Multidimensional energy poverty in Jordan between 2009 and 2018: Progress and possible policy interventions

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This study examined energy poverty in Jordan. A modified multidimensional energy poverty index (MEPI) was used to measure the scope and change in energy poverty based on two demographic and health surveys for 2009 and 2018. The MEPI is calculated at the national, regional, urban/rural, and wealth index levels. The results show that energy poverty increased slightly between 2009 and 2018. However, results indicate that Jordanian households deal with a moderate level of energy poverty. On a different level, most of the governorates show increased energy poverty, while two remain constant and one shows a decrease. The results demonstrate that differences based on urban/rural residences are not significant, whereas different levels of wealth index show a significant change throughout the study period. The findings introduce energy poverty to policymakers, recommending that further studies be conducted in Jordan to understand the socioeconomic determinants of energy poverty, as well as the health impacts and financial burdens that affect Jordanian households.

Keywords:
energy poverty, multidimensional energy poverty, MEPI, Jordan, sustainable development

Introduction and literature review

Energy poverty is an issue faced by modern society. Millions of people are affected by energy poverty, even if the context of the causes and consequences are different (Bouzarovski 2018, Szép et al. 2022). It arises when a household struggles to achieve "adequate levels" of necessary energy services in the home, including heating, cooling, lighting, and appliances (Thomson et al. 2017). A combination of three factors causes energy poverty: low income, high energy prices, and poor building quality (Bouzarovski 2014). There is still a debate among researchers regarding the definition

of energy poverty, differences between energy and fuel poverty, and approach used to measure those issues.

Moreover, these issues have become extensively recognised as societal challenges among academics, practitioners, and policymakers (Bouzarovski–Petrova 2015). Efforts to measure fuel poverty in the Middle East are still limited (Belaïd 2022). There is limited coverage of energy poverty in middle-income countries (Urquiza et al. 2019); Jordan is not an exception as an upper-middle-income country, and fuel poverty and energy poverty are both recognised in the literature. However, the latter is being used more frequently on the European scale (Thomson et al. 2017). González-Eguino (2015) argued that studies focusing on energy poverty in developing countries refer to the problem of energy access, whereas the same features are being studied in more prosperous countries as fuel poverty. In the same context, Bouzarovski–Petrova (2015) indicated that fuel poverty is more related to the "developed world", while energy poverty reflects the situation of the developing ones. Using the Capabilities Approach, fuel poverty was widely used in the United Kingdom for the first time and defined in the earliest studies as "the inability to provide warmth at home" (Bradshaw–Hutton 1983). Boardman (1991) later provided a more specific definition as "the inability to afford adequate warmth because of the inefficiency of the home" and added that an energy-poor household is when more than 10% of income is spent on energy by a householder to achieve comfortable temperatures. Moore (2012) raised the question of the relativity of fuel poverty because poverty has a relative definition. Setting a threshold that can change with time can be more accurate than using an absolute threshold (such as 10% income). In later years, fuel poverty was linked with subjective well-being and how poverty can impact it, especially with the release of the annual World Happiness Report by the United Nations. Issues such as productivity, healthcare, education, employment, and energy-related tariffs' "higher prices can lead to fuel poverty' can be associated with subjective well-being (Awaworyi Churchill et al. 2020).

Energy poverty is a "young field of science" (Guevara et al. 2022). The methods, concepts, and approaches used to understand this phenomenon are evolving. Defining energy poverty can vary depending on the case and metrics used to measure it. According to Rademaekers et al. (2016), there are two energy poverty scenarios. The first is when energy expenditure consumes a high proportion of income, and the second is when a household cannot afford sufficient energy expenditure. Both concepts of poverty can be intertwined, and examining energy poverty can provide insights into fuel poverty in return. Day et al. (2016) proposed a definition for energy poverty which states that "an inability to realise essential capabilities as a direct or indirect result of insufficient access to affordable, reliable, and safe energy services, and taking into account available reasonable alternative means of realising these capabilities". Thomson et al. (2019) defined energy poverty as "when a household is incapable of securing a degree of domestic energy services". According to this

definition, studying energy poverty should focus not only on heating, but also on cooling spaces. More frequent and intense heat waves can exert greater pressure on human life.

