COMPOSITE INDICATOR OF MULTIDIMENSIONAL ENERGY POVERTY AND ITS DETERMINANTS IN SOUTH AFRICA

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Abstract: Energy remains a major component of households' expenditures, which is also intricately linked to many Sustainable Development Goals (SDGs). Inadequate access to clean energy has been linked to some health problems, which disproportionately affect women and children. This paper analyzed the determinants of energy poverty in South Africa using the General Households Survey data of 2019 to 2021. The Alkire-Foster method of multidimensional poverty decomposition and Tobit regression model were used. The results showed that deprivation in access to electricity declined from 5.94% in 2019 to 4.51% in 2021, while heating with unclean energy increased 46.43% in 2019 to 49.67% in 2021. In the combined dataset, energy poverty incidence was highest in Western Cape (0.5281), while Northern Cape has the highest intensity (0.5965). Alkire-Foster multidimensional energy poverty indicator (MEPI) declined from 0.2183 in 2019 to 0.1814 in 2021. Black households, and farm households showed the highest deprivation with MEPI of 0.2250 and 0.3662 respectively in the combined data. The Tobit results showed that social grants, Western Cape province, black respondents, male headed households, tribal and farm areas residents had significantly higher MEPI. Also, increase in monthly income significantly reduced MEPI. It was concluded that although average MEPI in South Africa is generally low, attainment of the SDG on energy requires integration of programmes and interventions to promote clean energy access among black population, tribal and farm areas residents and those on social grants.

Keywords: Clean Energy, SDGs, Multidimensional Energy Poverty Indicator (MEPI), Alkire-Foster, South Africa

1. INTRODUCTION

Energy is an essential ingredient of economic growth and development [1]. The 21st Century is witnessing transformative changes in different business operations that can only be driven by access to adequate and sufficient energy [2]. Therefore, nations that are unable to efficiently meet up with their energy demands would forfeit significant dividends of globalization and may be forced to take the back seats in development, be it industrial, economic, social, or political [1]. The universal tone of energy supply debate is now changing towards adoption of environmentally benign technologies that can generate energies from some renewable resources [3]. This is a mitigative action to address climate change and some other pressing environmental problems that the world currently faces. Moreover, embracing renewable energy presents some social, economic, and environmental benefits. Besides its cost efficiency, renewable energy offers some inducement for employment opportunities' generation, improvement in people's welfare through access to cleaner air, increase in the array of energy products for consumers, environmental conservation, and sustainable development [4]. International energy policy makers are now emphasizing renewable and cleaner energy, as a global development initiative that will facilitate achievement of the seventh Sustainable Development Goal (SDG), which is also multifacetedly linked to some other SDGs [5,6].

In Sub-Saharan Africa (SSA), enhancement of access to clean energy is an initiative requiring more efforts based on the growing incidence of energy poverty [7]. This is a pertinent issue given that with about 50% of households in the world having access to electricity and about one-third cooking with energies from clean sources, SSA appears to be the most deprived region [8,9]. More importantly, about 770 million people globally lack access to electricity and majority of these people are from the SSA [10]. Domestically, energy constitutes an important component of households' expenditures [8]. However, the nature of energy being used for domestic purposes remains an issue of significant policy relevance [10]. This is due to their welfare impacts through differences in the level of discharged air pollutants, handling safety and utilization convenience [8,10]. Globally, available statistics have shown that there are about 2.4 billion people who rely on unclean energy sources like kerosene, biomass, coal, and fuelwood for heating and cooking activities [11].

In addition, with 84.4% electricity coverage in 2020, South Africa remains one of the countries in SSA with a great deal of luxurious access to clean energy [12]. The major challenge confronting the country is how to sustain access to clean energy for the achievement of the seventh SDG by 2030, given the international call to decarbonize electricity generation as a major prerequisite for climate change mitigation in the Paris Agreement [13]. South Africa's mandatory compliance with the Paris Agreement means a lot for the fragile energy sector given that more than 80% of total energy production is from thermal combustion of coals [14]. Due to its environmental impacts, international community has frowned at coal combustion and other associated activities that release Carbon into the atmosphere. Decarbonization of electricity generation remain a significant challenge in South Africa's although aspirations towards a switchover towards renewable energy had been registered [15]. Furthermore, with more than 45 GW installed capacity and growing debt of about US $24 billion [16,17], Eskom faces significant challenges in meeting up with national expectations in efficient service delivery if the use of coal is deemphasized as a way of embracing net zero carbon emissions as stipulated in the Paris Agreement. The economic woes of Eskom have been further amplified by about R50 billion unpaid debts that are owed by some municipalities [18]. Therefore, efficient delivery of energy services by Eskom has been marred by drastic decline in supply that has compelled concomitant national load shedding and unprecedented blackouts [16,19].

More importantly, the growing cost of electricity may compel poor households to utilize cheaper but unclean energy sources for some domestic purposes [20]. Also, exposure to pollutants from unclean energy sources portends some health risks to households' members. Some statistics have shown that in 2020, about 3.2 million people globally died prematurely due to exposure to air pollution with 32% being from ischaemic heart disease, 23% from stroke, 21% from lower respiratory infections, and 19% from chronic obstructive pulmonary disease (COPD), and 6% from lung cancer [11]. Similarly, women and children suffer more from the health consequences of environmental pollution that results from using energies from dirty sources [11]. In addition, under-5 children are more prone to acute lower respiratory infections [21-23], which is among the leading cause of under-5 mortality in the world [24]. In South Africa, acute lower respiratory infection is among the four topmost sources of death among under-5 children and its incidence is largely facilitated by exposure to pollutants from the use of unclean energy [21, 25,26].

