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Climate Change and Heat Stress Impacts: Does Seasonality of Labor Matter?

Arndt Feuerbacher and Anton Orlov

a.feuerbacher@uni-hohenheim.de

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Climate change impacts and labor productivity

- Research on climate change impacts has been mostly focused on changes on crop yields

  „Researchers looked for the car keys under the streetlight“ (Hertel & Lima, 2020)

- Recent studies highlight the relevance of heat stress impacts for the agricultural sector

  Lima et al. (2021) Env RL; Orlov et al. (2020) Glob. Environ. Change

- Especially low-income countries are characterized by high employment shares in agriculture and low scope of mitigation (e.g., lack of climatized tractor cabins)

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Contribution of this study

- There are still few economy-wide studies assessing the impacts of climate-change induced heat stress (< 10 studies found on Scopus)
  - Shocks are (mostly) modeled as annual averages across the national labor market
- Yet:
  1. Annual average heat stress shocks will differ within the country, due to different climate zones

     ⇨ Geographic segmentation of the (rural) labour market (e.g., by agroecological zones)
  2. Heat stress is not constant across the year, but seasonal

     ⇨ Incorporation of seasonal labour markets

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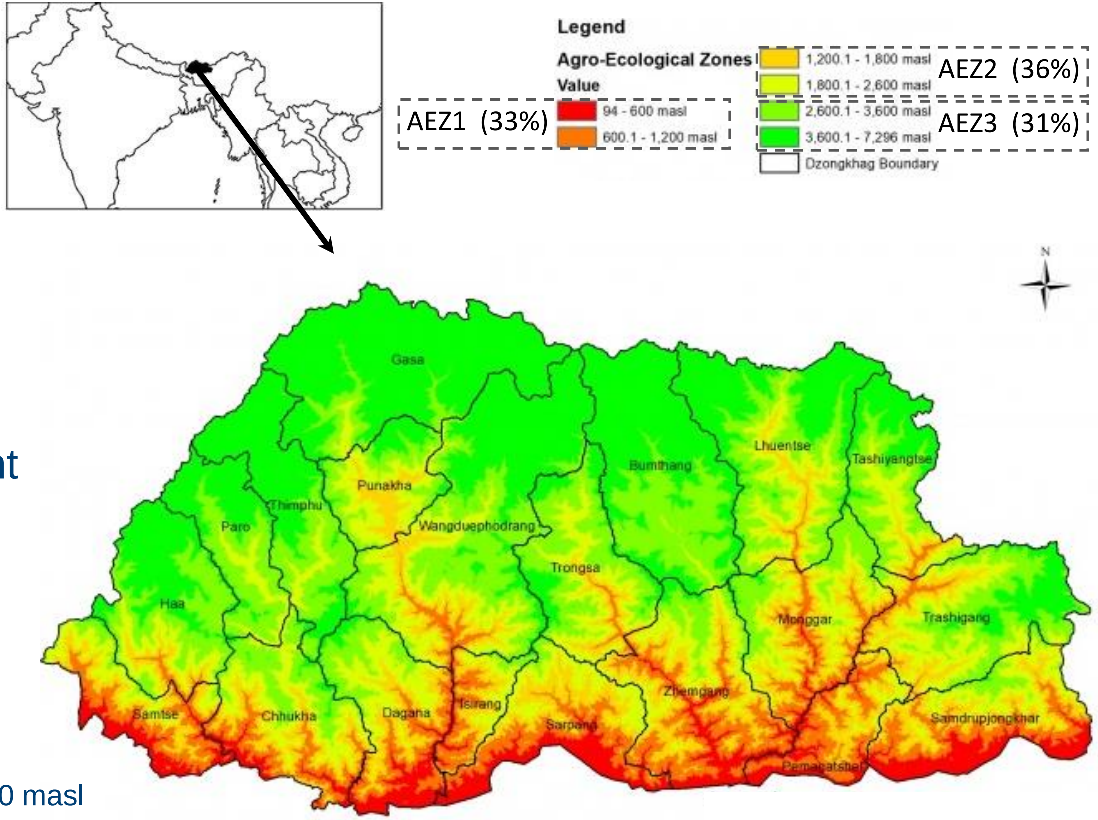
Case Study: Bhutan



- 2012 social accounting matrix (SAM)
  (Feuerbacher, Dukpa and Grethe 2017)
- Main crops: Rice, maize and potato
- Agric. labor ~50% of total employment
  - 26% of agric. HH income
  - 7% of total factor income
- Three agroecological zones
  AEZ1: Subtropical humid agroclimate < 1,200 masl
  AEZ2: Subtropical dry agroclimate, < 1,800 and > 1,200 masl
  AEZ3: Temperate climate > 1,800 masl