In developed countries, the problem is represented by issues related to energy affordability, season-related mortalities, and technological infrastructure of the household. In contrast, the main issues studied in developing countries are the modern energy service supply, unfavourable living conditions, limited economic opportunities, and health problems (Guevara et al. 2022, Samarakoon 2019). Measuring energy poverty remains part of the debate among scholars. Sovacool (2012) identifies four obstacles that can hinder energy poverty alleviation: technical, economic, political, and social. The author argues that all the above obstacles need to be addressed and solving one issue will not change the energy poverty status. Moreover, the author claims that governments should shift their focus from technical solutions to social, political, and cultural dimensions. Creutzfeldt et al. (2020) state that a lack of a unified definition, not being able to figure out who is responsible for energy poverty, and no agreed indicators to measure the issue can be obstacles to solving it.

Measuring energy poverty can be a complex task; it varies depending on the time and place (Siksnelyte-Butkiene et al. 2021). According to the European Parliament (2016), there are three methods of measurement. First is the direct measurement of energy services such as heating achieved compared to a standard. Second is the expenditure approach that measures the ratio of household income to energy expenditure against absolute and relative thresholds. Third is the consensual approach, in which individuals report their ability to achieve particular necessities.

The methods used to study the characteristics and extent of energy poverty at different levels have been growing steadily in terms of both quantity and complexity. Nevertheless, there is no agreement favouring a particular measurement approach over others (Herrero 2017), and perhaps the household level is the most important.

Adding to the previous debate on the measurement of energy poverty, approaches to measurement can take objective, subjective, and composite forms (Kelly et al. 2020). The objective approach is based on a measurable criterion. One example is the income/expenditure indicators, such as the 10% indicator discussed above. Low income/high expenditure energy poverty studies are shown in earlier studies by Hills (2012). The subjective approach is based on a household's self-assessment of living conditions. The researcher using this indicator asks household questions related to the ability to heat the home adequately or pay utility bills on time without arrears. The last approach considers the multidimensional nature of energy poverty. It measures energy poverty using a set of sub-indicators. An example of this approach is the multidimensional poverty index used in this study.

Economic privation, housing quality, type of tenure, and energy access are highlighted by Jessel et al. (2019) as factors that determine energy poverty as a chronic

phenomenon. Several tools have been used to combat energy poverty. "Economic subsidies, social tariffs on energy prices, social bonuses that limit the impact of the price on bills and houses' energy efficiency improvement" are examples of the tools mentioned (Vurro et al. 2022).

In their paper, Nussbaumer et al. (2012) reviewed and discussed the adequacy and applicability of the instruments used to measure energy poverty. Again, considering this, during that time, most of the studies focused on linking energy issues to the Millennium Development Goals (MDGs). The researchers criticised that previous studies focused mainly on people's ability to access energy. They proposed a new index that focuses on deprivation of access to modern energy services, called the multidimensional energy poverty index (MEPI)". The MEPI is derived from "the general multidimensional poverty index" (Alkire–Foster 2011, Alkire–Santos, 2010). It quantifies energy access and deprivation. The model assumes that "a person is energy poor if the combination of the deprivations faced exceeds a pre-defined threshold". The model considers many dimensions such as cooking, lighting, services provided through household appliances, entertainment/education, and communication.

Since energy poverty is multidimensional, it is more appropriate to measure it based on a composite indicator (Sadath–Acharya 2017); the researchers used an MEPI to assess the intensity and extent of energy poverty for Indian households. The dimensions used were lighting, cooking, and other additional measures. The results indicated extensive energy poverty in India, particularly in rural areas.

Adusah-Poku–Takeuchi (2019) examined energy poverty in Ghana based on the fifth and sixth Ghana Living Standards Survey datasets, measuring the progress in eradicating energy poverty, the gap between urban and rural areas, and a comparison based on regional differences. They used an MEPI that included five dimensions: cooking, lighting, services represented by means of appliances ownership, entertainment/education, and communication. The outcomes revealed that, between 2006-2013 in Ghana, energy poverty decreased by approximately 6%. Moreover, despite this change, they concluded that the rates of energy poverty are still high and regional differences are still present. They emphasised the importance of enhancing modern energy services.

