and frequent drought can increase the likelihood of local extinction.
13	Forest fire	Increased fire frequency could have adverse effects on the species and its habitat.

5. Key Findings

5.1. Vulnerability indicators

SN	Indicator	Rationale
Adaptive capacity		
14	Dispersal ability	Species with high dispersal ability are less vulnerable to climate change.
15	Dispersal opportunity	Species distributed in an area with limited dispersal opportunity are more vulnerable to climate change.
16	Genetic diversity	Species with low genetic variation are more vulnerable to climate change.
17	Feeding habit	Generalist species are likely to be less sensitive to climate change than specialists.
Other stressors		
18	Poaching	Poaching is likely to exacerbate vulnerability to climate change.
19	Human-wildlife interaction	The conflict between human and wildlife can worsen if wildlife enters human settlements in search of suitable habitat.
20	Pollution (water, waste)	Pollution of water sources in and around rhinoceros habitat can intensify climate change vulnerability.
21	Interspecific interaction	Climate change is likely to intensify interspecific interactions among wildlife species due to limited resources.

5.2. Vulnerability score

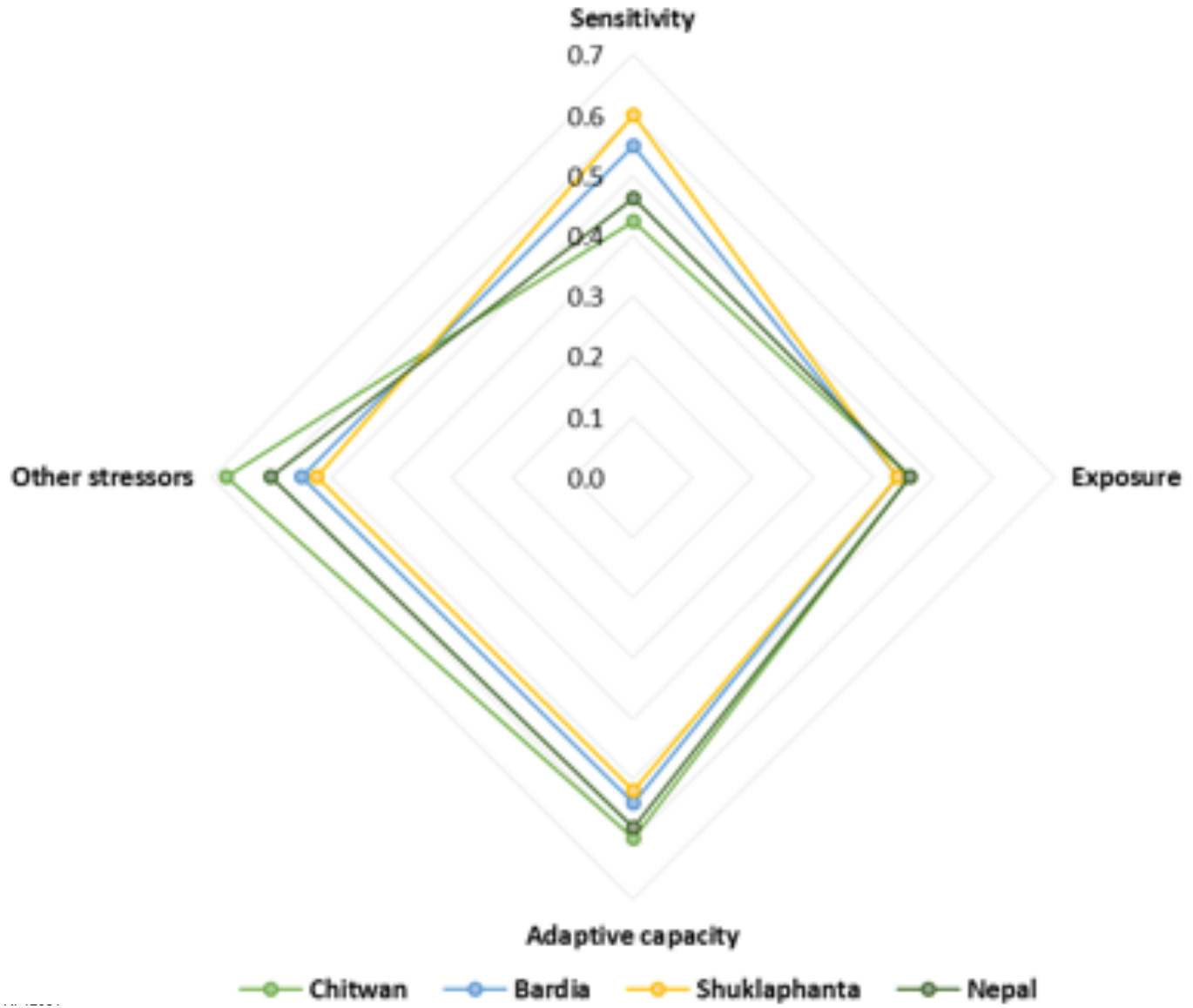
SN	Indicators	Vulnerability Score			
		Nepal	Chitwan	Bardia	Shuklaphanta
1. Sensitivity					
1.1	Habitat component-Food	4	3	4	5
1.2	Habitat component-Water	4	3	5	7
1.3	Special habitat requirements	5	5	7	8
1.4	Distribution range	5	4	7	7
1.5	Population size	4	3	7	8
1.6	Niche breadth	5	5	5	5
1.7	Susceptibility to diseases	5	5	5	5
1.8	Invasive species	5	6	4	3
2. Exposure					
2.1	Change in air temperature	3	3	3	3
2.2	Change in precipitation	2	2	2	2
2.3	Flood	6	7	4	3
2.4	Droughts	6	6	7	7
2.5	Forest fire	6	5	6	7

