Bipin Kumar Acharya

Dr. Acharya is a health demographer with research interest on:

- Spatial epidemiology of climate sensitive disease including Dengue and Scrub typhus
- Health geography and population health
- Currently associated with Nepal Open University and Nepal Health Research Council

He will share his work performed on modelling and mapping of climatically (environmentally) suitable areas based on ecological niche principle & machine learning methodology techniques used for Visceral leishmaniasis transmission in Nepal.

Climate Change and Its Impact on Spatial and Temporal Distribution of VL Transmission Risk in Nepal

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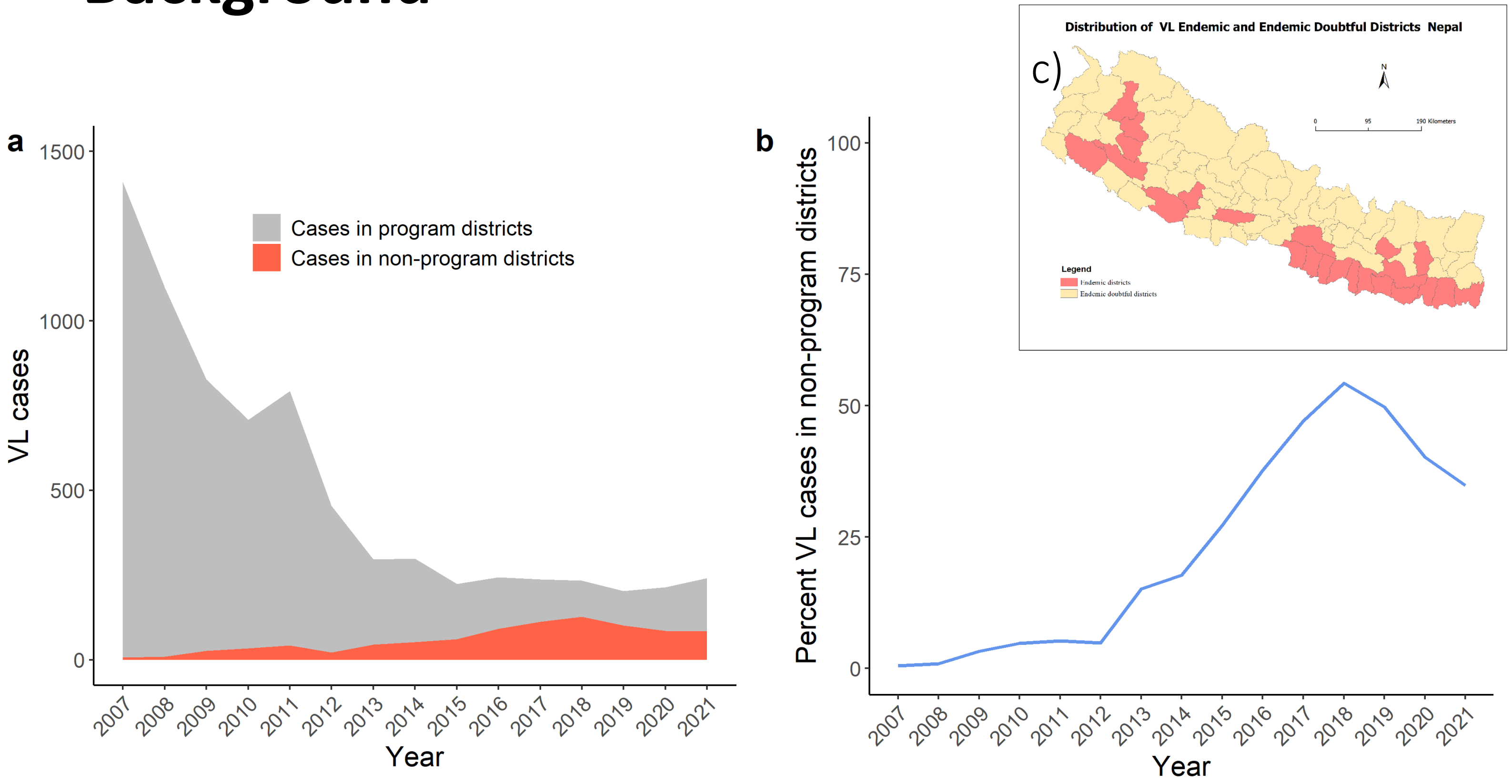
Contents

1. Background

What is VL?

- Visceral leishmaniasis (VL), also known as kala-azar, is a deadly vector-borne disease (VBD) caused by the protozoan parasite *Leishmania donovani* and is transmitted by the bite of an infected female sandfly.
- An estimated 50,000 to 90,000 new cases of VL occur worldwide annually, with only 25–45% reported to WHO.
- Although the distribution of VL is found across the world, it is more prevalent in 11 countries of Southeast Asia and East Africa.
- The VL elimination initiative has made great success in reducing the cases. For Example, Nepal had already achieved the elimination target as a public health problem of 1 case per 10,000 population at the district level.
- However indigenous cases continue to be reported in areas previously considered to be non endemic areas and this has posed significant challenge to elimination efforts and in 2022 2 districts in Nepal exceeded the elimination targets.