Mendoza et al. (2019) utilised an MEPI to measure energy poverty in 17 regions and 81 provinces. Using seven indicators, the researchers included two additional indicators: space cooling and personal computer ownership. This study measured the characteristics of regional energy poverty and its intensity between 2011-2016 using data generated from the 2015 Household Energy Consumption Survey. The results showed that energy poverty in the Philippines is slightly lower than in other Asian countries, indicating regional differences. Additionally, the results implied that the applied policies were more likely to reduce energy poverty, while stressing space for improvement in the future.

Pablo et al. (2019) studied energy poverty in Ecuador. The study constructed an MEPI using inputs from the European Union Energy Poverty Observatory (EPOV), which included three indicators: electricity bill payment delay, disproportionate expenditure, and hidden energy poverty, and a fourth indicator based on Boardman (1991) of 10%. The results indicated that measuring energy poverty can be difficult on a large scale. The use of pre-defined methods could also be limited, particularly because there was no precise definition of the phenomenon. In conclusion, Ecuadorian households may have suffered from energy poverty in both urban and rural areas but more severely in rural areas.

Sharma et al. (2019) examined the socioeconomic elements of energy poverty in India, taking Mumbai City as a case study. A field survey was distributed to 1000 households, with each 250 representing a different income group. The analysis used the consumption expenditure approach. The results showed that electricity consumption can be affected by monthly expenditure, house size, and education. This study suggests that improving efficiency and energy policies can help achieve sustainable energy for Indian households by implying that reducing energy poverty can be more complex than income poverty.

Recent studies such as Abbas et al. (2020) examined multidimensional energy poverty and provide more details on the socioeconomic factors that may affect the situation of households that suffer from such issues. This study used a multidimensional energy poverty index to examine energy poverty in six South Asian countries. Researchers have also suggested that policies that aim to improve the socioeconomic status of households will mitigate the occurrence of MEPI.

Castaño-Rosa–Okushima (2021) used a multidimensional energy index to study energy poverty in Japan. The model covered energy affordability and accessibility issues alongside the risks imposed by new technology on energy poverty. The results showed that the northern parts of Japan suffer from energy poverty in the winter season and the southern parts in the summer season.

Using data from the Household Expenditure and Income Survey in Jordan and Egypt, Belaïd (2022) studied fuel poverty in both countries. This study used a low income/high expenditure approach. The results indicated that fuel poverty in Jordan is higher than that in Egypt. Moreover, the results suggested that reducing inequality, access to education, and enhanced economic conditions are essential for alleviating fuel poverty in both countries.

This study builds on the current literature on energy poverty by utilising an MEPI to measure energy poverty in Jordan. Energy security, the dramatic increase in energy consumption, population growth, and the availability of renewable energy resources are among the main factors affecting energy development plans in Jordan (Jaber 2022). This study provides empirical results on energy poverty in Jordan. Moreover, it provides insights into the change in energy poverty during different periods.

Furthermore, this study contributes to the literature on energy poverty, particularly in the Middle East. It also aims to introduce energy poverty in the Jordanian context, allowing policymakers to realise it. Finally, this study can be a starting point for further research to better understand energy poverty concerning other technological and social problems.

Methodology and data

Data

The data used to estimate the MEPI for Jordan were based on the Demographic and Health Survey (DHS) conducted by the Jordanian Department of Statistics (Department of Statistics (DOS), ICF 2019). The survey was funded by the United States Agency for International Development (USAID) through the DHS Program (The DHS Program 2021). The DHS has been conducted in many countries worldwide. The data collected are related to households' health, fertility, and socioeconomic profiles, providing detailed information on housing characteristics, household possessions, and members. These data include many indicators of multidimensional energy poverty (Abbas et al. 2020). The data collected through the survey are nationally representative. The datasets are available in raw form (survey outputs), which provides a great advantage for treating the data and test indicators at the sub-national level. For this study, data from 2009 and 2017–2018 surveys were collected, cleaned, and used to calculate the MEPI in Jordan.

