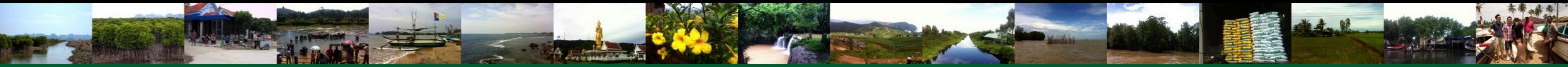

Country-wide human-elephant conflict risk assessment under future climate-induced changes in Thailand

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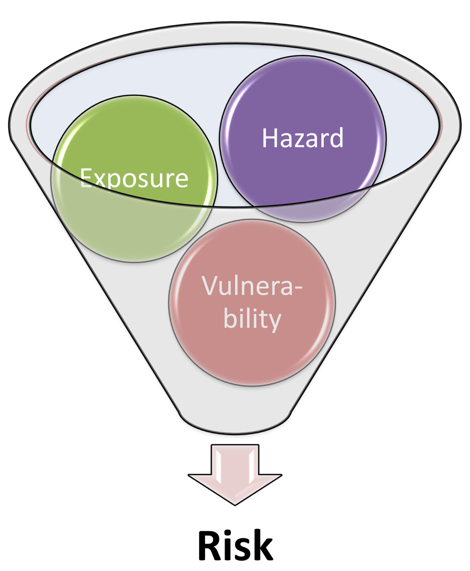
ABSTRACT: Humans and the endangered Asian elephants are under increasing competition for resources which deteriorates the sustainability of both the species conservation efforts and human development. With the multi-dimensional nature of such conflicts and the impending effects from climate change, human-elephant conflict (HEC) management needs broader assessment beyond reactively addressing direct losses. Here, adopting risk framework along with future projections under Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs), we proposed HEC risk assessment framework and analyzed its spatial distribution under baseline (2000-2019) and near future (2025-2044) for Thailand. Across all future scenarios, we projected four forest complexes in northern Thailand with an average of 1.7%-7.4% increase in HEC risk due to higher hazard and vulnerability from more favorable habitat conditions and increasing drought probability. 69% of Thailand forest complex, especially in lower latitude, were projected with risk reduction due mainly to decreasing habitat suitability. Our proposed framework is flexible allowing additional sub-indicators and can be extended to other areas and targeted species.

1. Background



- Some areas in Thailand, an average of 212 nights were annually spent by household in guarding crops against elephant-raiding and the HEC-induced cost is significant compared to the average household income (Jarungrattanapong et al., 2017)
- Wildlife threats are perceived as small frequent events and commonly neglected in disaster risk management policies (Gaillard, 2019), but they accumulate and erode society's ability to achieve sustainable development (UNISDR, 2015).
- Lack of landscape-scale assessment led to incomplete awareness of the situation and short-sighted decision-making (Gubbi et al, 2014; Goswami and Vasudev, 2017).

$$RISK = f(Hazard, Exposure, Vulnerability)$$

(UNSDIR, 2015; IPCC, 2012; IPCC, 2014)

HEC risk is defined as wild elephant occurrences (hazard) in overlapping areas with rural human population (exposure) who possess various vulnerable conditions (vulnerability).

Objective: Applied risk framework to quantify spatial distribution of HEC risk under baseline (2000-2019) and future (2025-2044) in Thailand

