Impact of heat stress on current and future agricultural labour productivity in India

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Background

Most climate research related to agriculture and food systems focuses on the impact climate change on crop yields and agricultural production losses. This neglects the negative impact of rising temperatures on agricultural labour productivity. Recently, several studies started to investigate this topic and showed that the economic impact of heat stress on labour (mainly agricultural workers) is larger than the climate change impact on crops (De Lima et al., 2021; Orlov et al., 2020). A major limitation of most of these studies is that they rely on aggregate national labour statistics as the main source for the location of workers and therefore do not account for the local impacts of climate change on productivity.

Objective

The aim of this project is to improve and refine existing methods to quantify the impact of heat stress on agricultural labour productivity with a case-study for India, one of the countries that will be affected most by heat stress (ILO, 2019). The findings will be relevant to formulate climate adaptation policies to reduce the impact of heat on workers and evaluate the costs of climate change.

Methods

We used a machine learning superlearner algorithm in combination with a large number of geospatial predictors and subnational labour statistics to create high-resolution (30 arc seconds) maps that show the geospatial distribution of agricultural workers in India.

The resulting maps are combined with:

- Annual wet bulb globe temperature (WBGT) projections that consider both humidity and temperature effects.
- Various exposure response functions (ERF) that relate work capacity lost to heat stress as measured by the WBGT.

The output are estimations for potential agricultural work capacity lost because of heat stress for the present and by the end of century.

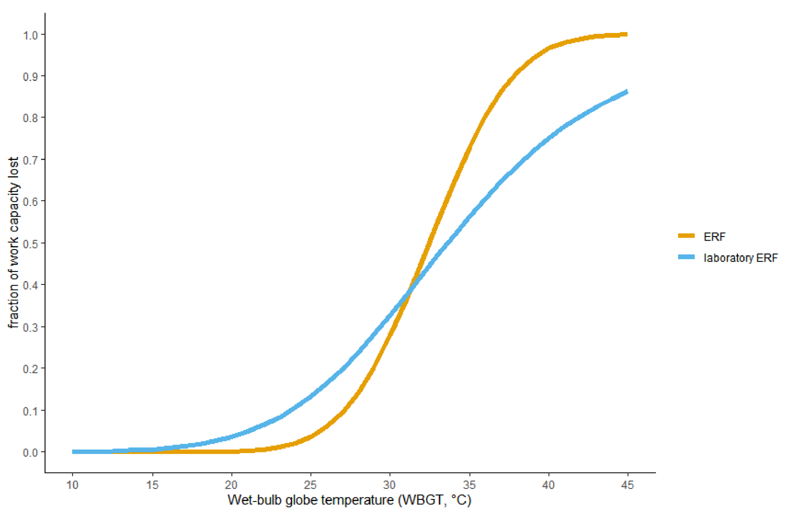

Figure 1. Epidemiological and laboratory-based exposure response functions (ERF) for high-intensity work, source: Kjellstrom et al. (2018), Foster el al. (2021).

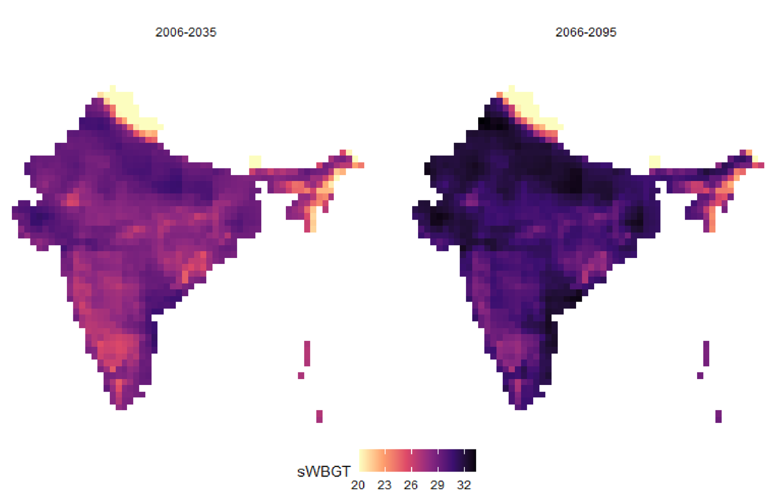

Figure 2. Mean annual (simple) sWBGT projections for 2006-2035 and 2066-2095, GFDL-ESM2M rcp85 r1i1p1 EWEMBI landonly, source: isimip2a.

