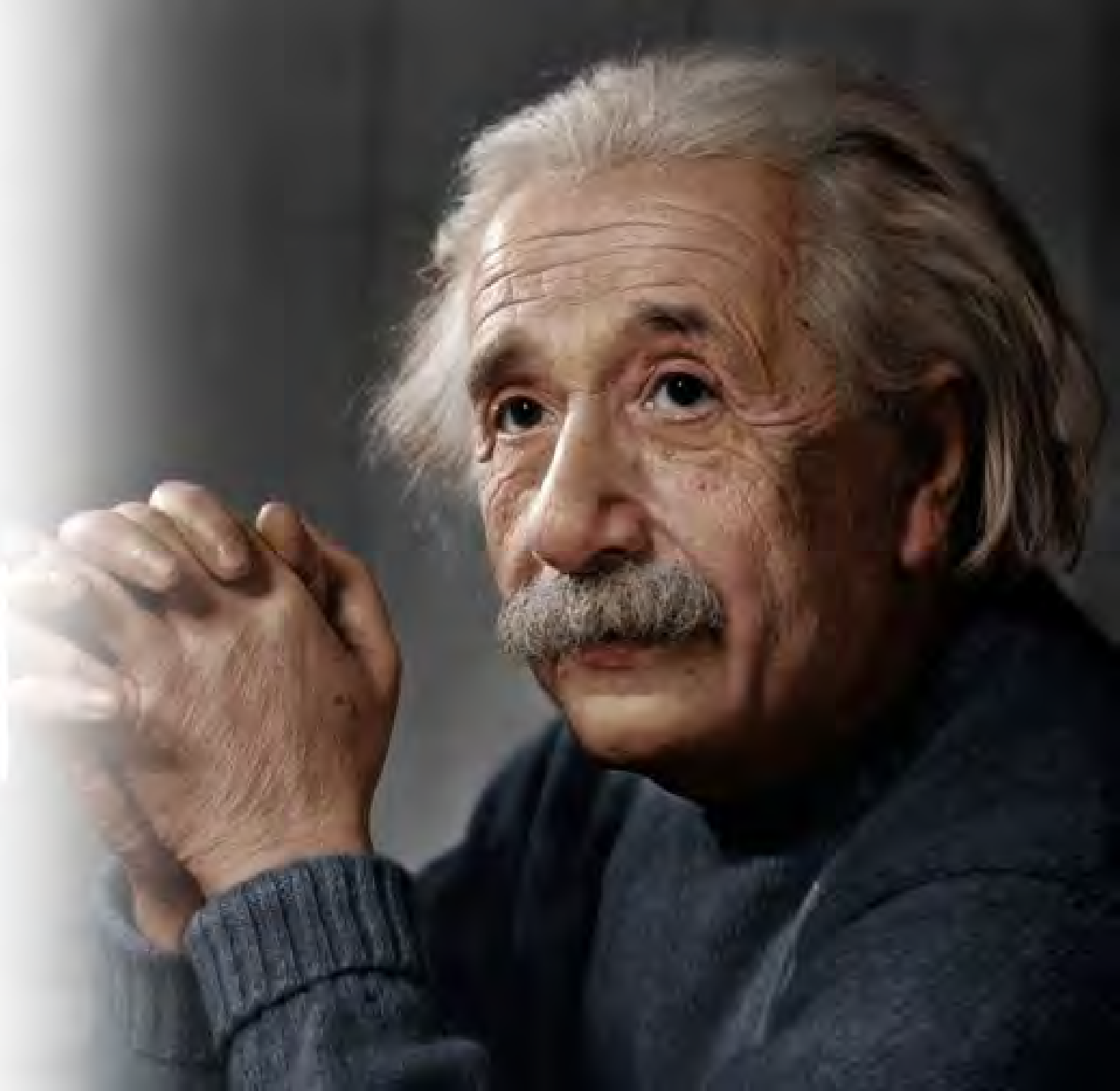
If the bee disappeared off the surface of the globe, then man would have only four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man.

— Albert Einstein



Importance of Pollination

Pollination: A regulating ecosystem services as it directly provides benefit that are essential for human well-being and sustainable ecosystem functioning.

Critical for preserving and **enhancing biodiversity** on Earth.

87.5% of the world's flowering wild plants rely on animal pollination for sexual reproduction (Ollerton et al. 2011).

Enhances livelihoods by ensuring successful crop production (Khan & Khan, 2004; Sharma et al. 2016).

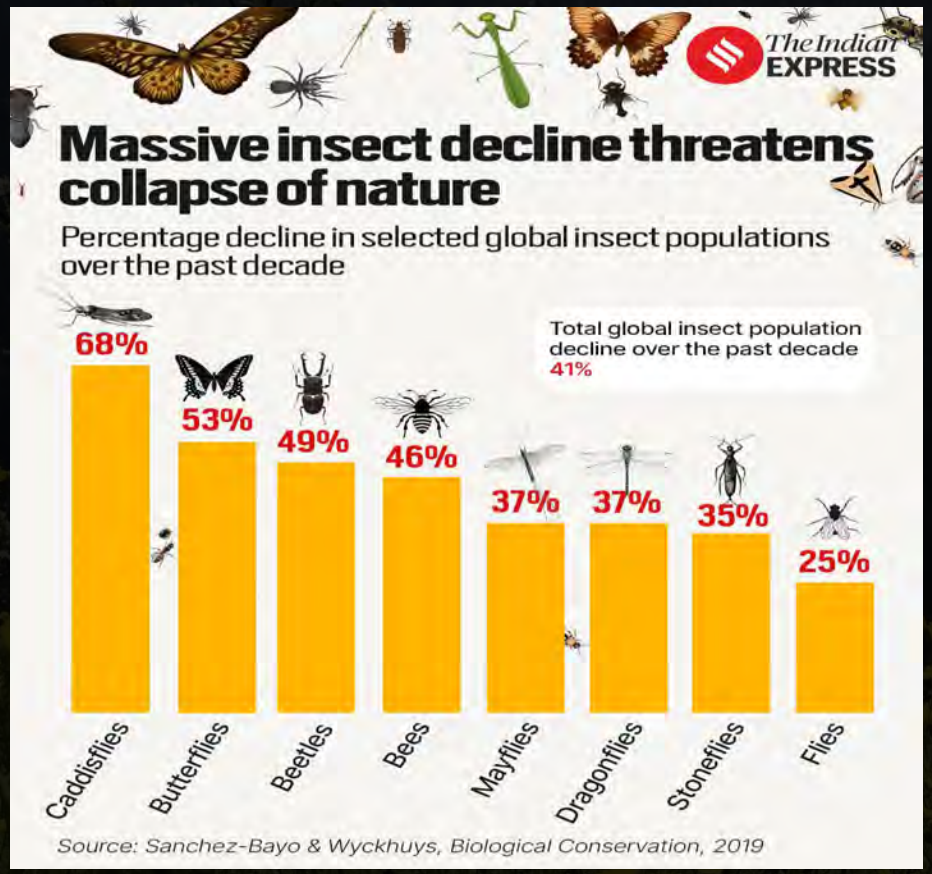
75% of World's important food crop annually depends on animal pollinators (Klein *et al.*,2007; Gallai *et al.*, 2009).

Human-domesticated animals depend on pollination for about **one-third** of their food directly or indirectly. (Costanza et al., 1997).

Crop pollination services provided by non-bees is 25–50% of the total number of flower visits.

Play a crucial role in **stabilizing terrestrial food webs** by supporting wild plants, which offer resources like food and shelter for various other organisms.

The global economic value attributed to a single year of biotic pollination services for important food crop valued 153 billion pounds (€) (Klein et al.,2007; Gallai et al., 2009).



Major threats to insect pollinators include

Climate Change

Monoculture

Invasive species

Habitat Loss, Degradation, and Fragmentation

Intensification of agricultural practices

Pollution

Use of pesticides

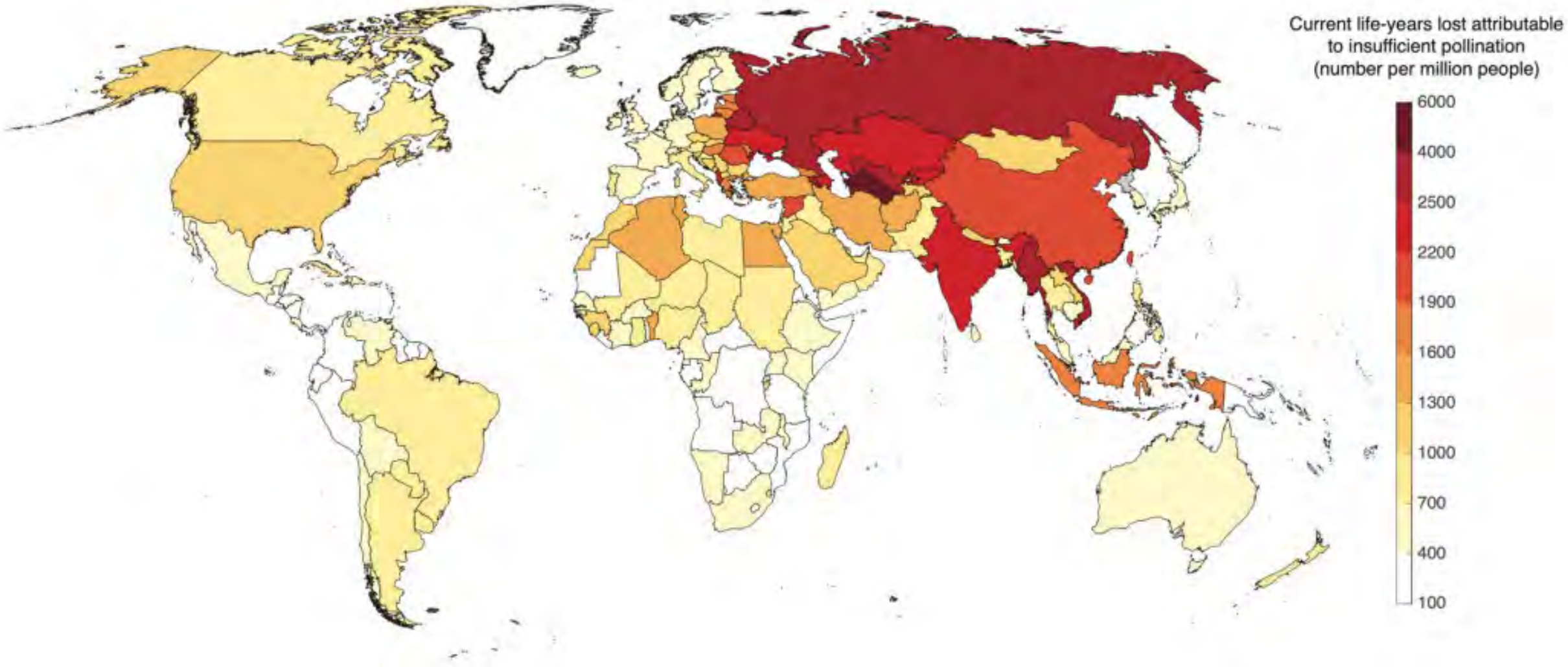
Threats to pollinators

- Approximately 16.5% of land pollinator species and 30% of island pollinator species worldwide are considered endangered with heigh risks of extinction (According to the IUCN's Red List).
- National Red List indicates over 40% of bee species are endangered.