2. Methodology

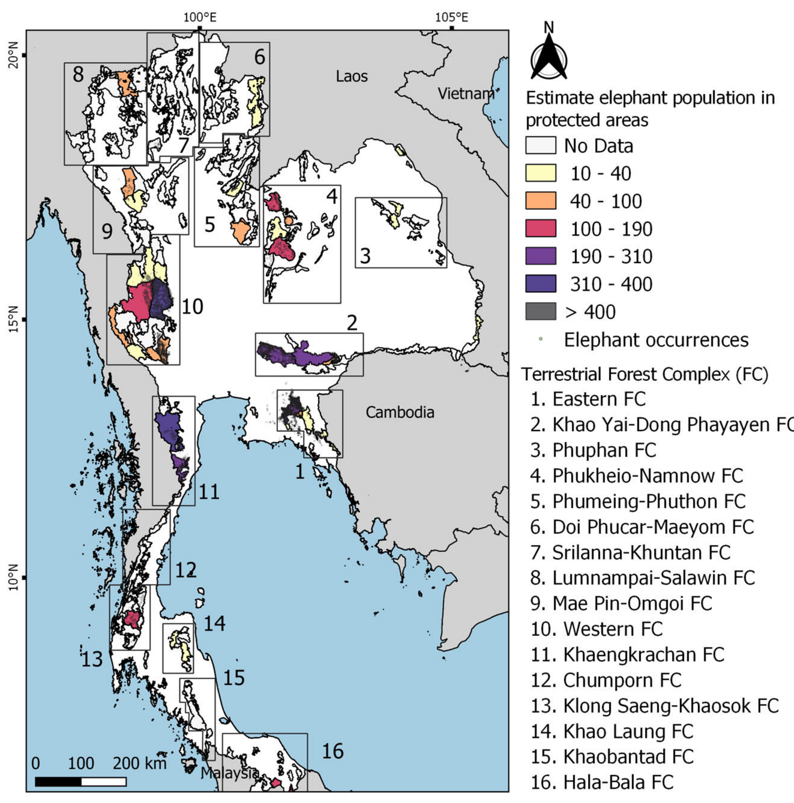


Fig 1: Distribution of terrestrial forest complex (FC) and the estimated wild elephant population.