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Unique features of database and model

- Extended SAM to incorporate seasonality of rural labor markets (monthly intervals) and seasonal leisure (see Feuerbacher et al. 2020)
- Rigidity of seasonal labor demand dependent on nature of activity

Food Policy 93 (2020) 101875

Contents lists available at ScienceDirect

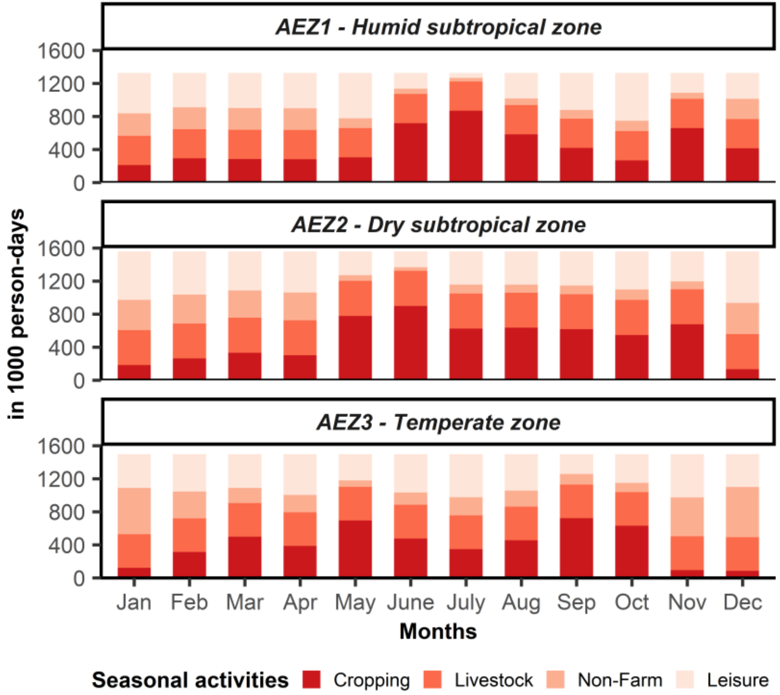
Food Policy

journal homepage: www.elsevier.com/locate/foodpol

Seasonal rural labor markets and their relevance to policy analyses in developing countries

Arndt Feuerbacher[a,b,*], Scott McDonald[b], Chencho Dukpa[c], Harald Grethe[b]

[a] Agricultural and Food Policy Research Group, University of Hohenheim, Schwerzstr. 46, 70599 Stuttgart, Germany
[b] Department of Agricultural Economics, Humboldt-Universität zu Berlin, Berlin, Germany
[c] Research and Development Center Yusipang, Ministry of Agriculture and Forests, Thimphu, Bhutan



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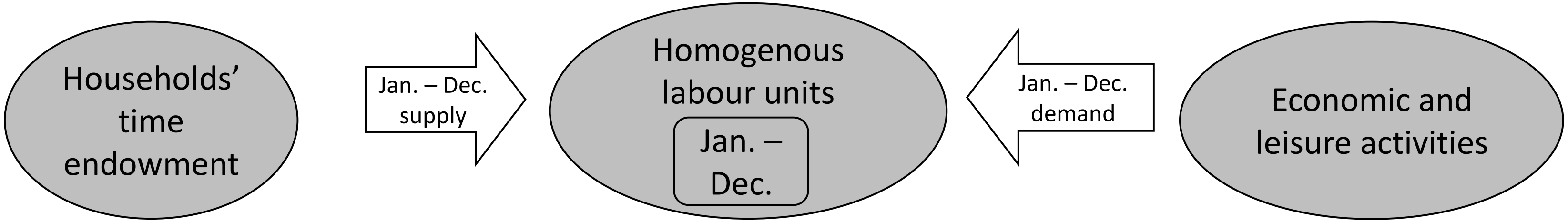
Underlying data

- Cropping calendars
  - Existing data supplemented by survey data
  - Cost of production studies
- Calibration of seasonal leisure and time endowment with empirical estimates for wage and income elasticities of labour supply
  (Boeters and Savard, 2013)