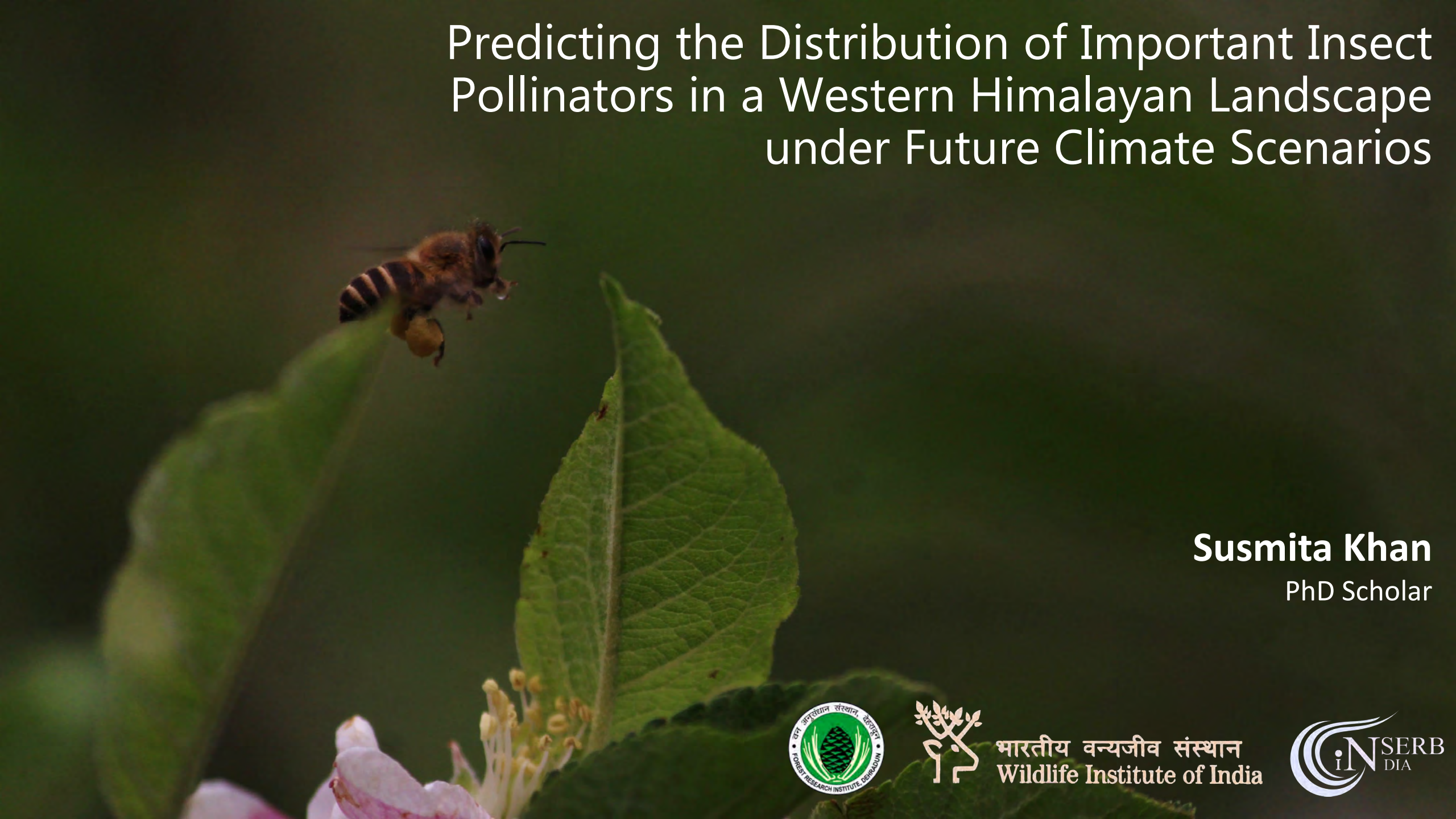
Global decline of pollinators

Decreases in pollinator numbers can result in a loss of pollination services, leading to severe ecological and economic consequences (Abrol, 2009).

Life-years lost per capita estimated to be attributable to insufficient pollination. Insufficient-pollination–related health conditions include dietary and weight factors (Smith et al, 2022).



Predicting the Distribution of Important Insect Pollinators in a Western Himalayan Landscape under Future Climate Scenarios



Susmita Khan
PhD Scholar

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

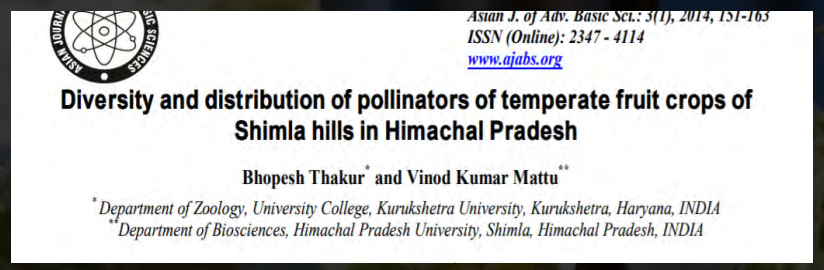
Importance of Himalayan landscape

- The Himalayan region is a biodiversity hotspot sustaining a rich array of species, facing increasing threats from a rapidly deteriorating environment and climate change.
- Formulation conservation strategy is very difficult due to its heterogenous nature throughout.
- Within the Indian Himalayan Region (IHR), the insect fauna comprises about 24,784 species/subspecies belonging to 26 orders, representing 38.1% of India's known diversity.
- In past few years decline in the number and diversity of pollinators has been noticed throughout the Hindu Kush Himalayan (HKH) region affecting crop pollination services due to various anthropogenic practices, parasites and diseases, invasive alien species, monoculture, and intensive farming methods and use of pesticides (Ahmad et al., 2003; Partap, 2010 a,b, 2011).

Major insect pollinator diversity as reported from world, India and IHR (Chandra et al., 2018).

Class/Order	World			India			IHR		
	Family	Genus	Species /Subspecies	Family	Genus	Species /Subspecies	Family	Genus	Species /Subspecies
Insecta	-	-	10,53,578	-	-	65,047	-	-	24,784
Hymenoptera	116	7738	1,50,659	68	-	12,605	52	816	3054
Lepidoptera	126	-	1,58,423	-	-	12,500	68	2,069	5,356
Diptera	188	-	1,60,000	87	-	>6000	64	437	1698
Coleoptera	176	29,500	3,89,487	-	-	22,299	107	2684	10,533

Past Research in this Landscape

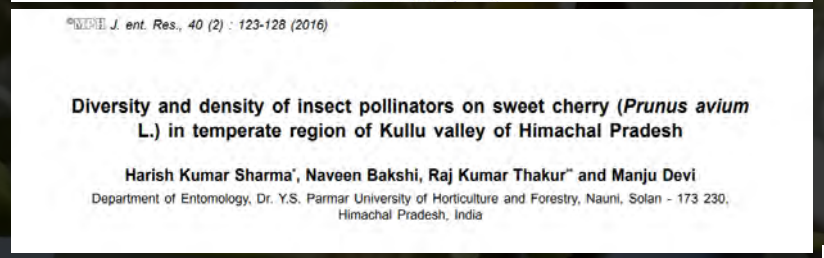


Asian J. of Adv. Basic Sci.: 3(1), 2014, 151-163
ISSN (Online): 2347 - 4114
www.ajabs.org

Diversity and distribution of pollinators of temperate fruit crops of Shimla hills in Himachal Pradesh

Bhopesh Thakur[*] and Vinod Kumar Mattu[**]

[*] *Department of Zoology, University College, Kurukshetra University, Kurukshetra, Haryana, INDIA*
[**] *Department of Biosciences, Himachal Pradesh University, Shimla, Himachal Pradesh, INDIA*



J. ent. Res., 40 (2) : 123-128 (2016)

Diversity and density of insect pollinators on sweet cherry (*Prunus avium* L.) in temperate region of Kullu valley of Himachal Pradesh

Harish Kumar Sharma*, Naveen Bakshi, Raj Kumar Thakur and Manju Devi**

Department of Entomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan - 173 230, Himachal Pradesh, India

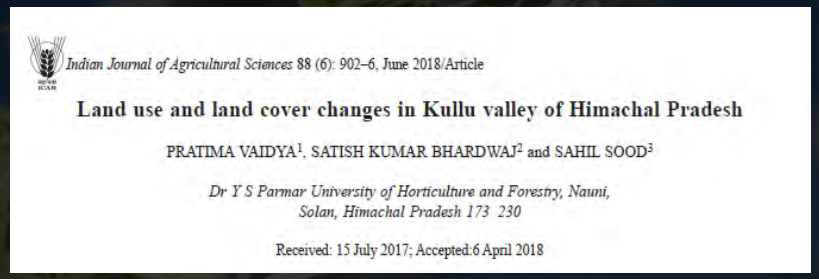
Effect of Changing Landscapes on Diversity, Distribution and Relative Abundance of Insect Pollinators on Apple Crop in Northwest Himalayas

V. K. Mattu[1], Thakur Bhagat[2]

[1]Sociobiology and Behavioural Ecology Research Lab
[2]Department of Biosciences, Himachal Pradesh University, Shimla (H.P.)-171005, India

Decreasing potential suitable habitat of bumble bees in the Great Himalayan National Park Conservation area

Amar Paul Singh, Agni Chandra, Kritish De, Virendra Prasad Uniyal & Sambandam Sathyakumar



Indian Journal of Agricultural Sciences 88 (6): 902–6, June 2018/Article

Land use and land cover changes in Kullu valley of Himachal Pradesh

PRATIMA VAIDYA[1], SATISH KUMAR BHARDWAJ[2] and SAHIL SOOD[3]

Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230

Received: 15 July 2017; Accepted:6 April 2018

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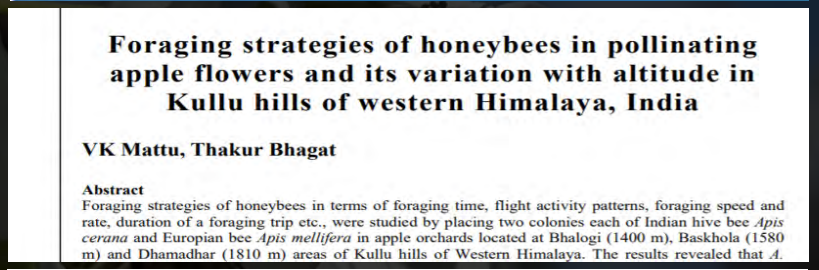
Article DOI : 10.23910/IJBSM/2016.7.5.1526

***Apis cerana* F. as an Important Natural Pollinator of Radish (*Raphanus sativus* L.) under Mid-hill Conditions of Himachal Pradesh**

Sharma Harish Kumar, Katna Sapna*, Rana B. S., Rana Kiran
Dept. of Entomology, Dr Y S Parmar University of Horticulture & Forestry, Nauni, Solan, Himachal Pradesh (173 230), India
*Correspondence to E-mail: sapnakatna@rediffmail.com

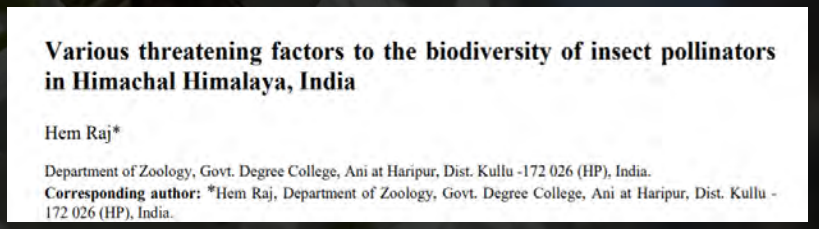
Online published on 26 November, 2018.



Foraging strategies of honeybees in pollinating apple flowers and its variation with altitude in Kullu hills of western Himalaya, India

VK Mattu, Thakur Bhagat

Abstract
Foraging strategies of honeybees in terms of foraging time, flight activity patterns, foraging speed and rate, duration of a foraging trip etc., were studied by placing two colonies each of Indian hive bee *Apis cerana* and Europian bee *Apis mellifera* in apple orchards located at Bhalogi (1400 m), Baskhola (1580 m) and Dhamadhar (1810 m) areas of Kullu hills of Western Himalaya. The results revealed that *A.*



Various threatening factors to the biodiversity of insect pollinators in Himachal Himalaya, India

Hem Raj*

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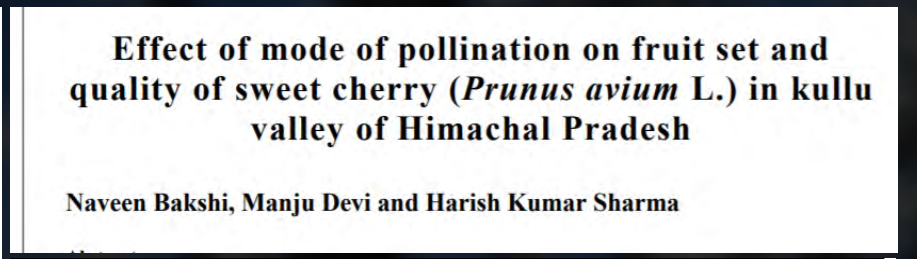
Corresponding author: *Hem Raj, Department of Zoology, Govt. Degree College, Ani at Haripur, Dist. Kullu - 172 026 (HP), India.