Background



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Cases in program districts	1403	1089	800	674	751	433	252	246	163	152	126	107	102	128	157
Cases in non-program districts	7	10	27	34	42	22	45	53	61	92	112	127	101	86	84
Percent cases in non-program districts	0.5	0.9	3.3	4.8	5.3	4.8	15.2	17.7	27.2	37.7	47.1	54.3	49.8	40.2	34.9

Questions

- Is the expansion of VL in previously not endemic districts related to climate change?
- What are optimal intervention strategies to mitigate the expansion of VL into new districts?

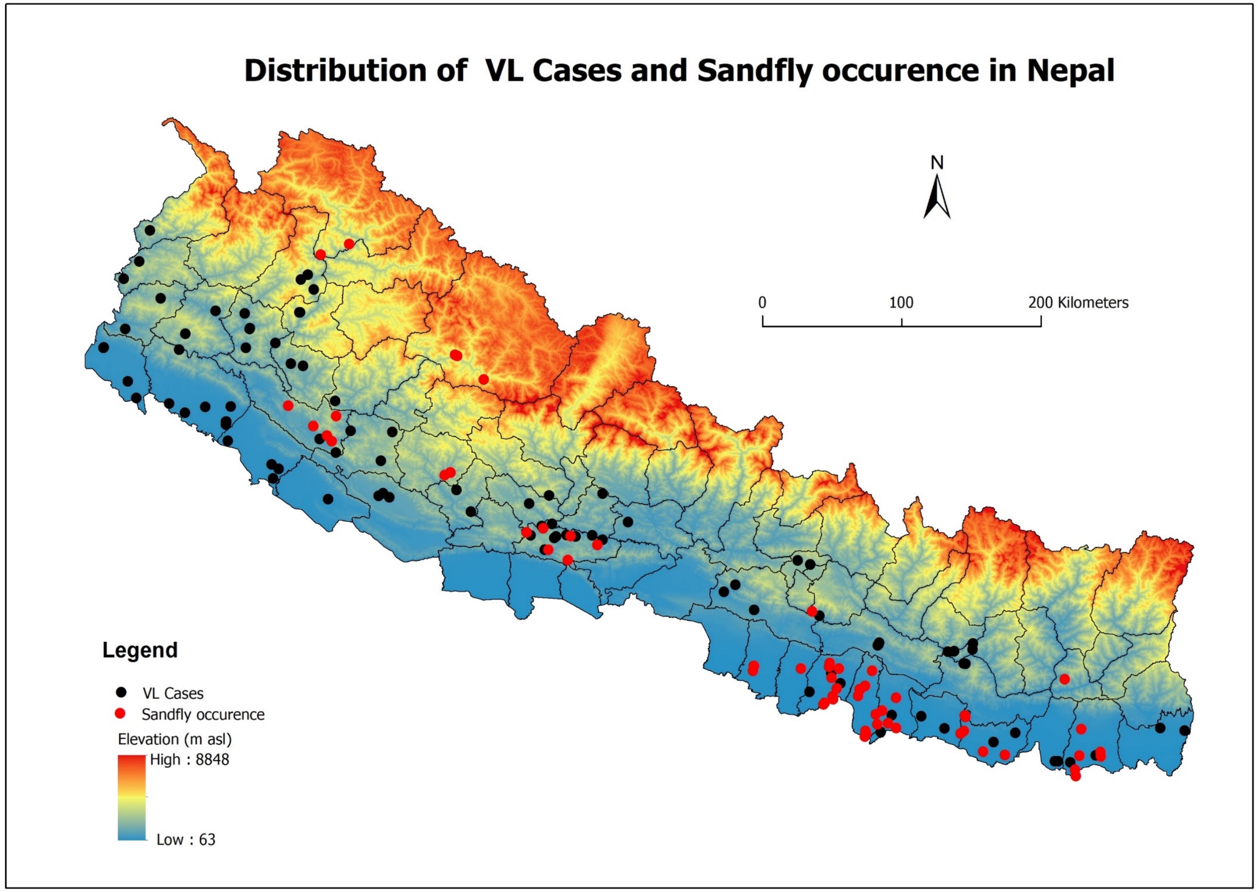
Objectives

1. Improve understanding of spatiotemporal transmission dynamics of VL in Nepal
2. Identify risk factors for geographic spread of VL to hitherto not endemic regions in Nepal
3. Develop tool to monitor current and future risk of VL transmission in Nepal to support planning of the National VL Elimination Programme.

Materials and Methods

Study area and Setting

- Nepal is located in roughly 26-30 North and 80-88 East, between China and India
- Diverse geography with elevation gradient 60 to 8848 meters from the sea level
- Climate is broadly subtropical monsoon climate. However due to the diverse topography, microclimate is prominent in Nepal
- Population distribution is heavily concentrated in low land Trai and middle hills