It should be noted that affordability is a major factor influencing the use of clean energy in South Africa [19]. Given a high level of inequality and poverty that is largely entrenched among the previously disadvantaged black population, past increases in electricity tariffs may have dampened equitable access to clean energy [19]. Therefore, except where electricity is utilized free of charge, energy poverty is expected to be a resonate of income poverty [27]. Pauw et al. [28] found income to be a factor influencing utilization of dirty fuels among residents of South Africa's highveld. Also, Ye and Koch [29] found that in South Africa, income reduced the incidence of energy poverty and households in the low-income categories contributed more to energy poverty. In other studies, income was also found to influence energy poverty [30-32]. In rural Bangladesh however, Barnes et al. [33] found that being energy poor necessarily implies being income poor.

The size of the household is another factor that can influence the choice of energy for domestic uses. It had been noted that the size and composition of households possess some ability to interact with some determinants of health, hereby constituting the major determinants of energy poverty [34]. In another study in Pakistan, less resource endowments, lack of education and female headed households were associated with energy poverty [35]. Ashagidigbi et al. [32] also found that energy poverty in Nigeria increased among households that were headed by males, older respondents, resident in rural areas and those from the North East geopolitical zone. Sokolowski et al [36] found that residence in rural areas and dependence on retirement and disability pensions were the major factors explaining energy poverty among some Polish households.

This paper seeks to add to existing literature on energy poverty in South Africa by constructing multidimensional welfare indicator using three representative datasets from 2019 to 2021. The study presents an avenue to gauge the utilization of clean energy during the COVID-19 pandemic in 2020-2021 with the pre-COVID era in 2019. The analyses will broadly provide some insights into the impacts of some interventions to enhance households' welfare during the COVID-19 pandemic on energy poverty in South Africa. Therefore, the findings of the paper will significantly contribute towards our understanding of South Africa's movement in achieving the seventh SDG.

2. MATERIALS AND METHODS

2.1. Data and Sampling Procedures

The data for this study were the General Household Survey (GHS) that were conducted between 2019 and 2021. South Africa conducts GHS every year as a way of monitoring progress in some economic development indicators. The data are highly representative and can be compared across different indicators for development and growth monitoring. The data collection followed the comprehensive sampling frame that was developed in 2013, which Statistics South Africa had been using for GHS since 2015 [37-39]. In the sampling frame, there are 103,576 enumeration areas (EAs) that were constituted from 3324 primary sampling units (PSUs). The sampling frame comprises of 33,000 dwelling units (DUs) which were selected to represent South African provinces, metropolitans, and the other geographical areas. Two stage stratified random sampling was used and samples allocated to each EA by following the probability proportional to size approach. Each of the years has sample weights for every respondent and comprehensive details on sampling procedures for these surveys had been provided in the studies' reports [37-39].

The collection of 2019 data was carried out by the Computer Assisted Personal Interviews (CAPI). The respondents for all the selected households were adult members. The enumerators directly interviewed these respondents in some face-to-face interviews. At the end of the survey, 19,649 households were successfully interviewed. However, due to COVID-19 pandemic in 2020 and 2021, the method of data collection changed to the Computer-Assisted Telephone Interviews (CATI).

CATI was implemented by contacting respondents through phone calls. The respondents were also adult members of the households. Data collection was carried out through phone calls and responses were recorded and entered on electronic questionnaire whose data contents were transmitted directly to main database on a server upon completion of interviews. In 2020 and 2021, successfully interviewed households were 8896 and 9626, respectively.

2.2. Alkire-Foster Multidimensional Poverty Index and Its Decomposition

his study adopts the Alkire and Foster [40] multidimensional poverty method. Contrary to some propositions of arbitrarily different weights in the computation of energy poverty [41], this study utilized equal weight for each of the selected energy attributes. However, selection of the attributes was guided by proposition by Nussbaumer et al. [41] with some modifications based on the available variables in the datasets. The cut-off points for each of the energy poverty attributes were first determined by coding deprived households as 1 and the non-deprived as 0. The composite indicator of energy poverty was explored from ownership of functioning electrical appliances or services (television, DSTV/M-Net subscription, computer/laptop, refrigerator/freezer, home security services, geyser and cell phone), access to electricity, and the form of energy that is being used for cooking, lighting, water heating and space heating. These twelve energy poverty attributes were equally weighted with each given a weight of 1/12. This is in conformation with Alkire and Foster [40] proposition that w_j being the weight attached to attribute j, and the sum of these weights should be equal to one [40]. Therefore, the attached weights are such that:

$$\sum_{j=1}^{n} w_j = 1 \quad (1)$$

The total weighted deprivation score (c_j) is given as:

$$c_j = w_1 D_1 + w_2 D_2 + w_3 D_3 + \cdots \ldots . w_{12} D_{12} \quad (2)$$

After taking the weighted deprivation score for each household, a cut-off of 0.4167 (5/12) was sets. This was arrived at based on the expectation that a household should at least have 2 electrical assets, have access to electricity and use energy from clean sources for at least one domestic purpose. This implies that to calculate the indicator of energy poverty, households that were deprived in five or more welfare attributes (z) were regarded as poor and coded 1, while the others with four or less deprivations were coded as 0. Let $c_j(z)$ denote censored deprivation and if $c_j \geq z$, then $c_j(z) = c_j$ but when it is $< z$, then $c_j(z) = 0$. Given that N denotes the total number of households and k denotes the number of energy poor households, the head-count ratio (H) can be expressed as:

$$H = \frac{k}{N} \quad (3)$$

The poverty intensity is expressed as:

$$A = \frac{\sum_{j=1}^{k} c_j(z)}{k} \quad (4)$$

The multidimensional energy poverty index (MEPI) is a product of the energy poverty incidence (H) and energy poverty intensity (A).

$$MEPI = H*A \quad (5)$$

As proposed by Alkire and Foster [40], the MEPI is decomposable across selected demographic groups and included attributes to understand the contributions of selected groups or attributes to overall energy poverty.