Effect of mode of pollination on fruit set and quality of sweet cherry (*Prunus avium* L.) in kullu valley of Himachal Pradesh

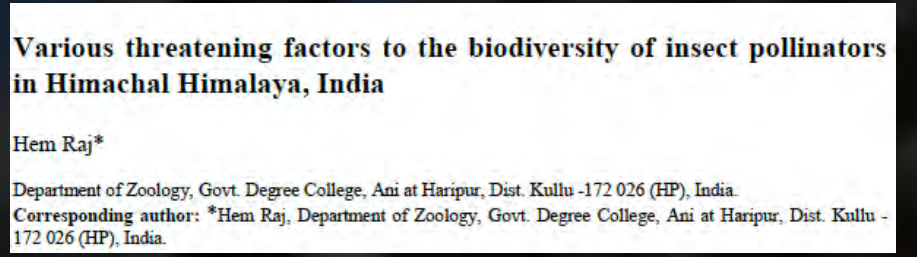
Naveen Bakshi, Manju Devi and Harish Kumar Sharma

Original Article

A Taxonomic Account of Hover Flies (Insecta: Diptera: Syrphidae) with 2 New Records from Mid Hill Zone of Himachal Pradesh, India

Jayita Sengupta[1]*, Atanu Naskar[2], Sumit Homechaudhuri[3], Dhriti Banerjee[4]

[1]*Senior Zoological Assistant, Diptera Section, Zoological Survey of India, Kolkata, India*
[2]*Assistant Zoologist, Diptera Section, Zoological Survey of India, Kolkata, India.*



Various threatening factors to the biodiversity of insect pollinators in Himachal Himalaya, India

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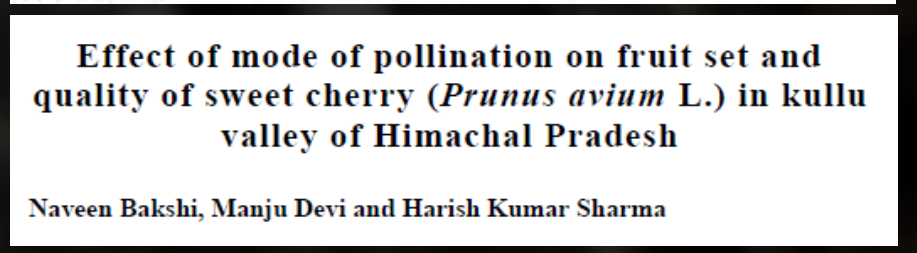


Effect of mode of pollination on fruit set and quality of sweet cherry (*Prunus avium* L.) in kullu valley of Himachal Pradesh

Naveen Bakshi, Manju Devi and Harish Kumar Sharma

However, assessment of pollinator diversity and distribution in landscape level focusing the climate change is still lacking

Objective

Identifying the impact of climate change on distribution of major pollinators of economically important horticultural crops in different warming scenarios across a western Himalayan landscape.

Study Area & Methodology

Study area

Himachal Pradesh- Horticultural State of The Country

- Diverse agro-climatic zones (Subtropical to High-altitude cold deserts) with huge potential for effective cultivation of a wide range of horticultural crops.
- Horticulture contribute significantly to the local livelihood and contribute to global economy.
- The Relatable Value (RV) of economic contribution of pollination for 32 crops (13 fruit crops, 5 oilseeds, 1 pulse crop, 2 spices, 2 tree nuts, and 9 vegetables) is 44.8% (Pratap et al., 2011).

Threats

- Rapidly shrinking forest cover, LULC change, and climate change has destructed the nesting habitat and shelter locations of various pollinators leading to pollinator decline (Sharma & Rana,2015).
- Farmers shifting the crop variety in lower altitude.












Primary Data collection

- Data were collected in 2021 and 2022 during the full bloom condition of plum and apple flowers.
- In every selected orchard a 50m*50m area was defined for sampling.
- Specimens were collected using pan trap, sweep net, bush beating , hand picking etc from 9.30 am in the morning to 4.30 pm in the evening for every alternate hour .
- 15 clusters of pan traps were set up for 9 am to 5 pm randomly in each plot.
- Visual observation made in 1m*1m area over flowering branches for 5 minutes.
- Wind velocity, availability of sunlight and raining probability were kept in mind as these affects the foraging greatly.

Visual representation of the sampling plot





Insect identification

- Dry collection of specimens were preserved in absorbent dry collection pouches and wet specimens such as collections from pan traps were preserved in 80% ethanol.

- Specimens were further handled in laboratory (washing, drying, pinning and labelling) and identified with standard identification keys using different body parts with the help of taxonomic experts from Zoological Survey of India, Kolkata.

Insect visitors

Total **124** species recorded under **75** genera and **28** families belonging to five order viz., **Hymenoptera**, **Lepidoptera**, **Diptera** and **Coleoptera** and **Thysanoptera** from the study area.

Species Occurrence Data

Primary data

- Sample was collected in total 42 locations (28 locations in Kullu valley and 14 locations in Tirthan valley).

Secondary data

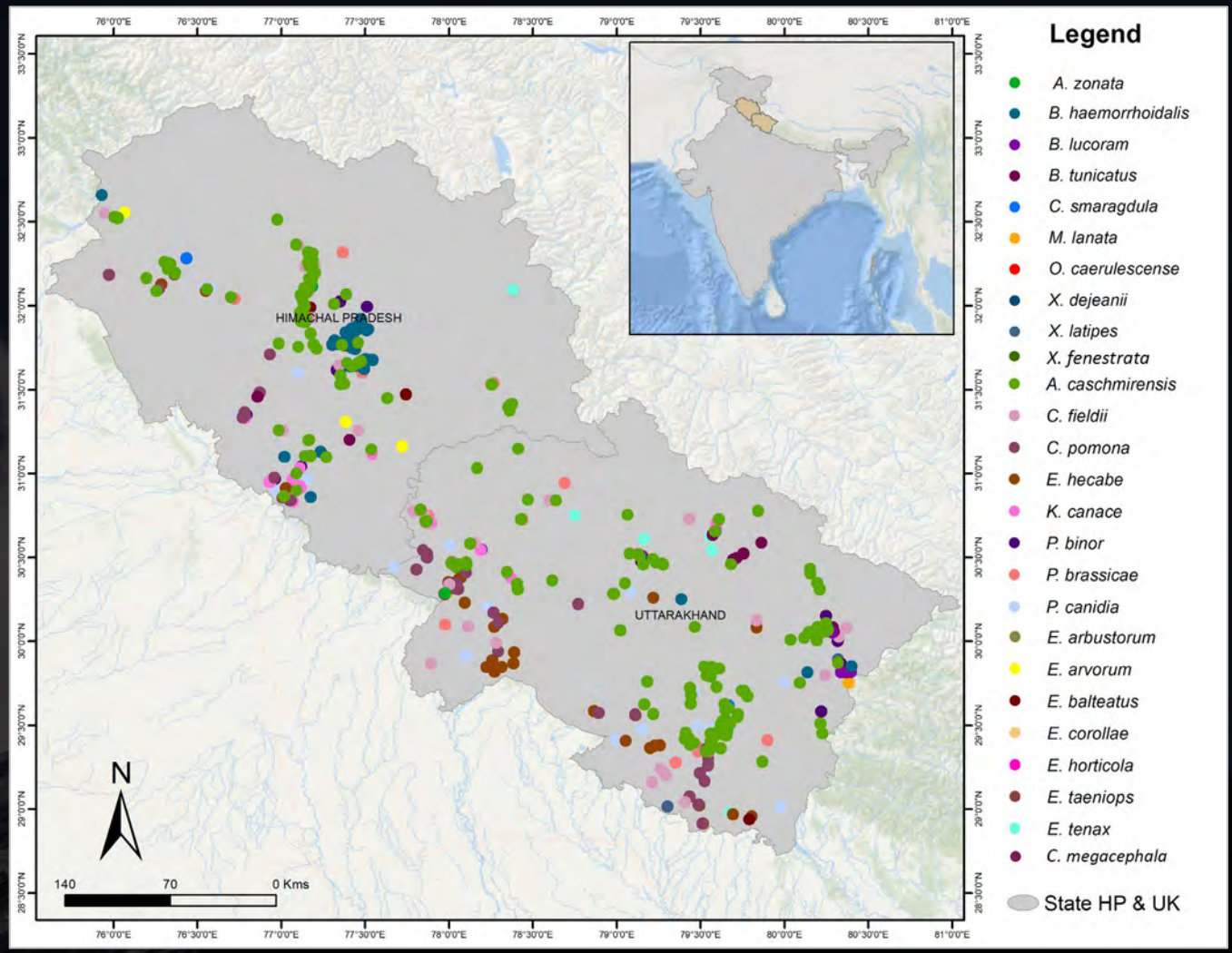
- Ooccurrence data from published literature

GBIF

- A total of 26 pollinator species belonging to Hymenoptera (10 species), Diptera (8 species), and Lepidoptera (8 species) were used for distribution modeling.

- These species were selected depending on their suitability as primary pollinators as per published data and the availability of secondary occurrence records.

Occurrence points of 26 pollinator species in the western Himalayan Biogeographic zone

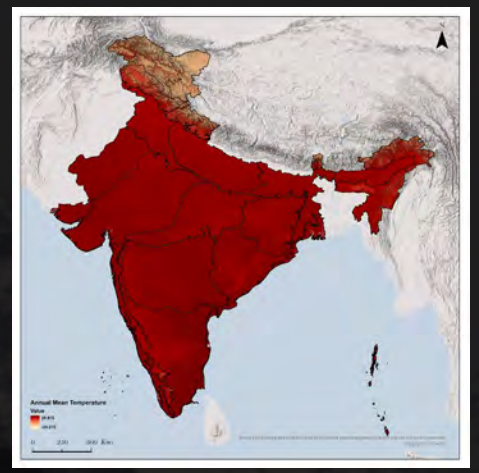


- A total of 489 occurrence (presence-only) records for hymenoptera, 220 occurrence records for Diptera, and 1484 occurrence records for Lepidopteran pollinators available in the Western Himalayan biogeographic zone (Himachal Pradesh and Uttarakhand) from secondary data sources were retrieved for distribution modeling.

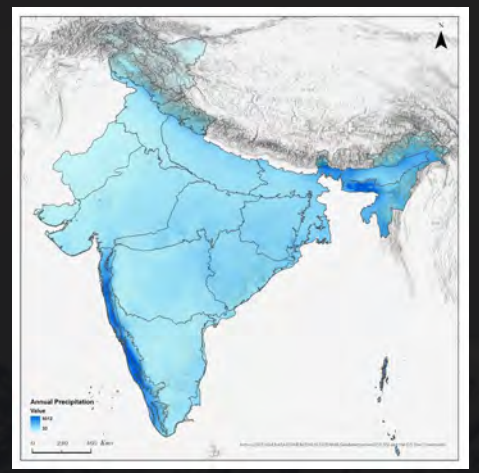
Environmental variables (Resolution: 1 sq. km.)