Table 1

Dimensions, indicators, and deprivation cutoff, including weights

Dimension	Indicator (weight)	Variable (weight)	Deprivation cutoff (Poor if…)
Cooking	Modern cooking fuel (0.2)	Type of cooking fuel (0.2)	Use any fuel beside electricity, LPG, kerosene, natural gas, or biogas
	Indoor pollution (0.2)	The household has a separate room used as a kitchen (0.2)	False
Services provided by means of household appliances	Household appliances ownership (0. 15)	Has refrigerator (0.15)	False
Communication	Telecommunication means (0.15)	Has internet access at home (0.07)	False
		Has mobile telephone (0.08)	False
Entertainment	Entertainment devices (0.15)	Has computer (0.15)	False
Sustainable energy source	Solar heater (0.15)	Has a solar heater (0.15)	False

Source: Authors' estimation based on Nussbaumer et al. (2012).

Recreating Nussbaumer et al. (2012) and considering Jordan's context, this study estimates the MEPI using five indicators representing energy deprivation. These indicators are cooking, represented by access to modern cooking fuel and indoor air pollution (availability of a separate room used as a kitchen); household appliances; communication; entertainment/education tools; and sustainable energy sources. Unlike the original index, access to electricity through the lighting indicator was not included because Jordan has 100% electricity access. Moreover, the survey did not include information related to access to electricity. Table 1 lists the dimensions used to describe energy deprivation in detail.

Selected dimensions and variables

According to Nussbaumer et al. (2013, 2012), choosing variables should reflect the demand for household energy services. Nussbaum (2003) listed central human capabilities. The proposed list is open-ended, and its capabilities can be increased or decreased according to societal needs and changes. According to Sen (2004), a list of capabilities cannot be fixed or considered complete. Moreover, choosing capabilities depends on why we use them. Sen (2004) argued that the priorities of societies can differ.

In this study, several dimensions with assigned indicators were selected based on the Jordanian context. Cooking is one of the basic needs of any household to prepare meals, and energy is needed as heat. Moreover, cooking can take a significant amount of time to prepare food, especially for women. In addition, different types of stoves are used for cooking. To conclude, a household can be considered energy-deprived if the cooking fuel is not modern. In our case, modern fuels include LPG, kerosene, electricity, natural gas, and biogas. Indoor pollution is a significant concern for households. A household with no separate room for the kitchen may suffer from poor indoor air quality and can be considered deprived of this dimension.

The ownership of household appliances is essential. Modern houses contain refrigerators. Communication and entertainment are vital for modern houses. These tools can be used for work and learning purposes apart from communication. The COVID-19 pandemic has taught us that a household lacking modern means of communication is considered deprived.

Finally, a solar heater was used to represent the sustainable energy. Jordan has more than 360 sunny days, which ensures that solar energy is abundant and available for households that use solar panels or heaters for water.

Measurement of the MEPI

The MEPI allows for the measurement of the severity and extent of energy poverty. For population n in individuals and dimension d, $Y=y_{ij}$ represents the achievement matrix of $n \times d$ of an individual i across variables j. $y_{ij} \geq 0$ represents the degree to which an individual's achievements $i = 1,2,3 \ldots n$ on variables $j = 1,2,3 \ldots d$. Every

row represents the achievements of individual *i* in various variables *j*, whereas the column vector represents the distributive achievements in variable *j* among individuals.

The MEPI recognises the unequal "importance" of the relevant selected indicators (Nussbaumer et al. 2012). Variable *j* is weighted according to the following formula:

$$\sum_{j-1}^{d} wj = 1 \ldots. \quad (1)$$

where w represents the weight.

Variable z_j is defined as the deprivation cutoff in variable *j*, which is used to define all individuals deprived of any variable. The deprivation matrix is defined as $g = [g_{ij}]$, $g_{ij} = w_j$ when $y_{ij} < z_j$ and $g_{ij} = 0$ when $y_{ij} \geq z_j$. Referring to Table 1, while the elements of the achievement matrix are not numeric in nature, the cutoff is defined as a set of conditions to be met. When a person *i* is deprived of variable *j*, the entry *ij* of the matrix is equivalent to the variable weight w_j, and zero when the person is not deprived.