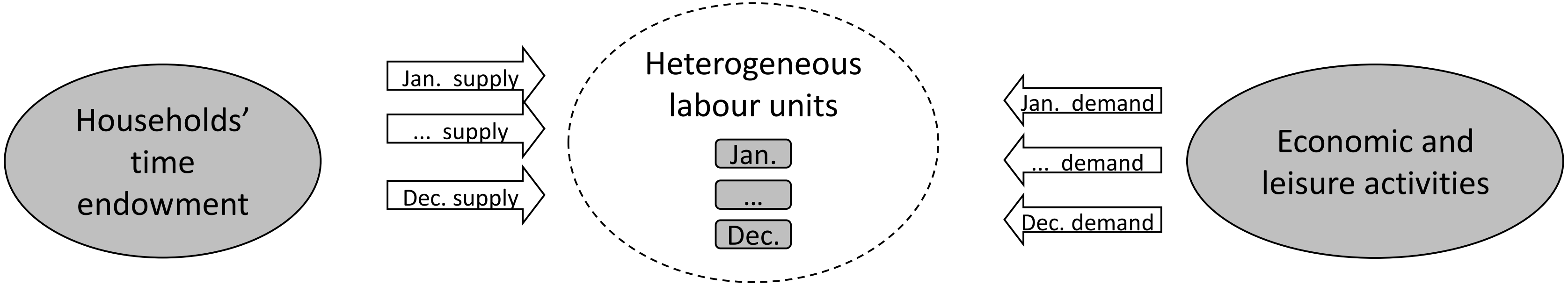
Photo: Arndt Feuerbacher

Annual and seasonal depiction of labour markets

Annual model:



Seasonal model:



Source: Own illustration

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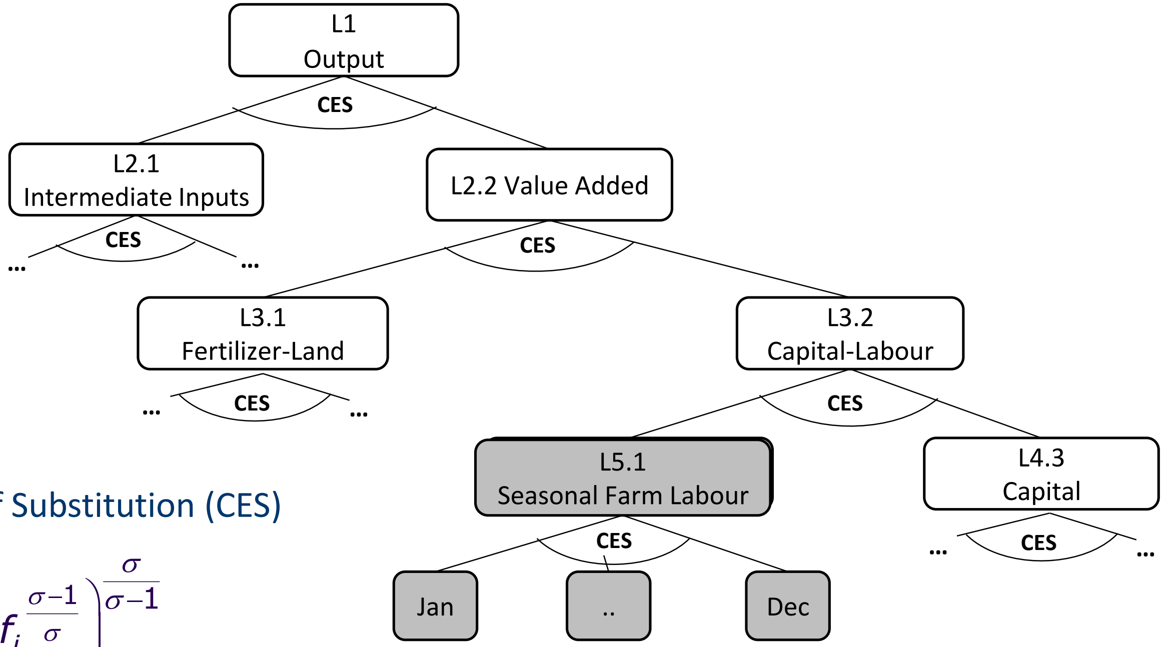
Labour Demand



Constant Elasticity of Substitution (CES)

$$X(f_i) = a\left(\sum_i \delta_i f_i^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

σ = Degree of intertemporal substitution

⇨ Rigidity of seasonal labour demand

Source: Own illustration

Rigidity of seasonal labour demand

Problem: No empirical point estimates for σ of seasonal labour demand

⇨ Sensible assumptions for parametrization, sensitivity analysis to test robustness