Environmental data

Annual trends

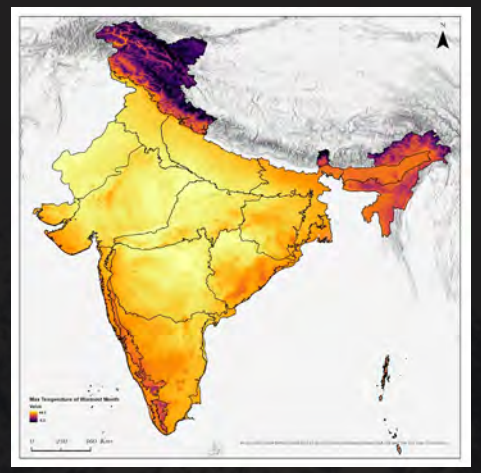


Bio 1
Annual Mean Temperature

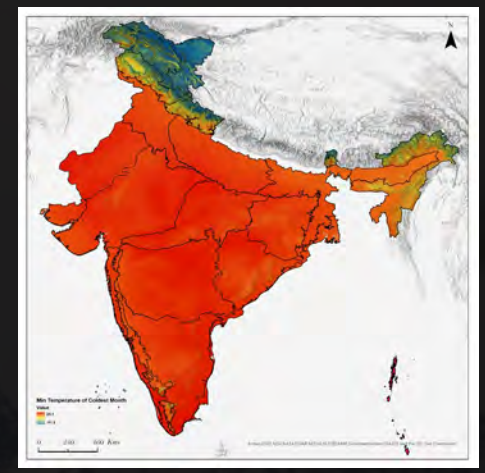


Bio 12
Annual Precipitation

Seasonality

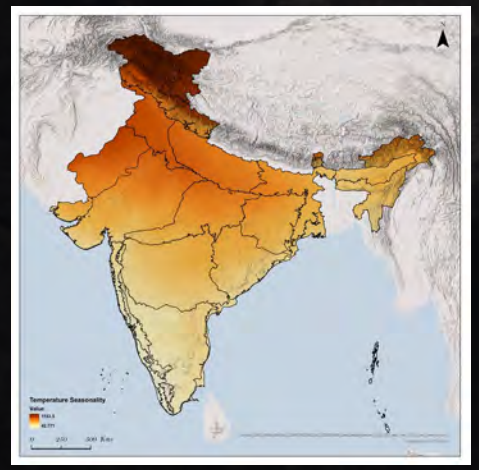


Bio 5
Max Temperature of Warmest Month

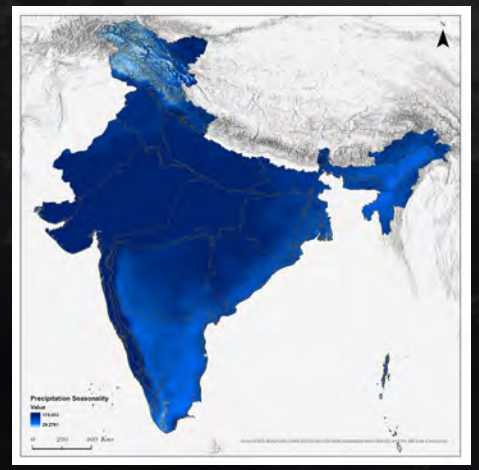


Bio 6
Min Temperature of Coldest Month

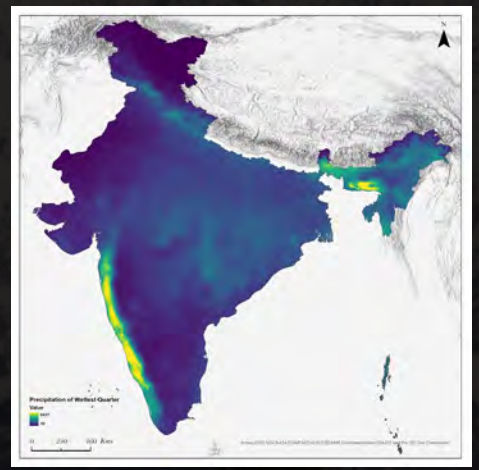
Extreme environmental factors



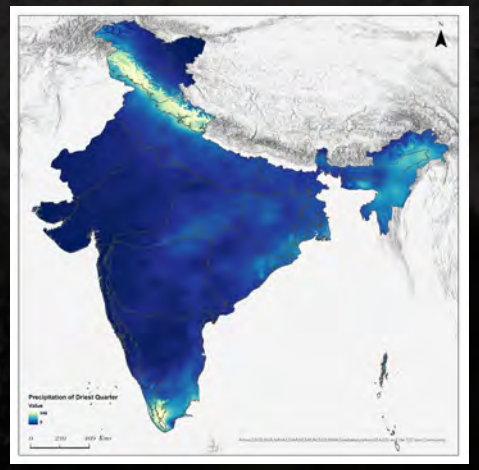
Bio4
Temperature Seasonality



Bio 15
Precipitation Seasonality



Bio 16
Precipitation of Wettest Quarter

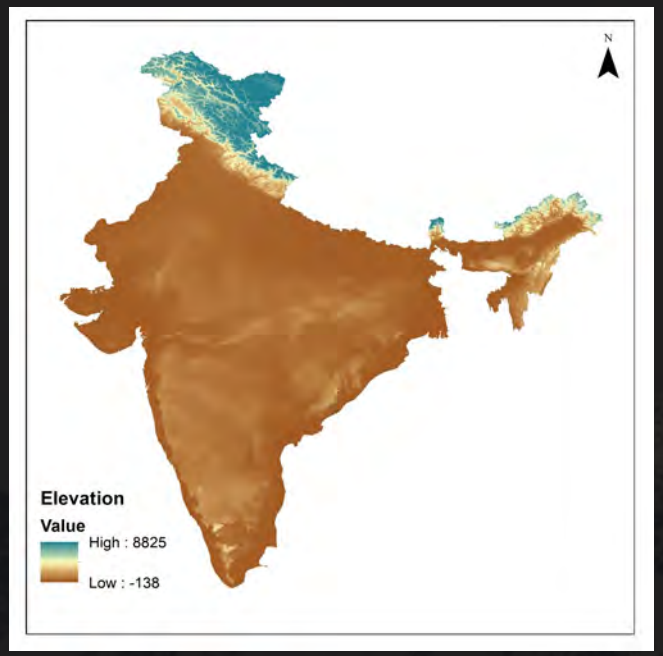


Bio 17
Precipitation of Driest Quarter

Environmental data

Elevation

Aster DEM



Future scenario

The SSP126 optimistic scenario (also considered the best-case scenario), was chosen because under the 2015 Paris Agreement, countries committed to reducing greenhouse gas emissions aiming to 'hold the increase in the global average temperature to well below 2°C above pre-industrial levels.'

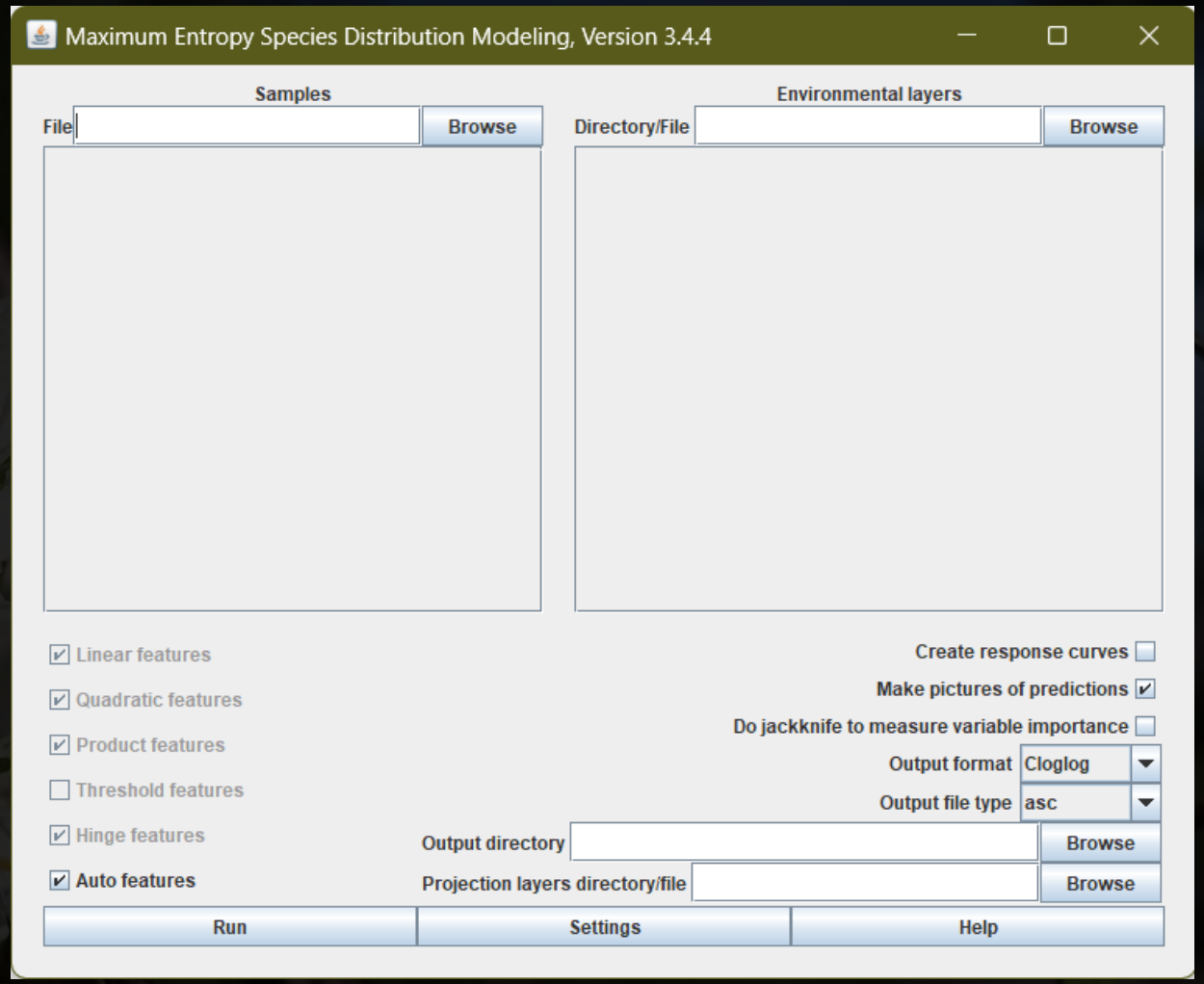
And due to elevation-dependent warming, Asian high mountains are projected to experience warming of 2.1°C ± 0.1°C. (Mountain Research Initiative EDW Working Group, 2015; Han et al., 2023).

The latter scenario (SSP585) was considered to understand the worst climate impact on the distribution of these species.

Analysis

Distribution modeling

- Maxent is a widely used presence only software to identify species distribution in a geographic space (Phillips et al., 2006).
- The presence points were split to 80% for training (i.e., building the model), and 20% were kept for testing the model.



Model performance

- The model performance was assessed using the area under the Receiver Operating Characteristics (ROC) curve (AUC) value.
- For Hymenoptera, AUC values ranged from 0.930 to 0.979, for Diptera from 0.949 to 0.996, and for Lepidopteran species from 0.955 to 0.979.

Analysis

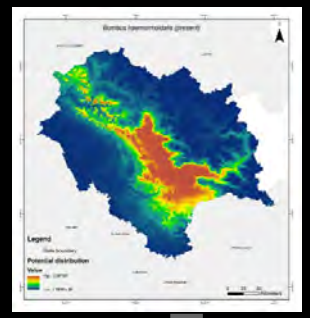
Species occurrence points
- Field data
- Published data
- GBIF data

Data filtered and duplicate points removed

Final presence points + 8 Bioclimatic variables from Worldclim & DEM

Model trained (Training data: 80% & test data: 20% in Maxent

Present

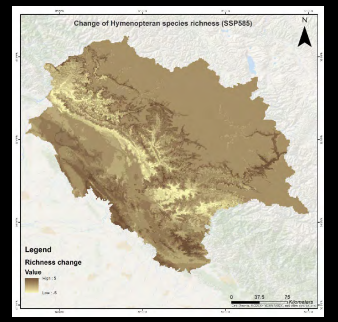


Projected future distribution

Present richness hotspot

Future richness hotspot

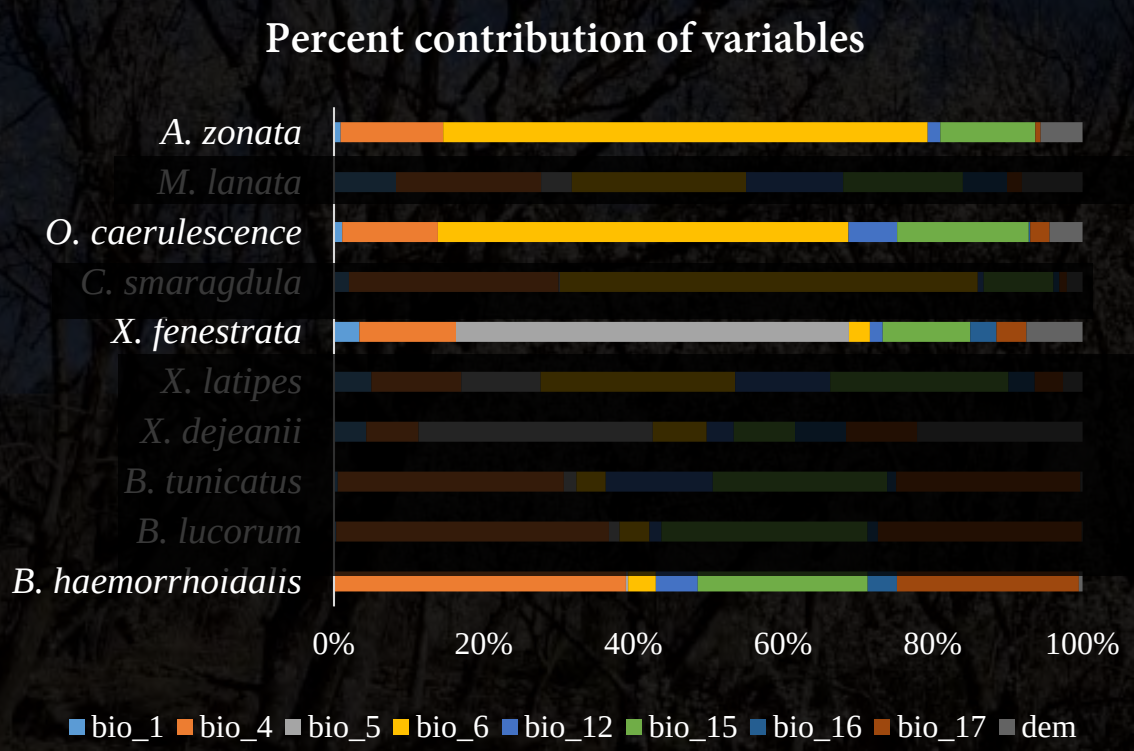
Richness shift and species contribution



Results

Hymenoptera

Percent contribution of the variables used in modelling the distribution of Hymenopteran species