To sum up all the deprivation counts suffered by a person, a column vector c is constructed across the *i* entries.

$$ci = \sum_{j}^{d} = 1gij\ldots. \quad (2)$$

To define a person as "multidimensionally energy poor", the cutoff $k > 0$ is defined. This cut-off is applied across the column vectors. When $c_i > k$, a person is considered energy-poor. Thus, $c_i(k)$ equals zero when $c_i \leq$ k and equals c_i when $c_i > k$. In short, $c(k)$ is the censored vector of the deprivation counts. Defining the value of k depends on the level of deprivation cutoff of interest. According to Nussbaumer et al. (2012), there are three identified deprivation cutoffs: severe (1/2), acute (1/3), and vulnerable (1/5). This study applies an acute poverty cutoff to determine multidimensionally energy-poor households. Accordingly, a cutoff $k \geq 0.3$ is used in the process. This implies that a person can be considered energy-poor if deprived in one or two dimensions or does not benefit from different energy services supplied by electricity.

The incidence of energy poverty is represented by:

$$H = \text{q} / \text{n}.\ldots \quad (3)$$

where H is the headcount ratio, representing the proportion of people considered energy poor, q is the number of multidimensionally energy-poor people (where $ci > k$), and n is the total population.

The intensity of multidimensional energy poverty "A" is calculated according to the following equation:

$$A = \sum_{i=1}^{n} Ci(k)/q \ldots. \quad (4)$$

where A is the intensity, $Ci(k)$ is the deprivation count of the multidimensional energy poor, and q is the number of multidimensionally energy-poor people.

Finally, to estimate the MEPI, information based on the incidence and intensity of energy poverty can be formulated as follows:

$$\text{MEPI} = H \times A \ldots. \quad (5)$$

Results and discussion

An MEPI was estimated for Jordan in 2009 and 2018. Moreover, the index was estimated for the governorates, wealth index, and urban/rural levels. Figures 1 shows the spatial distribution of the MEPI at the governorate level for 2009 and 2018, respectively. The results show that the MEPI in Jordan was 0.20 in 2009 and 0.21 in 2018. The results reveal that the MEPI has increased by 0.01 during nine years, which is the period between the two surveys. However, if MEPI<0.6, households suffer from moderate energy poverty (Nussbaumer et al. 2012).

Nonetheless, energy poverty, with an average of 0.20 over nine years means that the issue is persistent and not truly realised. Ignoring energy poverty can lead to unfavourable consequences in the future. Energy poverty is not only connected to social welfare, but also other factors such as the socioeconomic situation of households and environmental impacts such as climate change. Table 2 lists more details regarding the values of the headcount ratio, intensity of energy poverty, and the MEPI.

