Energy Poverty in Central and South Asia

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What are the drivers of energy poverty, and what are the outcomes of being energy poor in Central and South Asia?

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What is Energy Poverty?

- "A household having reliable and affordable access to both clean cooking facilities and to electricity, which is enough to supply a basic bundle of energy services"
  International Energy Agency, https://www.iea.org/articles/defining-energy-access-2020-methodology

- "An inability to realize essential capabilities as a direct or indirect result of insufficient access to affordable, reliable and safe energy services, and taking into account of available reasonable alternative means of realizing these capabilities"
  Day R, Walker G, Simcock N. Conceptualizing energy use and energy poverty using a capabilities framework. Energy Policy 2016;93:255–64.

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Theoretical framework

- Drivers (Muller and Yan, 2016)
  - Individual and household level characteristics, e.g. demographics, income, household size
  - Regional level factors, e.g. production characteristics, energy source availability, pricing
- Health Outcomes (Gordon et al., 2014)
  - Access to clean cooking and heating methods, and the reduced use of biomass fuels minimizes exposure to household air pollution as well as burdens related to the collection thereof
  - Access to refrigeration and medical technology positively affects health concerns
- Education Outcomes (Winther et al., 2017)
  - Rescheduling of time-use, improved learning environments, and better access to information induces changes to school performance, enrolment and time spent studying
- Gender-specific Outcomes (Rewald, 2017)
  - The effects of energy poverty materialize differently for women and men
  - Findings remain to this day, however, "mostly mixed, minimal, or unclear"

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What is the state of energy poverty in Central and South Asia?

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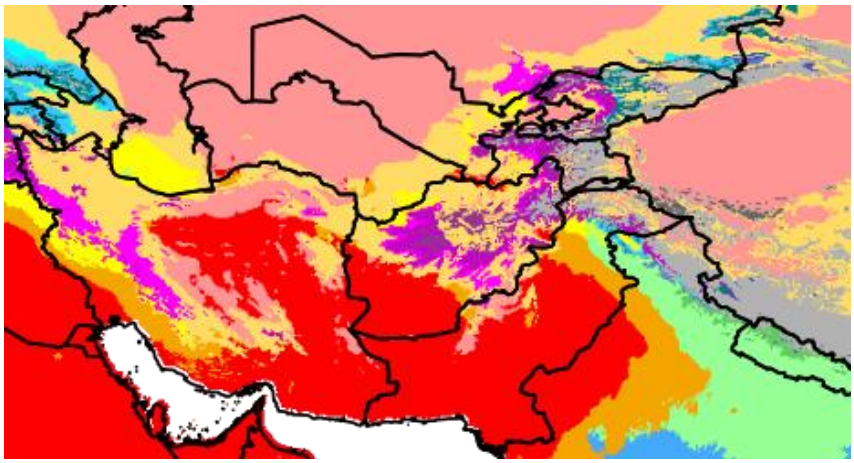
Research Area



Beck, H.E., Zimmermann, N.E., McVicar, T.R., Vergopolan, N., Berg, A. and Wood, E.F., 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. Scientific data, 5, p.180214.

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Multidimensional Energy Poverty Index

- Complex quantifiable and comparable measure of energy poverty
- Framework developed by Nussbaumer, Brazilian and Modi (2012)
- Inspired by Human Development Index, Energy for Development Index, and Multidimensional Poverty Index
- Metric focusing on quantifying energy deprivation, as opposed to energy access
- Dimensions of the MEPI reflect the state of a group with regards to their capabilities to satisfy their energy needs for the use of energy services

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Multidimensional Energy Poverty Index

Indicator	Weight	Dimension
Household has electricity	0.2	Lighting
Household has a TV or radio	0.13	Entertainment / Education
Household has refrigerator	0.13	Household appliance
Household uses clean cooking fuel	0.2	Modern cooking fuel
Household uses clean cooking fuel, or food cooked in separate kitchen/building/outdoors	0.2	Indoor pollution
Household has a mobile phone or landline	0.13	Communication

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New Multidimensional Energy Poverty Index