2.3. Tobit Regression Model

Tobit regression model was used to analyse the determinants of multidimensional energy poverty and it is specified in the equation below as:

$$\mathrm{MEPI_i} = \alpha_k + \beta_{jk} \sum_{j=1}^{22} H_{ik} + e_{ik} \quad (6)$$

where i denotes the households, k denotes the time periods of the analyses, α_k are the constant terms for kth period, β_{jk} are the estimated jth parameters, H_{ik} are the independent variables and e_{ik} denotes the error terms. The independent variables are: provinces [Eastern Cape (yes = 1, 0 otherwise), Northern Cape (yes = 1, 0 otherwise), Free State (yes = 1, 0 otherwise), KwaZulu Natal (yes = 1, 0 otherwise), North West (yes = 1, 0 otherwise), Gauteng (yes = 1, 0 otherwise), Mpumalanga (yes = 1, 0 otherwise), and Limpopo (yes = 1, 0 otherwise)], population group [Coloured (yes = 1, 0 otherwise), Asian/Indian (yes = 1, 0 otherwise), White (yes = 1, 0 otherwise)], gender [male headed households (yes = 1, 0 otherwise)], age of households' heads, number of members less 5 years, number of members 5 to 17 years, number of adult members 60 years plus, monthly salary (R'000), total monthly grants (R'000), geography [tribal areas (yes = 1, 0 otherwise), Farm (yes = 1, 0 otherwise)] and year of data collection [2020 (yes = 1, 0 otherwise) and 2021 (yes = 1, 0 otherwise)].

3. RESULTS

Table 1 shows the distributions of deprived households in the selected energy poverty attributes in the selected years. It reveals that in the combined households' data, the highest deprivations were shown in security service (91.74%), computer (79.66%), geyser (75.50%), space heating (47.51%), and pay TV subscription (43.78%). Deprivations in the use of clean energy for cooking increased from 14.03% in 2019 to 14.83% in 2020, before it declined to 14.33% in 2021. Similarly, the proportions of the households that were deprived in the use of clean energy for space heating increased from 46.43% in 2019 to 49.67% in 2021. Deprivations in the use of clean energy for lighting and water heating decreased between 2019 and 2020, but slightly increased in 2021.

Table 1: Distribution of Deprived Households in the Selected Welfare Attributes

Year	2019		2020		2021		All	
Variables for MEPI	Freq	%	Freq	%	Freq	%	Freq	%
Television	3518	17.90	915	10.29	1130	11.74	5563	14.57
Pay TV Subscription	9723	49.48	3271	36.77	3717	38.61	16711	43.78
Computer	15790	80.36	7047	79.22	7573	78.67	30410	79.66
Fridge/Freezer	3995	20.33	1044	11.74	1130	11.74	6169	16.16
Security Service	17874	90.97	8260	92.85	8887	92.32	35021	91.74
Geyser	14874	75.70	6722	75.56	7225	75.06	28821	75.50
Cell phone	850	4.33	217	2.44	302	3.14	1369	3.59
Electricity Access	1168	5.94	380	4.27	434	4.51	1982	5.19
Cooking Energy	2757	14.03	1319	14.83	1379	14.33	5455	14.29
Lighting Energy	1207	6.14	368	4.14	428	4.45	2003	5.25
Water Heating	2685	13.66	1135	12.76	1295	13.45	5115	13.40
Space Heating	9124	46.43	4232	47.57	4781	49.67	18137	47.51

Table 2 shows the distribution of poverty incidences and intensities across some selected demographic characteristics. It reveals that across the provinces, between 2019 and 2021, Western Cape and KwaZulu Natal consistently had the highest energy poverty incidences, while Northern Cape, Mpumalanga and Limpopo provinces had the least incidences. However, Northern Cape and North West exhibited the higher multidimensional poverty intensities across the period while Limpopo consistently had the least. In the combined data, Western Cape (0.5281), KwaZulu Natal (0.4901) and North West (0.4256) had the highest energy poverty incidences, while Limpopo (0.2067) and Northern Cape (0.2447) had the lowest values. However, energy poverty intensities were highest in Northern Cape (0.5965), Gauteng (0.5675) and North West (0.5521). Furthermore, across the population groups, white respondents had the lowest multidimensional energy poverty incidences and intensities across the periods, while black respondents had the highest. Across gender, female headed households had higher energy poverty incidences across time, although poverty intensities were higher among male headed households. In addition, based on place of residence, urban residents generally had lower multidimensional energy poverty incidences and intensities, while those from farm settings had the highest incidences and intensities.

Table 2: Distribution of Multidimensional Energy Poverty Incidences and Intensities Across Selected Demographic Variables