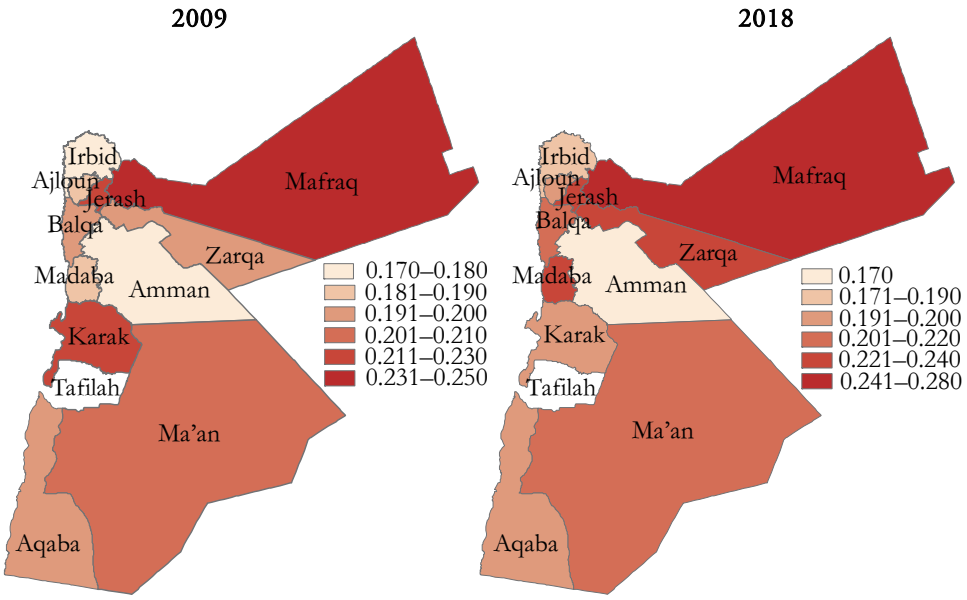
Table 2

Detailed results for Jordan, governorates, and the urban/rural levels

Comparison level/year	Headcount ratio (*H*)		Intensity of energy poverty (*A*)		MEPI	
	2009	2018	2009	2018	2009	2018
Jordan	0.53	0.60	0.38	0.36	0.20	0.21
Mafraq	0.65	0.78	0.38	0.36	0.25	0.28
Zarqa	0.52	0.63	0.39	0.39	0.20	0.24
Jerash	0.56	0.71	0.38	0.32	0.22	0.23
Madaba	0.51	0.62	0.38	0.38	0.19	0.23
Ma'an	0.54	0.61	0.39	0.36	0.21	0.22
Balqa	0.51	0.55	0.40	0.38	0.20	0.21
Tafila	0.52	0.56	0.38	0.37	0.19	0.21
Ajloun	0.49	0.62	0.38	0.32	0.19	0.20
Karak	0.60	0.56	0.39	0.37	0.23	0.20
Aqaba	0.51	0.56	0.39	0.35	0.20	0.20
Irbid	0.47	0.56	0.38	0.34	0.18	0.19
Amman	0.44	0.46	0.38	0.37	0.17	0.17
Urban	0.48	0.59	0.38	0.36	0.18	0.21
Rural	0.62	0.64	0.38	0.36	0.24	0.23

Figure 1

Results for the MEPI in Jordan



Amman and Irbid are the least multidimensionally energy-poor regions in both years, with a MEPI value of 0.17 and 0.18, respectively. Mafraq, a governorate in the country's northern region, has the highest MEPI value of 0.25 and 0.28 in 2009 and 2018, respectively. The city of Mafraq accommodated the biggest refugee camp in the country, which was established after the civil war in Syria. The sudden increase in the number of inhabitants placed pressure on resources and opportunities in Jordan. Zarqa witnessed an increase in the MEPI of 0.04, whereas in Karak, the MEPI decreased by 0.03. It is worth noting that Amman is the densest governorate in the country; Figure 2 shows the population growth in Jordan from 2009 to 2018.

Regarding urban/rural residences, the results show that the energy poverty of urban residences increased by 0.03. However, rural residences show a decrease in energy poverty of 0.01. It is worth noting here that 0.98 of the population lives in urban areas, which means that an increase in energy poverty is not a good sign regarding development, among the other social circumstances of the urban areas. The results also show that the differences between urban and rural areas are not significant in terms of the availability of modern and sustainable energy.

Figure 2

Population in Jordan for the selected years (DOS 2020)