Rigid
($\sigma = 0.1$)
e.g., cropping

Semi rigid
($\sigma = 0.2$)
e.g., livestock

Flexible
($\sigma > 0.2$)
e.g., forestry


Photo: Arndt Feuerbacher


Photo: Arndt Feuerbacher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Model setup

- Computable General Equilibrium (CGE) model
  - Static Applied General Equilibrium (STAGE) version 2 (McDonald & Thierfelder, 2015)
  - Single-country, comparative-static and based on the 2012 Bhutan SAM
    - Recursive-dynamic mode possible with seasonal model, see recent COVID-19 study with seasonal infection peaks (Feuerbacher, McDonald and Thierfelder 2020 - https://mpra.ub.uni-muenchen.de/103370/1/MPRA_paper_103370.pdf)
  - Two setups: Annual and seasonal model
  - Closure:
    - Flexible exchange rate and fixed external balance
    - Investment driven closure
    - Fixed internal balance and government expenditure volume
    - All factors except arable land (land supply curve) are fixed
    - Factors are mobile across activities within their segments

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Heat Stress Scenario

- Heat stress scenario is based on SSP2 („Middle of the road“) and RCP 6.0
  - Representative Concentraction Pathway with a radiative forcing of 6 W/m^2 in 2100
- The heat stress impact on worker productivity is estimated based on wet bulb globe temperature (WBGT) using the ISO/NIOSH metric (similar to Lima et al., 2021)
  - Agriculture = work intensity of 400W
- Differentiation between outdoor and indoor activities
  - Outdoor: Cropping, cattle herding and forestry activities
  - Indoor: All remaining (postharvest activities, textile weaving, alcohol brewing)

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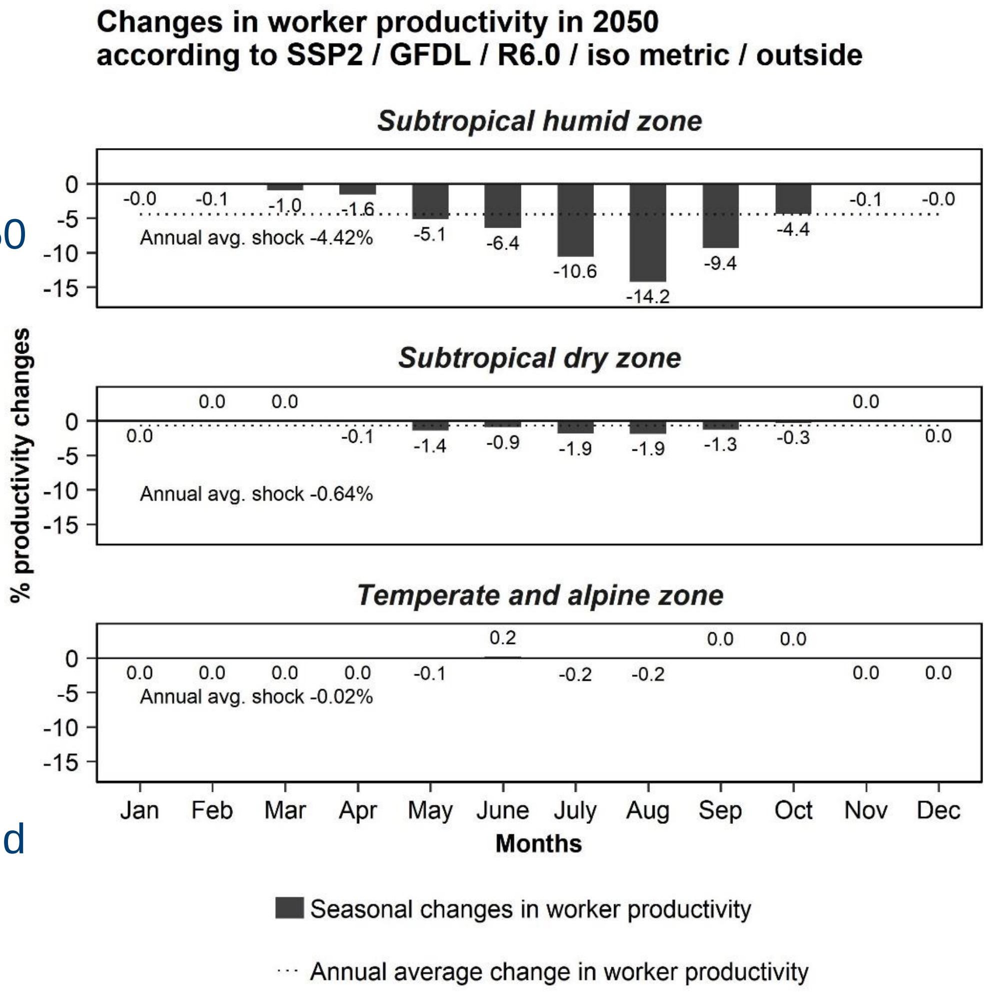
- Projected heat stress impacts in 2050 for outdoor activities
  - Most adverse impacts in the subtropical humid zone
  - Strong seasonal pattern
- Scenario is run in two model setups:
  - Annual model (annual shocks on labor productivity within each AEZ)
  - Seasonal model (monthly shocks on labor productivity within each AEZ)
- No other climate impacts assumed and world market prices remain constant



