Valuing the joint effect of adult literacy and economic growth on renewable energy consumption in African zone

Оцінка спільного впливу грамотності дорослих та економічного зростання на споживання відновлюваної енергії в африканській зоні

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Purpose: in this paper, the author tries to find out how the major two variables in economy called Economic growth (EG) and adult literacy rate (ALR) influence the behaviour of African people in different zones on renewable energy consumption (REC).

Design/Method/Approach: The research is basically quantitative in nature and 52 African counties have been selected zonal-wise considering time series database from 1990 to 2018 (nearly 29 years). It is observed that EG has positive and significant impact on REC in Northern Africa Zone (NAZ) and ALR has positive and significant on REC in NAZ and Eastern African Zone (EAZ). Conversely, EG and ALR act as joint effect, it emphasises positive and significant on REC in EAZ only.

Findings: Sustainable development practice and social development are interconnected issues that are being tried to grab my most of the developing and underdeveloped economies, where their education level and economic growth can be influencing factors to change their behavioural characteristics to use renewable energy to ensure income and environmental sustainability.

Practical implications (if applicable): This paper is constructed by zonal-wise which will help future researchers to build-up behavioural changing polices on REC in zonal basis. The developing and under developing economies can be somehow dependent on the population-behaviour which can affect to ensure environmental and social-sustainability.

Paper type: theoretical.

Key words: renewable energy, economic growth, adult literacy rate, sustainable development, environmental sustainability.

Мета роботи: у статті автор намагається з'ясувати, як дві основні змінні економіки – економічне зростання та рівень грамотності дорослих впливають на поведінку африканців у різних зонах щодо споживання відновлюваної енергії.

Дизайн/Метод/Підхід дослідження: Дослідження в основному носить кількісний характер, для дослідження було відібрано 52 африканські країни за зонами з урахуванням бази даних часових рядів з 1990 по 2018 рік (майже 29 років). Помічено, що економічне зростання має позитивний і значний вплив на споживання відновлюваної енергії в зоні Північної Африки, а рівень грамотності дорослих має позитивний і значний вплив на споживання відновлюваної енергії в зоні Північної Африки і Східно-африканській зоні. І навпаки, економічне зростання та рівень грамотності дорослих діє як спільний ефект, він підкреслює позитивний і значуще споживання відновлюваної енергії тільки в Східно-африканській зоні.

Результати дослідження: Практика сталого розвитку та соціальний розвиток є взаємопов'язаними проблемами, які намагаються охопити більшість країн, що розвиваються та слаборозвинених економік, де їхній рівень освіти та економічне зростання можуть впливати на зміни їх поведінкових характеристик, щоб використовувати відновлювані джерела енергії для забезпечення доходів та екологічної стійкості.

Практична цінність дослідження: Ця стаття побудована зонально, що допоможе майбутнім дослідникам розробити політику зміни поведінки на REC на зональній основі. Економіка, що розвивається, і країни, що розвиваються, можуть якось залежати від поведінки населення, яка може вплинути на забезпечення екологічної та соціальної стійкості.

Тип статті: теоретична.

Ключові слова: відновлювані джерела енергії, економічне зростання, рівень грамотності дорослих, сталий розвиток, екологічна стійкість.

1. Introduction

Renewable is defined as clean and green energy, which collects generally from renewable resources, consider to ensure the environmental sustainability, is a booming innovation that can reduce the cost of energy production with ensuring the future development with sustainable way. Across the world, especially in European and North-American countries, the usage of solar and wind energy is growing as breaking record factor at the time of sluggish production of national electricity grid. Moreover, renewable energy means energy production and consumption from that source that is

not depleted when used in daily activities. Renewable energy is considered budding chunk of energy production and consumption, ensuring the environmentally friendly energy with lower-cost of production, is well-renowned factor low or zero carbon emission to ensure future way of sustainability. The trend of using renewable energy has been drastically uplifted due to continuous supply of electricity with minimum level of costing. The government of middle-income countries and high-income countries consist policy based on huge participation of local people and shirt-term credit loan basis.

Renewable energy consumption helps to ensure uninterrupted power supply with fuel diversification method. IRENA (2016) measures that the usage of renewable energy guarantees to enhance macro-economic growth level, reduce unemployment, ensuring of social welfare with individual welfare. Engineers and experts have been able to formulate the consumption pattern of renewable energy in cost-effective way which can afford lower level consumer group. A report of (NRDC and ACERA, 2013) shows that the usage of renewable energy in Chile, can add the additional GDP into (USD 2.24 billion) with expanding 7,800 direct and indirect jobs scope in forecasting year 2028. Japan the Asian booming country, has been capable to add 23.3 gigawatts (GW) of solar PV, that can help the consumer to use electricity in cost-effective way and feel flexible to handle (IRENA and CEM, 2014).

