Modelling of the climate change impacts on the Iranian riverine fish species diversity as a hot spot area

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Introduction

Co-occurring biodiversity and global heating crises are systemic threats to life on Earth as we know it, especially in relatively rare freshwater ecosystems , such as in Iran.

The objectives of our study are to

(i) estimate climate heating impacts on the fish species distribution in different categories (total, endemic, non-native, native, IUCN red-list),

(ii) estimate climate heating-based alterations in fish species richness patterns.

Methods

Study area

The study area was Iran (Fig.1).

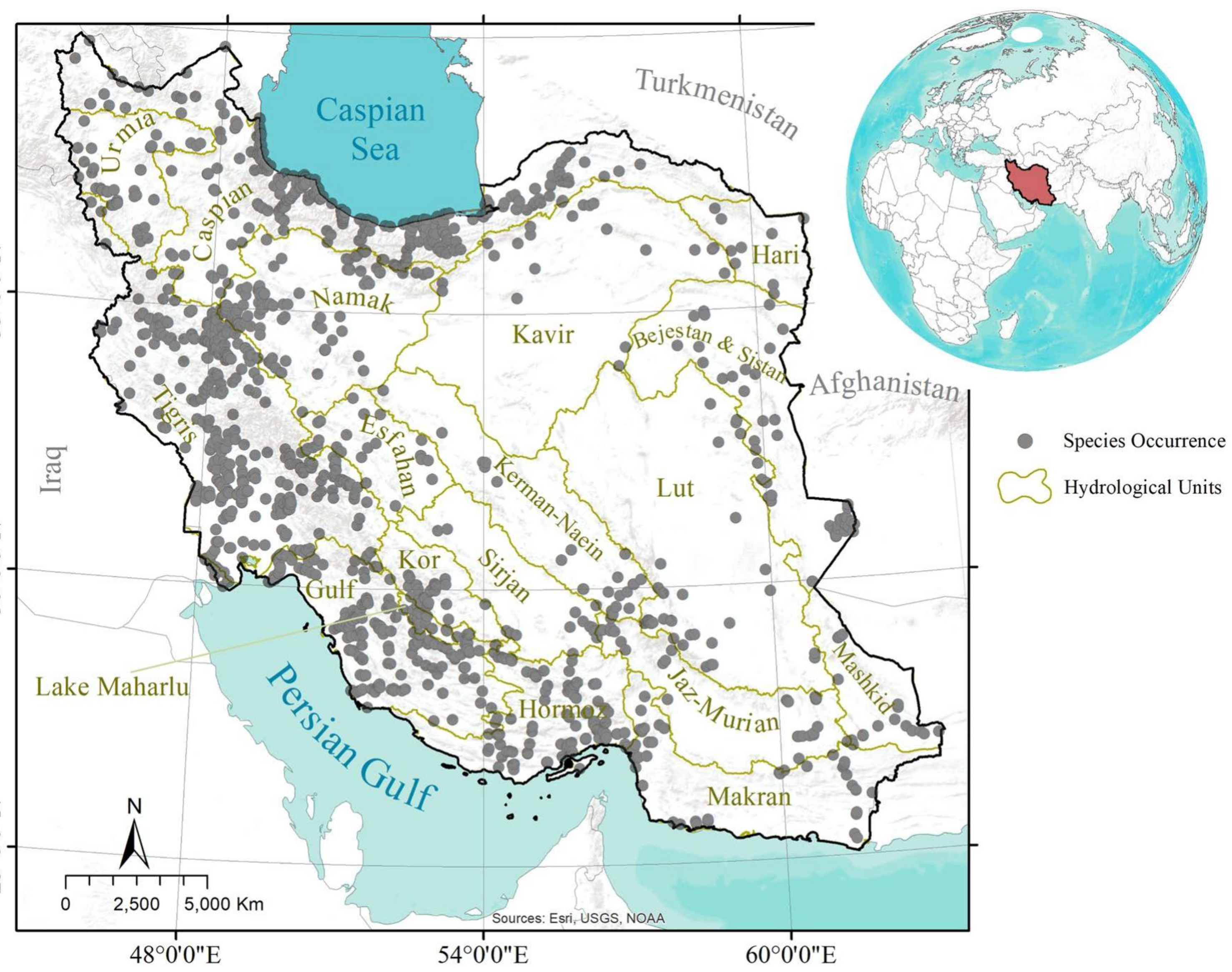


Fig.1: The study area and major hydrologic units in Iran.