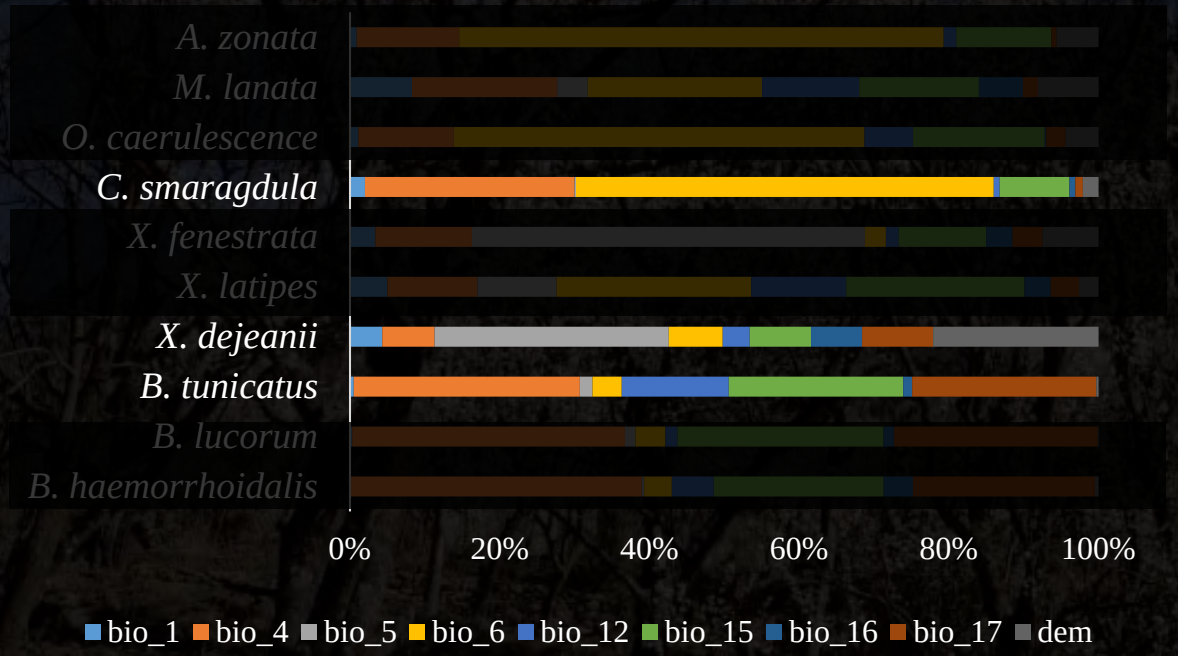
Change in area (%) in mid-century scenario(2041-2060)

Species		SSP126_60	SSP585_60
Amegilla zonata (Fabricius,1775)		-20.121	-7.522
Bombus haemorrhoidalis (Smith,1852)		-28.521	-33.891
Osmia caerulescence (Linnaeus,1758)		-31.551	-27.762
Xylocopa fenestrata (Fabricius,1798)		-28.391	-20.025

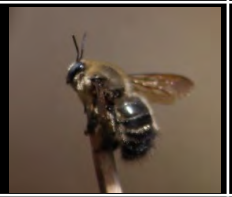
Results

Hymenoptera

Percent contribution of the variables used in modelling the distribution of Hymenopteran species



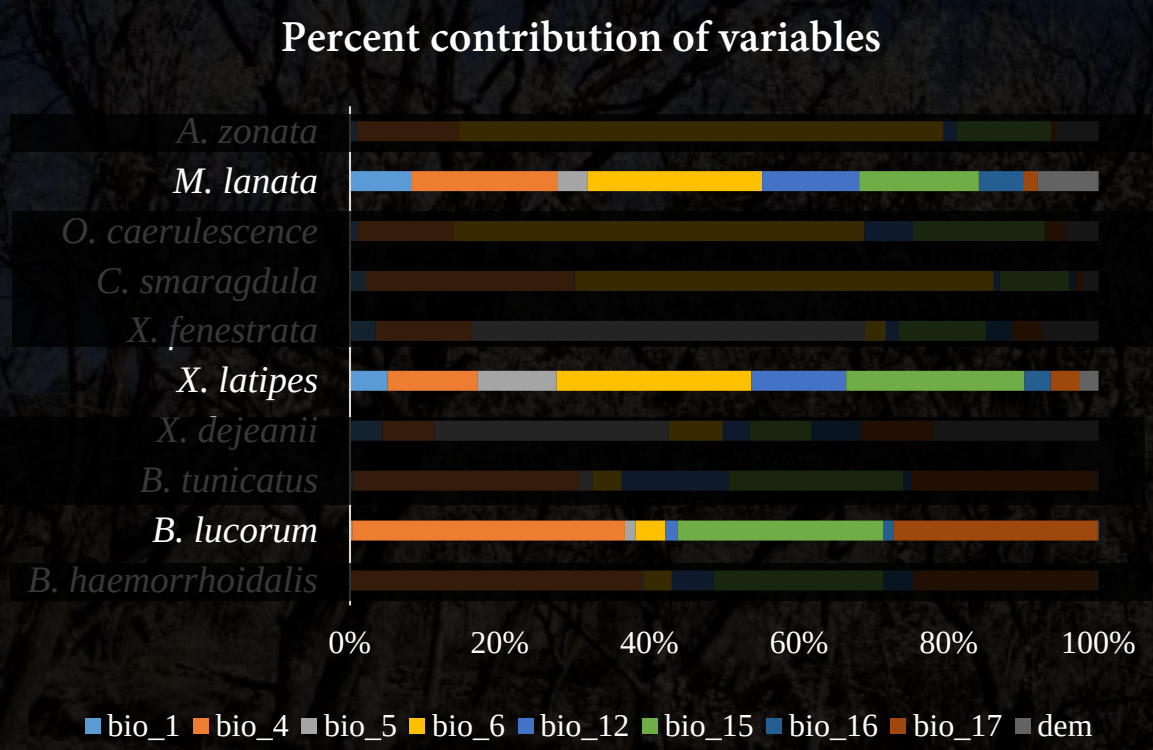
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Bombus tunicatus (Smith,1852) 	-14.027	-14.412
Ceratina smaragdula (Fabricius,1787) 	-10.804	-3.472
Xylocopa dejeanii (Ma, 1938) 	-3.161	-7.389

Results

Hymenoptera

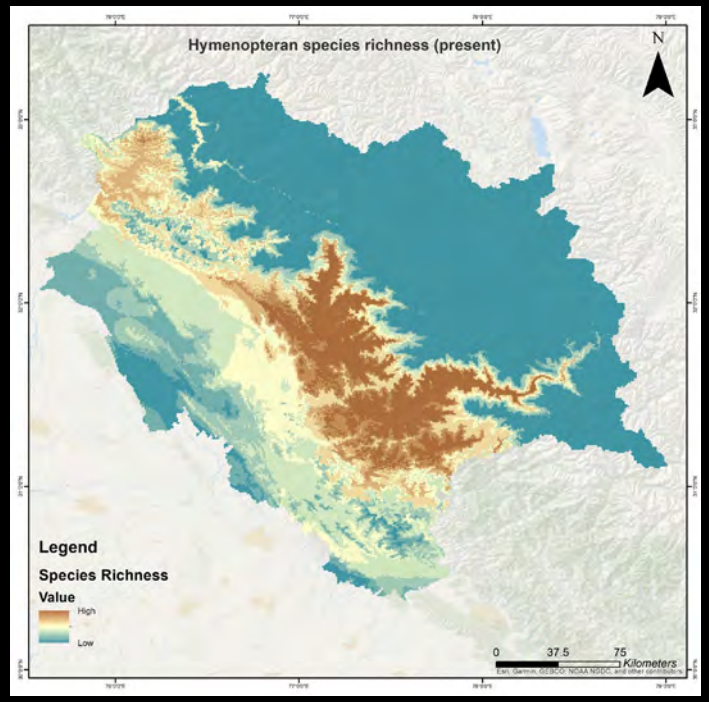
Percent contribution of the variables used in modelling the distribution of Hymenopteran species

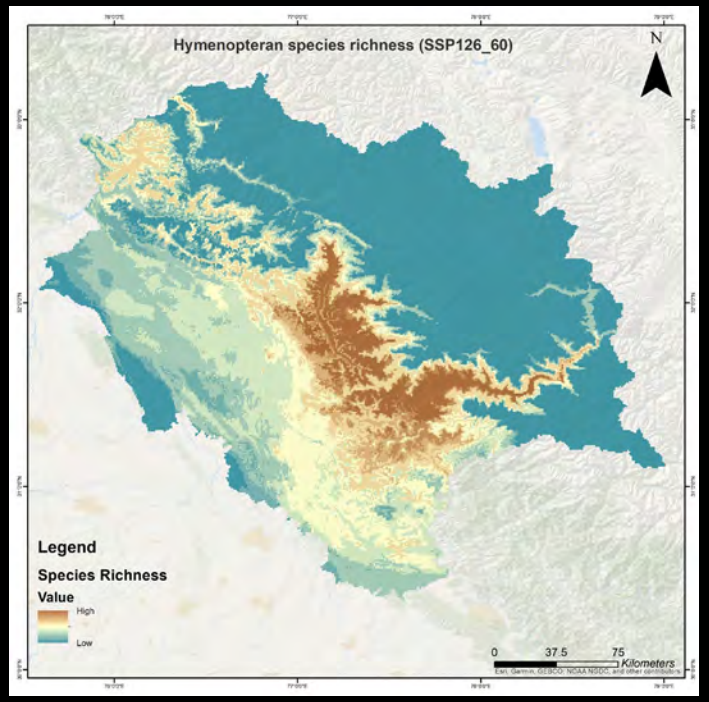


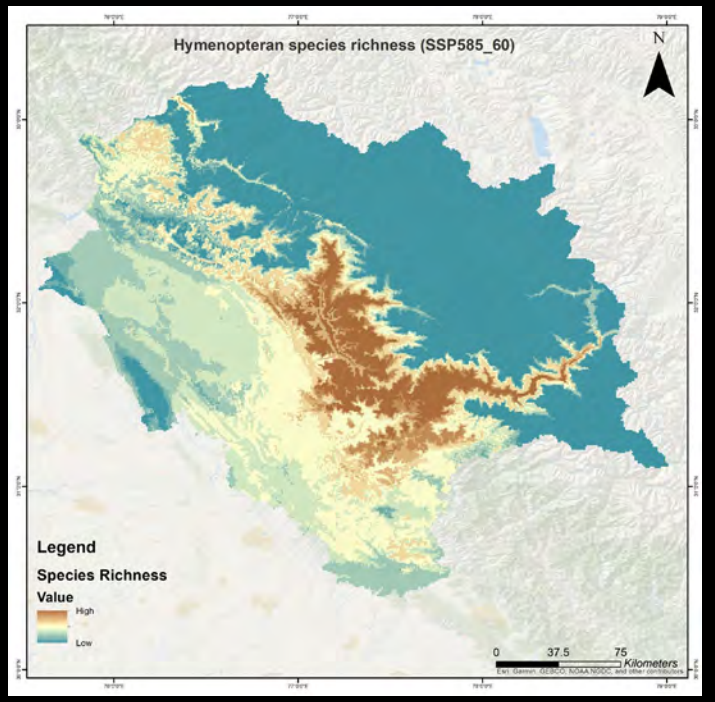
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Bombus lucorum (Linnaeus,1761) 	1.058	10.336
Megachillae lanata (Fabricius, 1775) 	28.503	36.460
Xylocopa latipes (Drury,1773) 	18.693	22.679

