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Targeting Energy Poverty under the Energy Efficiency Obligation Scheme: A Survey-Based Analysis for Türkiye

Rabia Cin & Sermin Onaygil

Istanbul Technical University - Energy Institute



Content

- Background & Motivation
- Scope
- Methodological Steps
- Results
- Conclusion

Background & Motivation

- Türkiye defined **EEOS actions** in both **NEEAP I (2018)** and **NEEAP II (2024)**
- **EEOS** implementation is **scheduled for 2027**
- **EEOS and energy poverty are interconnected**
- Combating energy poverty is gaining policy relevance across Europe
- A clear **energy poverty policy gap persists in Türkiye**
- EEOS must be carefully designed to **avoid exacerbating existing vulnerabilities**
- **Integrating energy poverty goals** into EEOS could help **close this policy gap**

Targeting???

EEOS Practices

- **The United Kingdom**
 - 10% indicator
 - Low Income High Cost (LIHC)
- **Ireland**
 - Households receiving specific social benefits, residing in social housing, or living in pre-identified target areas.
- **France**
 - Households below per capita income thresholds
- **Austria and Greece**
 - Households eligible for special electricity tariffs



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Composite indexes combine multiple factors (income, housing, energy access, affordability) to offer a more holistic assessment of energy poverty.

- **MEPI:** Focuses on **basic energy access and appliance ownership**; common in developing countries.
- **EPI:** Captures **housing-related deprivation** in developed countries.
- **CEPI:** Adds **seasonal and non-thermal indicators** (e.g. summer overheating, poor lighting).
- **EPVI:** Regional vulnerability index using **socio-economic, climatic, and building data**.

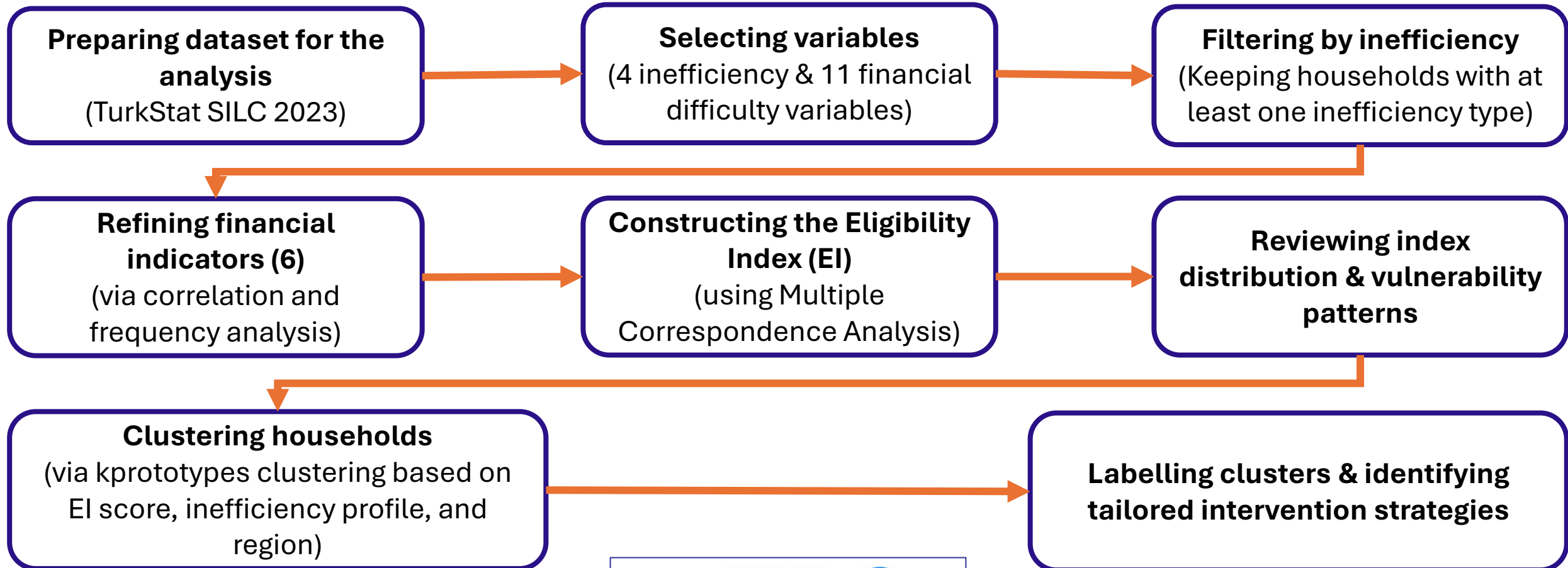
A major challenge in index construction is selecting relevant indicators and assigning appropriate weights.

- **Predefined weights** (equal or policy-based),
- **Expert judgment**,
- **Statistical methods** (e.g. PCA),
- **Machine learning-based weighting**, which allows for data-driven optimization and pattern recognition.

Scope

Developing a **data-informed targeting framework** to identify and classify **financially vulnerable households living in inefficient dwellings**, supporting **equitable energy poverty interventions under a future EEOS in Türkiye.**

Methodological Steps



Preparing dataset for the analysis & Selecting variables

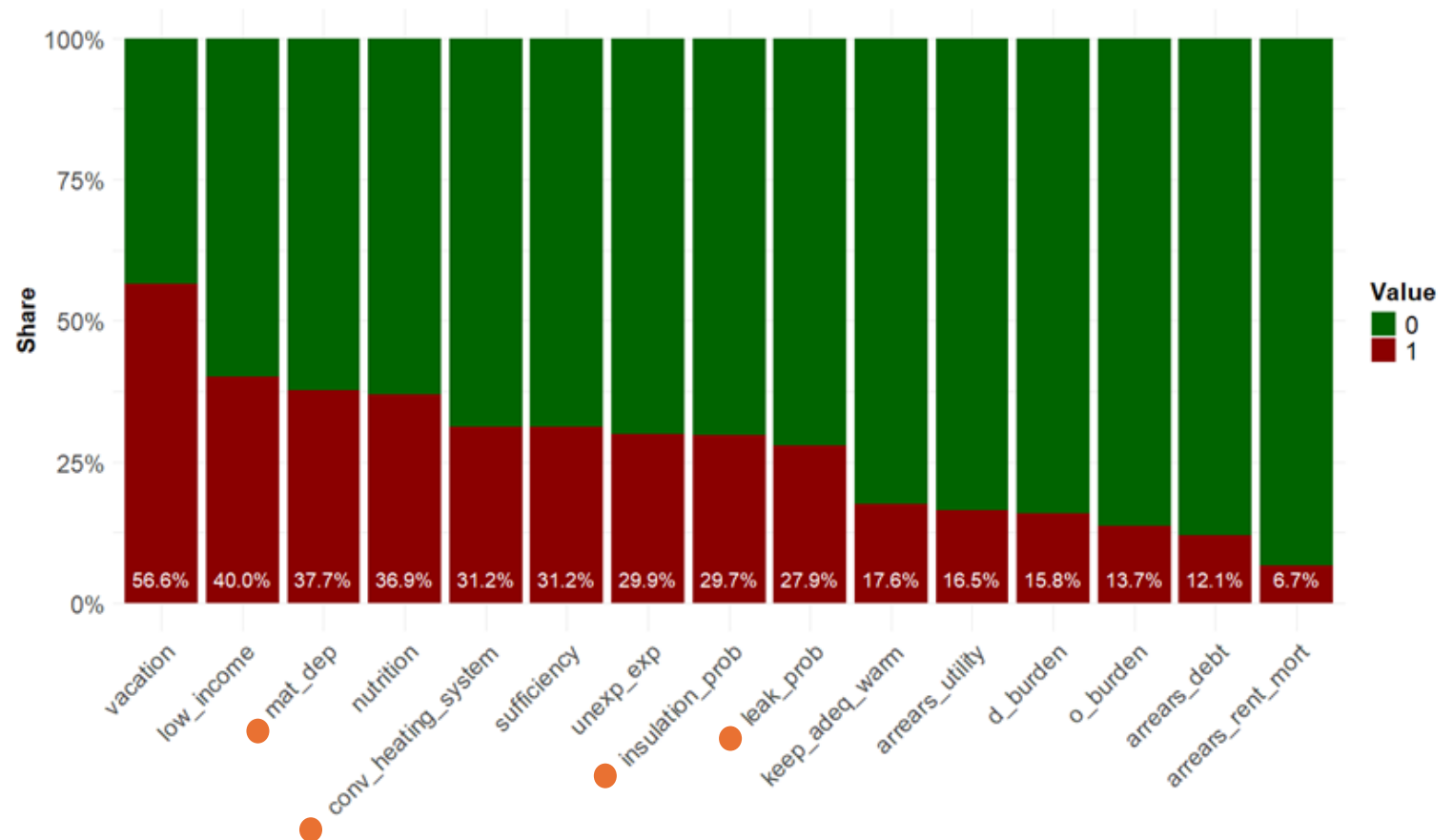
Initial sample: **24,932** households

Exclusion of households without essential amenities
(toilet, bathroom, kitchen, piped water)