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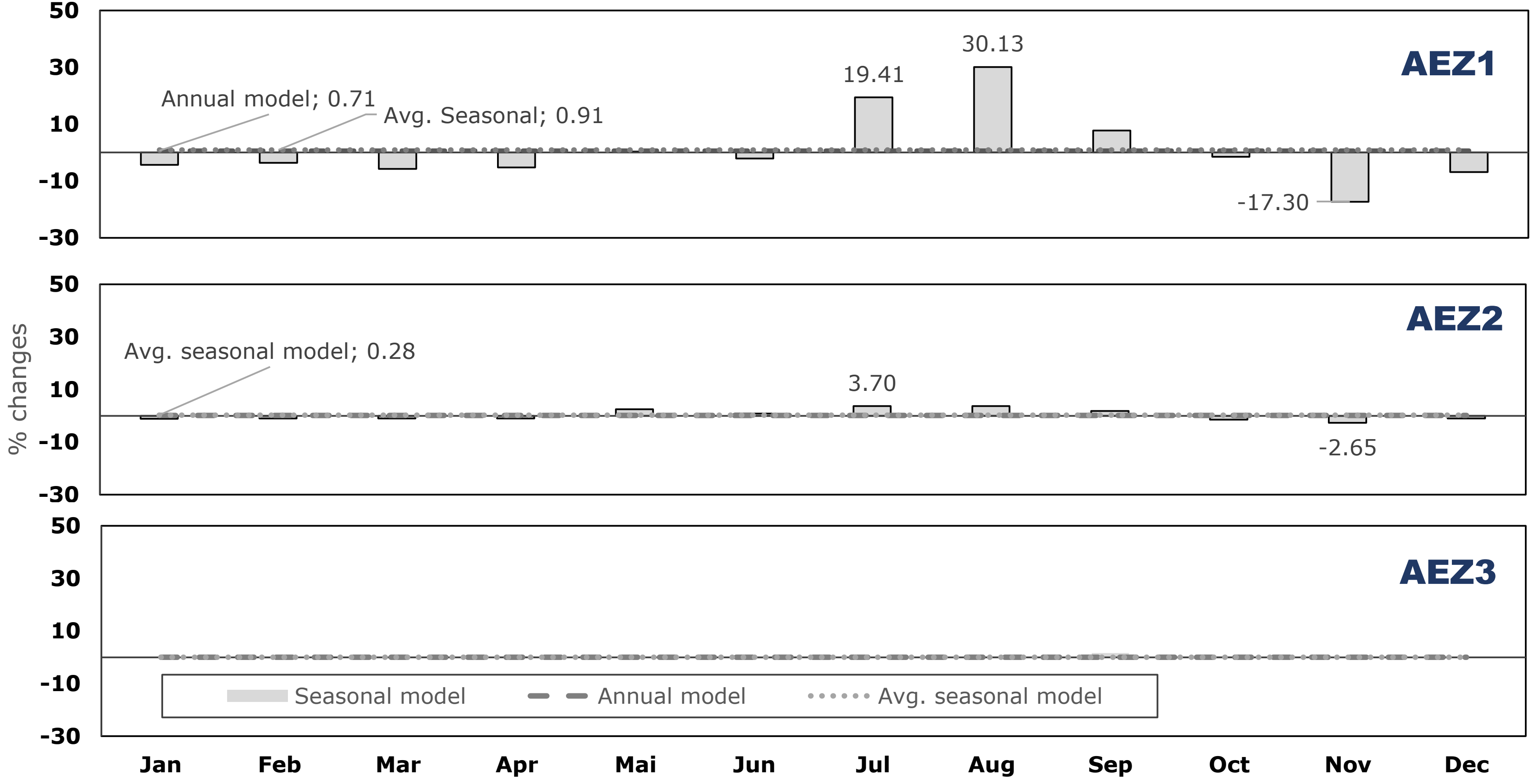