Studied species

131 riverine fish species (i.e., 91 natives, 28 endemics, 12 non-natives, and 13 threatened) were selected for modeling .

Environmental variables

Nine variables were identified:

Elevation, maximum site river width, site average annual precipitation, site slope, site mean annual air temperature, site maximum air temperature of the warmest month, site minimum air temperature of the coldest month, air temperature difference between the coldest and warmest months of the year, and HU occupancy of the target species.

To avoid collinearity, Spearman correlations test was done. Any variables with a high correlation (r >|0.75|) was removed.

Species distribution modelling

- Maximum Entropy (MaxEnt) algorithm in R programming and the dismo package were applied.
- Ten fold cross-validation method to measure model accuracy.
- AUC (area under the receiver operating characteristic curve (ROC)) metric to assess model accuracy.
- Projection of the models for the future was used both RCP 4.5 and 8.5 scenarios in the 2050s and 2080s.
- Range shift was calculated according to Table 1.

Parameter	Percent of loss	Percent of gain	Species range change
Formula	(Loss/NC*) × 100	(Gain/NC) × 100	% of Gain−% of Loss

Results

- AUC values ranged from 0.74 to 0.99 (i.e. acceptable).
- The most important variable determining fish occupancy was HU location, followed by elevation, climate variables, and slope.
- Species will react differently in the advent of future climate heating (Figs.2, 3 & 4).