5.2. Vulnerability score

3. Adaptive capacity					
3.1	Dispersal ability	5	5	5	5
3.2	Dispersal opportunity	5	6	5	4
3.3	Genetic diversity	5	5	4	4
3.4	Feeding habit	7	7	7	7
4. Other stressors					
4.1	Poaching	6	6	6	7
4.2	Human-wildlife interaction	6	7	6	5
4.3	Pollution (Water, waste)	6	7	5	5
4.4	Interspecific interaction	6	7	5	4

Notes on vulnerability score: 0 is the lowest and 10 is the highest level of vulnerability for sensitivity, exposure and other stressors, whereas 0 is the highest and 10 is the lowest vulnerability for adaptive capacity .

5.2. Vulnerability score



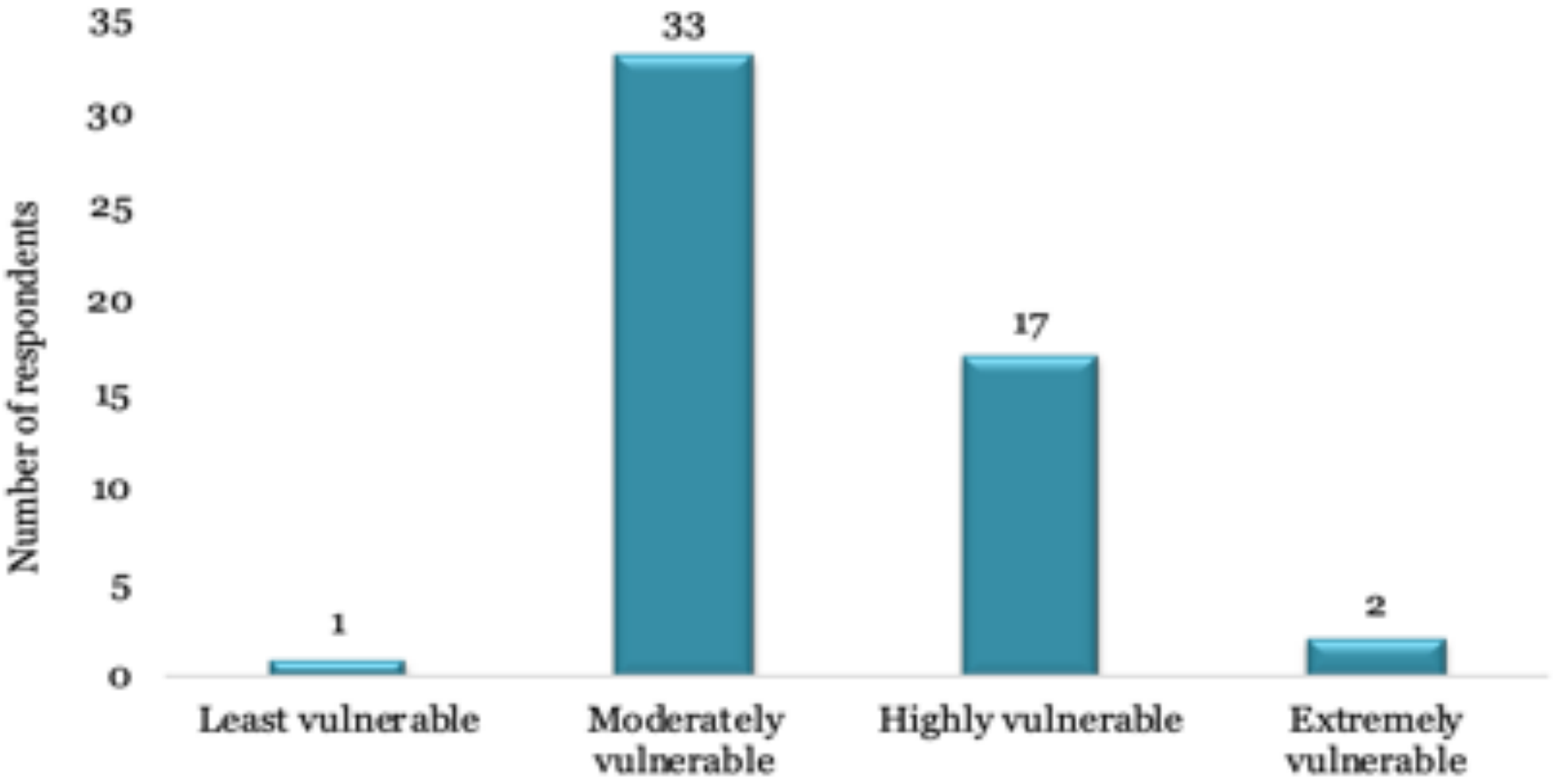
- The likelihood of **invasive plant species** and **severe floods** in Chitwan National Park
- Fragmented **habitat**, **small population size**, **droughts** and **forest fire** in Bardia and Shuklaphanta National Parks