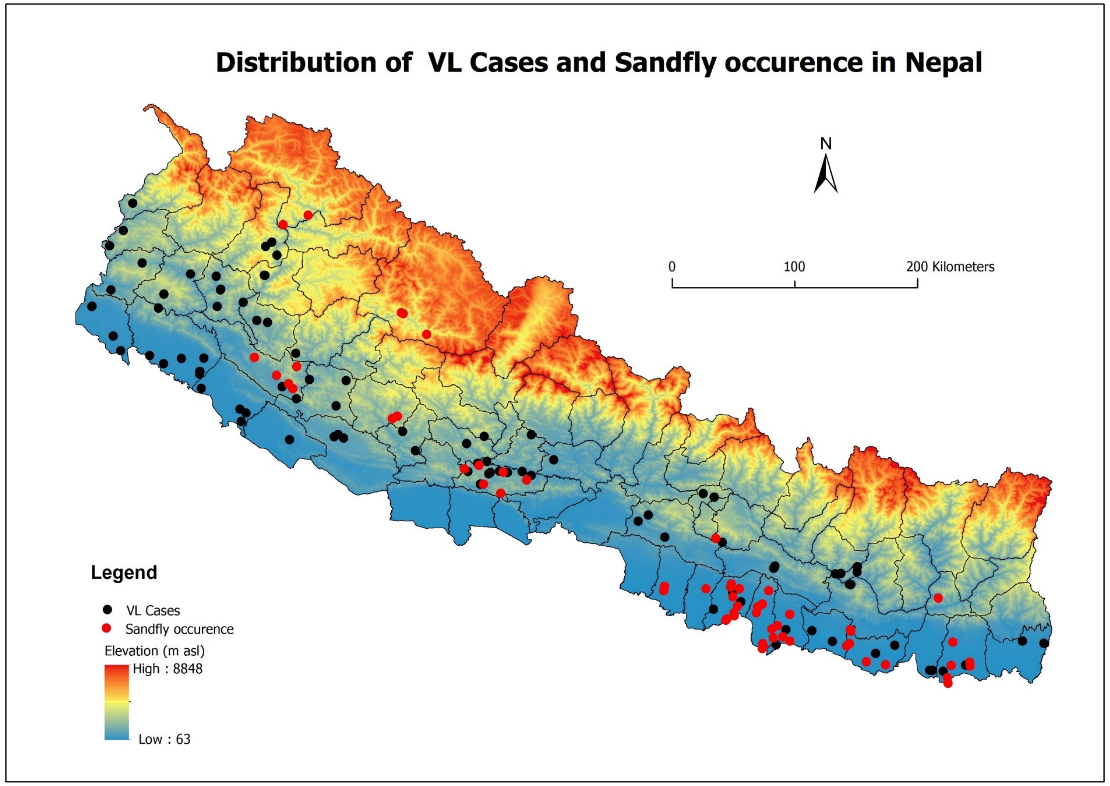
Materials and Methods

VL Data sources

Geolocation data of vector sandfly (63) were collated from previous literature.

In addition, 96 address level VL cases were also collected from the EDCD and subsequently geocoded.

Both vector location and VL cases location subsequently merged



Predictor Variables

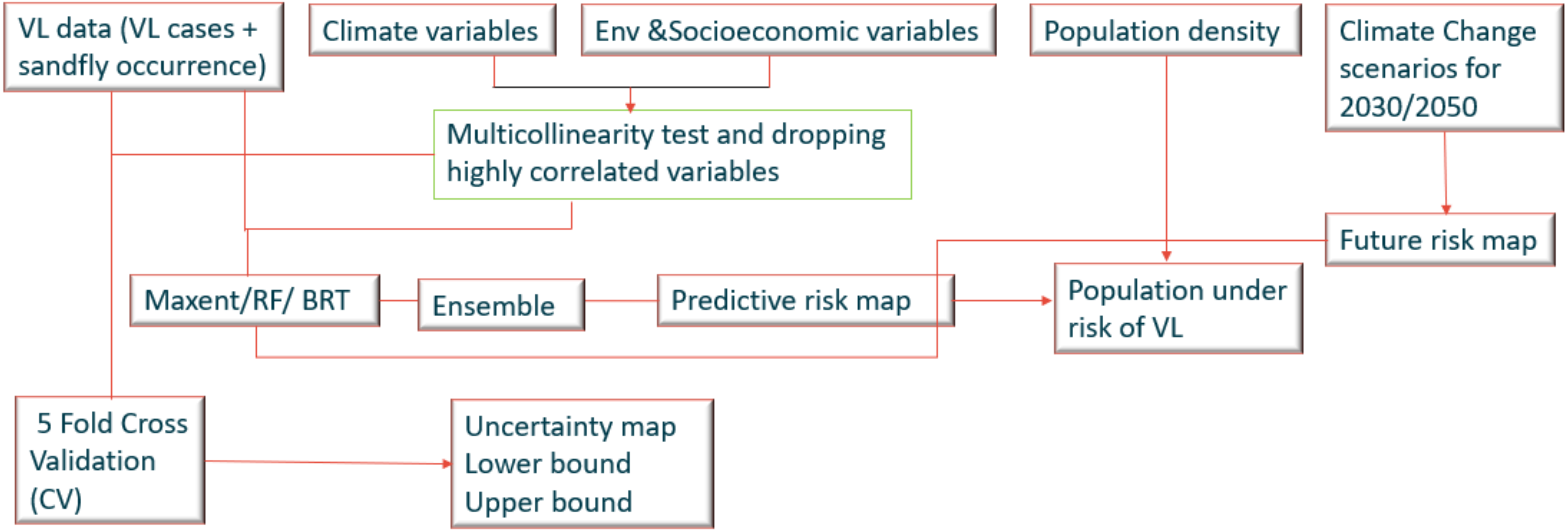
- 19 bio-climatic variables were retrieved worlclim geoportal (https://www.worldclim.org/ (https://www.worldclim.org/) via geodata package in R
- Normalized Difference Vegetation Index (NDVI), Night Time Light (NTL) were then addended to account the environmental and socioeconomic influences on the distribution of VL transmission
- Grided population was retrieved from worlpop for the year 2020