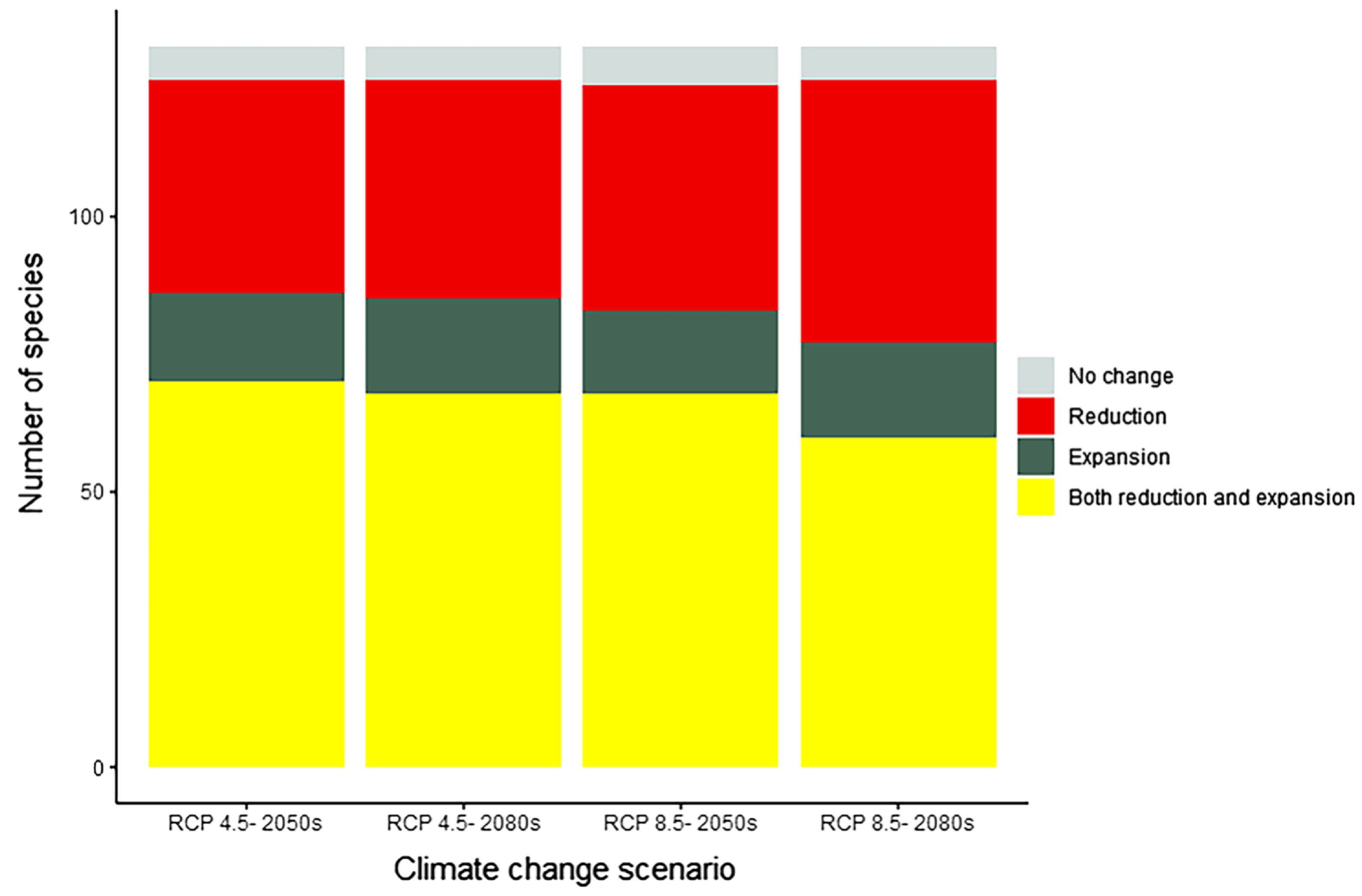
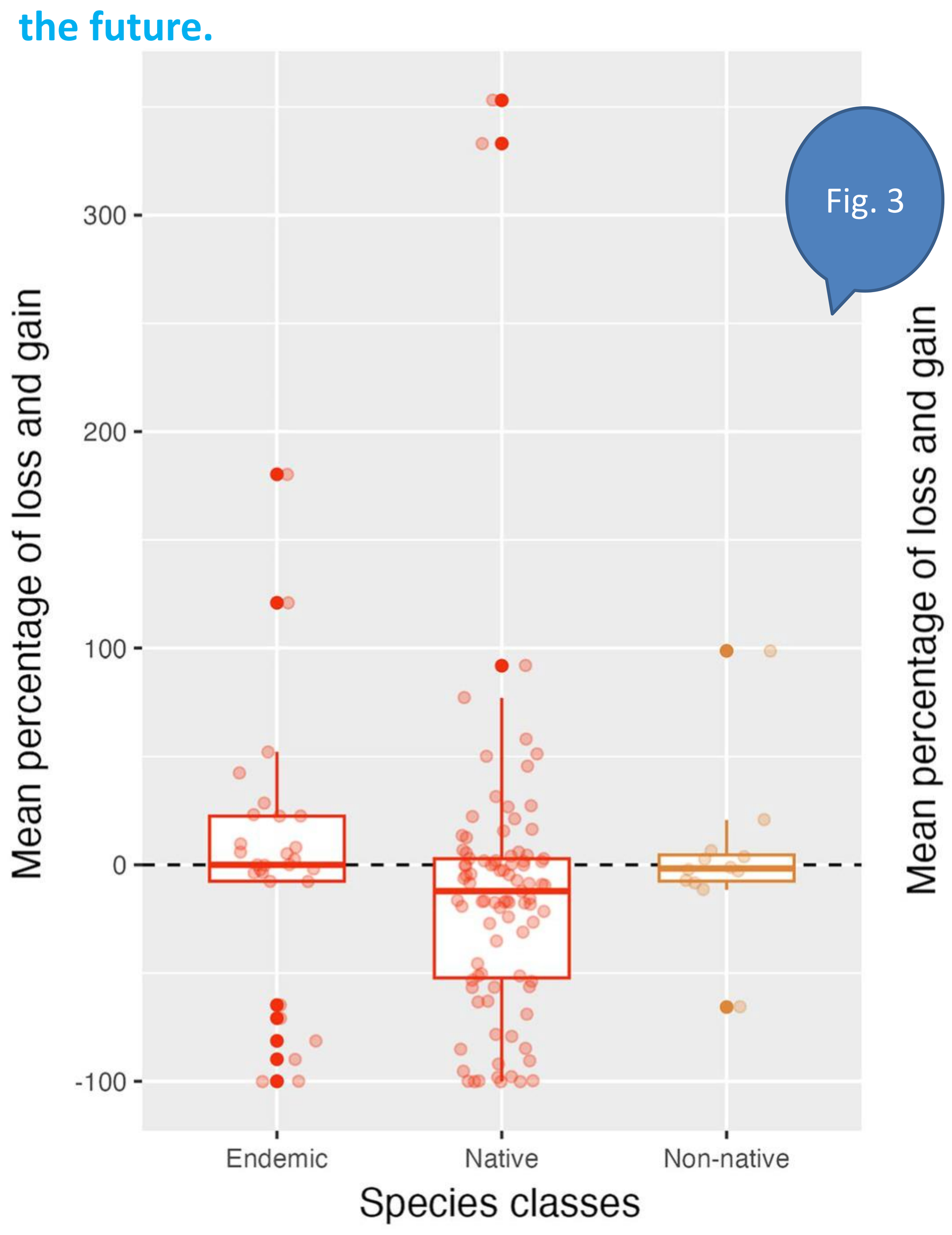


Fig.2: Number of species with habitats that are predicted to either change or remain nearly stable in the future.