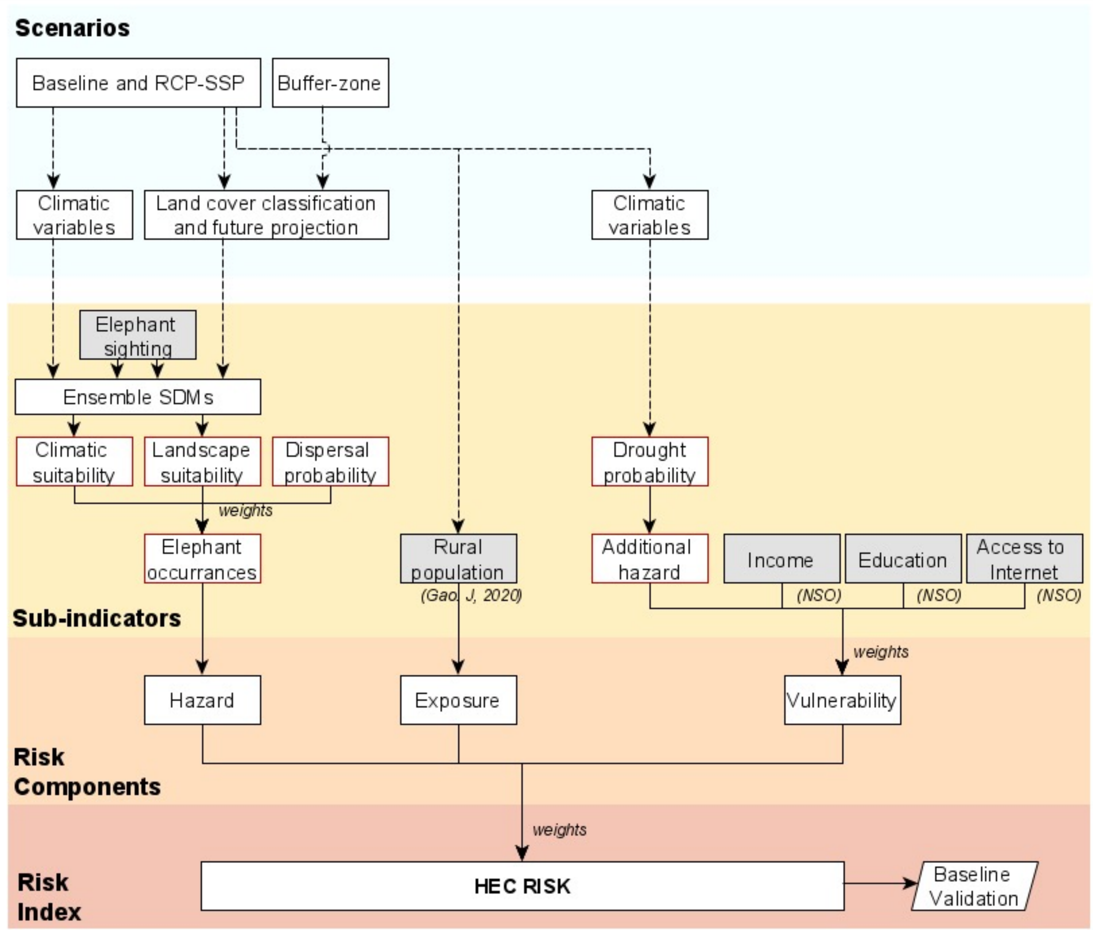


Fig 2: HEC risk framework, red-boxes are sub-indicators that were simulated in this study, gray boxes are directly obtained from existing data

Table 1. Four future scenarios in this study

		Climate Change	
		RCP4.5-SSP2 'Middle-of-the-road'	RCP8.5-SSP5 'Business-as-usual'
Buffer Zones	Yes	A1 (no land conversion in buffer zone)	A2 (no land conversion in buffer zone)
	No	B1	B2

Table 2. Climatic dataset used

Variables	Dataset	Spatial resolution	Temporal resolution
Min temperature Max temperature Precipitation	ERA5 reanalysis (**Baseline**) NEX-GDDP (**Future**)	~25 km	Daily
Bioclimatic variables	Drought indicators ($KBDI_{standard\ anomaly}$ >1.5)		

$$KBDI^{t-1} + \frac{[800 - KBDIt^{-1}][0.968e^{(0.0486\times Tmax)} - 8.3]\times 10^{-3}}{1 + 10.88e^{(-0.0441\times Prannual)}} - (100\times Pr)$$

Table 3. Land cover and land features used

Variables	Dataset	Spatial resolution	Temporal resolution
Baseline			
Land cover			
- Abandon	Image classification from		
- Crops	MOD09,	500 m	2014-2016
- Plantations	SRTM,	90 m	2000
- Built-up	ALOS-PALSA (yearly composite)	25 m	2015
- Water			
Transport	GRIP4 and Thai Railway	Vector	-
Water	HydroSHED and JRC	30 m	2014-2016
TRI	SRTM	90 m	2000
Future			
Land cover	1. **Land demand projection** based on IIASA trajectory and other assumptions, 2. **Spatial allocation** using **CLUS model**	500 m	2045
Others	Assumed static		

Table 4. Future land demand projection assumptions

LC Type	Assumption
Water	Constant from 2015
Built-up	Gao, J. & O'Neill, B. C., 2020
Forest	Increase up to 40% (Master Plan, 2019)
Agriculture	A function of production demand & yield Production (tonnes) (R^2= 0.9) $P_{SSP2\ SSP5} = \beta_{P0} + \beta_{P1}x_1 + \beta_{P2}x_2 + \beta_{P3}x_3$ Yield (tonnes/ha) (R^2 >0.7) $Y_{SSP5} = \beta_{Y0} + \beta_{Y1}x_2$ $Y_{SSP2} = {}^2/_3 Y_{SSP5}$ x_1 agriculture to GDP (%), x_2 GDP.PPP, x_3 rural pop
Abandon	Fulfill after other land demands are met

Normalization: $I'_i = \frac{X_i - \min(X)}{\max(X) - \min X}$

Index aggregation: $CI_i = (\prod_{i=1}^{n} I'^{w_i}_i)^{\frac{1}{\sum_{i=1}^{n} w_i}}$