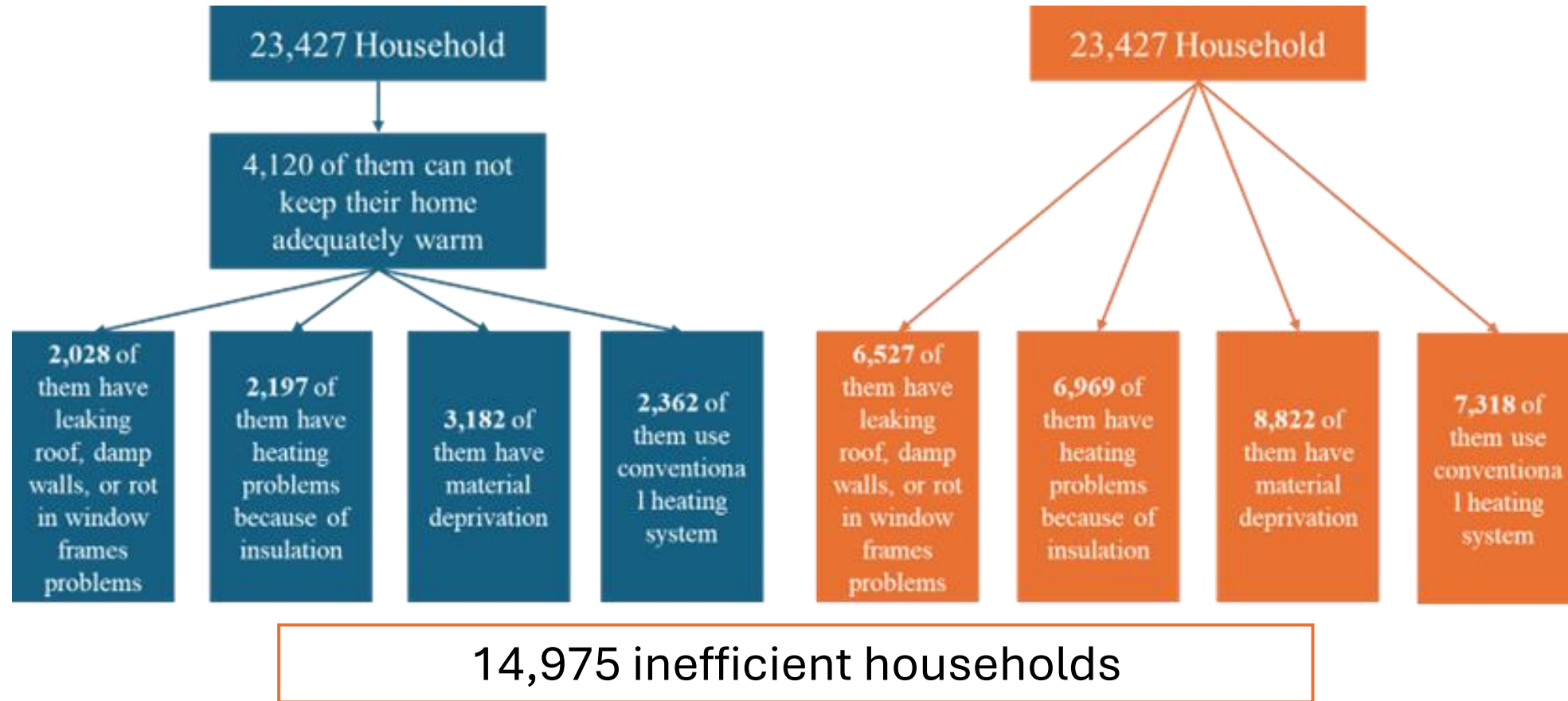
24,015 households

Exclusion of dwellings 50+ years old

Final sample: **23,427** households

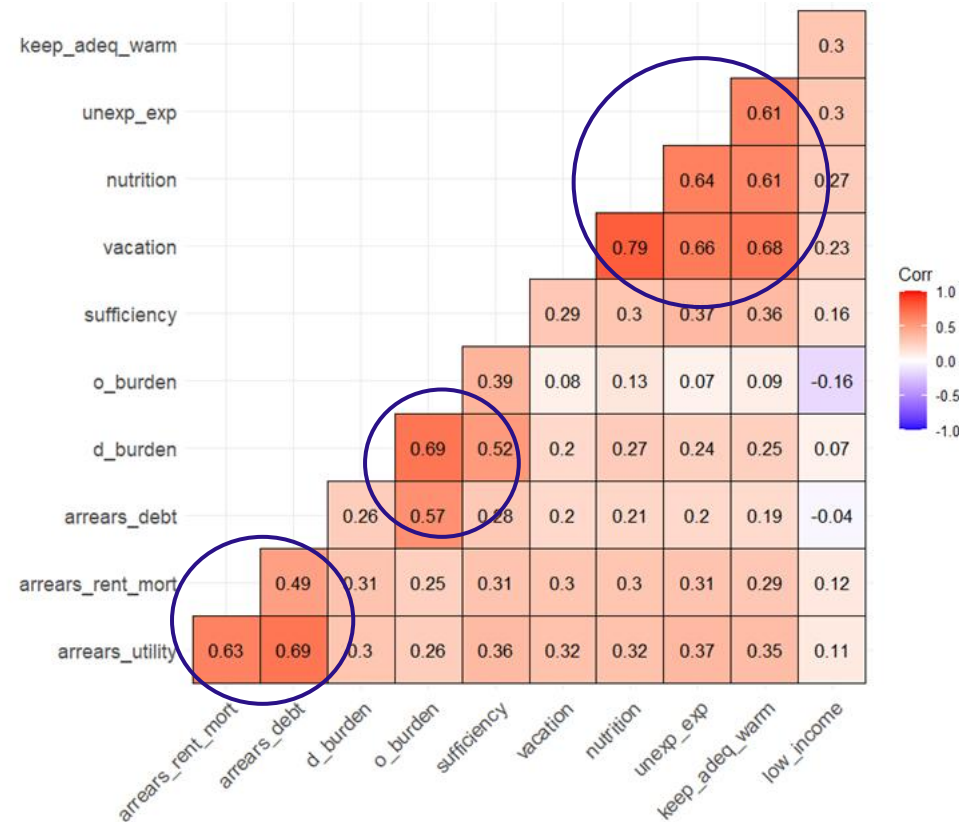


Filtering by inefficiency



Refining financial indicators

Tetrachoric Correlation Matrix of Financial Difficulty Variables

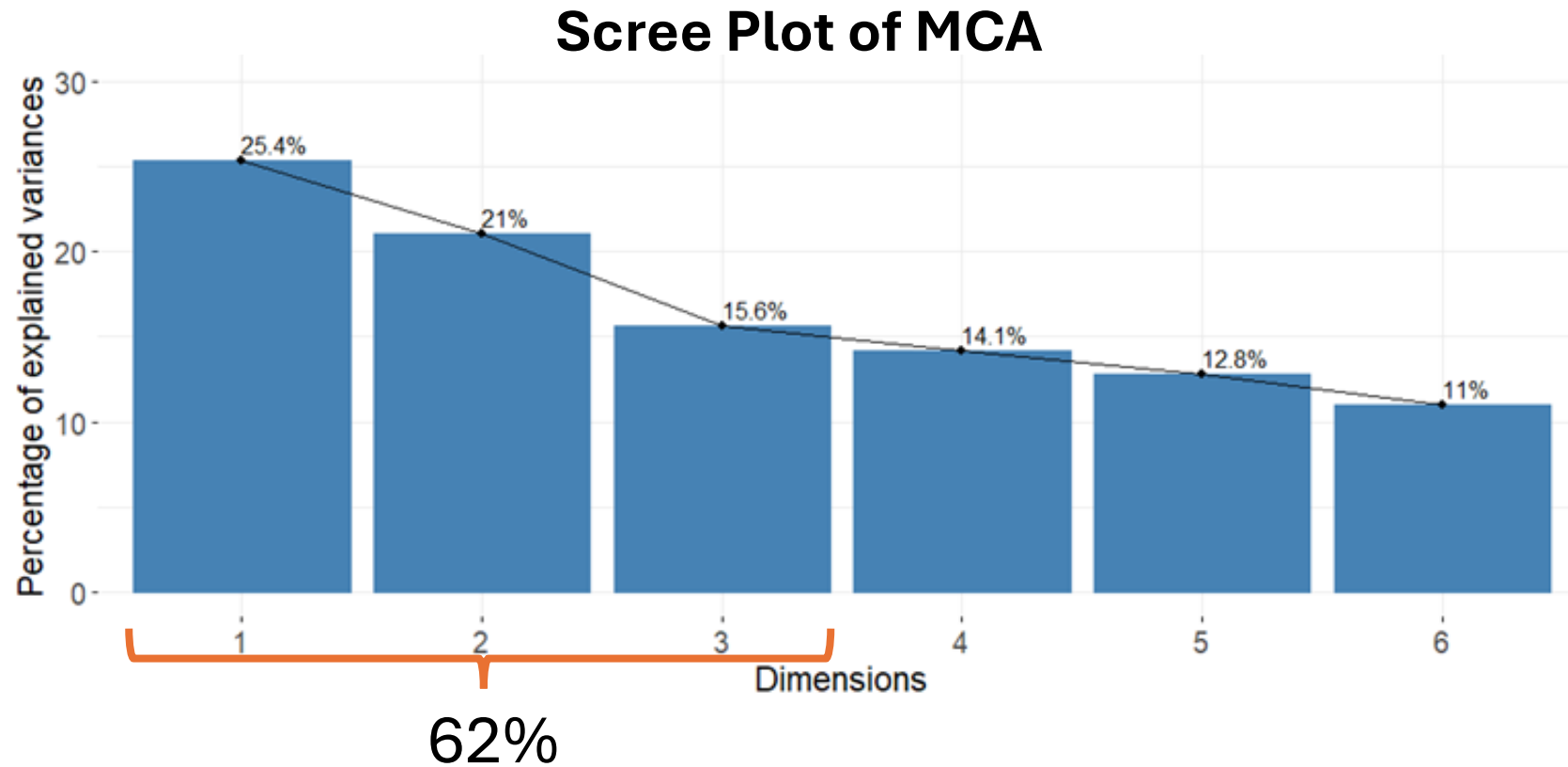


Selected financial indicators for the Eligibility Index:

- **low income**
- **sufficiency**
- **keep_adeq_warm**
- **nutrition**
- **arrears_utility**
- **o_burden**



Constructing the Eligibility Index (EI) via MCA



Constructing the Eligibility Index (EI) via MCA

Contribution and Cos² Values of Each Category

Categories	Dim1 Contrib. (%)	Dim1 Cos ²	Dim2 Contrib. (%)	Dim2 Cos ²	Dim3 Contrib. (%)	Dim3 Cos ²
low_income_0	0.039	0.001	20.354	0.424	24.851	0.384
low_income_1	0.025	0.001	13.231	0.424	16.155	0.384
keep_adeq_warm_0	9.625	0.465	3.603	0.144	0.288	0.009
keep_adeq_warm_1	20.913	0.465	7.830	0.144	0.625	0.009
nutrition_0	14.038	0.344	6.092	0.124	18.699	0.282
nutrition_1	8.524	0.344	3.699	0.124	11.354	0.282
sufficiency_0	9.696	0.303	3.376	0.088	10.450	0.201
sufficiency_1	10.236	0.303	3.564	0.088	11.031	0.201
o_burden_0	1.191	0.091	7.357	0.464	0.011	0.001
o_burden_1	4.767	0.091	29.440	0.464	0.045	0.001
arrears_utility_0	5.873	0.319	0.408	0.018	1.820	0.061
arrears_utility_1	15.075	0.319	1.046	0.018	4.671	0.061

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Contribution and Cos² Values of Each Indicator

Indicators	Dim1 (25.4%)		Dim2 (21%)		Dim3 (15.6%)	
	Contrib. (%)	Cos ²	Contrib. (%)	Cos ²	Contrib. (%)	Cos ²