	2019			2020			2021			All Respondents		
	Incidence	Intensity	MEPI	Incidence	Intensity	MEPI	Incidence	Intensity	MEPI	Incidence	Intensity	MEPI
Western Cape	0.5793	0.5498	0.3185	0.4706	0.5169	0.2433	0.4863	0.5395	0.2624	0.5281	0.5404	0.2854
Eastern Cape	0.3665	0.5370	0.1968	0.2929	0.5135	0.1504	0.3074	0.5172	0.1590	0.3362	0.5281	0.1776
Northern Cape	0.2691	0.5991	0.1612	0.2128	0.6008	0.1278	0.2135	0.5837	0.1246	0.2447	0.5965	0.1460
Free State	0.4128	0.5456	0.2252	0.3101	0.5213	0.1616	0.3408	0.5251	0.1789	0.3686	0.5354	0.1974
KwaZulu Natal	0.5187	0.5524	0.2865	0.4819	0.5261	0.2535	0.4491	0.5271	0.2367	0.4901	0.5394	0.2643
North West	0.4446	0.5668	0.2520	0.4051	0.5301	0.2147	0.4088	0.5421	0.2216	0.4256	0.5521	0.2349
Gauteng	0.4063	0.5814	0.2362	0.3248	0.5406	0.1756	0.3179	0.5546	0.1763	0.3659	0.5675	0.2076
Mpumalanga	0.3506	0.5554	0.1947	0.1890	0.4676	0.0884	0.2593	0.5571	0.1444	0.2910	0.5426	0.1579
Limpopo	0.2347	0.4978	0.1168	0.1979	0.4645	0.0919	0.1527	0.4677	0.0714	0.2067	0.4857	0.1004
Black	0.4472	0.5598	0.2503	0.3655	0.5328	0.1947	0.3776	0.5392	0.2036	0.4097	0.5491	0.2250
Coloured	0.2339	0.5321	0.1245	0.1442	0.4643	0.0669	0.1565	0.4892	0.0766	0.1982	0.5145	0.1019
Asian/Indian	0.0614	0.5659	0.0347	0.0190	0.4583	0.0087	0.0331	0.6832	0.0226	0.0479	0.5780	0.0277
White	0.0159	0.5108	0.0081	0.0148	0.5714	0.0084	0.0076	0.5208	0.0040	0.0139	0.5245	0.0073
Male	0.3746	0.5709	0.2139	0.3044	0.5414	0.1648	0.3175	0.5501	0.1746	0.3449	0.5606	0.1934
Female	0.4130	0.5427	0.2241	0.3587	0.5201	0.1866	0.3599	0.5253	0.1891	0.3858	0.5335	0.2058
Urban	0.2940	0.5568	0.1637	0.2046	0.5439	0.1113	0.2114	0.5458	0.1154	0.2547	0.5524	0.1407
Tribal	0.5652	0.5483	0.3099	0.5034	0.5160	0.2598	0.5076	0.5254	0.2667	0.5333	0.5344	0.2850
Farm	0.6104	0.6570	0.4010	0.5336	0.6125	0.3268	0.5232	0.6194	0.3241	0.5724	0.6397	0.3662
All	0.3910	0.5584	0.2183	0.3295	0.5309	0.1749	0.3373	0.5379	0.1814	0.3631	0.5478	0.1989

Table 2 further shows the distribution of MEPI across selected demographic variables. It reveals that between 2019 and 2021, MEPI 0.1989. However, between 2019 and 2020, MEPI slightly declined from 0.2183 to 0.1749 respectively, while a slight increase was recorded between 2020 (0.1749) and 2021 (0.1814). Across the provinces, Limpopo had the lowest average MEPI, while Western Cape, Kwa-Zulu Natal and North West were among those with the highest values. The results further show that white respondents had the lowest MEPI while black respondents had the highest values across time. Based on gender, MEPI for female respondents was slightly higher than that for male respondents across time. Also, based on economic sectors, respondents from urban areas had the lowest average MEPI across time, while those from farm areas had the highest values.

Figure 1 shows the distributions of households' MPI in 2019, 2020, 2021 and the combined data. The results showed that across the years, majority of the respondents had less than 0.50 MEPI. Specifically, 60.90%, 67.05%, 66.27% and 63.69% had MEPI of <0.25 in 2019, 2020, 2021, and combined data respectively.

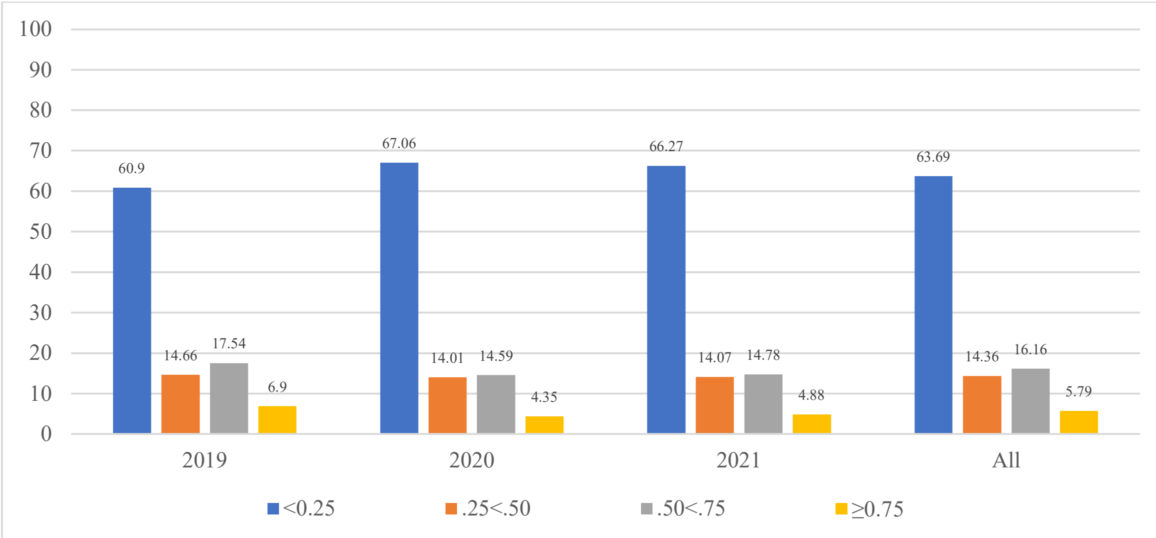

Fig. 1. Distribution of Alkire-Foster MEPI in South Africa (2019 – 2021)

Table 3. Distribution of MEPI in South Africa Across Selected Demographic Characteristics