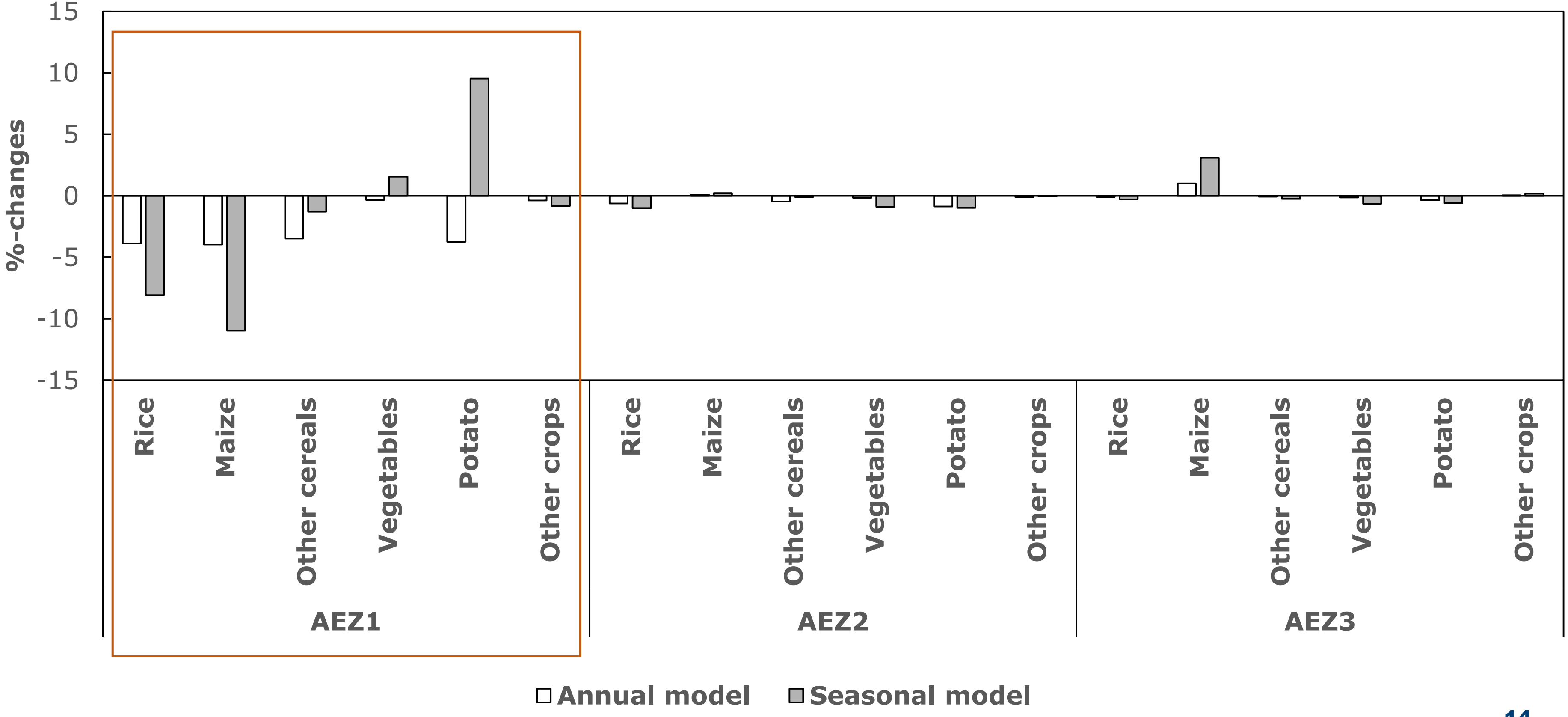
Results: Wage rates