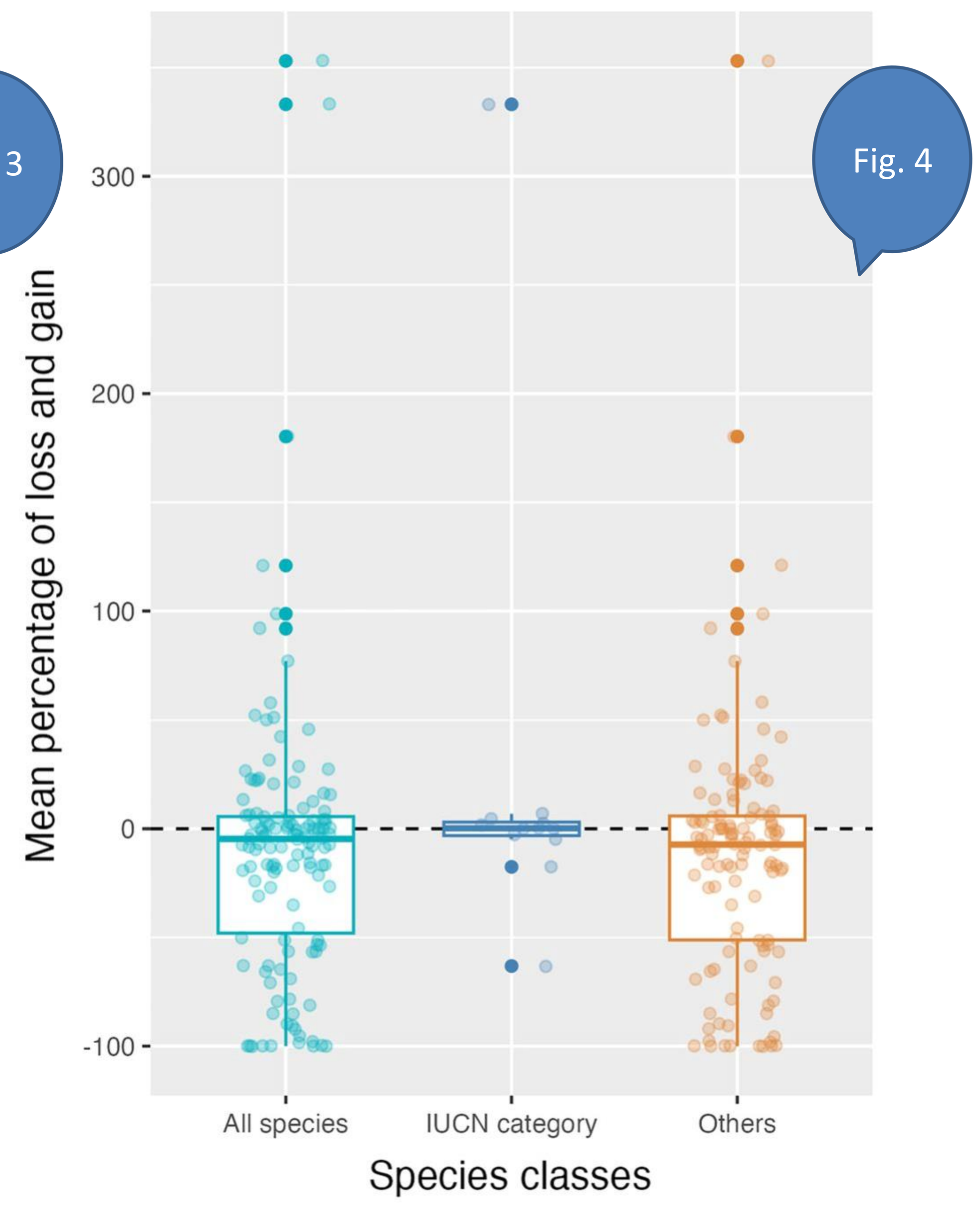


Fig.3: Percentages of losses and gains in the ranges of endemic, non-native, and native fish species.
Fig.4: Percentages of losses and gains in the distributions for all species, IUCN red list species, and other species.