	2019				2020				2021			
	<0.25	0.25< 0.50	0.50< 0.75	≥0.75	<0.25	0.25< 0.50	0.5< 0.75	≥0.75	<0.2 5	.25<0. 50	0.5<0. 75	≥ 0.75
Province												
Western	42.07	21.41	28.01	8.52	52.94	22.27	19.66	5.13	51.3	19.01	23.08	6.54
Eastern	63.35	17.77	13.15	5.74	70.71	17.15	7.51	4.62	69.2	19.26	6.85	4.63
Northern	73.09	10.62	8.04	8.25	78.72	8.97	5.32	6.99	78.6	9.17	6.00	6.17
Free State	58.72	16.69	18.04	6.56	68.99	13.19	14.62	3.20	65.9	15.46	14.53	4.10
KwaZulu	48.13	13.69	32.39	5.79	51.81	13.46	31.73	2.99	55.0	13.30	28.33	3.29
North	55.54	14.11	22.73	7.62	59.49	15.44	20.38	4.68	59.1	17.16	17.52	6.20
Gauteng	59.38	14.96	16.22	9.45	67.52	14.12	13.27	5.10	68.2	12.94	12.78	6.07
Mpumalan	64.94	13.96	15.46	5.65	81.10	13.39	4.20	1.31	74.0	9.63	10.86	5.43
Limpopo	76.53	11.99	9.84	1.64	80.21	13.19	5.83	0.77	84.7	10.34	4.06	0.86
Race												
Black	55.28	16.54	20.17	8.01	63.45	15.21	16.46	4.88	62.2	15.63	16.59	5.55
Coloured	76.61	10.89	9.54	2.96	85.58	10.67	3.00	0.75	84.3	8.61	5.95	1.10
Asian/Indi	93.86	2.81	2.05	1.28	98.10	0.95	0.95	0.00	96.6	0.00	1.99	1.32
White	98.41	0.69	0.76	0.14	98.52	0.84	0.00	0.63	99.2	0.19	0.57	0.00
Gender												
Male	62.54	13.59	16.13	7.74	69.56	13.01	12.57	4.86	68.2	12.92	13.25	5.58
Female	58.70	16.10	19.44	5.76	64.13	15.17	16.95	3.75	64.0	15.39	16.52	4.09
Sector												
Urban	70.60	12.89	10.59	5.92	79.54	10.70	5.49	4.27	78.8	10.48	6.50	4.16
Tribal	43.48	18.32	31.24	6.96	49.66	18.84	28.05	3.45	49.2	19.29	26.59	4.88
Farm	38.96	14.29	22.51	24.24	46.64	16.42	19.40	17.54	47.6	15.17	19.81	17.34
All	60.90	14.66	17.54	6.90	67.05	14.01	14.59	4.35	66.2	14.07	14.78	4.88

Table 3 shows the distribution of the computed MEPI at the province, race, gender, and sector levels in 2019, 2020 and 2021. At the provincial level, Western Cape, Kwa-Zulu Natal, and North West had the lowest proportions of their respondents with <0.25 MEPI at 42.07%, 43.18%, and 55.54% respectively in 2019 while Limpopo and Northern Cape had the highest proportions with 76.53% and 73.09% respectively In 2020, Kwa-Zulu Natal and Western Cape had the lowest proportions of the respondents with <0.25 MEPI at 51.81% and 52.94%, respectively. Also, Mpumalanga and Limpopo had the highest percentages of the respondents with <0.25 MEPI with 81.10% and 80.21% respectively. In 2021, Limpopo and Northern Cape had highest proportions with <0.25 MEPI with 84.73% and 78.65% respectively. Figure 2 also shows that in the combined data, Limpopo and Northern Cape had the highest proportions of their respondents having <0.25 with 79.33% and 75.53% respectively. The figure also shows that Western Cape and KwaZulu Natal had the lowest proportions with <0.25 MEPI with 47.19% and 50.99% respectively.

Table 3 also shows that black respondents had the lowest proportions having MEPI of <0.25 in all the time periods. Specifically, 55.28%, 63.45% and 62.24% of the black respondents had <0.25 MEPI in 2019, 2020 and 2021, respectively as against 98.41%, 98.52% and 99.24% for white respondents. Similar results are provided in Figure 3 which shows that in the combined dataset, black respondents had the lowest proportion with MEPI <0.25 at 59.03%. Based on gender, the proportions of the respondents wit≥hMEPI <0.25 were lower among female headed households across all the periods studied. In Figure 3, 65.51% and 61.42% of male and female headed households had MEPI <0.25. Table 3 also shows that in 2019, 2020 and 2021, the respondents from farm and tribal residences had the lowest proportion with MEPI <0.25. Similar results had been provided in Figure 3.

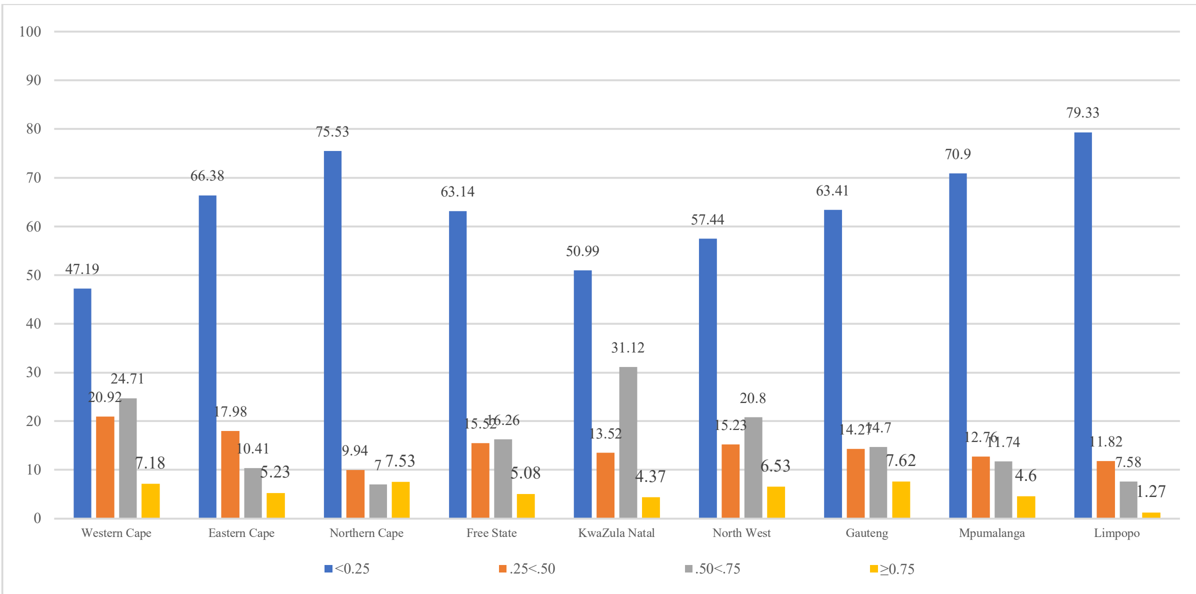

Fig. 2. Distribution of Alkire-Foster MEPI Across South Africa Provinces in Combined Data