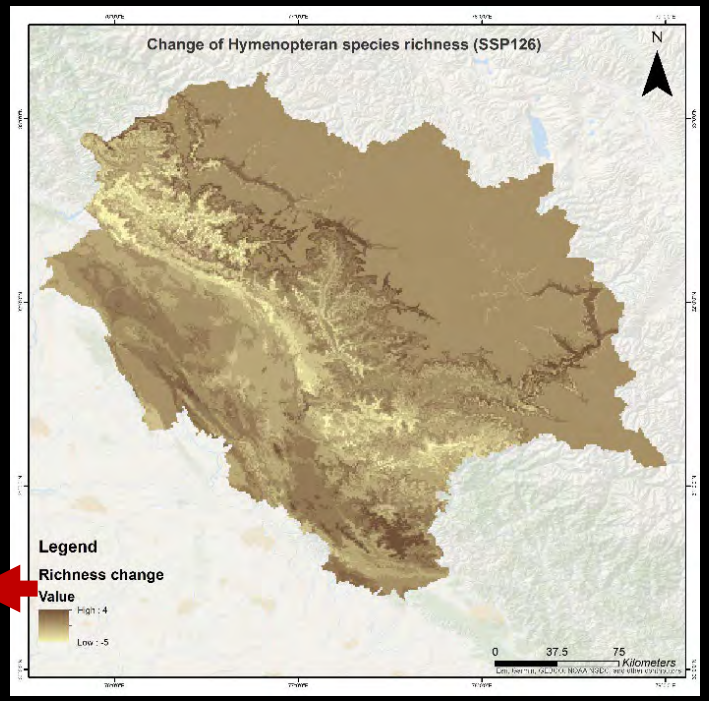
Richness Hotspot

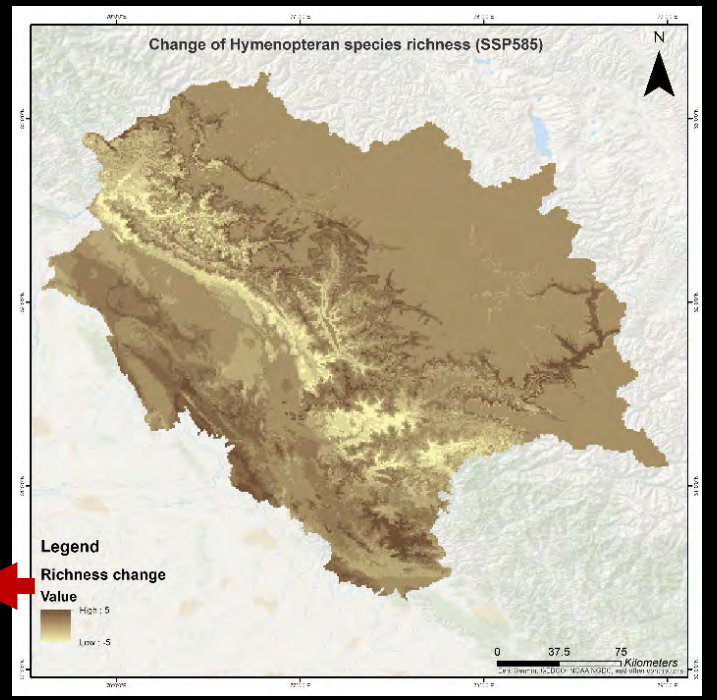






Richness Shift

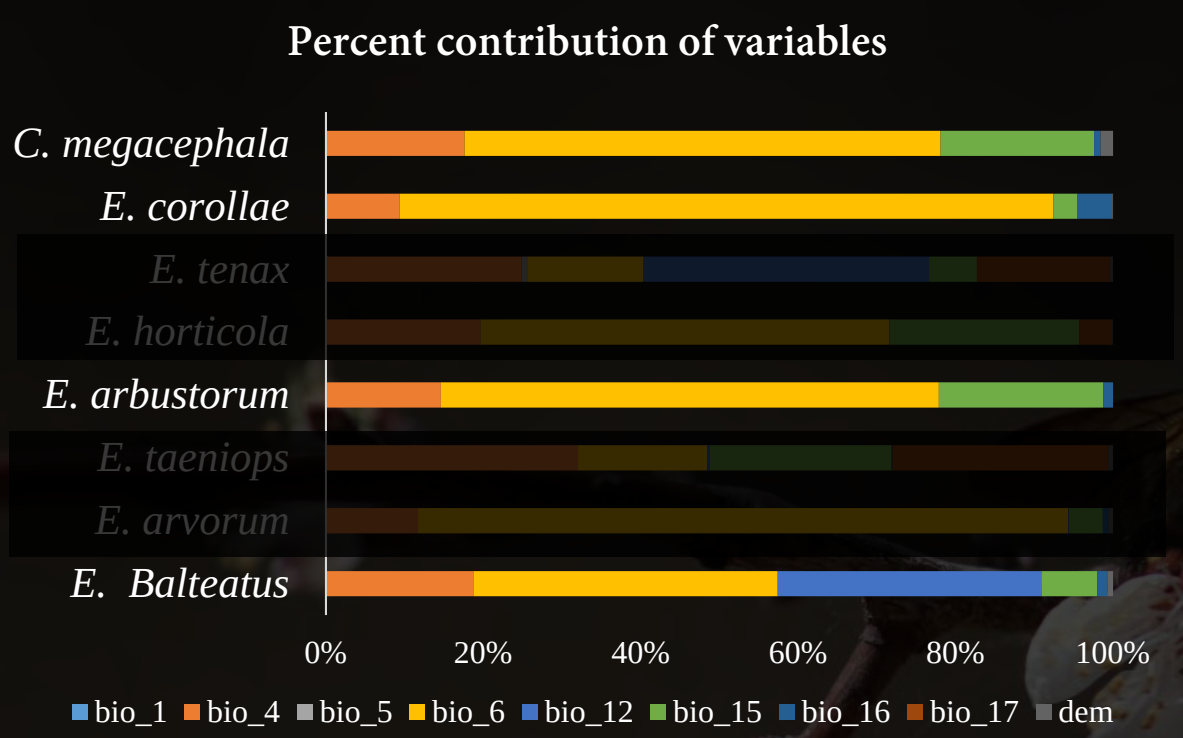




Results

Diptera

Percent contribution of the variables used in modelling the distribution of Dipteran species



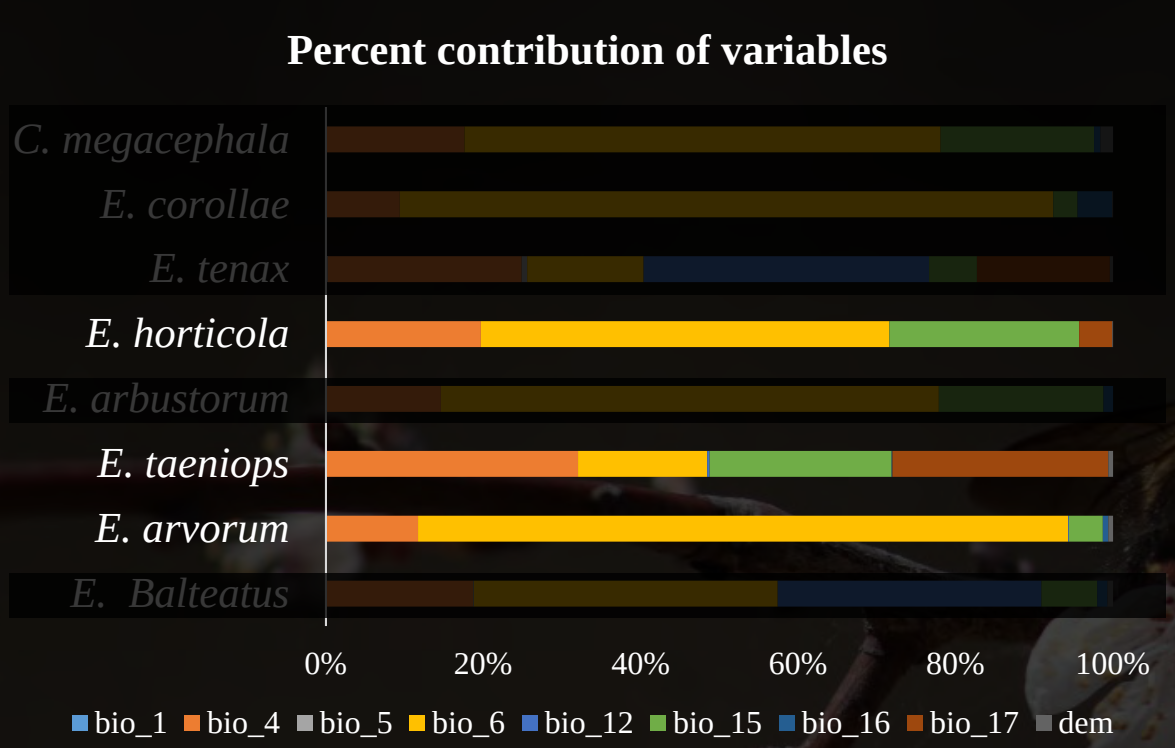
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Eupeodes corollae (Fabricius, 1794) 	-17.838	-8.603
Chrysomya megacephala (Fabricius, 1794) 	-34.777	-11.512
Eristalis arbustorum (Linnaeus, 1758) 	-25.842	-3.711
Episyrphus balteatus (De Gear, 1776) 	-16.201	0.882

Results

Diptera

Percent contribution of the variables used in modelling the distribution of Dipteran species



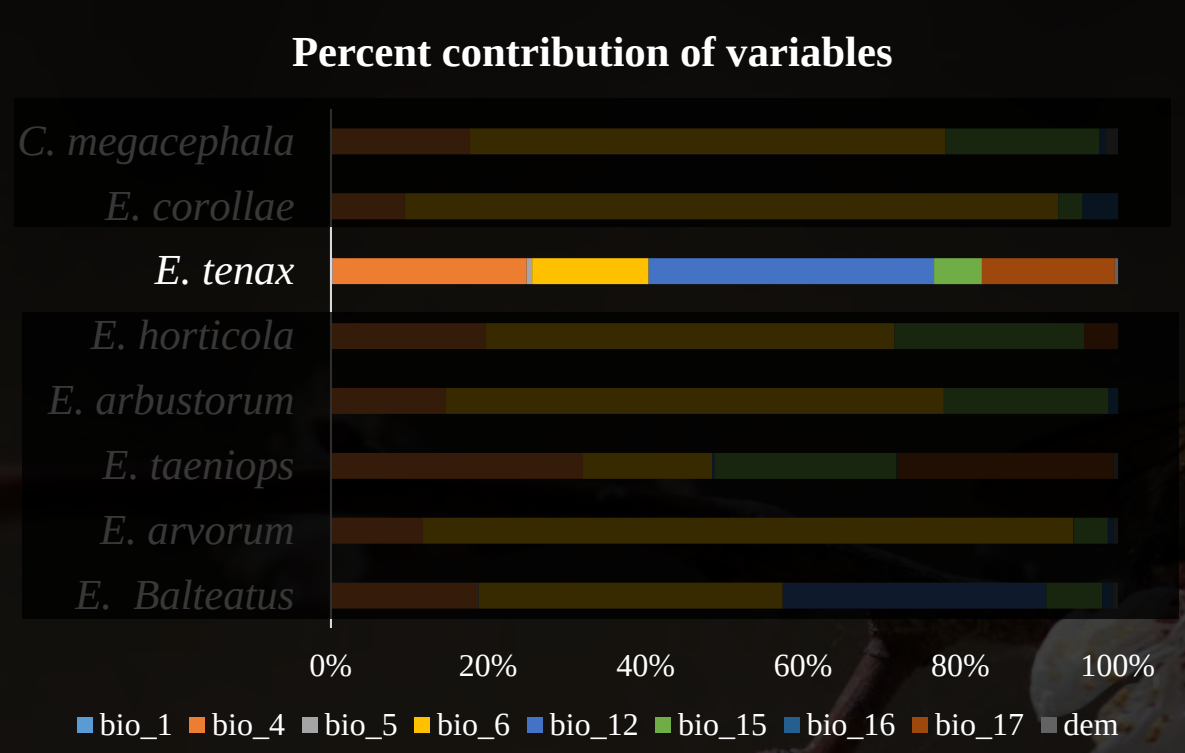
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Eristalinus arvorum (Fabricius, 1787) 	-2.400	-10.820
Eristalis horticola (De Gear, 1776) 	-2.911	-10.017
Eristalinus taeniops (Wiedemann, 1818) 	-6.244	0.450

Results

Diptera

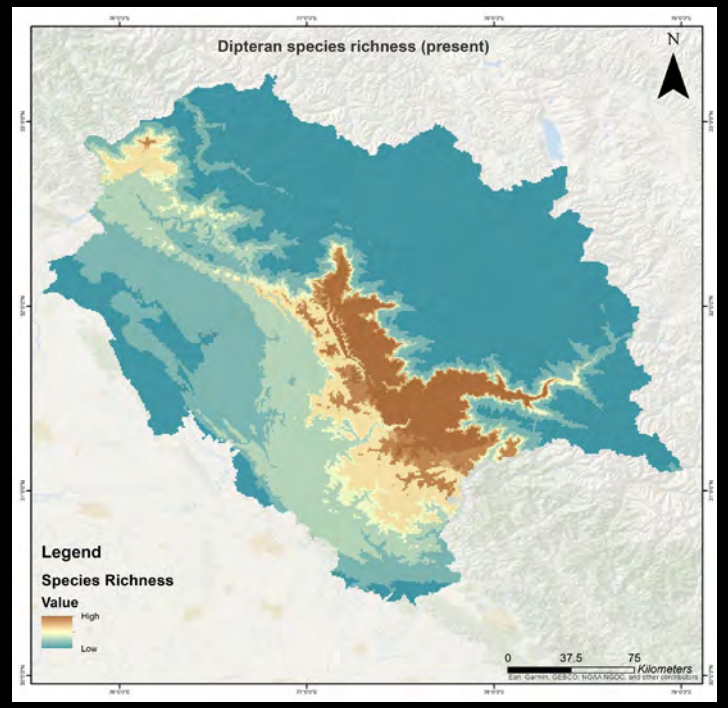
Percent contribution of the variables used in modelling the distribution of Dipteran species