low_income	0.064	0.001	33.585	0.424	41.006	0.384
keep_adeq_warm	30.538	0.465	11.433	0.144	0.913	0.009
nutrition	22.562	0.344	9.791	0.124	30.053	0.282
sufficiency	19.931	0.303	6.941	0.088	21.481	0.201
o_burden	5.958	0.091	36.797	0.464	0.057	0.001
arrears_utility	20.948	0.319	1.454	0.018	6.491	0.061



Constructing the Eligibility Index (EI) via MCA

Previous and Normalized Contribution Values of Each Indicator

Indicators	Dim1 (25.4%)		Dim2 (21%)		Dim3 (15.6%)	
	Contrib. (%)	Normalized Contrib. (%)	Contrib. (%)	Normalized Contrib. (%)	Contrib. (%)	Normalized Contrib. (%)
low_income_1	-	-	-	-	41.006	57.707
keep_adeq_warm_1	20.913	45.243	-	-	-	-
nutrition_1	-	-	-	-	30.053	42.293
sufficiency_1	10.236	22.144	-	-	-	-
o_burden_1	-	-	36.797	100.000	-	-
arrears_utility_1	15.075	32.613	-	-	-	-

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arrears_utility_1	15.075	32.613	-	-	-	-

Normalised contrib. * explained variance

Indicators	Weights	Normalised weights
low_income	0.09	0.145
keep_adeq_warm	0.115	0.185
nutrition	0.066	0.106
sufficiency	0.056	0.091
o_burden	0.21	0.339
arrears_utility	0.083	0.134

Constructing the Eligibility Index (EI) via MCA

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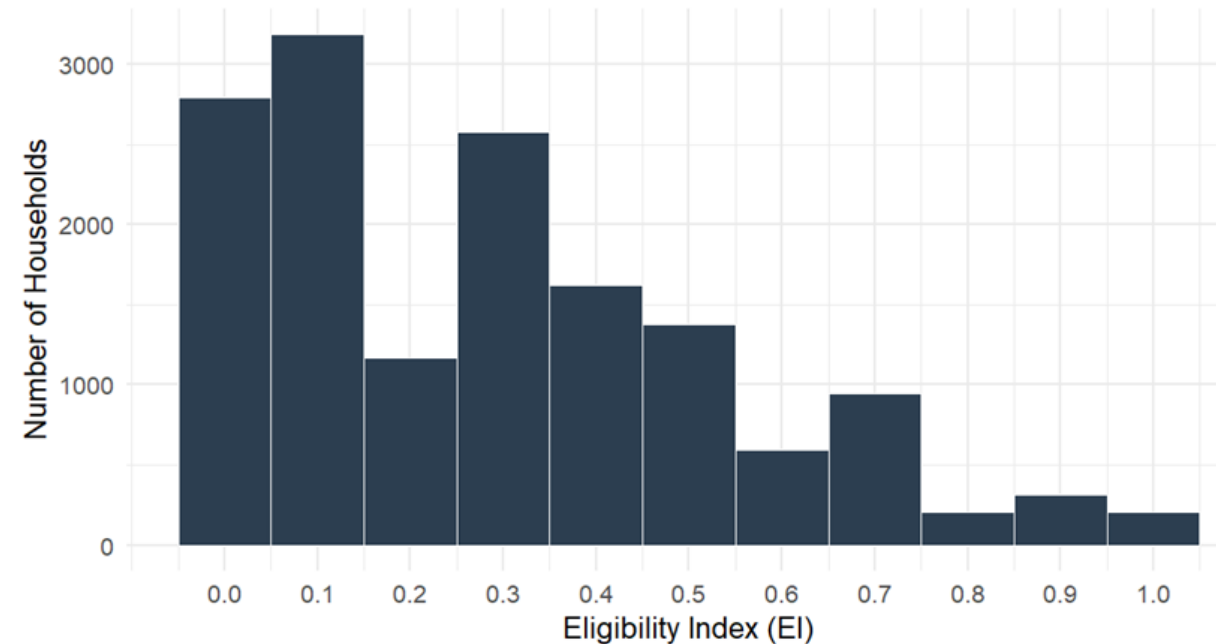
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$$EI = 0.339 \times x_{o_burden} + 0.185 * x_{keep_adeq_warm} + 0.145 \times x_{low_income} + 0.134 \times x_{arrears_utility} + 0.106 \times x_{nutrition} + 0.091 \times x_{sufficiency}$$

The EI scores range between 0 and 1, where higher scores indicate greater vulnerability.