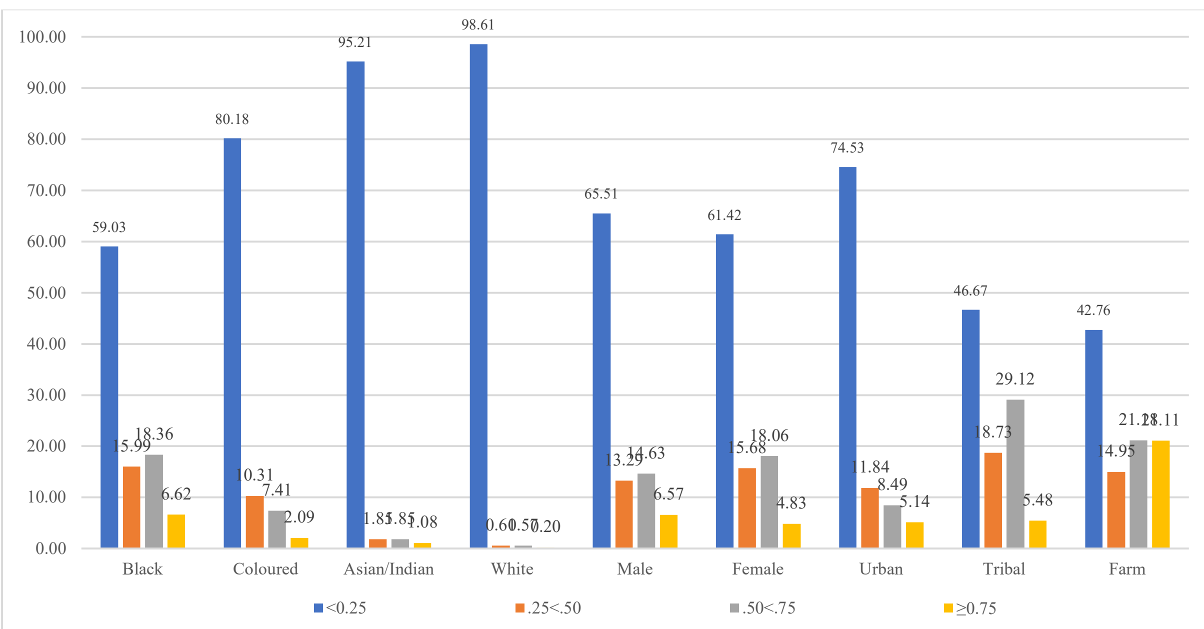

Fig. 3. Distribution of Alkire-Foster MEPI Across Races, Gender and Economic Sectors in Combined Data

3.1. Determinants of Alkire-Foster Energy Multidimensional Poverty Indicator

Table 4 presents the results of Tobit regression of the determinants of MEPI that was computed using the Alkire-Foster approach. The model produced a good fit for the data given the statistical significance ($p<0.01$) of the computed likelihood ratio Chi-Square statistics ($p<0.01$). This implies that the parameters that were estimated in each of the models cannot be concluded to be jointly equal to zero.

Table 4. Tobit Results of the Determinants of Multidimensional Energy Poverty Indicator (MEPI)

	2019		2020		2021		All Respondents	
	Coefficient	t stat	Coefficient	t stat	Coefficient	t stat	Coefficient	t stat
Province								
Eastern Cape	-0.093***	-9.73	-0.041***	-3.10	-0.057***	-4.41	-0.072***	-10.76
Northern Cape	-0.107***	-15.08	-0.043***	-4.33	-0.065***	-6.75	-0.082***	-16.67
Free State	-0.095***	-13.05	-0.082***	-8.52	-0.077***	-8.59	-0.088***	-17.91
KwaZulu Natal	-0.073***	-9.12	-0.030***	-2.93	-0.064***	-6.56	-0.061***	-11.39
North West	-0.087***	-10.00	-0.045***	-3.97	-0.061***	-5.64	-0.070***	-12.03
Gauteng	-0.100***	-11.01	-0.070***	-5.64	-0.093***	-7.73	-0.091***	-14.50
Mpumalanga	-0.080***	-7.26	-0.093***	-6.13	-0.063***	-4.32	-0.078***	-10.17
Limpopo	-0.095***	-10.12	-0.030***	-2.24	-0.063***	-4.93	-0.069***	-10.52
Population Group								
Coloured	-0.089***	-10.28	-0.059***	-4.49	-0.064***	-5.03	-0.080***	-12.72
Asian/Indian	-0.147***	-10.33	-0.059**	-2.41	-0.078***	-3.64	-0.116***	-10.89
White	-0.166***	-20.15	-0.062***	-4.56	-0.082***	-6.14	-0.131***	-21.17
Female	-0.017***	-4.03	-0.011**	-1.98	-0.015***	-2.71	-0.014***	-5.12
Age of Head	-0.002***	-9.70	-0.001***	-3.94	-0.001***	-3.18	-0.001***	-10.92
Child less 5	0.007	1.76	0.013***	2.68	0.014***	2.74	0.010***	3.70
Child 5 to 17	-0.026***	-12.78	-0.014***	-5.37	-0.016***	-6.17	-0.021***	-15.07
Adult 60 plus	-0.039***	-7.09	-0.043***	-5.66	-0.044***	-6.03	-0.041***	-10.60
Salary	-0.002***	-15.37	-0.003***	-14.90	-0.002***	-12.38	-0.002***	-23.13
Total grants	0.032***	12.65	0.022***	6.96	0.020***	6.47	0.027***	16.01
Geography								
Tribal	0.096***	17.68	0.118***	16.59	0.119***	17.33	0.107***	29.21
Farm	0.243***	22.68	0.222***	14.21	0.205***	14.02	0.230***	30.31
Year								
2020	-	-	-	-	-	-	-0.054***	-16.21
2021	-	-	-	-	-	-	-0.050***	-15.38
Constant	0.402***	40.43	0.259***	17.84	0.268***	19.45	0.362***	50.75
var(e)	0.072		0.060		0.063		0.067	
Number of observations	19649		8896		9626		38174	
LR chi2(22)	3229.1***		1405.9***		1424.1***		6058.06***	
Log likelihood	-2091.2		-83.3		-334.8		-2686.3	

