Human populations in the world’s mountains: patterns and potential controls

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Motivation

- **Strong reciprocal interactions** and **feedbacks** between human populations / societies and biodiversity in mountain social-ecological systems under change:
  - Ecosystem services $>$ Human populations / societies (including far downstream)
  - Anthropogenic pressures $>$ Ecosystems & biodiversity

- Need **reliable estimates** of mountain populations and their dynamics to ensure any **interventions** are **appropriately resourced** and effective **policies** are developed

Ebner et al. (2022), *Anthropocene*
The status quo

- Several alternative mountain delineations, gridded population datasets, and urban extent datasets exist

- Previous studies have sought to combine them to quantify human populations in / near mountains globally

However:

- Only singular combinations of possible inputs have been used

- Regional and urban mountain population dynamics have received much less attention

- Little work on exploring potential drivers of / influences on human population density in mountains specifically

- Workflows have not been consistently reproducible and transparent
Aim, Research Questions & Methods

To develop and apply a fully reproducible and efficient workflow to address several outstanding research questions, such as:

- To what extent do estimates of the global human population living in and around mountains depend on input data choices?
- How have mountain population counts and densities varied spatially and temporally over recent decades?
- How do population density estimates in mountains compare with those of their wider regions?
- Which mountainous regions are undergoing the most profound population changes?
- What proportion of the mountain population can be considered “urban”, and to what extent are recent population change and urban extent change in mountains spatially related?
- To what extent are mountain population densities within individual mountain regions related to topographic, climatic, and protected-area variables, and how have these dependencies changed in time and space over recent decades?

- Exclusively open-source data and (script-based) software applied
2015 “Global mountain population” ranged from 344 m to 2.29 bn, depending on the dataset combinations used

How one delineates mountains makes a considerable difference!

Choice of population data secondary, but still influential.
Population vs. Urban Extent Change

At “sub-mountain range scale” (GMBA Mountain Inventory v2), from 1975 to 2015 (according to one selected combination of population and urban extent data):
Population vs. Urban Extent Change (HMA)

At “sub-mountain range scale” (GMBA Mountain Inventory v2), from 1975 to 2015
(according to one selected combination of population and urban extent data):
Population Density by Climatic Regions

Sayre et al. (2020), Global Ecology and Conservation
Further Analysis of Potential Controls / Drivers

Population density (1975 and 2015) vs. numerous climatic, topographic, and other potential covariates (e.g. protected area proportions, urban extent proportions), again at sub-mountain range scale:
Conclusions

- Variability in mountain population estimates is dominated by the choice of mountain delineation

- In many regions, population increases over recent decades have been associated with strong urbanization in both extent and population, although population and urbanization trends are disconnected in some regions

- In parts of Africa especially, mean mountain population densities are notably higher than densities more generally, suggesting that mountains provide important “refugia” for human populations in certain dry and/or hot climate zones

- At “sub-mountain range scale”, moderate and high mountain population densities occur under a relatively wide range of climatological and topographic conditions, although climatic controls (especially temperature) are generally stronger and may have strengthened over time

- These findings could help inform future projections of mountain population dynamics under coupled climatic and demographic scenarios

- Transparency & reproducibility are key if society / decision makers are to trust scientific outputs, but are still often lacking! (though the situation is improving thanks to many funders, publishers, GEO, and others)
Conclusions
GEO Mountains

The Global Network for Observations and Information in Mountain Environments

Objectives:

- To increase the discoverability, accessibility, and use of mountain data
- To apply mountain data and information for scientific, policy, and practical impact
- To build and share capacity across a community of mountain researchers, practitioners, and policy makers
Many thanks!