Energy security is well connected and well-known issues that is solely related in our Marco-economic level, where energy security connects to use the energy in continuous and sustainable way with affordable cost. Energy security is vital factor for food production, water refinery, agricultural activities, fish-cultivation, social welfare with business opportunities creation. Energy security is correlated with political, economic, environmental, social, technical where a proper planning to consume energy can be handy tool to change social-scenario in lower-developed countries.

2. Review of Literature

In recent world, the demand for energy has been increasing recklessly due to population growth, economic and technological progress and innovation, where a major portion of population depends on the continuous flow of energy due to earn their daily livelihood. Haider et al. (2015) demonstrate the current energy scarcity and potential energy sources in Bangladesh. The energy security condition is not so satisfactory in Bangladesh because the reservation of gas, oil, coal, mineral is going to depletion for the huge demand fulfilment of infrastructure development purposes (Islam et al., 2014). According to the paper of Uddin et. al (2018), more than one-third portion of power production are solely depending on imported fossil-fuel energy while 65% power generation are well dependent on natural gas reservation in Bangladesh.

Gershon and Emekalam (2021) designs a research paper on the trend of renewable energy consumption in Nigerian economy based on Toda Yamamoto approach, where the author shows the real GDP and emissions level of Co^2 are vital determinants for importing oil products in Nigeria. The renewable energy consumption has significant prospects for future production but no nation has acquired absolute advantage over their competitive nations on consuming renewable energy (Egbetokun et al, 2020). Some developing countries face huge challenges due to the use of fossil fuel that causes high-level costing and environmentally unsustainable (Gershon and Nwokocha, 2017). Energy consumption accelerate the economic growth and wide volume of industrialization but the production of renewable energy did not constitute significantly due to excess energy demand in world (Fubara et al., 2019).

Apergis and Payne (2010) analyse the effect of renewable energy consumption in Eurasian countries using the panel data. Omri (2013) denotes that there is tri-connection relation among society, environment and energy, where energy demand has been increasing due to higher

population growth. U.S.E.I. Administration (2013) mentions that most of the Organization for Economic Cooperation and Development (OECD) countries have been experiencing high demand of energy to ensure their long run economic acceleration. Azad et al. (2014) focus the Production, Consumption and Prospect of Renewable Energy in Australian economy,

Omri and Nguyen (2014) analysed the energy consumption on sixty-four countries where they found significant effect of trade openness on income clusters separately from the highest income earners countries. This study mentions that renewable energy consumption raises when the zonal GDP and carbon-emissions raises. Trading Economics (2017) analysed that Nigerian households use biomass and petroleum products to fulfil their daily needs, also 96.3% of Nigeria's exports most of the products made by crude oil. On the other hand, 61% of Nigerian households can normally access to 26.26TWh of electricity but shortage of electricity hinders the development of rapid industrialization and economic resource efficiency. Basically, under-developed countries face a huge crisis of using renewable energy which cannot help them for ensuring sustainability.

Most of the energy consumption happens in non-Organization for Economic Cooperation and Development (OECD) countries where they think about long-term economic growth and development. Researchers are working as optimistic behaviour to enhance the image of energy without hampering environment, following the procedure of sustainable development as well. The population growth is the main factors for high-demand of energy usage, where around 9 billion people will demand energy in 2030 (Cohen, 2001).

Azad et al. (2014) developed a research paper based on Australian economy, Australian energy sector is developed based on non-renewable sources like: oil, gas, coal where 96% energy consumption came from non-renewable sources, this paper focuses the way and guidance to use the renewable energy usage ideas on their economy.

3. Methodology and Research Design

Guan et al. (2021) considers a panel data to measure the impact of Renewable Energy Sources on Financial Development, and Economic Growth on emerging economies, where the authors use Pooled Mean Group (PMG) and Cross-Sectional Augmented Autoregressive Distributed Lag (CS-ARDL) to estimate the effect of usage renewable energy on financial development and economic growth in Chinese economy. The author uses times series data from year 1990 to 2018 (nearly 29 years) to measure the trend of consuming renewable energy on low-income Countries. The author will compare zonal data based on world bank data sources in low-income countries.