Across all the results, there is considerable consistency in the levels of statistical significance and sign of the estimated parameters. The estimated parameters for the respondents' province of residence are with negative sign and show statistical significance ($p<0.01$). The results generally imply that if other variables are held constant, the respondents from Western Cape had significantly higher average MEPI than those from other provinces. Specifically, when compared with those from Western Cape, the respondents from Eastern Cape had their MEPI significantly reduced ($p<0.01$) by 0.093, 0.041, 0.057 and 0.072 in 2019, 2020, 2021 and in the combined dataset respectively. Also, in comparison with respondents from Western Cape, those from Northern Cape had their MEPI significantly reduced ($p<0.01$) by 0.107, 0.043, 0.065 and 0.082 in 2019, 2020, 2021 and in the combined dataset respectively. When compared with those from Western Cape, the respondents in Free State had their MEPI reduced by 0.093, 0.082, 0.077 and 0.088 in 2019, 2020, 2021 and in the combined dataset respectively. MEPI significantly declined ($p<0.01$) among respondents from Kwa-Zulu Natal ($p<0.01$) by 0.073, 0.030, 0.064 and 0.061when compared with those from Western Cape. The results also revealed that in comparison with those from Western Cape, respondents from North West had their MEPI significantly reduced ($p<0.01$) by 0.087, 0.045, 0.061 and 0.070 in 2019, 2020, 2021 and in the combined dataset respectively. Among the respondents from Gauteng, when compared with those from Western Cape, MEPI significantly declined ($p<0.01$) by 0.100 in 2019, 0.070 in 2020, 0.093 in 2021 and 0.091 in the combined dataset. Among the respondents from Mpumalanga, when compared with those from Western Cape, MEPI significantly ($p<0.01$) declined by 0.080, 0.093, 0.063 and 0.078 in 2019, 2020, 2021 and in the combined dataset. Finally, compared to the respondents from Western Cape, those from Limpopo had their MEPI significantly reduced ($p<0.01$) by 0.095 in 2019, 0.030 in 2020, 0.063 in 2021 and 0.069 in the combined data.

In line with expectations, the results in Table 4 revealed that the parameters of respondents' race are with negative sign across all the estimated models and statistically significant ($p<0.01$). The MEPI of the coloured respondents was significantly lower ($p<0.01$) by 0.089 in 2019, 0.059 in 2020, 0.064 in 2021 and 0.080 in the combined dataset when compared with that of black respondents. In addition, the respondents that were of Asian origin had their MEPI significantly reduced ($p<0.05$) by 0.147, 0.059, 0.078 and 0.116 in 2019, 2020, 2021 and in the combined dataset respectively, when compared with those of black respondents. The white respondents had their MEPI being significantly reduced ($p<0.01$) by 0.166 in 2019, 0.062 in 2020, 0.082 in 2021 and 0.131 in the combined dataset when compared with black respondents.

Furthermore, contrary to expectation, MEPI of female respondents is significantly reduced ($p<0.05$) by 0.017 in 2019, 0.011 in 2020, 0.015 in 2021 and 0.014 in the combined dataset when compared with that of male respondents. Also, as the number of under-5 children increased by one unit, MEPI significantly increased ($p<0.01$) by 0.013, 0.014 and 0.010 in 2020, 2021 and in the combined dataset respectively. However, one unit increase in the number of households members 5 to 17 years of age significantly decreased ($p<0.01$) MEPI by 0.026 in 2019, 0.014 in 2020, 0.016 in 2021 and 0.021 in the combined dataset. Table 4 also shows that an increase in the number of respondents who were 60 years and above significantly reduced ($p<0.01$) MEPI by 0.039 in 2019, 0.043 in 2020, 0.044 in 2021 and 0.041 in the combined dataset.

The parameters of monthly salary are with negative sign and statistically significant ($p<0.01$) in all the estimated models. The results indicate that MEPI will decline by 0.002 in 2019, 0.003 in 2020, 0.002 in 2021 and 0.002 in the combined data if monthly salary increases by R1000. However, social grant variables have positive parameters that are statistically significant ($p<0.01$) in all the estimated models. These results indicate that increasing social grants by R1000 will result in MEPI increasing by 0.032 in 2019, 0.022 in 2020, 0.020 in 2021 and 0.027 in the combined data. In addition, Table 4 further shows that in line with expectation, the parameters of tribal and farm residence in the estimated models are with positive sign and statistically significant ($p<0.01$). Specifically, respondents from tribal areas had their MEPI significantly increased ($p<0.01$) by 0.096 in 2019, 0.118 in 2020, 0.119 in 2021 and 0.109 in the combined dataset when compared with those from urban areas. Similarly, respondents who were residing in farm areas had their MEPI significantly increased ($p<0.01$) by 0.243 in 2019, 0.222 in 2020, 0.205 in 2021 and 0.230 in the combined dataset when compared with those from urban areas. The time variables also revealed that compared with 2019, MEPI in 2020 and 2021 significantly declined ($p<0.01$) by 0.054 and 0.050 respectively.