Materials and Methods

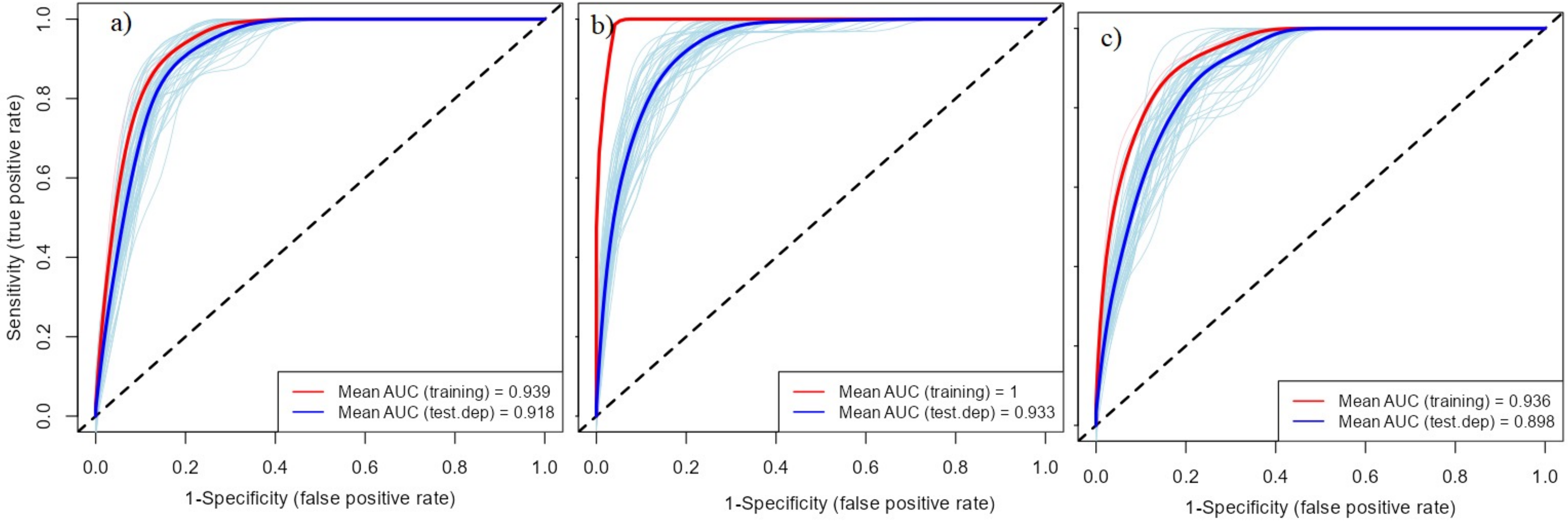
Modelling and Prediction

- Three different machine learning algorithms – Random Forest (RF), Boosted Regression Trees (BRT) and Maxent- were applied to fit the model
- The geolocation data were split into training and test data using the 5-fold cross validation (CV) in the proportion of 70 and 30
- Model Accuracy was evaluated using the AUC Value of ROC curve
- The best fit model were then ensembled to predict the current and future distribution of VL risk
- Uncertainty maps were computed for the 2.5th percentile and 97th percentage
- Population at risk was computed by overlaying the VL risk map with grided population layer