Table 1 – Countries Name and World Bank Code

Country Name	WB Country Code	Region
Algeria	DZA	Northern Africa (NAZ)
Egypt	EGY	
Libya	LBY	
Morocco	MAR	
Sudan	SDN	
Tunisia	TUN	
Burundi	BDI	Eastern Africa (EAZ)
Comoros	COM	
Djibouti	DJI	
Eritrea	ERI	
Ethiopia	ETH	
Kenya	KEN	
Madagascar	MDG	
Malawi	MWI	

Country Name	WB Country Code	Region
Mauritius	MUS	
Mozambique	MOZ	
Rwanda	RWA	
Seychelles	SYC	
Somalia	SOM	
South Sudan	SSD	
Tanzania	TZA	
Uganda	UGA	
Zambia	ZMB	
Zimbabwe	ZWE	
Angola	AGO	Middle Africa (MAZ)
Cameroon	CMR	
Central African Republic	CAF	
Congo (Democratic)	COD	
Congo	COG	
Equatorial Guinea	GNQ	
Gabon	GAB	
Sao and Principle	STP	
Botswana	BWA	Southern Africa (SAZ)
Eswatini	SWZ	
Lesotho	LSO	
Namibia	NAM	
South Africa	ZAF	
Benin	BEN	Western Africa (WAZ)
Burkina Faso	BFA	
Cape Verde	CPV	
Cote de Ivory	CIV	
Gambia	GMB	
Ghana	GHA	
Guinea	GIN	
Guinea-Bissau	GNB	
Liberia	LBR	
Mali	MLI	
Mauritania	MRT	
Niger	NER	
Senegal	SEN	
Sierra Leone	SLE	
Togo	TGO	

Table 2 – Variables indication of independent variables that affect dependent variable

Independent Variable Name	Variable Indication	Measurement Unit	World Bank Indicators	Literature References
1. Electricity Production from Renewable Resources	EPRR	Electricity production from renewable sources, excluding hydroelectric (kWh)	EG.ELC.RNWX.KH	Zaharia et al., 2019
2. Electricity Production from Coal Resources	EPCR	Electricity production from coal sources (% of total)	EG.ELC.COAL.ZS	Zaharia et al., 2019

3. Electricity Production from Nuclear Resources	EPNR	Electricity production from nuclear sources (% of total)	EG.ELC.NUCL.ZS	Zaharia et al., 2019
4. Electricity Production from Oil Resources	EPOR	Electricity production from oil sources (% of total)	EG.ELC.PETR.ZS	Zaharia et al., 2019
5. Electricity Production from Natural Gas Resources	EPGR	Electricity production from natural gas sources (% of total)	EG.ELC.NGAS.ZS	Caruso et al., 2020
6. Electricity Access of People	EAP	Access to electricity (% of population)	EG.ELC.ACCS. ZS	Caruso et al., 2020
7. Labour Force	LF	Labor force participation rate for ages 15-24, male (%) (national estimate)	SL.TLF.ACTI.1524.MA.NE.ZS	Zaharia et al., 2019 ; Ahmed and Shimada, 2019
8. Agricultural Land	AL	Agricultural land (sq. km)	AG.LND.AGRI.K2	
9. GDP per Capita	GDP	GDP per capita (current US$)	NY.GDP.PCAP.CD	IAEA, 2001
10. Population Density	PD	Population density (people per sq. km of land area)	EN.POP.DNST	IAEA, 2001
11. Population	TP	Population, total	SP.POP.TOTL	IAEA, 2001
12. Terms of Trade	TOT	Net barter terms of trade index (2000 = 100)	TT.PRI.MRCH.XD.WD	Zeng et al., 2018
13. Economic Growth	EG	GDP growth (annual %)	NY.GDP.MKTP.KD.ZG	Nababan and Sihol, 2015
14. Literacy Rate (LR)	ALR	Literacy rate, adult total (% of people ages 15 and above)	SE.ADT.LITR.ZS	Caruso et al., 2020
15. Research and Development Cost	RDC	Research and development expenditure (% of GDP)	GB.XPD.RSDV.GD.ZS	Zaharia et al., 2019
16. Private Participation Energy Investment	PPEI	Investment in energy with private participation (current US$)	IE.PPI.ENGY.CD	Eder et al, 2019
17. Natural Resources Usage	NRU	Total natural resources rents (% of GDP)	NY.GDP.TOTL.RT.ZS	Zeng et al., 2018
18. Trade Openness	TO	Trade (% of GDP)	NE.TRD.GNFS.ZS	Zeng et al., 2018
19. Gasoline Price	GP	Pump price for gasoline (US$ per liter)	EP.PMP.SGAS.CD	Nababan and Sihol, 2015
20. Capital Accumulation	CA	Gross capital formation (current US$)	NE.GDI.TOTL.CD	Ahmed and Shimada, 2019
21. Carbon Emission	CE	Total greenhouse gas emissions (KT of CO2 equivalent	EN.ATM.GHGT.KT.CE	IAEA, 2001
22. Urban People	DU	Urban population (% of total population)	SP.URB.TOTL.IN.ZS	Eder et al, 2019
23. Energy Import	EI	Energy imports, net (% of energy use)	EG.IMP.CONS.ZS	IAEA, 2001