3. Results & Discussions

Validation of baseline risk: average **AUC = 0.71± 0.01**

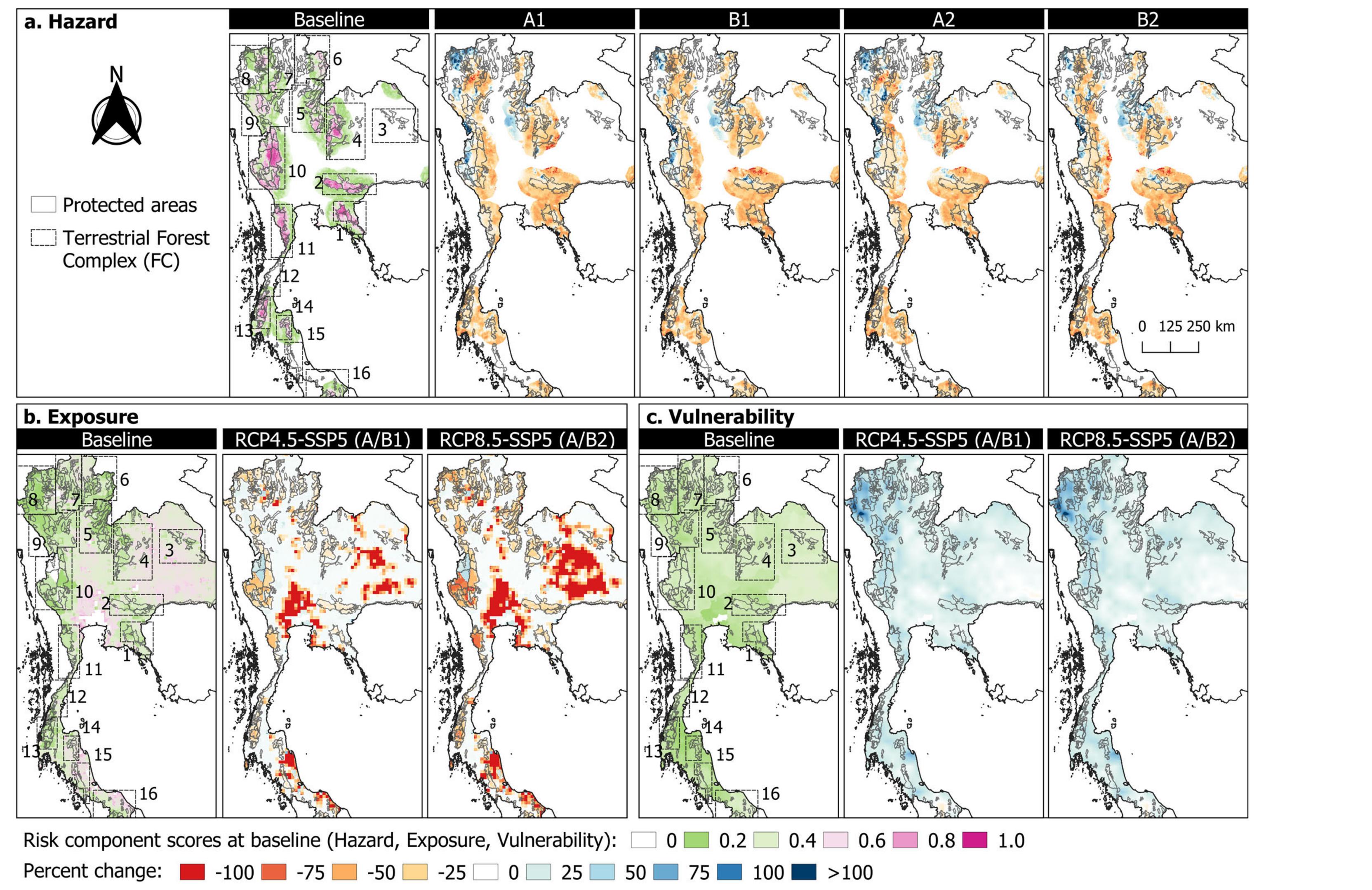


Fig 3. . Spatial distribution of baseline risk components including Hazard (a), Exposure (b), and Vulnerability (c) along with their average percent change under future scenarios.