Analysis workflow



3. Results

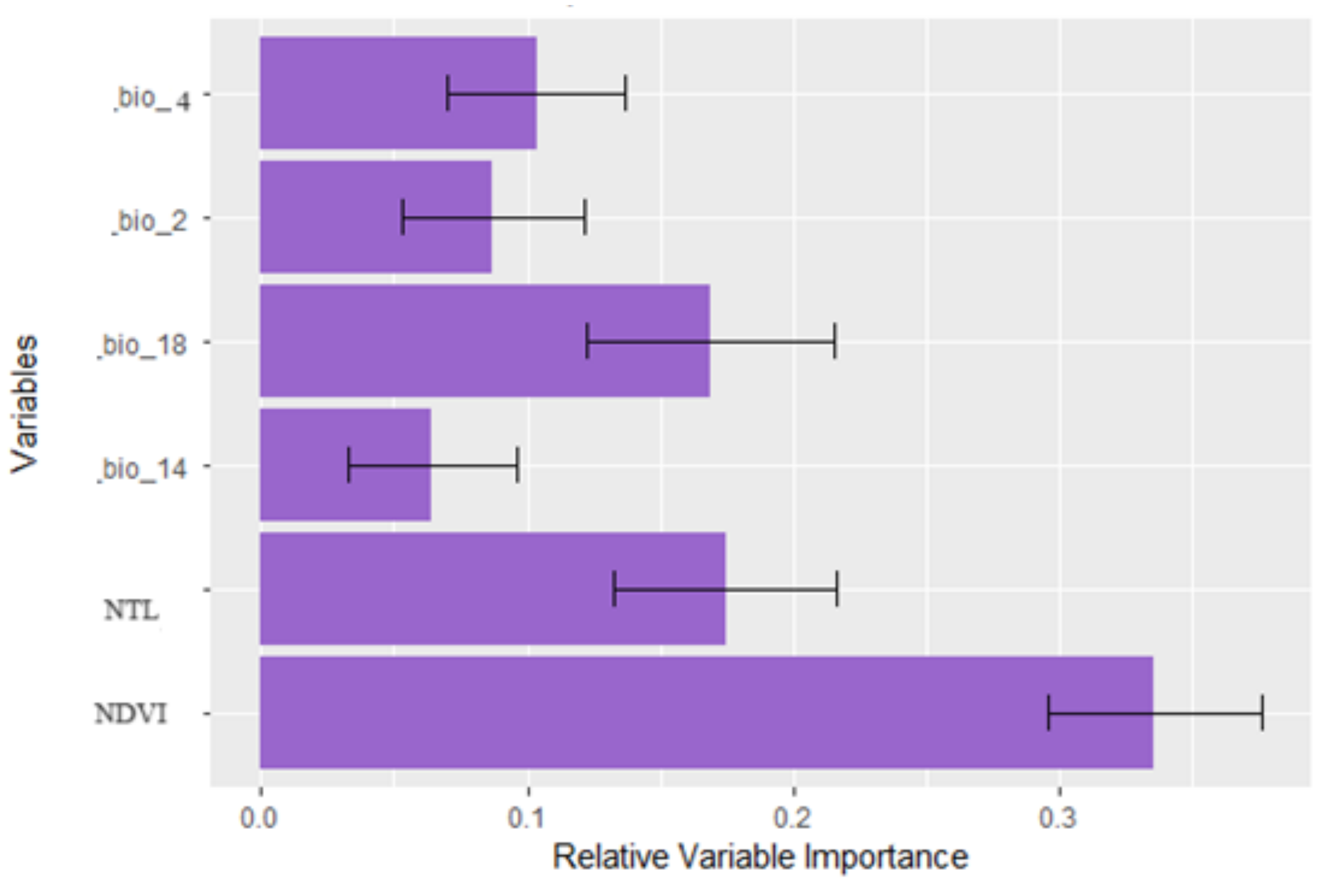


Area under curve (AUC) of 10-fold cross validation with 100 replicates a) MaxEnt b) RF and c) BRT run. *The red and blue line are mean AUC of training and test data, respectively*

All machine learning methods, maxent, RF and BRT, performed very well with the selected variables with a mean test AUC of 0.918, 0.933 and 0. 898, respectively in fivefold cross validation