- The southern Caspian HU faces the highest future species reductions followed by the western Zagros and northwestern Iran (Fig. 5).

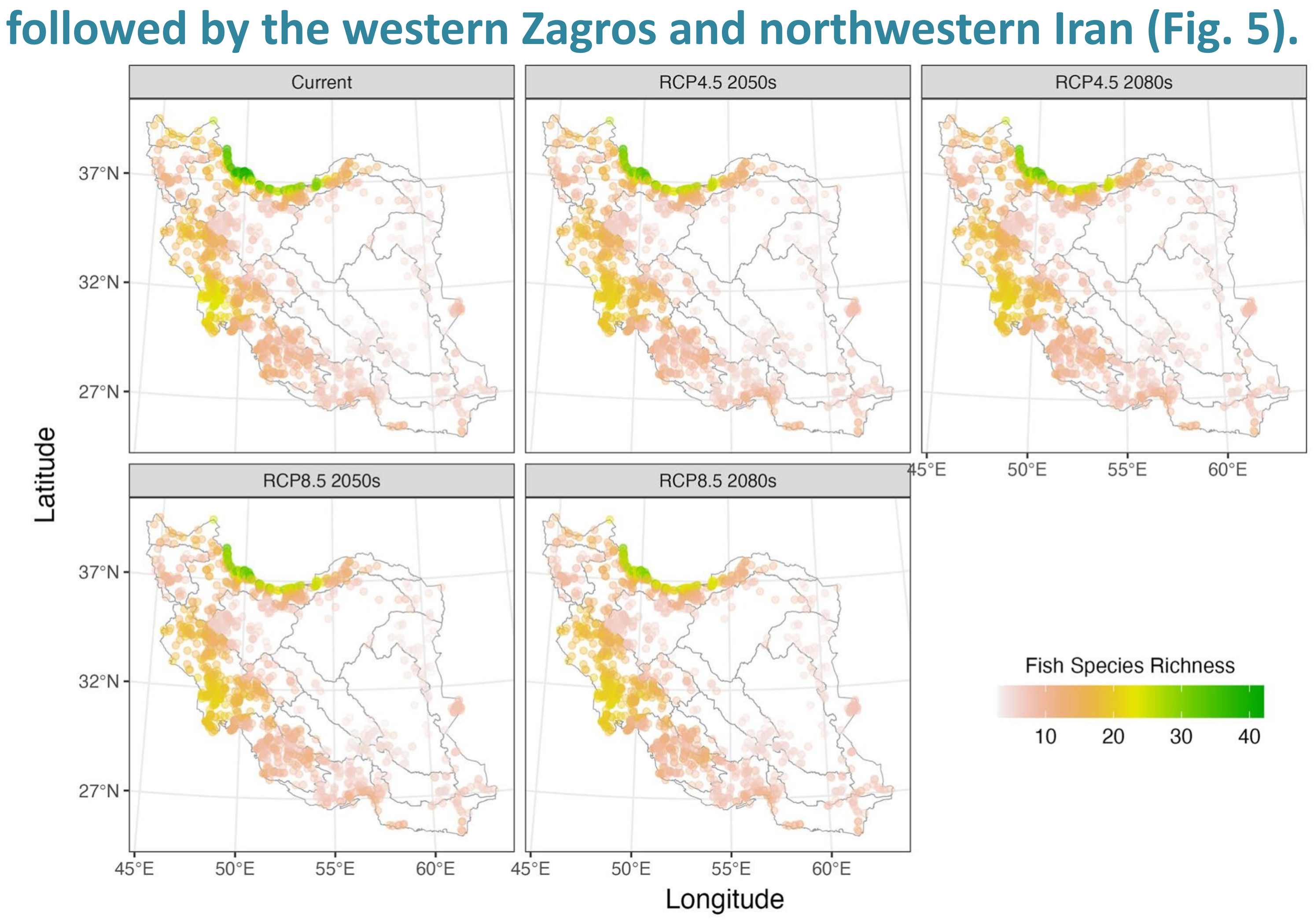


Fig.5: Fish species richness in sites at current and different future scenarios per HU.

Conclusion

To mitigate climate heating impacts, it is crucial to reduce the human pressures from land use, river fragmentation, and impaired hydromorphology and water quality. A number of strategies e.g. stakeholder education, designation of protected rivers, barrier removal, and riparian shading should be considered.