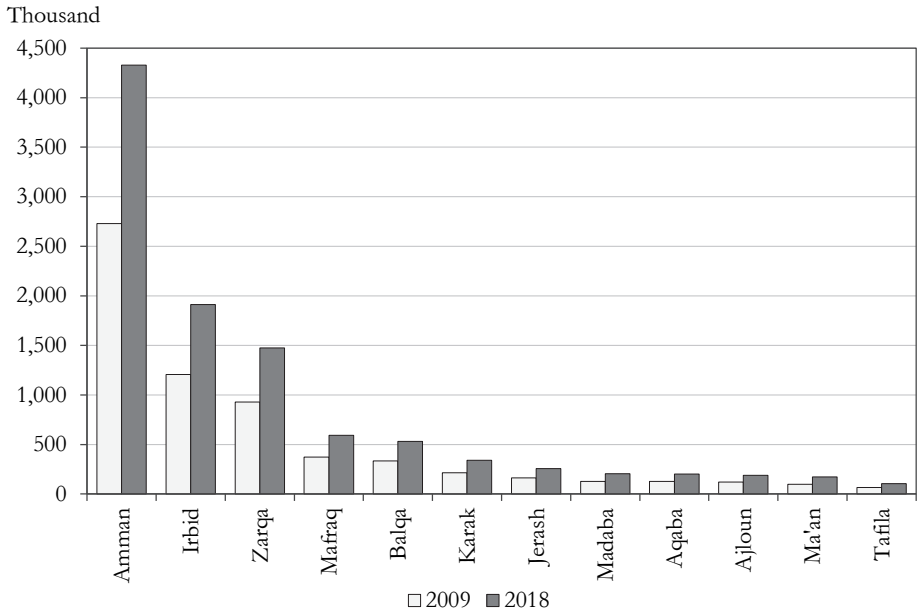


Figure 3 illustrates more information about the status of the MEPI in Jordanian governorates for the years of study. Some governorates showed a slight change in MEPI from 2009. Nine out of twelve showed an increase in MEPI from 2009 to 2018. In contrast, Amman and Aqaba showed no change between 2009 and 2018, whereas Karak slightly improved the MEPI within the study period.

Figure 4 illustrates the difference in the MEPI based on the wealth index. Overall, the MEPI changed over the study period. The poorest and poorer categories improved over time. The MEPI for the poorest category decreased from nearly 0.36 to nearly 0.25, while the poorer showed a lesser change. However, the situation for the other categories showed an increase in the MEPI. While an increase in the MEPI itself was not a good sign concerning households themselves, it was evident that the differences between the different categories decreased.

Figure 3

MEPI in Jordanian governorates

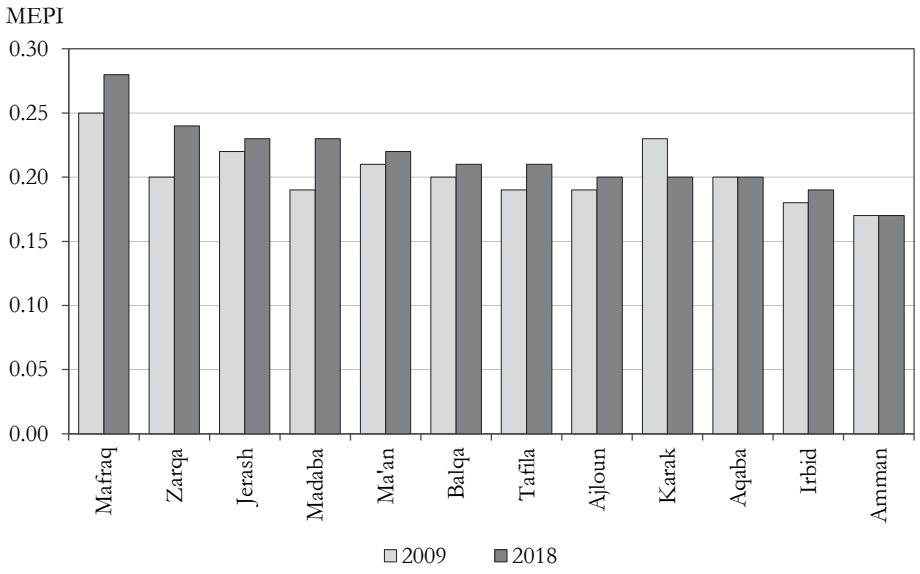
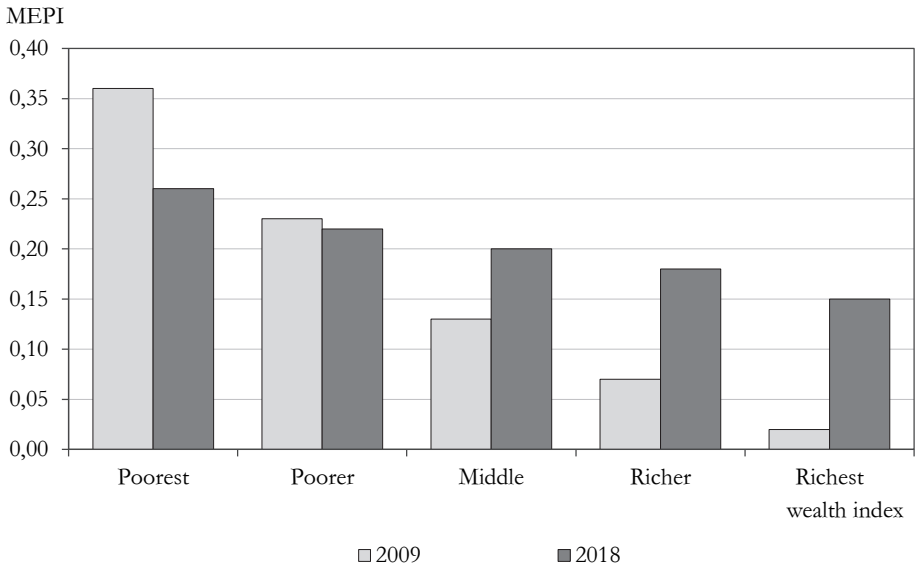