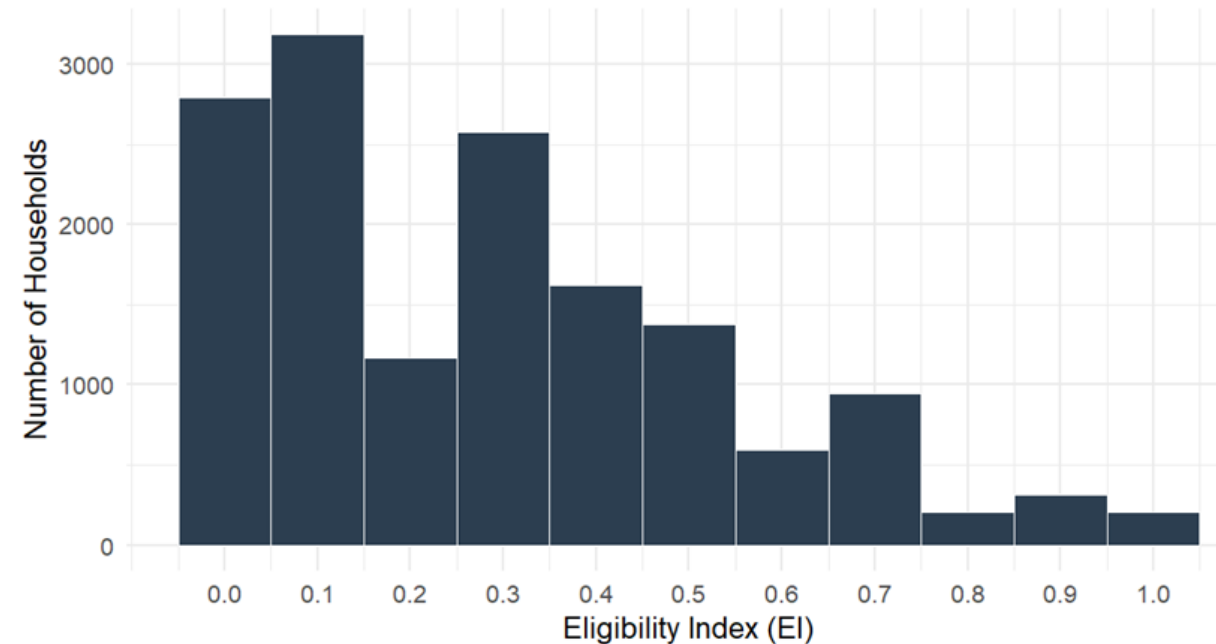
Reviewing index distribution & vulnerability patterns

EI Distribution Across Households with At Least One Inefficiency Indicator

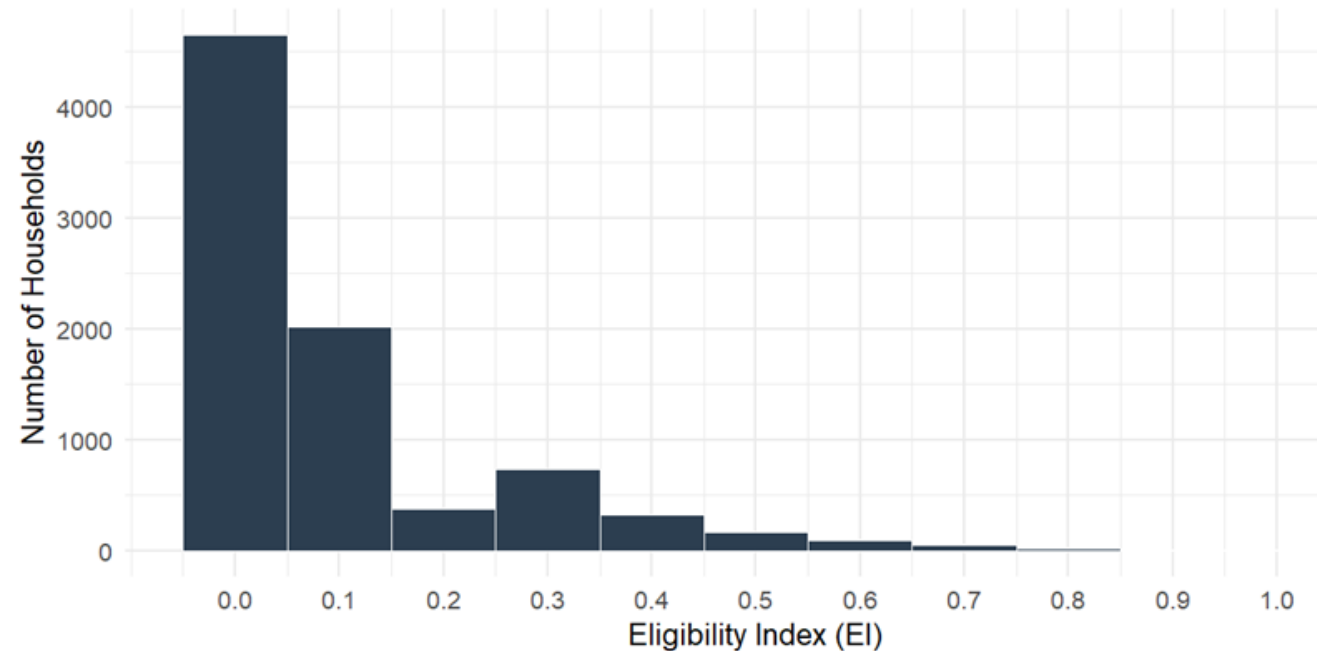


Reviewing index distribution & vulnerability patterns

El Distribution Across Households with At Least One Inefficiency Indicator



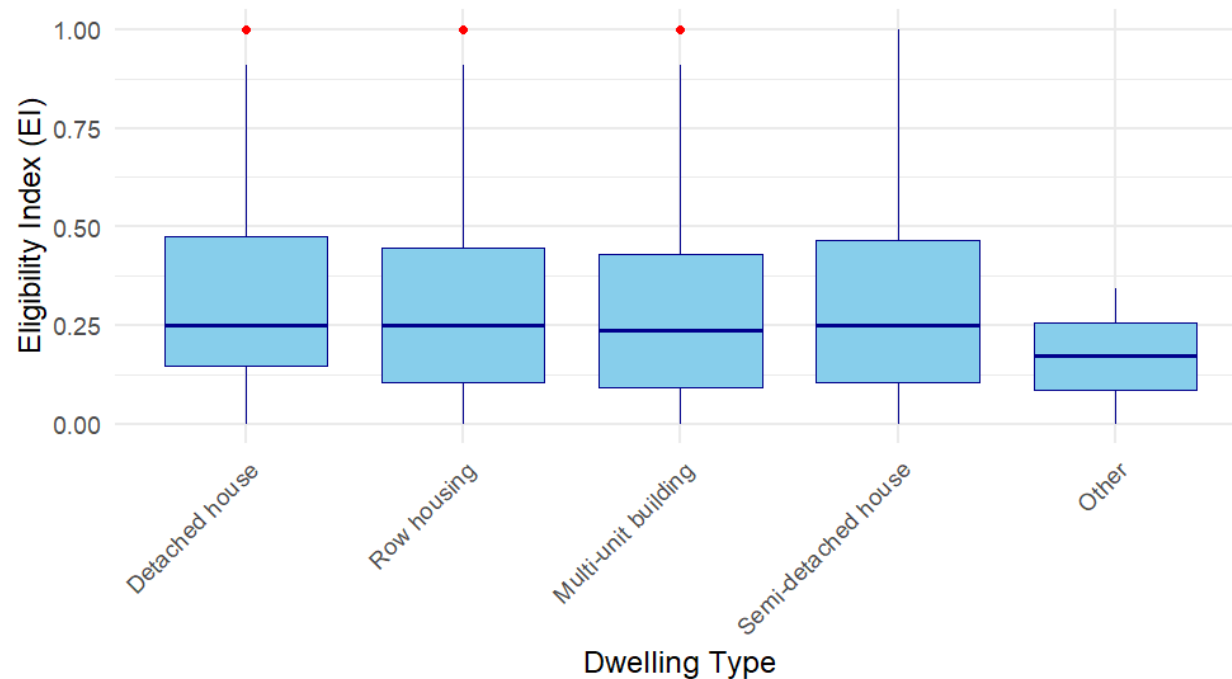
El Distribution Across Households without Inefficiency Problems