Scenario based on SSP2, RCP6.0, iso-metric, 400 Watts, GFDL model



Results: Agricultural output

Scenario based on SSP2, RCP6.0, iso-metric, 400 Watts, GFDL model



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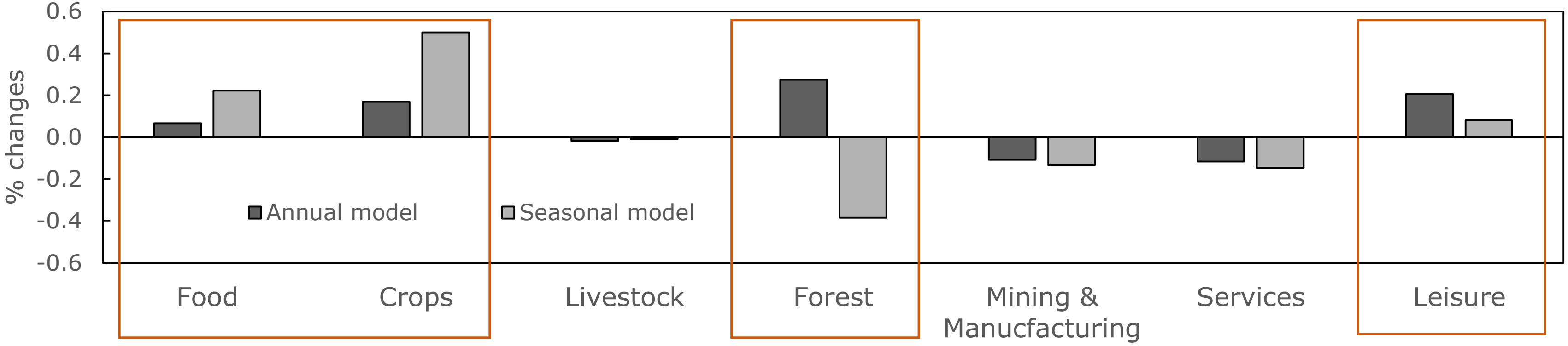
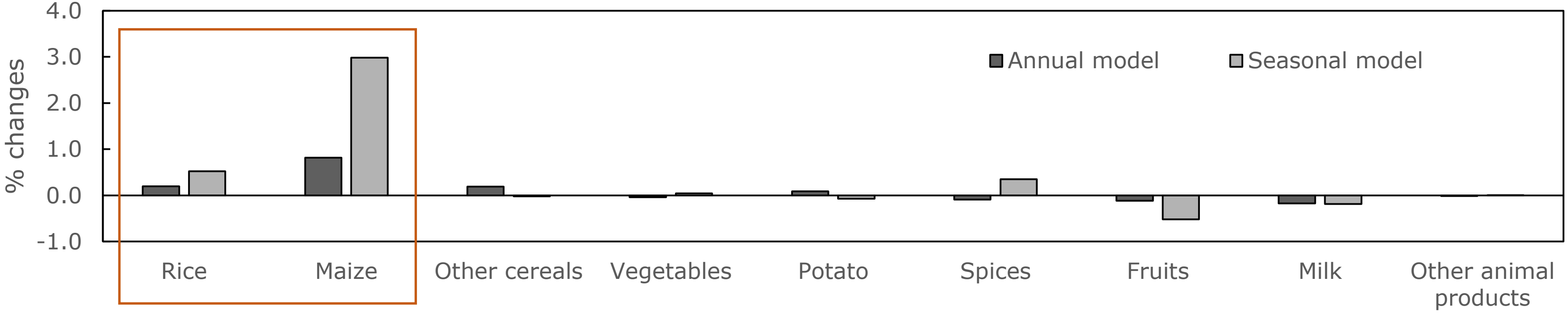
Results: Purchaser prices

Scenario based on SSP2, RCP6.0, iso-metric, 400 Watts, GFDL model





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Results: Macro-level

Scenario based on SSP2, RCP6.0, iso-metric, 400 Watts, GFDL model

	% changes	
	Annual model	Seasonal model
GDP	-0.08	-0.11
Absorption	-0.06	-0.08
Consumption	-0.17	-0.25
Consumption Non-Agri. HH	-0.10	-0.13
Consumption Agri. HH	-0.30	-0.48
Investment	0.00	0.01
Government	0.00	0.00
Import	0.01	0.02
Export	0.01	0.03
Food purchaser prices	0.07	0.22
Food production	-0.54	-0.93
Farm labor wages	0.24	0.38
Arable land supply	-0.75	-1.37