An average 1.7% to 7.4% increase in risk (4 FCs)

An average -3.1% to -57.9% risk reduction in 11FC

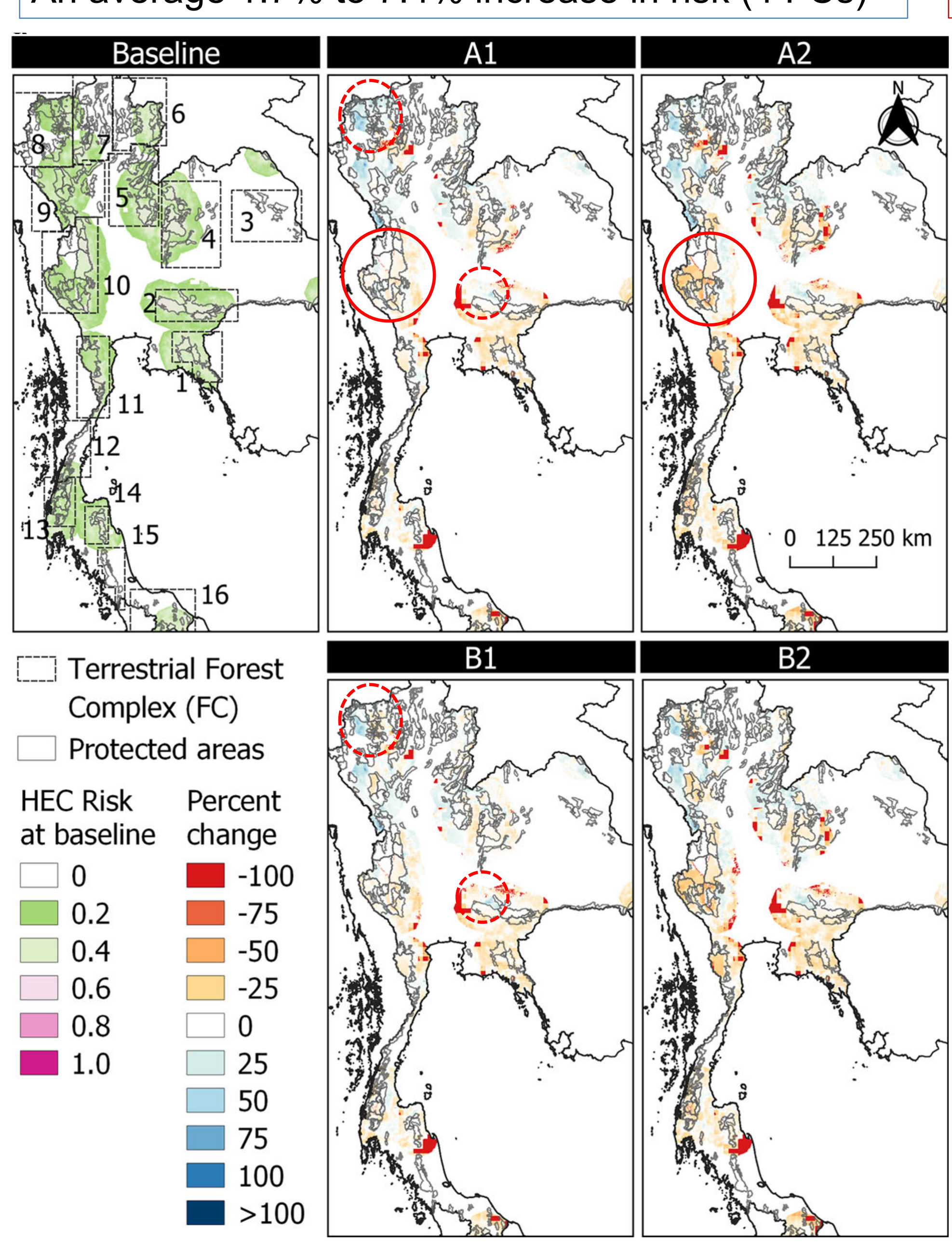


Fig 4. The HEC risk for baseline and percent change under four future scenarios.