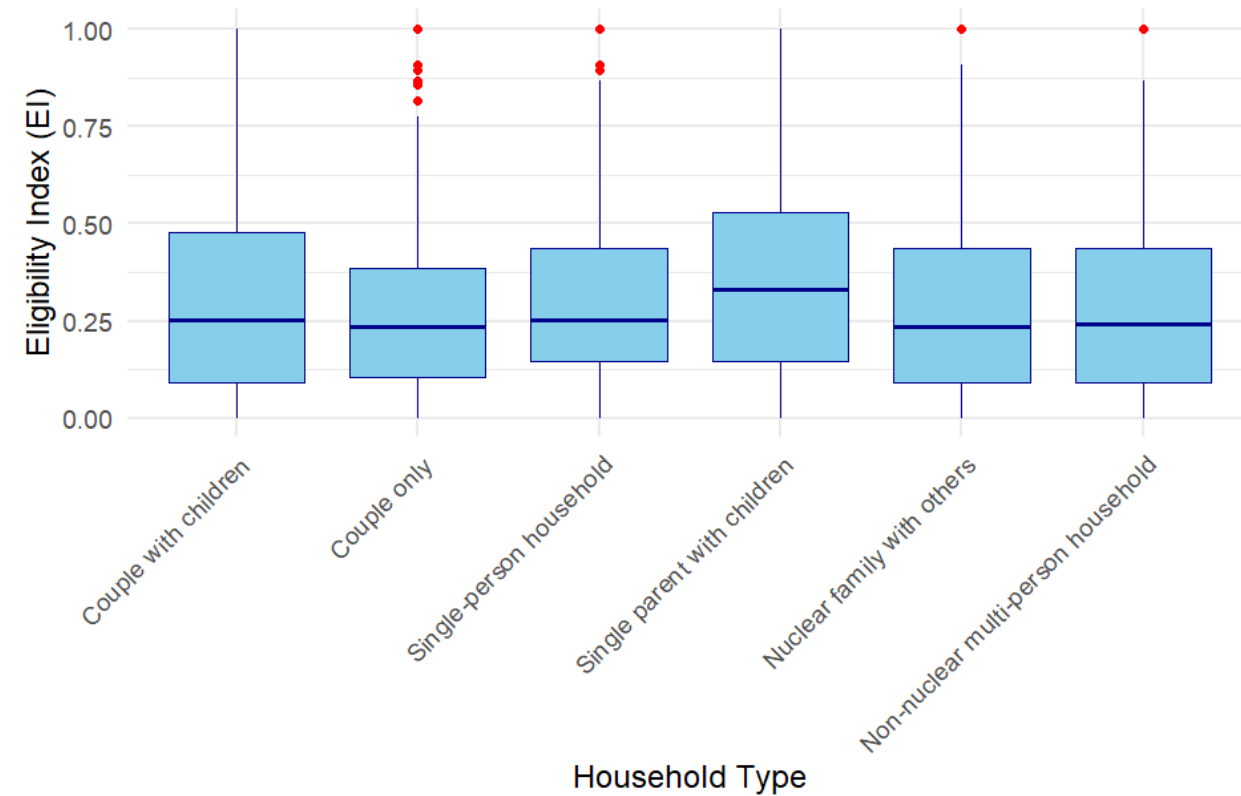
Inefficiency and financial difficulty often emerge together.