Indicator	Weight	Dimension
Household has electricity	0.2	Lighting
Household has a TV or radio	0.1	Entertainment / Education
Household has refrigerator	0.07	Household appliance
Household has fan or air conditioner	0.03	
Household uses clean cooking fuel	0.2	Modern cooking fuel
Household uses clean cooking fuel, or food cooked in separate kitchen/building/outdoors	0.1	Indoor pollution
Household has a mobile phone	0.07	Communication
Household has a computer	0.03	
Walls built using improved materials	0.1	Energy efficiency
Roof built using improved materials	0.1	

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Methodology

- The matrix of achievements for i individuals across j variables is given by $n \times d$ matrix $Y = [y_{ij}]$, where y_{ij} represents the achievements of individual i in the variable j, and d variables and n individuals
- Each variable j is assigned a weight w_j such that $\sum_{j=1}^{d} w_j = 1$
- The deprivation cut-off z_j in variable j is used to identify all the instances deprived in the variable
- The deprivation matrix $G = [g_{ij}]$ is defined such that $(i,j)^{th}$ element of the matrix is equivalent to w_j- weight of variable j when the individual i is deprived in variable j (i.e. $y_{ij} < z_j$), and it's zero when the individual i is not deprived in variable j (i.e. $y_{ij} \geq z_j$)
- The i^{th} element of the vector of deprivation counts is given by $c_i = \sum_{j=1}^{d} g_{ij}$ which represents the sum of weighted deprivations suffered by individual i
- The framework uses poverty cut-off $k > 0$ across the deprivation counts vector to give $c(k)$- the censored vector of deprivation counts. An individual is considered energy poor if their weighted deprivation count c_i exceeds the predefined cut-off k. Therefore, $c_i(k)$ is set equal to zero if $c_i \leq k$ and equal to c_i if $c_i > k$

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Methodology

- Headcount ratio H
  - Proportion of people that are considered energy poor
  - Let n be the total number of individuals and we define q as number of energy poor people, i.e. $q = \sum_{i=1}^{n} 1_{\{c_i>k\}}$ where $1_{\{c_i>k\}} = 0$ if $c_i \leq k$ and $1_{\{c_i>k\}} = 1$ if $c_i > k$
  - Therefore, $q = \sum_{i=1}^{n} 1_{\{c_i>k\}}$ gives the total number of individuals deemed as energy poor and $H = \frac{\sum 1_{\{c_i>k\}}}{n} = \frac{q}{n}$ gives the proportion of the individuals that are energy poor.
- Intensity of multidimensional energy poverty A
  - Given by $A = \frac{\sum_{i=1}^{n} c_i(k)}{\sum_{i=1}^{n} 1_{\{c_i>k\}}} = \frac{\sum_{i=1}^{n} c_i(k)}{q}$ which represents the average of the censored weighted deprivation counts
- Multidimensional Energy Poverty Index $MEPI$
  - Product of the incidence and the intensity of energy poverty
  - Given by $MEPI = H \times A$

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Data

- Demographic and Health Surveys (USAID)
  - Afghanistan 2015
    - 24,400 Households
  - Pakistan 2017
    - 14,500 Households
  - Tajikistan 2017
    - 7,800 Households
- Life in Kyrgyzstan (IGZ, FAO, IFPRI, UCA)
  - Kyrgyzstan 2016
    - 2,500 Households
- Multiple Indicator Cluster Surveys (UNICEF)
  - Kyrgyzstan 2018
    - 7,200 Households

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Results: MEPI

Country	Data Source	n	q	k	H	A	MEPI
Afghanistan	DHS 2015	24,185	17,635	0.3	0.73	0.51	0.37
Kyrgyzstan	LiK 2016	2,519	1,249	0.3	0.50	0.36	0.18
Kyrgyzstan	MICS 2018	6,960	202	0.3	0.03	0.36	0.01
Pakistan	DHS 2017	14,447	5,901	0.3	0.41	0.53	0.21
Tajikistan	DHS 2017	7,840	589	0.3	0.08	0.38	0.03

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Results: New MEPI

Country	Data Source	n	q	k	H	A	MEPI
Afghanistan	DHS 2015	24,101	20,087	0.3	0.83	0.60	0.50
Kyrgyzstan	LiK 2016	154	127	0.3	0.82	0.51	0.42
Kyrgyzstan	MICS 2018	6,960	1,885	0.3	0.27	0.35	0.09
Pakistan	DHS 2017	14,438	6,686	0.3	0.46	0.54	0.25
Tajikistan	DHS 2017	7,840	1,042	0.3	0.13	0.39	0.05