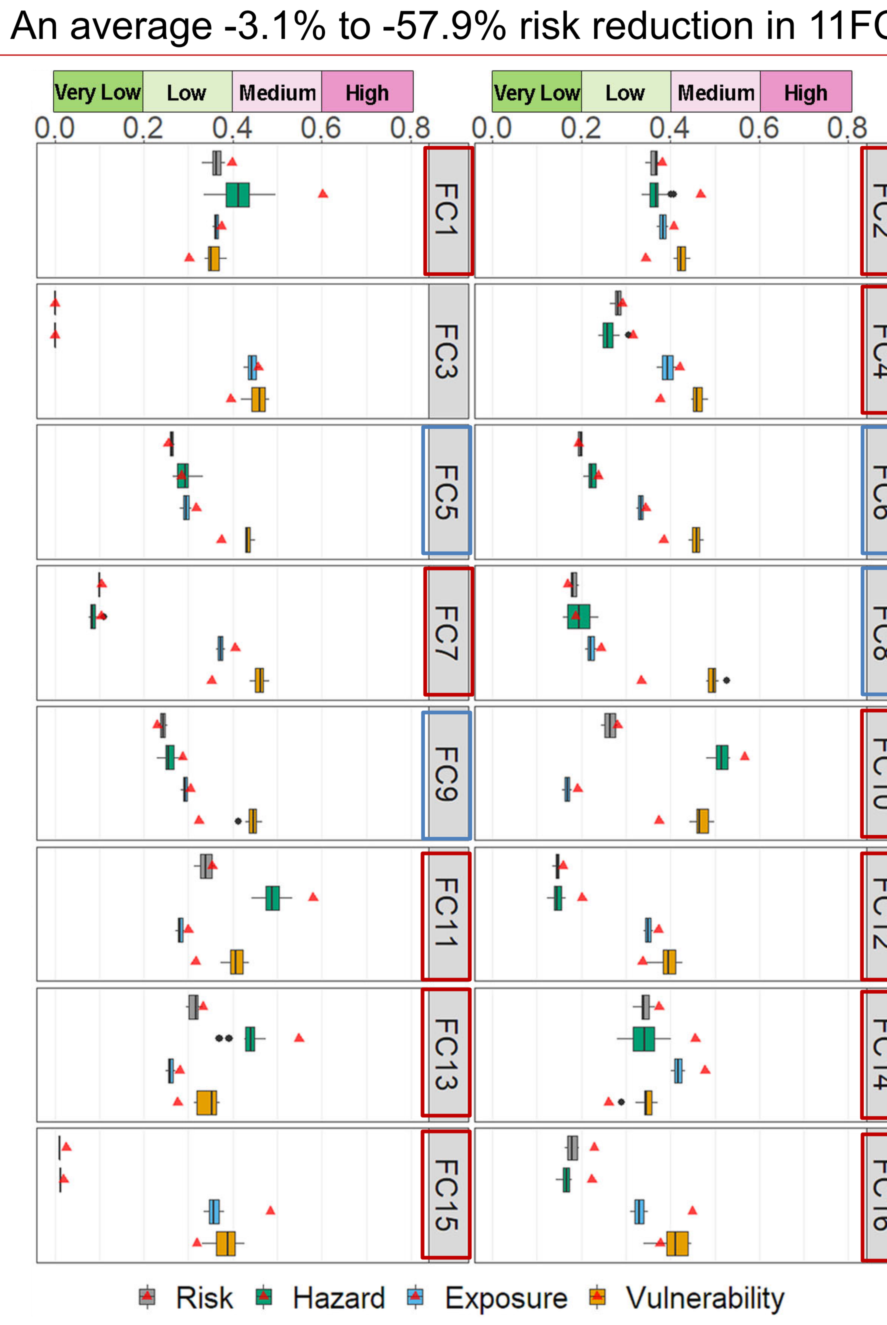


Fig 5. Boxplots of the future HEC Risk and underlying components including *Hazard*, *Exposure*, and *Vulnerability*. The red triangle represented the baseline value.

4. Conclusions & Future Work

- The proposed framework can identify degree and direction of changes in HEC risk.
- Future policies can base on projected maps to
  i) limited human access in areas with existing low human population but high future HEC risk [north],
  ii) implement habitat restoration in area with currently high elephant population but lower future habitat suitability [eastern FC, western FC, and southern region].
- More broadly, the findings attested the importance of climate change consideration in conservation planning which showed to impact both wild elephants and humans.
- Spatial policy like buffer zones can create both negative and positive impacts on HEC risk. More specific policy should be evaluated.
- Future work can expand variable that represent human dimensions and obtain validation from other locations

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