Reviewing index distribution & vulnerability patterns

The Distribution of EI Scores Across Different Dwelling Types

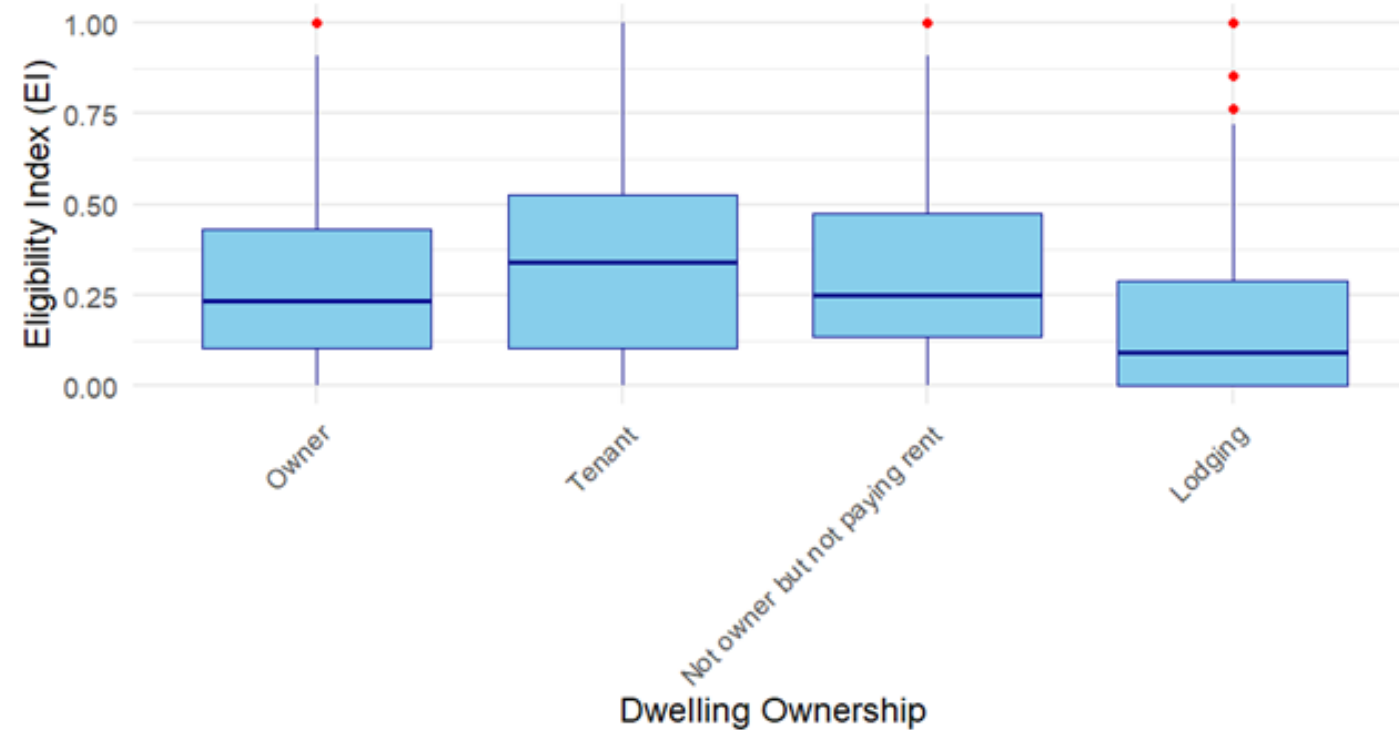


The Distribution of EI Scores Across Different Household Types



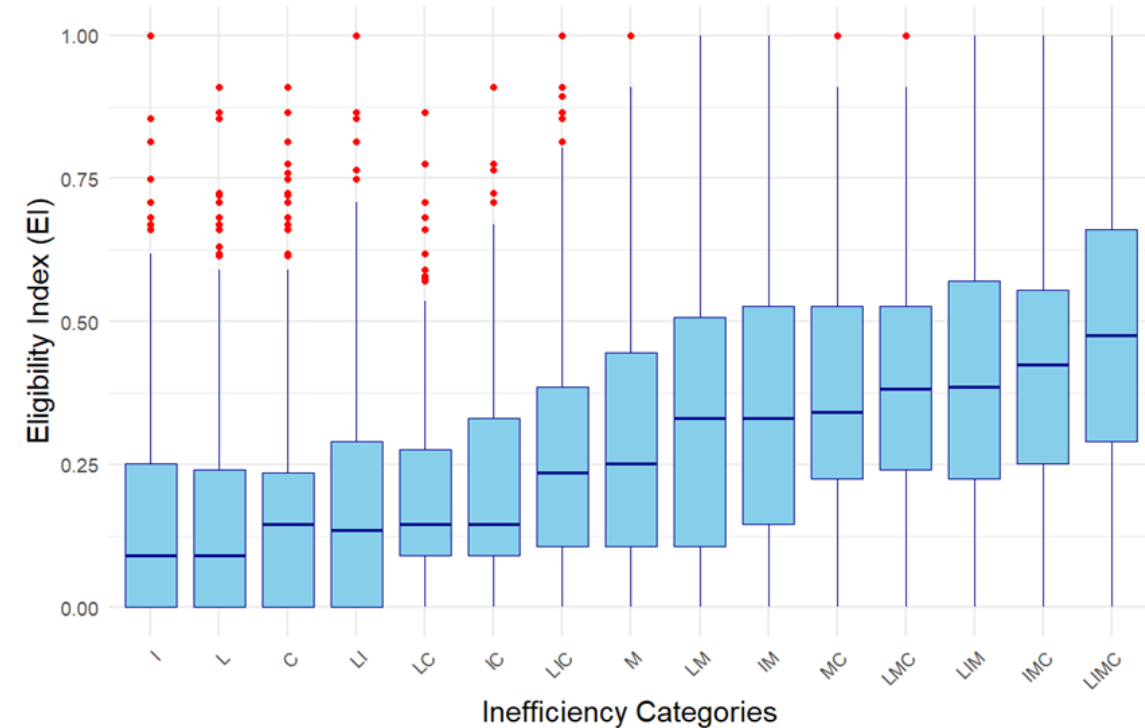
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The Distribution of EI Scores Across Different Dwelling Ownership Status



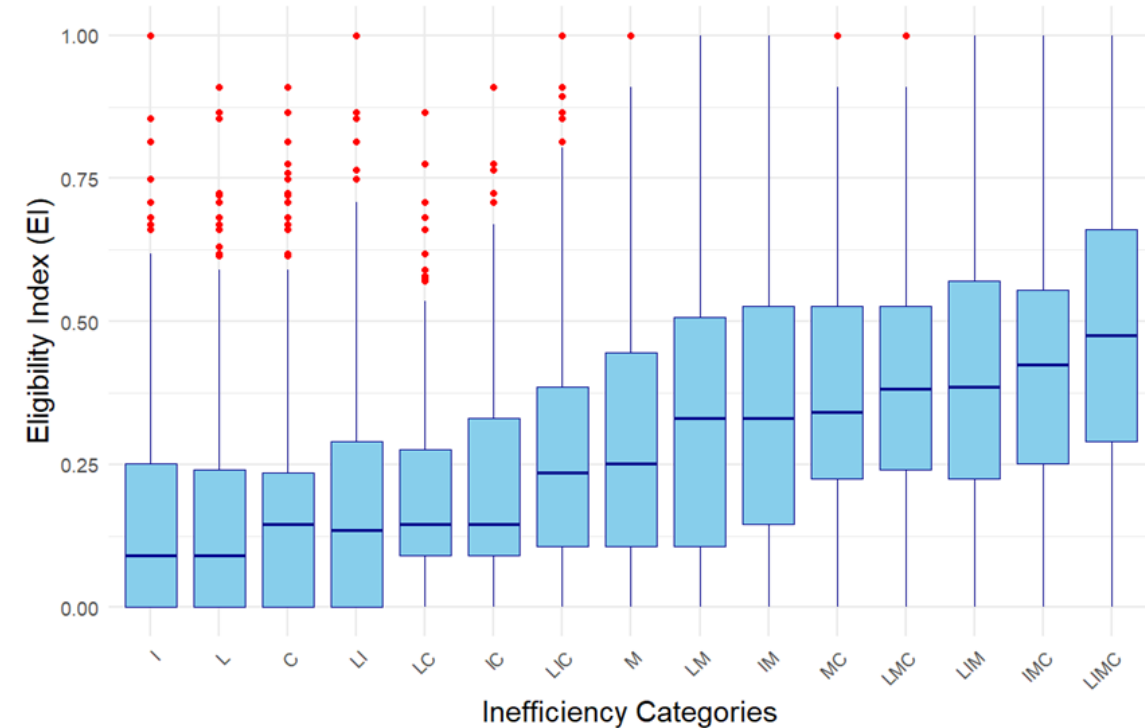
Reviewing index distribution & vulnerability patterns