3. Results

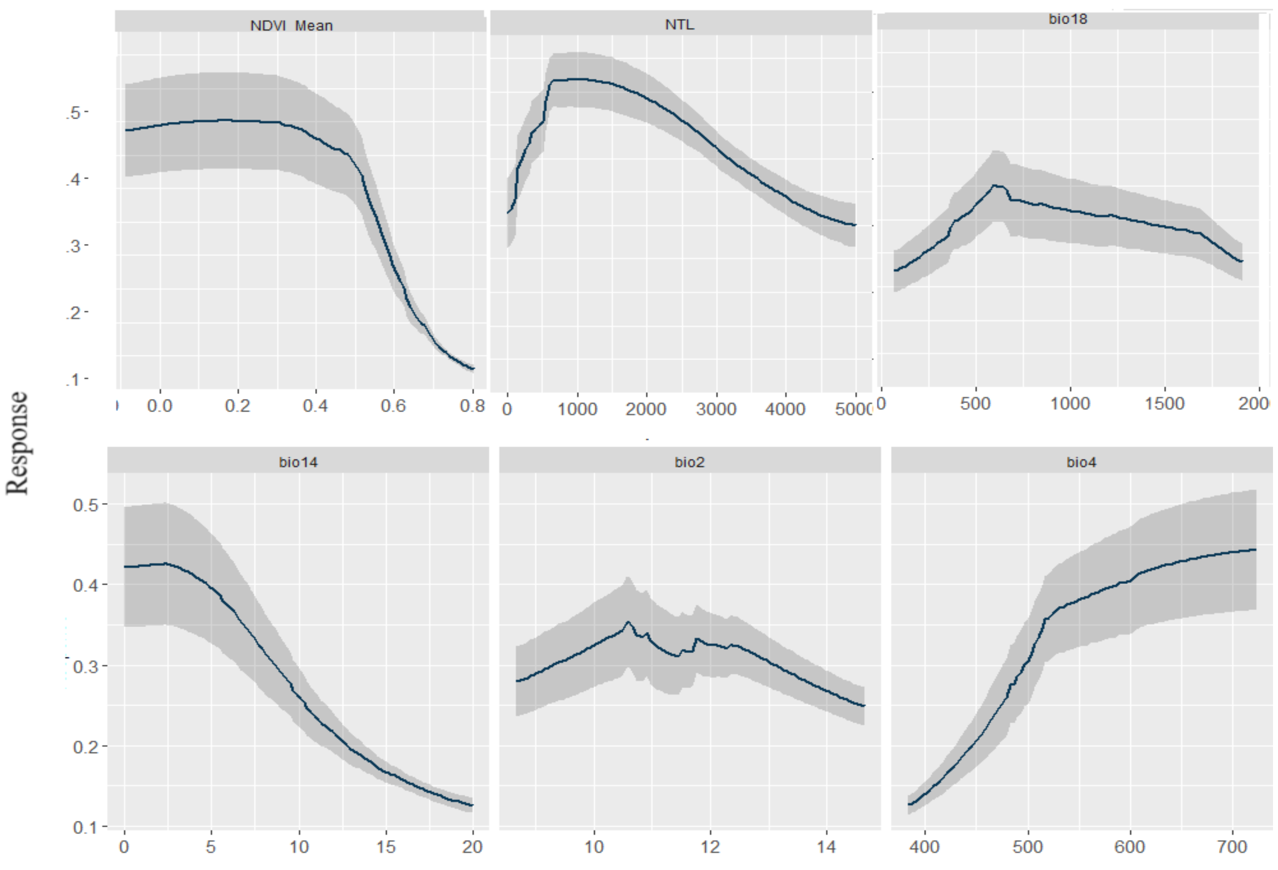
Important variables



- Night time light distribution, NDVI and Precipitation in the warmest quarter were most important variables the shaping the spatial distribution of VL risk in Nepal

3. Results

Response curve



Distribution of values

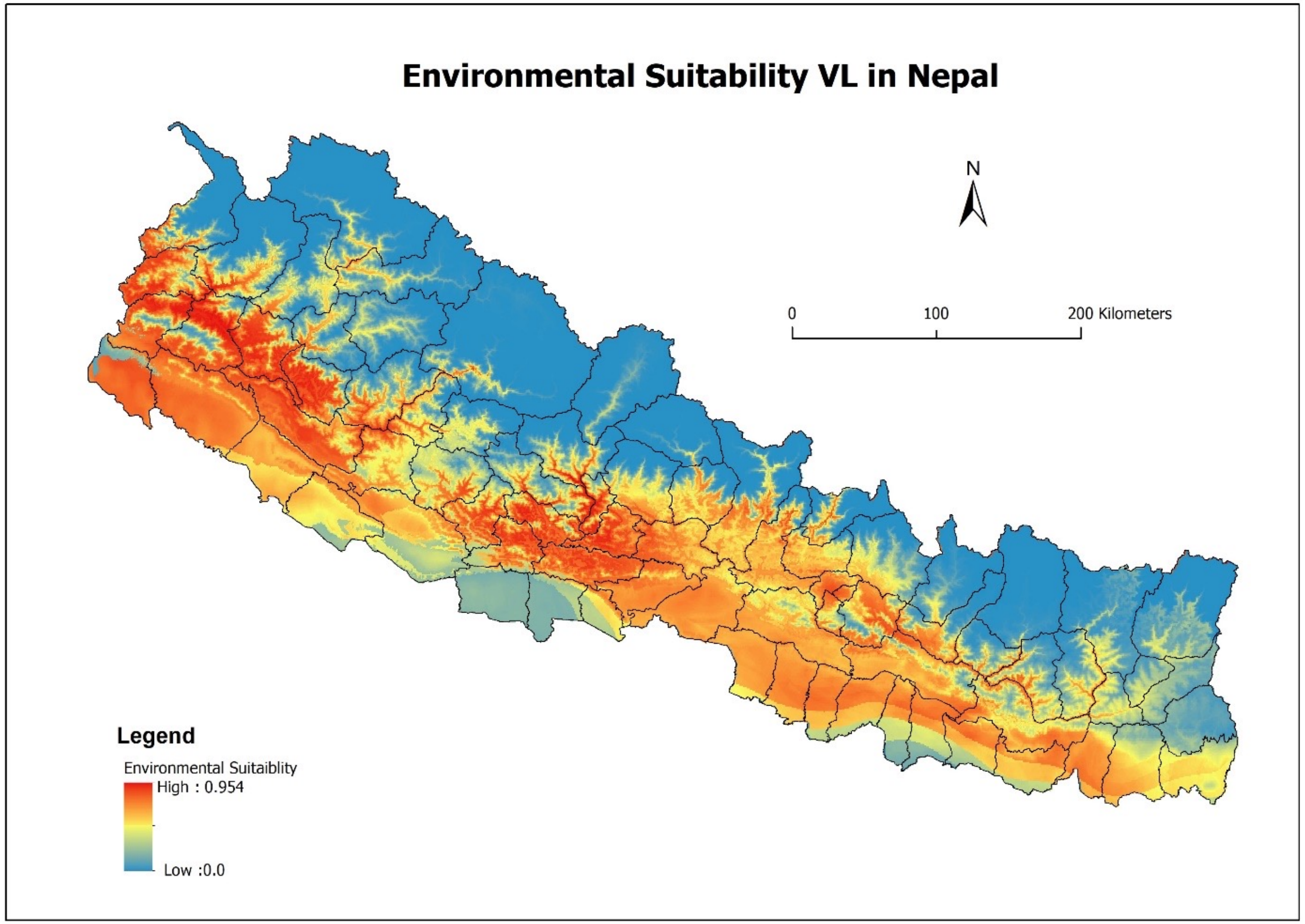
Response curve of finally selected 7 variables. *Black line shows the mean value of response while the grey shaded area shows its variability among 30 sub models.*

3. Results

Spatial distributing patterns

- **Environmental suitability** for VL transmission is **high across Nepal**, apart from high-elevation areas