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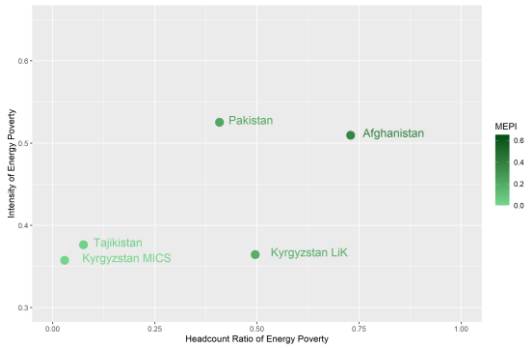
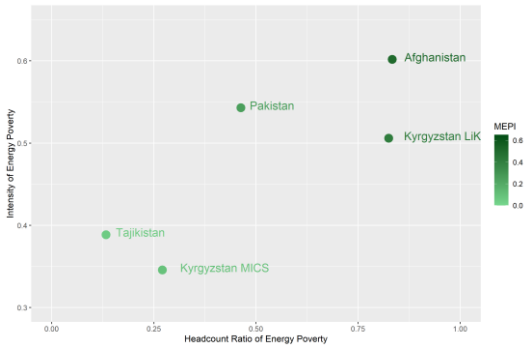
Results: Headcount vs Intensity

MEPI



New MEPI



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Results: National Level

MEPI (Kyrgyzstan MICS)

New MEPI (Kyrgyzstan MICS)

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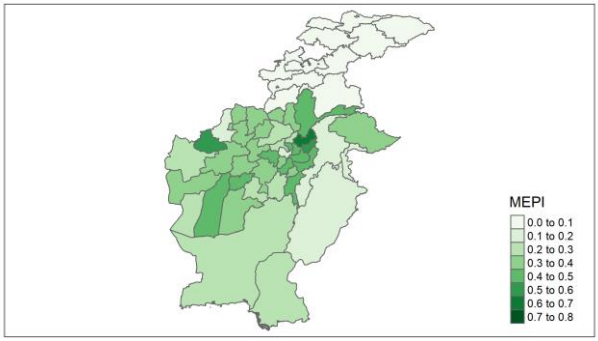
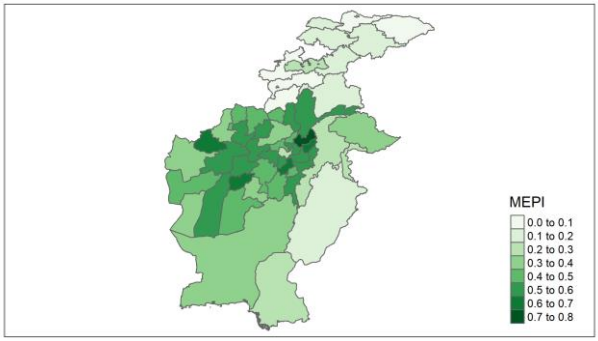
Results: Regional Level

MEPI (Kyrgyzstan MICS)



New MEPI (Kyrgyzstan MICS)



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Results: Urban vs Rural MEPI

Country	Data Source	Factor H	Factor A	Factor MEPI
Afghanistan	DHS 2015	2.83	1.14	3.22
Kyrgyzstan	LiK 2016	2.35	1.00	2.34
Kyrgyzstan	MICS 2018	2.78	0.99	2.74
Pakistan	DHS 2017	4.17	1.15	4.81
Tajikistan	DHS 2017	21.99	1.06	23.22

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Conclusions

- Findings
  - Incidence and intensity of energy poverty varies greatly both on the national and subnational level
  - Enhancing the original MEPI by additional factors does not affect the intensity as much as the incidence of energy poverty
  - Staggering urban-rural divide with regards to the headcount ratio
- Work in progress
  - Perform sensitivity analysis using different cut-off values and weights
  - Create energy poverty index on the household level
  - Use findings to analyze the determinants and outcomes of energy poverty
  - Extend analysis to districts of Pakistan, as well as to Kazakhstan and Turkmenistan

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