Boxplot of distribution of EI Scores across these categories

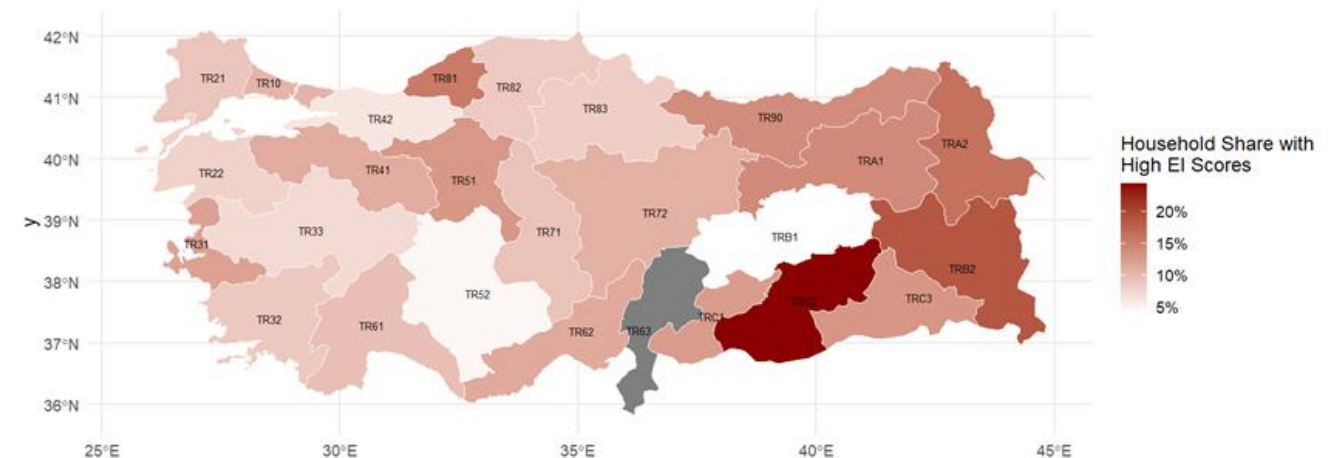


Reviewing index distribution & vulnerability patterns

Boxplot of distribution of EI Scores across these categories



Household Share with High EI Scores (0.6–1.0) across the NUTS2 Regions



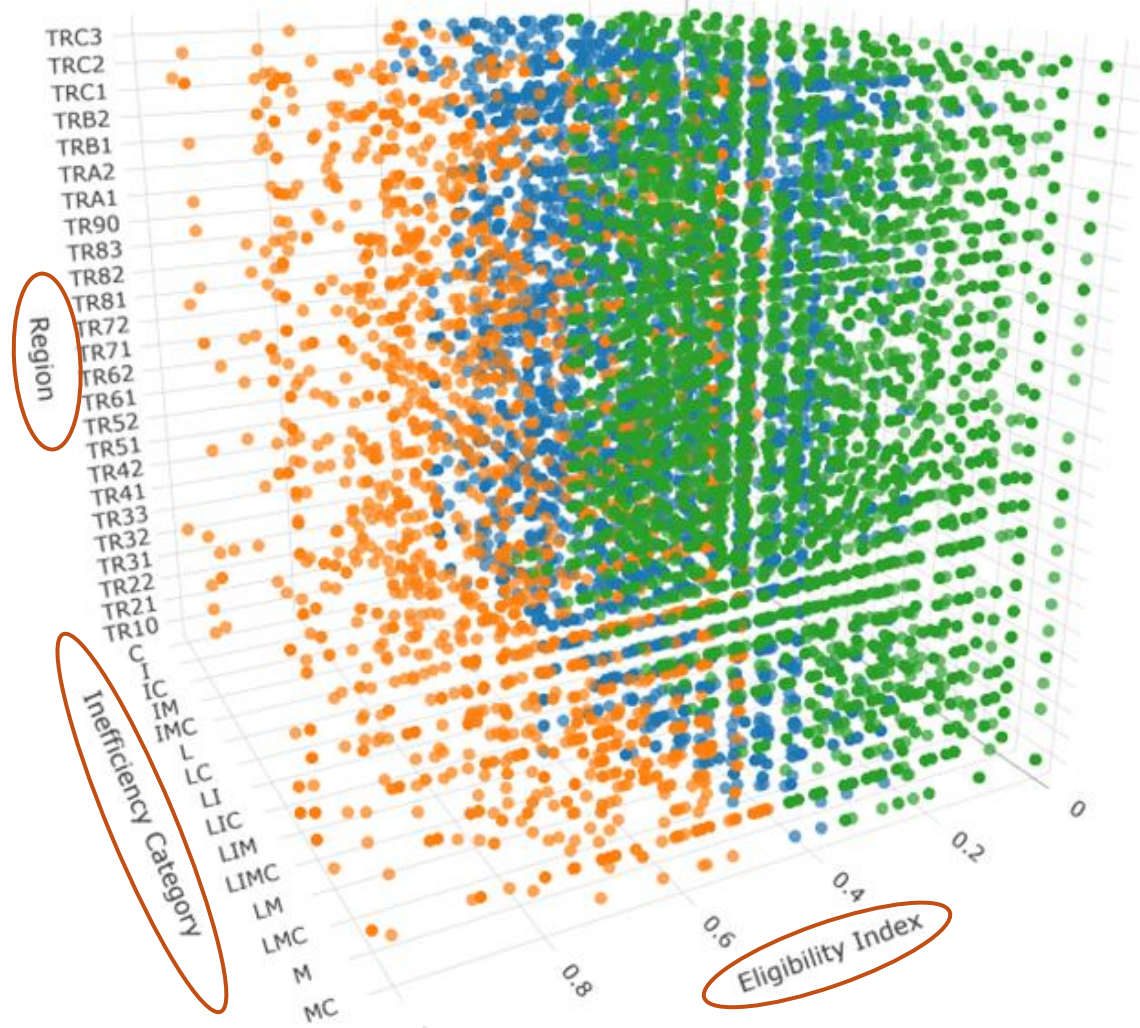
Clustering household

Kprototypes clustering

(Mix type clustering algorithm)

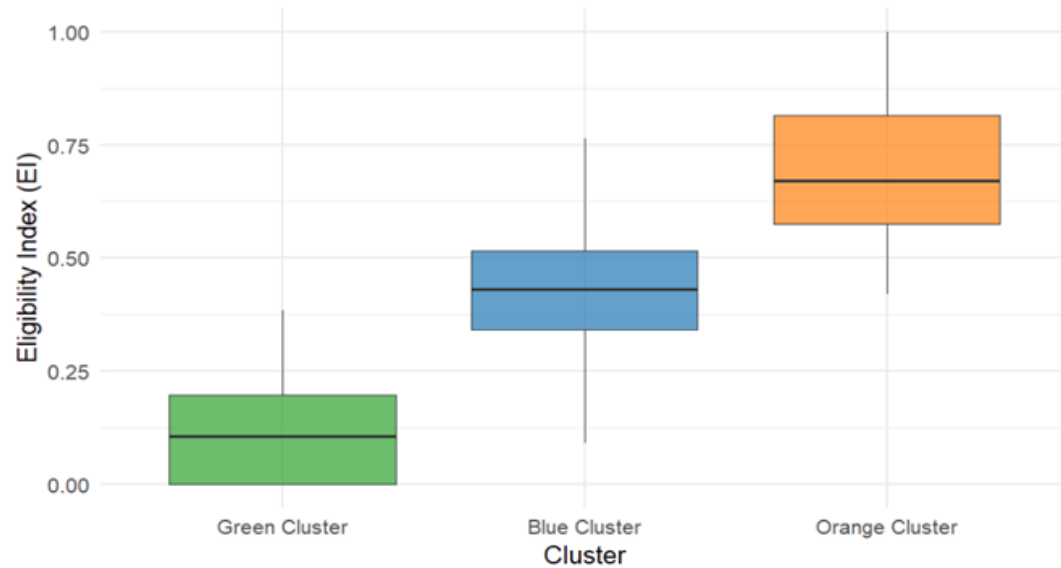
- EI scores
- Inefficiency Categories
- Region