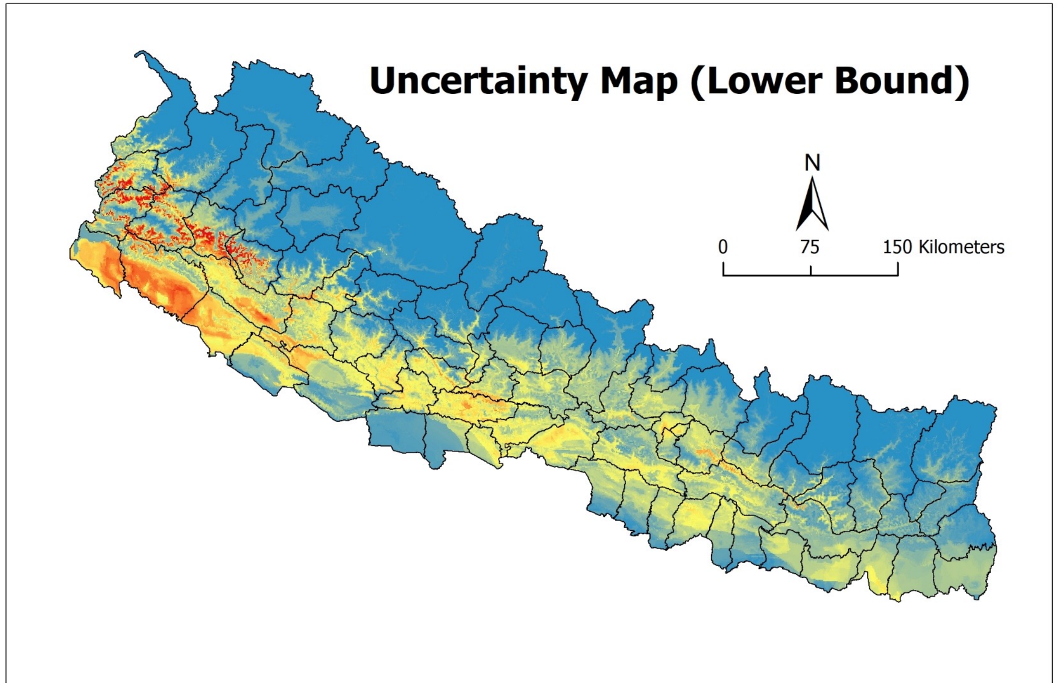
- **Environmental suitability** is predicted to be **highest in the West and centre of Nepal**; most programmatic activities have focused on districts in the East



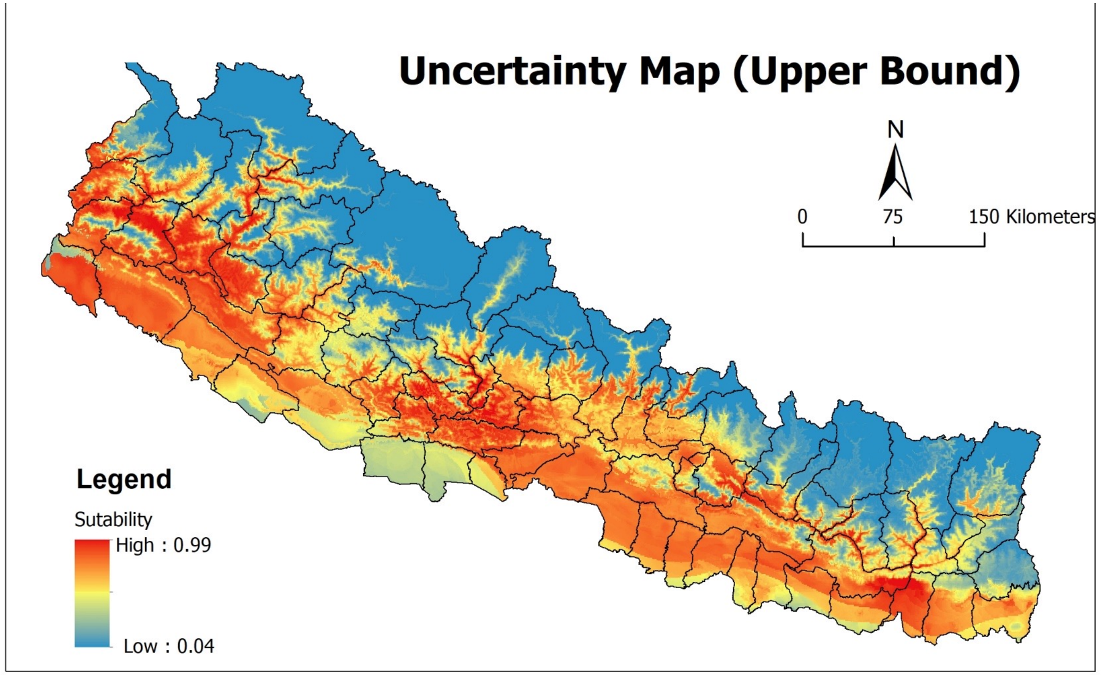
- Although mountains may not be suitable for VL transmission, **VL may be spreading in valleys in mountainous areas**