4. DISCUSSION

The results generally indicated a decline in the MEPI between 2019 and 2020. However, there was a slight increase in MEPI in 2021. This finding had been further buttressed by the Tobit regression results which show that utilizing the combined dataset, there was a significant reduction in MEPI in 2020 and 2021 when compared with 2019. However, the proportions of households without access to electricity declined between 2019 and 2020, with a slight increase in 2021. It should be noted that in terms of access, the country had made significant progress in ensuring access to electricity by majority of the population, being one of the energy secure countries in Africa [12]. However, energy woes in South Africa seem to have commenced in 2007 when load shedding commenced, the problem seems to have worsened [14,15]. Inadequate supply of electricity remains a major development challenge [42], although the finding further shows the positive impacts of government's economic and energy policies in reducing energy poverty [43]. More importantly, the government is now seeking a sustainable energy development pathway after the pandemic through promotion of Eskom efficiency to ensure drastic reduction in load shedding [44].

The results also showed some spatial difference in the levels of clean energy deprivation in South Africa. Specifically, Western Cape, Kwa-Zulu Natal and North West were among the provinces with the highest average MEPI. Also, MEPI was significantly lower in other provinces when compared with Western Cape. Although access to electricity is just one of the twelve indicators that were utilized in computing the MEPI, the findings can be juxtaposed with a report that indicated that access to electricity was lowest in Kwa-Zulu Natal, North-West and Gauteng [45]. The finding also shows that Limpopo had the lowest average MEPI which can be linked to a report that indicated it to have the highest electricity coverage in South Africa [45]. The finding can also be compared with that of Ismail and Khembo [46] who reported that residence in Gauteng and Limpopo reduced MEPI among South African provinces. Also, Mbewe [47] found that the least contributions to the number of energy households were made by Northern Cape and Western Cape provinces Eastern Cape and Gauteng made the highest contributions.

In line with the finding of Ismail and Khembo [46], black respondents showed the highest energy poverty among the races in South Africa. This underscores concentration of poverty among black South Africans despite several economic interventions and transformation programmes that have been implemented over the years [48]. More importantly, inequality in access to economic resources, lapses human capital development and locational factors can explain differences in poverty among the different races in South Africa [48,49]. Also, being a female headed households reduced MEPI. This can be linked to some gender factors influencing access to resources and its welfare implications in South Africa [50], and it is inconsistent with the findings of some previous studies [46,51]. However, Dunga et al. [52] reported a similar finding. Although the limited resources at the disposal of female households' heads often compels prioritization of food and other essentials services before energy, many women are also willing to take some menial jobs to provide for the needs of their families [53-55].

The results also showed that as households' heads ages increased, MEPI significantly decreased. This gives some indications that younger households' heads were poorer in clean energy. This is contrary to some previous studies that found age to either show statistical insignificance [56] or be positively associated with energy poverty [32]. Literature emphasizes the role of household heads' age in explaining energy poverty with proposition that younger households' heads are expected to be energy secure [30,57]. However, the contextual aggregation of some welfare attributes into MEPI as done in this study is different from a unidimensional poverty estimation that focuses on energy expenditures and its insecurity as adopted in some other studies.

In addition, the composition of household members also significantly influenced energy poverty. The results indicate that while the number of households' members less than 5 years increased energy poverty, the number of the members who were 5-17 years and >60 reduced it. The results are in tandem with the finding of Drescher and Janzen [58]. Specifically, the positive association between the number of under 5 children and MEPI may be a reflection of expected high financial commitments to take care of these kids and the fact that parents with many members would prioritize meeting the food needs of the children. In addition, the number of households' members aged 60 years plus reduced MEPI. This reflects the higher likelihood of households in this category having many of the electrical assets that had been used in this study.

The results further showed the role of income in the reduction of MEPI. This is expected because high income earners will prioritize utilization of clean energy and some electrical assets. Some authors have highlighted the negative correlation between energy poverty and households' incomes [59,60] However, income realized from social grants increased energy poverty because of the very high likelihood of recipients of such grants not to spend them on the provision of clean energy. It should also be noted that recipients of social grants in South Africa are largely selected based on some welfare deprivation parameters like being unemployed, deformity and low-income level. In a related manner, households from tribal and farm settings had higher MEPI when compared with their urban counterparts. This is expected due to prevailing poverty in tribal and farm areas that would often compel utilization unclean energy sources. Also, dirty energy sources like fuelwood and animal dungs are always in abundance supply in tribal and farm areas.

CONCLUSION

The seventh SDG seeks to ensure access to clean energy from affordable and reliable sources. South Africa subscribes to this global agenda, but compliance with the Paris Agreement remains a fundamental obstacle to progressive eradication of energy poverty given the requirement to reduce electricity generation from thermal combustions. This study analysed the magnitude and dimension of multidimensional energy poverty among South African households using the Alkire-Foster approach. The study provides a quick and reliable evaluation of the country's movement towards achievement of the SDG on energy with data covering 2019 and 2020 and 2021 which were the periods of national disaster due to COVID-19 pandemic. The results have revealed some progress, although 2021 which happens to be the peak time of COVID-19 infections and health policy interventions in South Africa witnessed a slight decrease in access and utilization of clean energy. The results have underscored some spatial and temporal variability in energy poverty with Western Cape and KwaZulu Natal being among the most affected. There is therefore the need to evaluate energy poverty in each province with a goal of identifying the major constraints influencing access and affordability. Such evaluation would prompt national marginal reforms targeted at the most deprived provinces, with bias towards black population, female headed households, social grant holders and residents in tribal and farm areas.

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