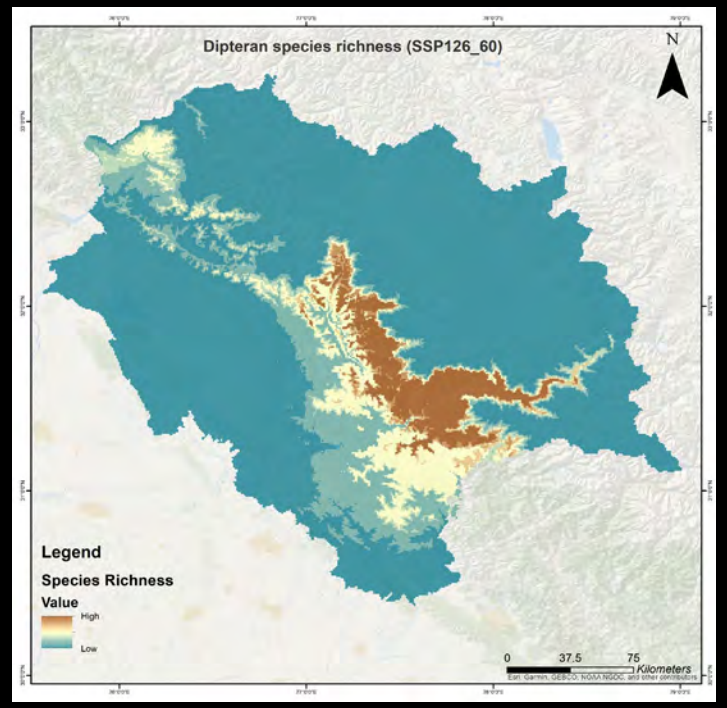


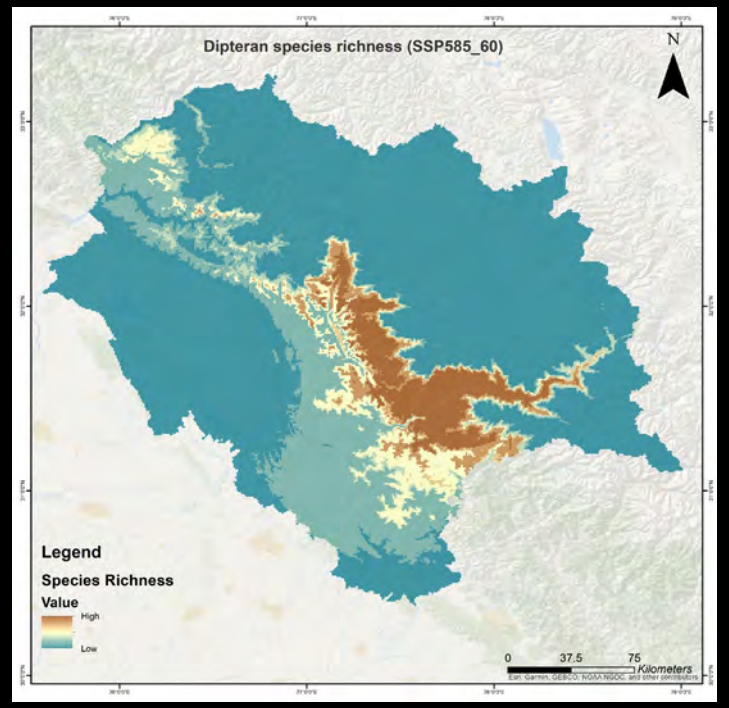
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Eristalis tenax (Linnaeus, 1758)	6.713	8.524

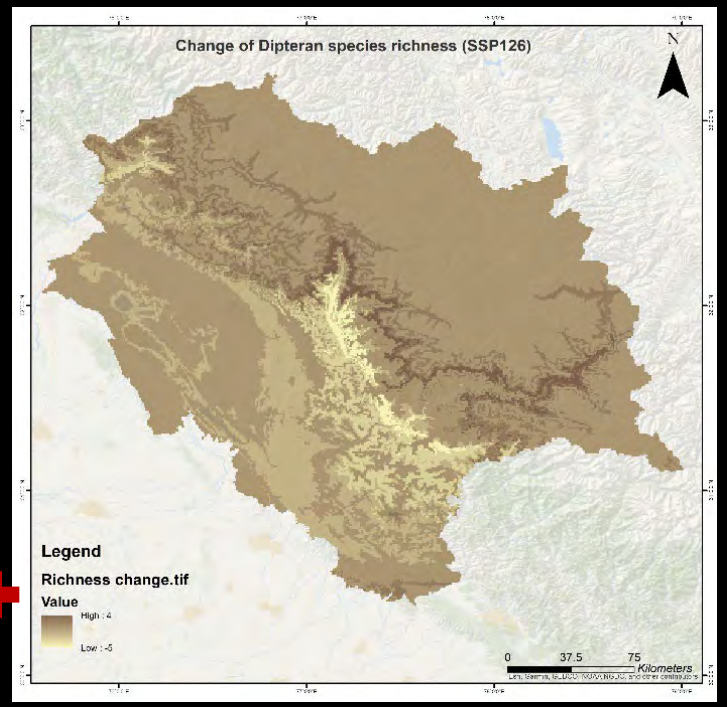
Richness Hotspot

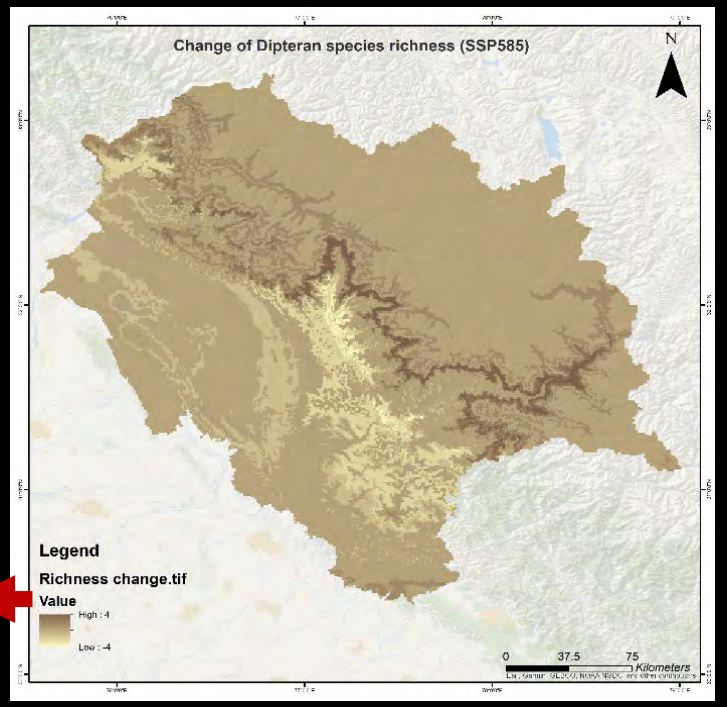






Richness Shift

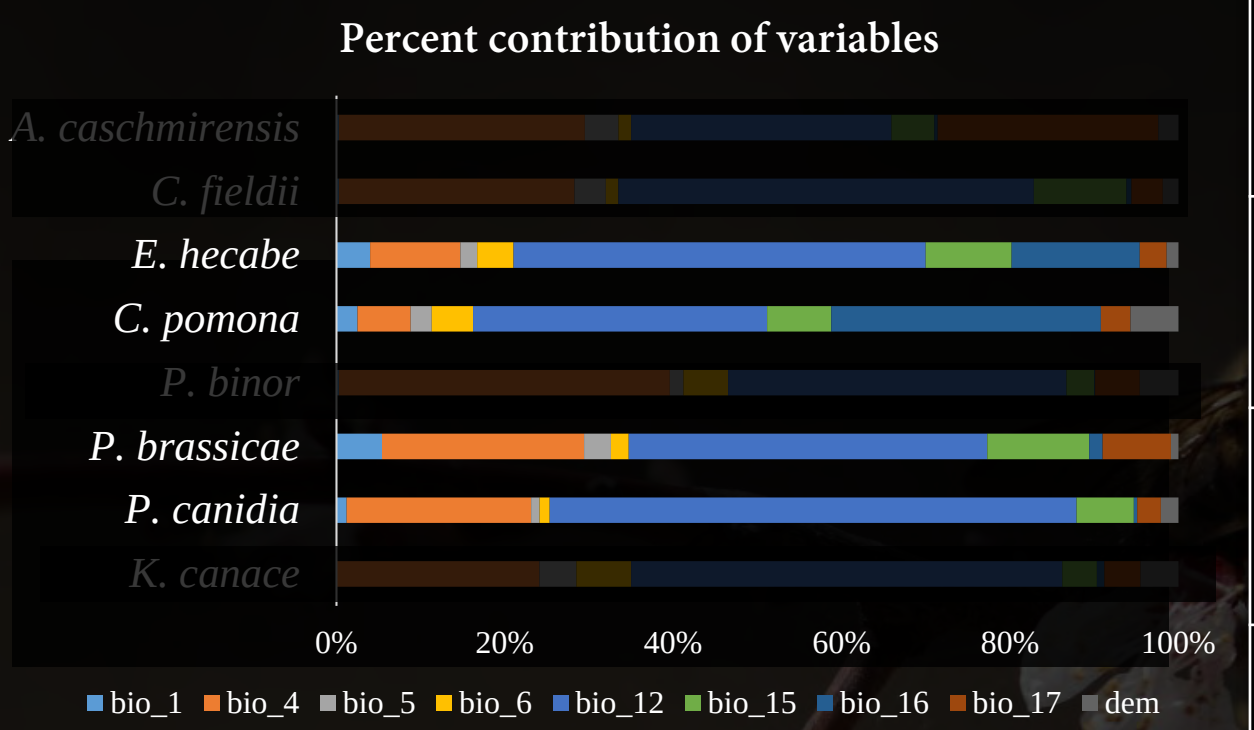




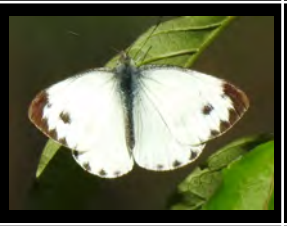
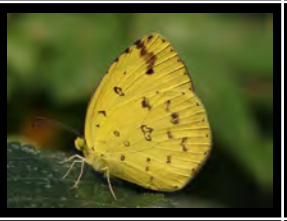
Results

Lepidoptera

Percent contribution of the variables used in modelling the distribution of Lepidopteran species



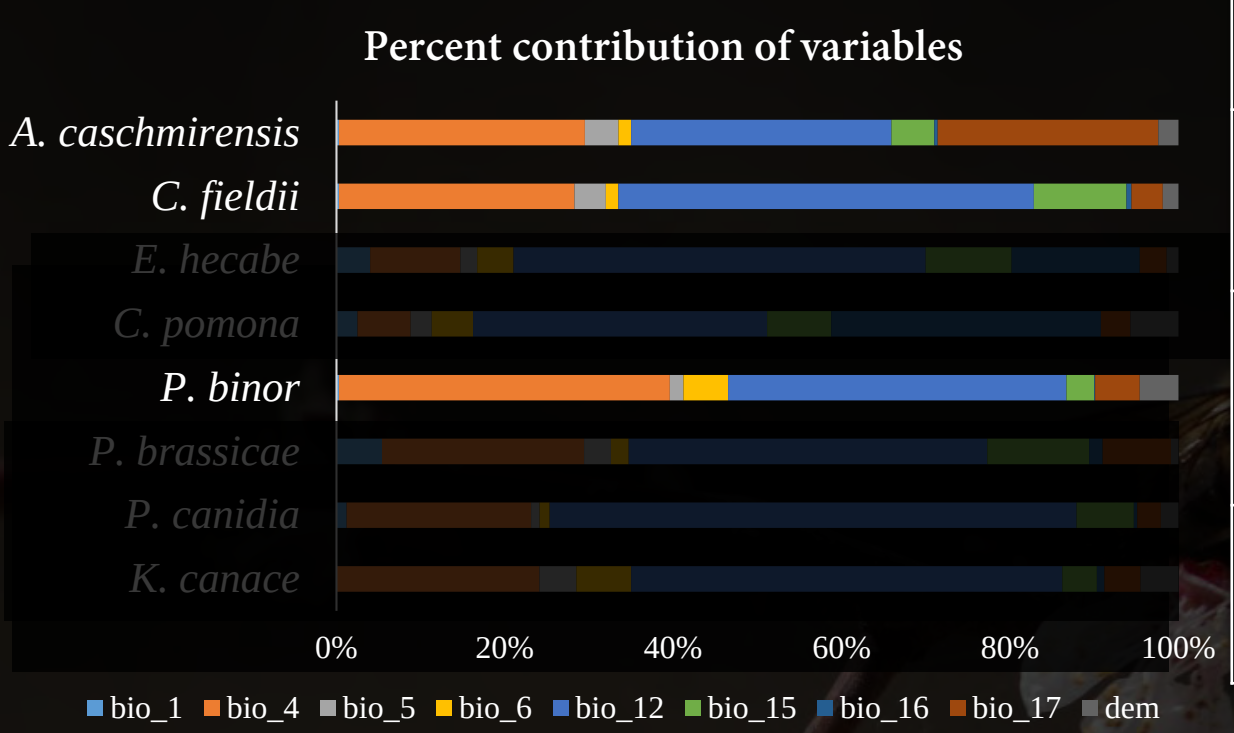
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Pieris canidia **(Sparrman, 1768)** 	6.9138	6.087
Pieris brassicae **(Linnaeus, 1758)** 	22.694	27.789
Eurema hecabe **Linnaeus, 1758)** 	25.672	23.251
Catopsilia pomona **(Fabricius, 1775)** 	6.042	8.592

Results

Lepidoptera

Percent contribution of the variables used in modelling the distribution of Lepidopteran species