Uncertainty maps – 95% confidence intervals around predicted suitability for VL

2.5th percentile of suitability for VL transmission



97.5th percentile of suitability for VL transmission



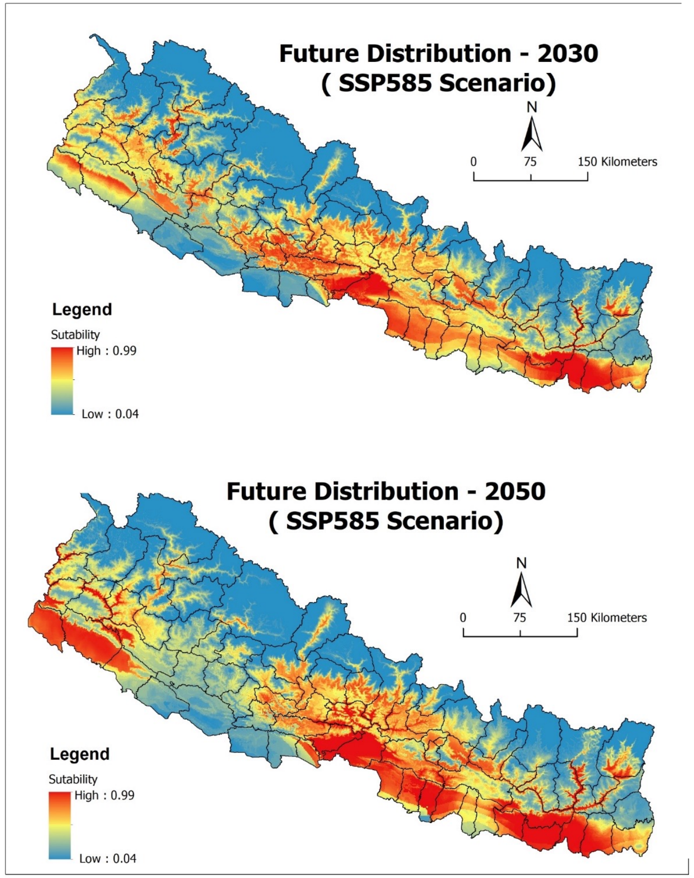
The greatest uncertainty in predictions around environmental suitability for VL transmission is in western Nepal and in mountain valleys where fewer sites have been sampled, especially for sandflies.

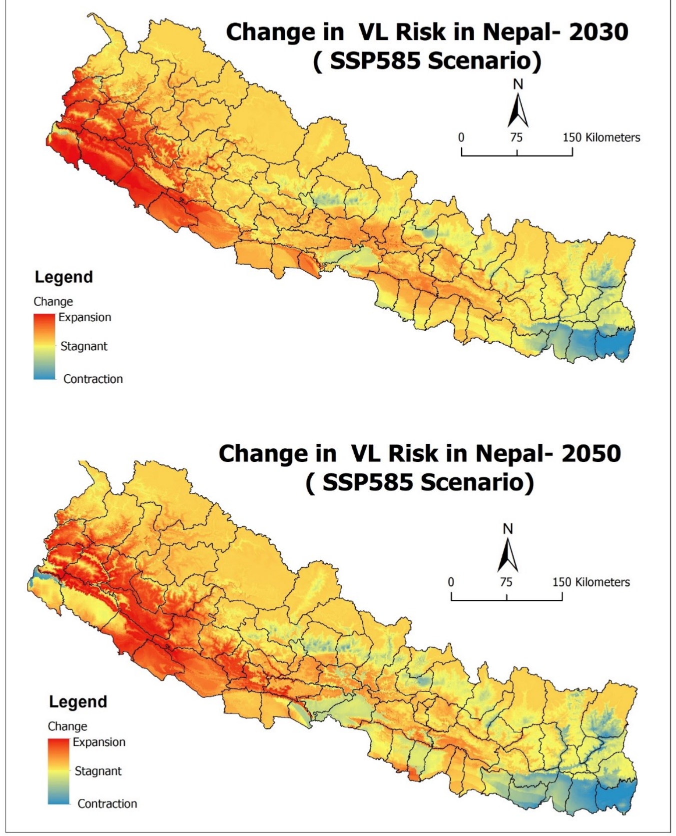
Change in risk relative to Current

Absolute risk

Change in risk relative to the current distribution

- A greater degree of global warming is expected to lead to an overall faster expansion of VL transmission.
- Some areas, especially in the east and centre of Nepal will experience a faster contraction of VL transmission.





Forecast of environmental suitability of VL in 2030 and 2050 – pessimistic scenario
5K increase in Global Mean Surface Air Temperature till the end of the century

Population at risk now and in 2030 and 2050 for two different scenarios (SSP245and SSP585)

Scenarios	Year	Total population	Population at risk	Percent population at risk
Base year	2020	25652250	20612522.28	80.35366209
ssp245	2030	43293636	25662886	59.27634722
ssp585	2030	43293636	34219161	79.03970228
ssp245	2050	61855683	44521965	71.97716174
ssp585	2050	61855683	50162087	81.09535707

4. Discussion and Conclusion

- Climate and environmental variables together with geolocation data can predict the environmental risk of VL transmission in Nepal

- Night time light (NTL), NDVI and Precipitation of warmest quarter (bio6) of the year strongly influence the spatial distribution of VL suitability in Nepal.

- However, other variables not taken into account in this study, e.g. human mobility and open border between India and Nepal could play a role in cross boarder transmission

- Currently lowland Tarai from east to the west and lower middle hills is suitable for VL transmission with the western areas being more suitable compared to the east.

- Under climate change, the spatial shift of VL transmission is anticipated from east to the west. However VL suitability areas remain more or less stagnant in the future.

- The VL elimination initiatives should focus on west Nepal where VL indigenous cases have been reported recently but have not been included in the elimination intervention

Contributors to this study

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Q&A

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Thank you!

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