3D Cluster Visualization



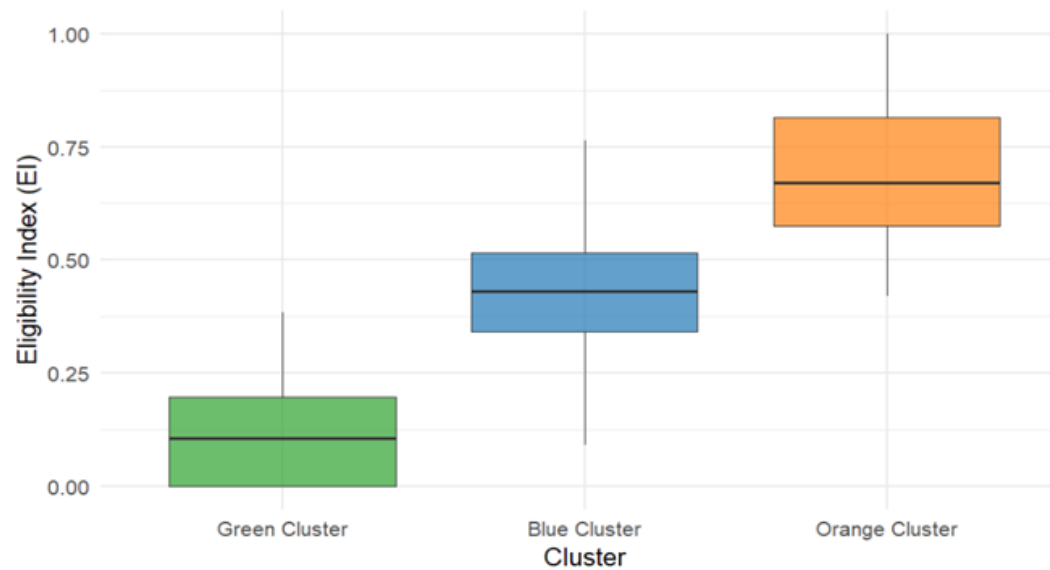
Clustering households

Distribution of EI by Cluster

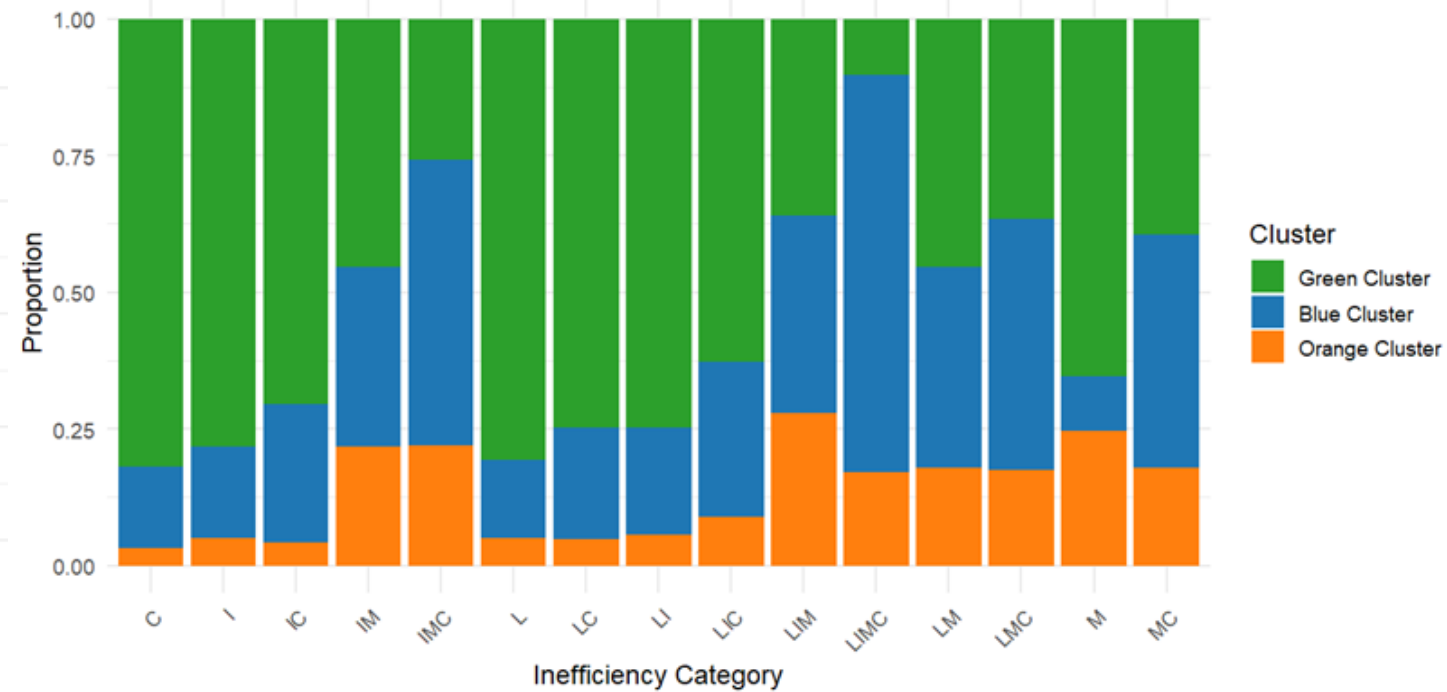


Clustering households

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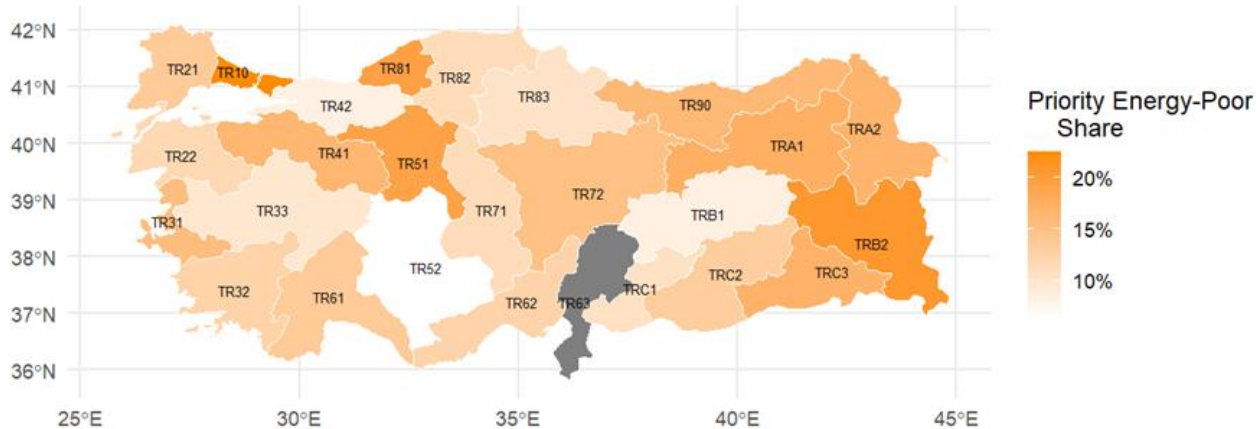


Distribution of Inefficiency Categories by Cluster

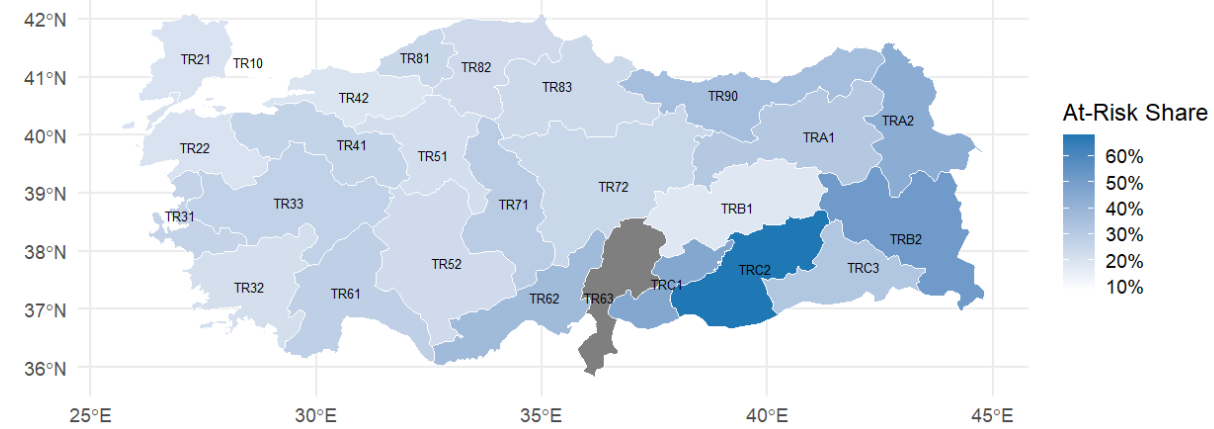


Labelling clusters & identifying tailored intervention strategies

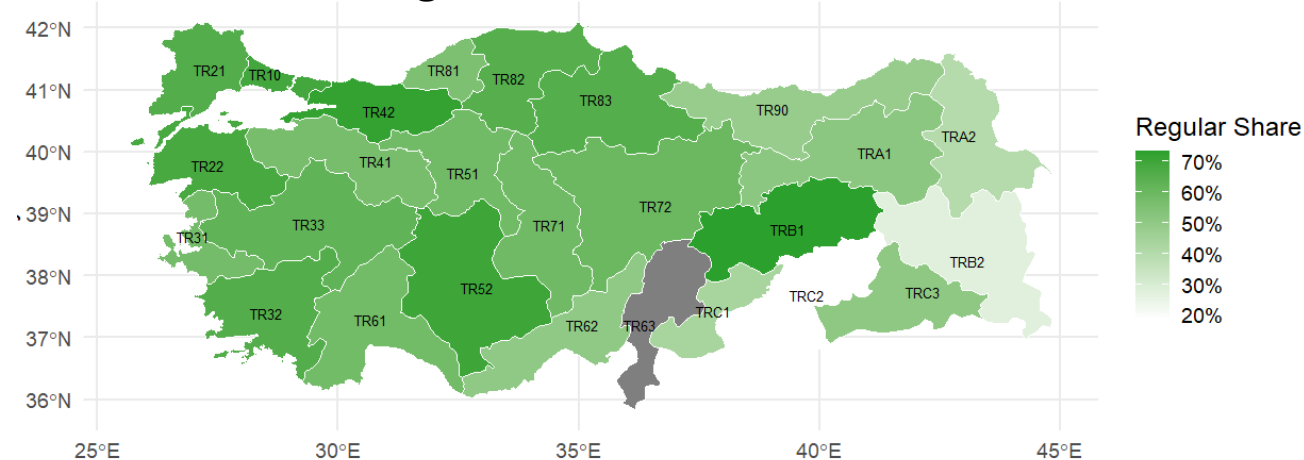
Priority Energy-Poor Households Distribution



At-Risk Households Distribution



Regular Households Distribution



Labelling clusters & identifying tailored intervention strategies

The clustering results reveals a **conceptually aligned segmentation** and highlight the need for **differentiated policy responses**.

Priority Energy-Poor households (15%, ~2.25 million Households)

- Exhibit the highest eligibility scores and the most complex inefficiency profiles.
- **Require immediate and comprehensive interventions.**
- **Should receive the highest level of support under an EEOS.**

At-Risk households (30%, ~4.5 million Households)

- Show moderate vulnerability and mixed inefficiency patterns.
- **Would benefit from preventive, targeted EEOS measures before their conditions worsen.**

Regular households (55%, ~8.25 million Households)

- Are less vulnerable but still experience inefficiency problems.
- **Suitable for co-financing approaches such as low-interest loans or credit-based programs to encourage household contribution and promote cost-effective upgrades.**

Conclusion

This study provides the first comprehensive and data-informed energy poverty targeting framework for a potential EEOS in Türkiye.

The framework identifies households that are both vulnerable and technically eligible, enabling more effective and equitable interventions.

Spatial disparities reveal that energy poor households is concentrated in eastern and southeastern Türkiye, requiring regional policy tailoring.

In Istanbul, the absence of At-Risk households and the dominance of both Priority and Regular groups indicate deep social inequality.

The SILC dataset lacks key variables such as appliance efficiency, energy expenditures, and heating fuel type, and only provides regional data at a broad level, limiting the ability to perform precise, household-level analysis and develop well-targeted interventions.



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cin16@itu.edu.tr