Figure 4

The MEPI based on the wealth index



Conclusions

This study utilised an MEPI to examine energy poverty in Jordan in 2009 and 2018. Despite the well-established literature on energy poverty, there is still a research gap on the situation and extent of energy poverty in the Middle East in general and in Jordan. The results revealed that the MEPI in Jordan slightly increased between 2009 and 2018, specifically, by 0.01. Considering these results, it can be concluded that Jordanian households suffer from moderate energy poverty. Furthermore, the results indicated that energy poverty may increase if not addressed at an early stage. The problem of energy poverty is linked to many other issues such as climate change, health, and social justice.

In addition, the spatial distribution of energy poverty was estimated. The results showed that disparities between the different governorates in Jordan are not high. However, nine governorates witnessed an increase in energy poverty, especially in Mafraq, a region that hosts the largest refugee camp in the country. Amman and Aqaba witnessed no change, while Karak's energy poverty decreased. Urban areas showed increased energy poverty, while rural areas showed the opposite. Finally, I estimated energy poverty based on the wealth index. The results showed variations between the two years of concern. Poor houses showed an improvement in energy poverty, signs of improvement in living conditions, and ownership of modern energy means. On the other hand, the rich showed signs of increased energy poverty, which requires more research efforts and shows a continuous decrease in inequalities between different social levels.

To further identify energy poverty in Jordan, the author suggests the following policy interventions.

1. The concept of energy poverty in the national energy plan was included by identifying the scope of energy poverty within the context of Jordan. The current Jordan Energy Strategy and Energy Efficiency Plan does not address energy poverty. On the contrary, it focuses only on energy efficiency, which is not the only determining factor of energy poverty.
2. The differences in residential energy consumption during different seasons were assessed to better understand the impacts of climate variations on energy consumption within households.
3. It is recommended to start collecting fuel/energy poverty data by adding more questions to the national surveys about utility bill arrears and coping with indoor ambient temperatures during the summer and winter. The MEPI lacks information on this because it tries to capture energy poverty through the lens of available energy services and does not consider other factors or dimensions.
4. It is recommended to broaden the programs launched by the government to support poor people in improving house efficiency by creating house renovation fund programs.

5. The results suggest a revision of current energy subsidy programs to benefit energy-poor households and increase the support to households that utilise solar energy for electricity generation.

The results prove that energy access does not necessarily mean that energy poverty is alleviated; however, achieving energy access can solve this issue. The problem of energy poverty is still not fully realised at the household and policymaker levels. The empirical results of this study shed light on the need to better understand the causes and effects of energy poverty on Jordanian households. Further studies are needed to understand the socioeconomic factors, health impacts, and financial burdens, or more precisely, the multidimensional impacts of energy poverty on Jordanian households.

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