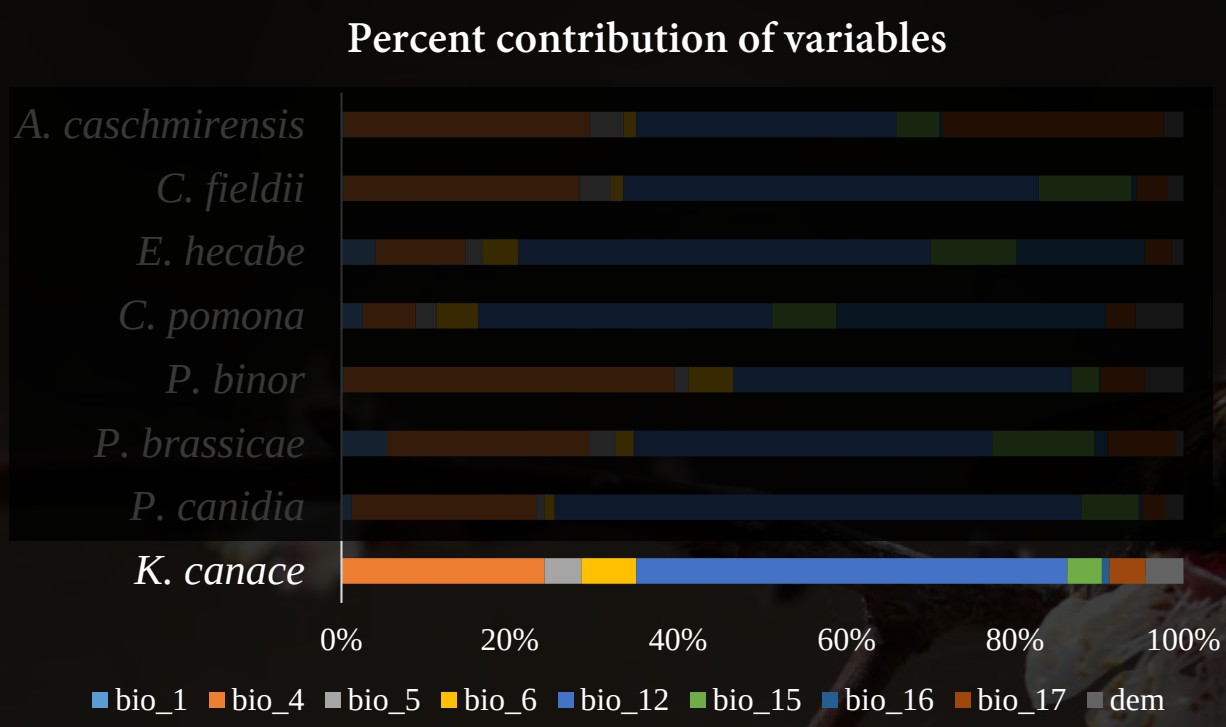
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Papilio bianor **(Cramer, 1777)** 	-0.388	17.020
Colias fieldii **(Ménétriés, 1855)** 	19.521	-20.541
Aglais caschmirensis **(Kollar, 1848)** 	1.342	-16.913

Results

Lepidoptera

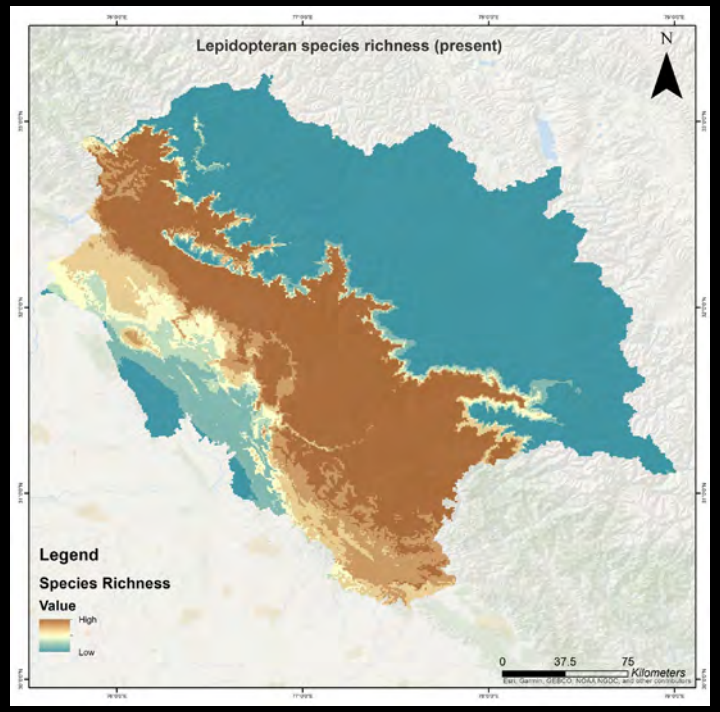
Percent contribution of the variables used in modelling the distribution of Lepidopteran species

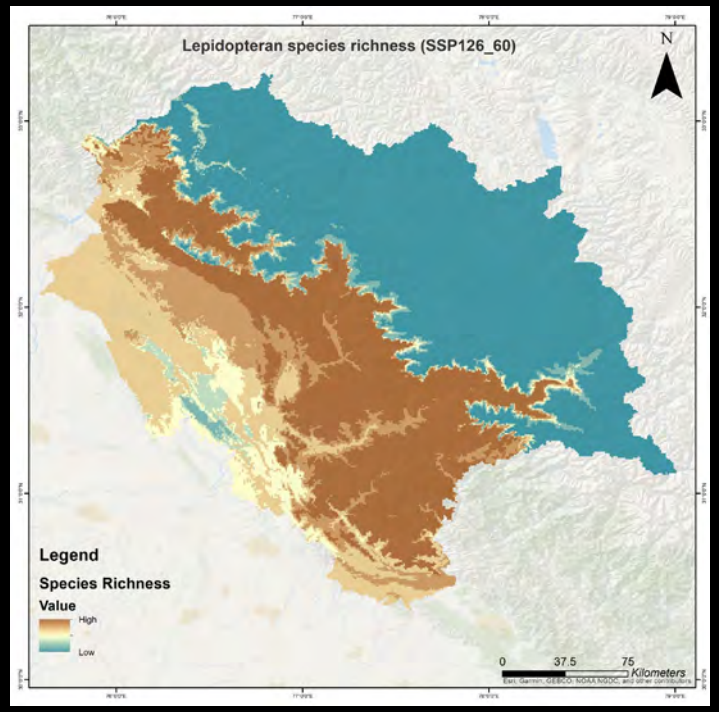


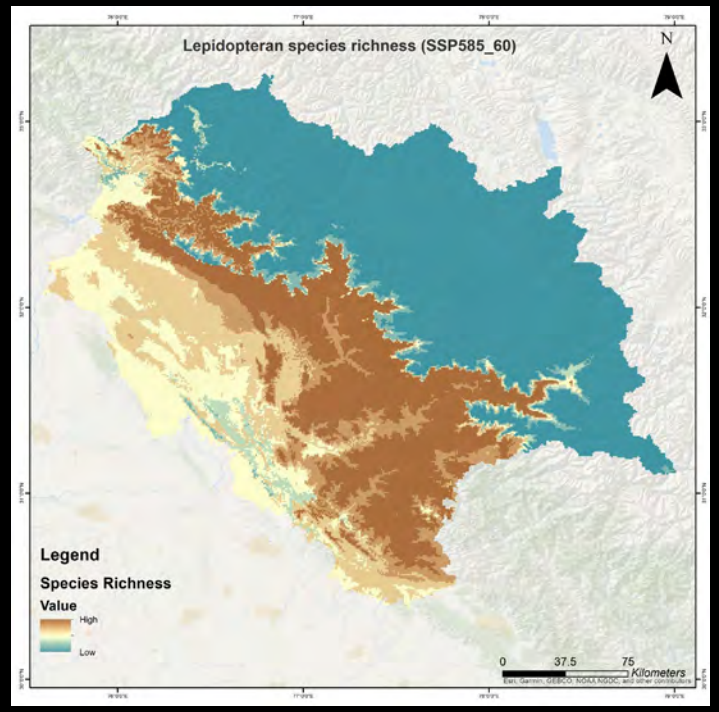
Change in area (%) in mid-century scenario(2041-2060)

Species	SSP126_60	SSP585_60
Kaniska canace **(Linnaeus, 1763)**	-24.364	-37.386

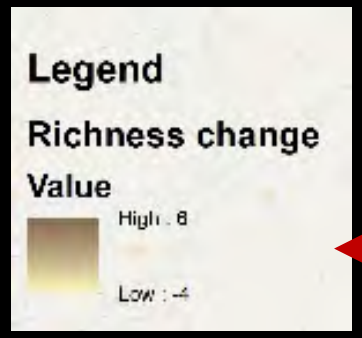
Richness Hotspot

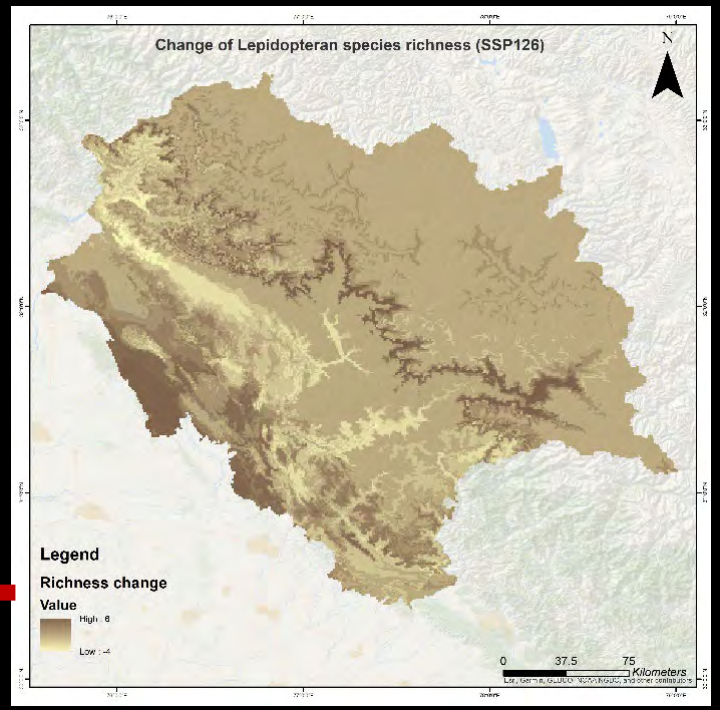


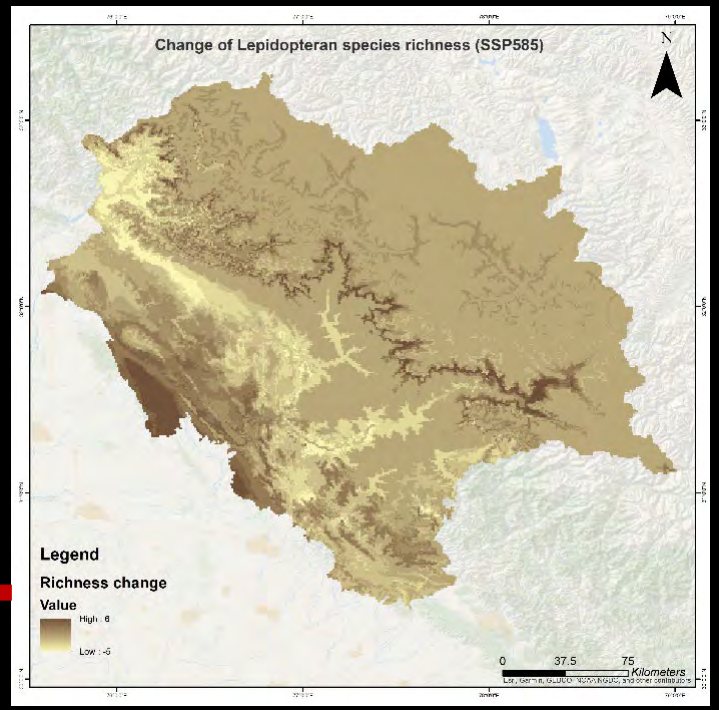




Richness Shift







Key findings

- Distribution modelling analysis showed that majority of dipteran and hymenopteran species are expected to face habitat loss however, the lepidopteran community can expect increased habitat suitability.
- Additionally, a majority of species are expected to undergo a distribution range shift towards the north and northwest in case of Hymenoptera and north to northeast in case of Dipteran and Lepidopteran species.

Significance & Recommendations

- Results of distribution model reveal heterogeneous responses among insect taxa to changing climatic conditions emphasizing the need for targeted conservation efforts to protect vulnerable species and their habitats.
- Given that the suitable habitats and conservation priority areas of insects do not adhere to international boundaries, international agreement addressing comprehensive pollinator conservation initiatives for protecting transboundary natural habitats of pollinators need to be formulated.

Contribution to various global policies and targets

Convention on Biological Diversity (CBD), Target 2:

> “Sustainably manage and enhance the benefits of biodiversity by 2020, with a particular focus on pollination services.”

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Thank You