5.3. Vulnerability index

Rhinoceros Population	Vulnerability Score			
	Sensitivity	Exposure	Adaptive capacity	Other stressors
Chitwan-Parsa	0.43	0.46	0.58	0.68
Bardia	0.55	0.44	0.53	0.55
Shuklaphanta	0.60	0.44	0.50	0.53
Overall (Nepal)	0.46	0.46	0.55	0.60

Rhinoceros population	Combined Vulnerability score		Vulnerability index
	Potential impact	Resilience	
Chitwan-Parsa	0.52 (High)	0.58 (High)	Moderate (HH)
Bardia	0.51 (High)	0.53 (High)	Moderate (HH)
Shuklaphanta	0.52 (High)	0.50 (High)	Moderate (HH)
Overall (Nepal)	0.51 (High)	0.55 (High)	Moderate (HH)

5.3. Vulnerability index



Majority (> 60%) of key informants consider that rhinoceros in Nepal are likely to be **moderately vulnerable**

Key points

- The rhinoceros in Nepal is likely to be **moderately vulnerable** to the impacts of climate change
- The potential impacts are likely to be **high**, but its adaptive capacity may offset these impacts
- Climate change **may not directly impact** the physiology of the rhinoceros
- Extreme weather events such as **floods and droughts,** limited availability of resources especially due to the prevalence of **invasive species**
- **Other stressors** such as poaching, human-wildlife conflict and pollution are likely to increase vulnerability

Way forward

6.1. Manage current and future habitat

- Existing suitable habitat of rhinoceros, including corridors both in and outside the protected areas
- Future suitable habitat and identify climate refugia to manage potential habitat for rhinoceros (Priority- Bardia and Shuklaphanta)

6.2. Initiate research focusing on climate change impacts

- Long-term experimental research on rhinoceros and its habitat
- Development of innovative population monitoring techniques using an integrated approach, including genetic sampling

Way forward

6.3. Continue to reduce vulnerability from other stressors

- Continue implementation of good practices such as zero poaching, pollution control and park-people partnership strategies
- Minimize the likely impacts of proposed infrastructures on rhinoceros and its habitat

6.4. Plan for climate refugia

- Develop a flood model to identify climate refugia for rhinoceros during the likely events of severe floods
- Identify and create suitable corridors for rhinoceros and remove anthropogenic barriers to facilitate dispersal to higher and safe grounds

Way forward

6.5. Facilitate rhinoceros for thermoregulation

- Plan and manage wetlands in strategic locations where rhinoceros can wallow in adequate water and mud
- Create and maintain wetlands especially in Shuklaphanta to ensure adequate wallowing sites for rhinoceros

6.6. Maintain mosaic of grasslands

- Create and maintain adequate grasslands for rhinoceros
- Control the spread of invasive plant species in grassland habitats particularly in Chitwan National Park

Way forward

6.7. Initiate rhinoceros health monitoring

- Plan and manage wetlands in strategic locations where rhinoceros can wallow in adequate water and mud

- Create and maintain wetlands especially in Shuklaphanta to ensure adequate wallowing sites for rhinoceros

7. Acknowledgements

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Thank you
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