Results

Highest numbers of working hours lost are observed in the North-Eastern region and the Eastern and Southern coastal regions, where heat stress is highest and farmer density is the highests, coinciding with the major rice growing areas. The total number of working hours lost ranges from 47-104 billion hours in the present (2006-2023) to 110-165 billion hours by end of century (2066-2095), depending on the type of ERF used. Note that the estimates do not include adaptations that people area already making, such as starting early in the morning when humid heat is less intense.

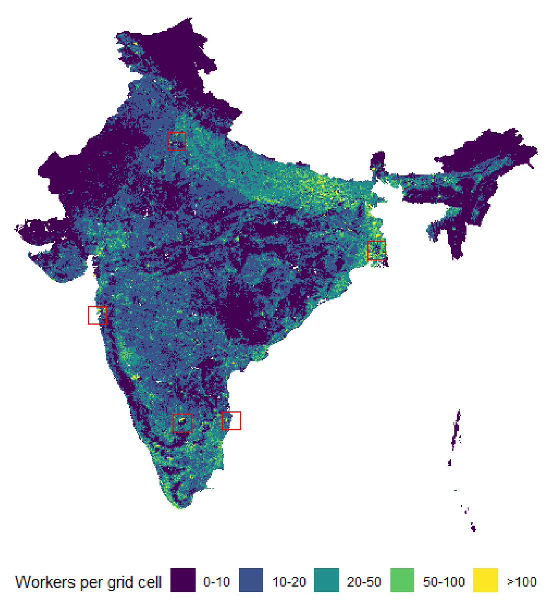

Figure 3. Geographical distribution of agricultural workers

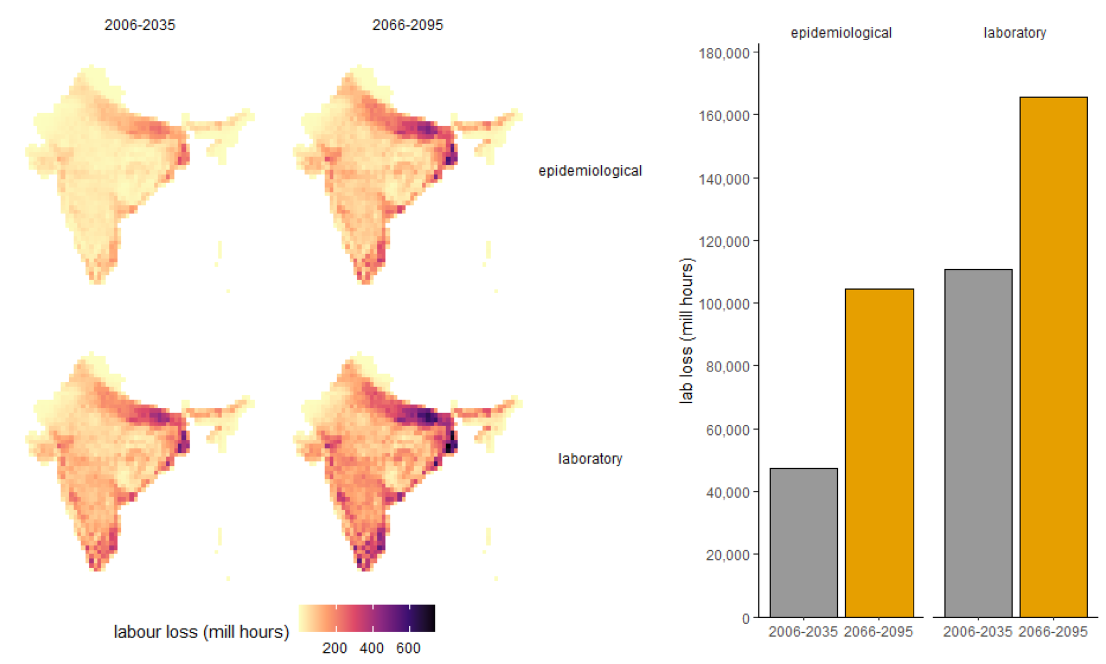

Figure 4. Geographical distribution (a) and total (b) working hours lost for two types of ERF for the current period and end of century.

Conclusions

- Previous studies failed to take into account labour participation rates and location of workers, resulting in overestimation of hours lost by a factor two.
- Nonetheless, the analysis showed that labour loss in India is already substantial and will further increase in the future as a consequence of climate change.
- Possible climate adaptation policies to reduce the impact of heat stress on agricultural workers include a change in working hours, regular breaks, shade and hydration.

Next steps

- Update sWBGT projections with results for multiple GCMs (CMIP6) to explore uncertainy in climate projections.
- Use survey data to account for intra-annual changes in the number of workers, in particular migrant work.
- Add calculations for construction workers, who are also exposed to heat stress.
- Estimate economic losses related to the loss of labour productivity caused by heat stress.
- Write paper for a scientific journal.

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