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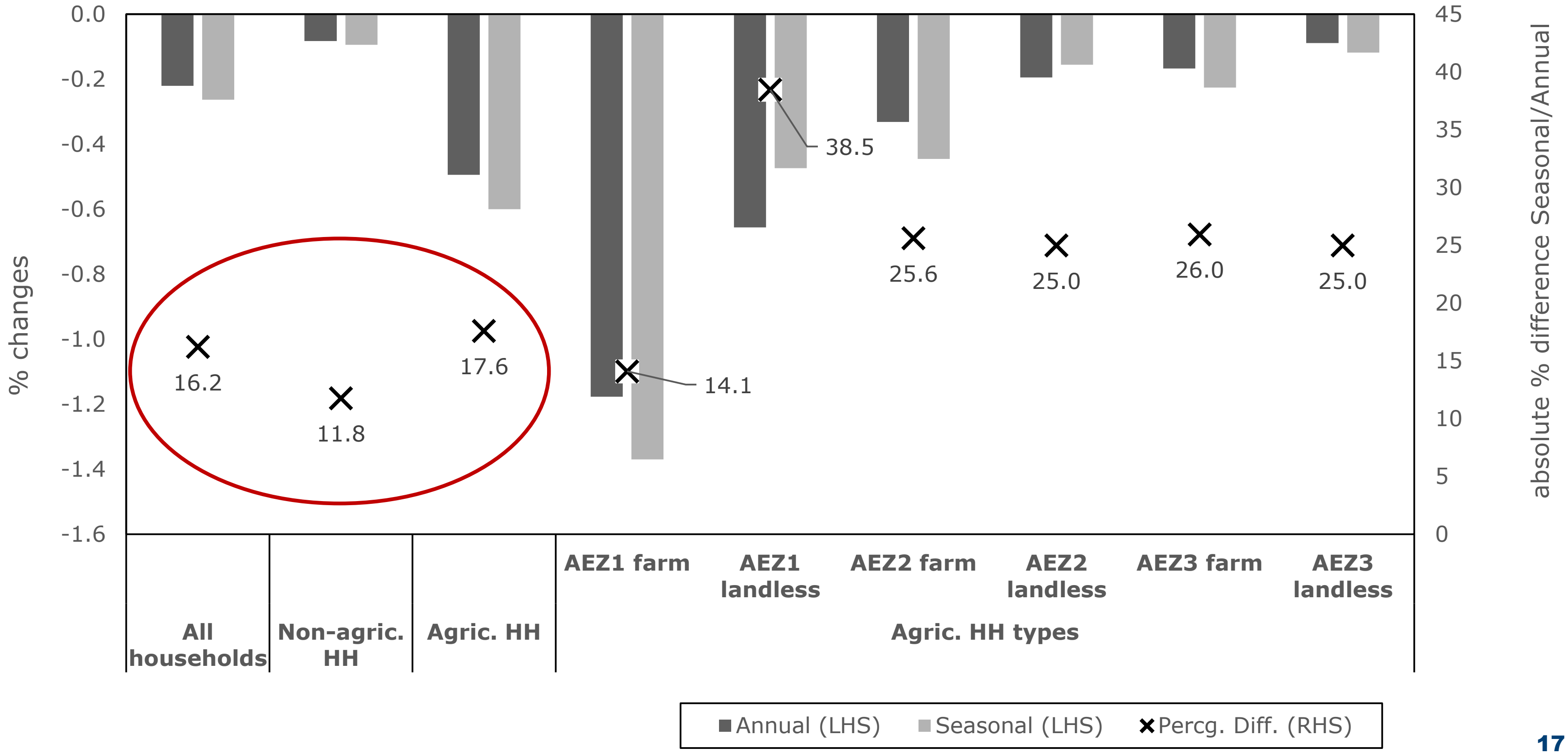
Welfare effects incl. leisure

(equivalent variation as a % of household expenditure)



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Conclusions

- Preliminary results show: Modelling heat stress impacts in an annual or seasonal model leads to different results
  - Omitting the seasonal dimension of heat stress shocks understates the impacts on the agricultural sector (food security) and agricultural household welfare
  - 18% higher welfare decline if seasonality is considered
- The relevance of seasonality in low-income countries is unquestionable, ignoring it means we still look for the keys under the streetlight
- Economic cost of heat stress (and climate change) likely to be substantially understated when ignoring seasonality
  - Data challenge immense for global models, but less for single country analysis

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Next steps and future research

- Results are preliminary and more robust simulations are needed (varying RCP, GCM models, assessment metrics, etc.)

- While seasonality is a blind spot, small population, mountainous terrain and temperate climate makes Bhutan not the ideal case study ⇨ India, Bangladesh are other monsoon economies with much higher exposure to heat stress

- Future research: Adjusting the annual labor productivity shock by the growing season may be a “shortcut” to avoid seasonal disaggregation

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Thanks for your attention!

Contact: a.feuerbacher@uni-hohenheim.de