24. Life Expectancy	LE	Life expectancy at birth, total (years)	SP.DYN.LE00.IN	Caruso et al., 2020
25. Income Inequality	II	Gini index (World Bank estimate)	SI.POV.GINI	IAEA, 2001
Dependent Variable: Renewable energy consumption (% of total final energy consumption)				

Source: Author Own Compilation, 2022

4. Econometric Model

The author considers 25 independent variables, that can influence renewable energy consumption in different zones of Africa, affect positively or negatively on renewable energy consumption. The author divides two classifications to run regression. Firstly, the author considers only general variables and secondly the author considers only the socio-economic variables for different zones. Model type 1, the author considers only general variables and for model type 2, the author only socio-economic variables.

4.1 Multiple Regression Model

Model Type 1: (For Unrestricted Model)

$$REC= \beta0 + \beta1\ EAP + \beta2\ LF + \beta3\ AL + \beta4\ GDP + \beta5\ PD + \beta6\ TP+ \beta7\ TOT+ \beta8\ EG+ \beta9\ ALR +$$
$$+\beta10\ RDC + \beta11\ PPEI + \beta12\ NRU + \beta13\ TO+ \beta14\ GP + \beta15\ CA + \beta16\ CE + \beta17\ DU + \beta18\ EI +$$
$$+\beta19\ LE + \beta20\ II + u$$

Model Type 2: (For Restricted Model)

$$REC= \beta0 + \beta1\ EAP + \beta2\ LF + \beta3\ AL + \beta4\ GDP + \beta5\ PD + \beta6\ TP+ \beta7\ TOT+ \beta8\ RDC + \beta9\ PPEI +$$
$$+\beta10\ NRU + \beta11\ TO+ \beta12\ GP + \beta13\ CA + \beta14\ CE + \beta15\ DU + \beta16\ EI + \beta17\ LE + \beta18\ II + u$$

4.2 Joint Hypothesis Testing

For analysing the joint hypothesis testing, the author considers some variables which do not include two variables named Economic growth (EG) and Average Literacy Rate (ALR) in model.

Ho: Null Hypothesis: $EG=ALR=0$
Ha: Alternative Hypothesis: $EG \neq ALR \neq 0$

In this paper, the author tries to find out the effect of independent variables on dependent variable name, named renewable energy consumption, in zonal-wise. The author compares the two different models named unrestricted and restricted to measure the impact in zonal-basis.

5. Research Result

From the table no 3, it is found that how does economic growth and adult literacy rate affect renewable energy consumption positively or negatively. On the other hand, from Table 4, is it observed that how economic growth and adult literacy rate jointly can affect REC level in zonal wise.

5.1 Multiple Regression Result for General and Socio-economic Variables

5.1.1 Multiple Regression Result of Northern Africa

5.1.1.1 Multiple Regression Result of General Variables in NAZ

In this area, EAP has negative connectivity with renewable energy usage, if the electricity access has been increased by 1 percent, then renewable energy usage will be reduced by 37 percent, that is 1

percent level of statistically significant. If the AL has been increased by 1,00,000 square kilometres, then renewable energy consumption will be reduced by 5 percent. If the Population density (people per sq. km of land area) has been increased by 1 percent, then renewable energy consumption will be reduced by 57 percent, it is statistically significant at 1 percent level.

Table 3 – Zonal-wise multiple regression analysis for African countries

Variable Name		Dependent Variable: Renewable energy consumption (% of total final energy consumption)										
		Co-efficient Sign	1. Multiple Regression NAZ_ General Variables	2. Multiple Regression NAZ_ Socio-Economic Variables	3. Multiple Regression EAZ_ General Variables	4. Multiple Regression EAZ_ Socio-Economic Variables	5. Multiple Regression MAZ_ General Variables	6. Multiple Regression MAZ_ Socio-Economic Variables	7. Multiple Regression SAZ_ General Variables	8. Multiple Regression SAZ_ Socio-Economic Variables	9. Multiple Regression WAZ_ General Variables	10. Multiple Regression WAZ_ Socio-Economic Variables
1	EPRR	**β1**	0.000		-0.000***		0.000		0.000		0.000	
2	EPCR	**β2**	0.110		0.154**		NA		-0.027		-0.210***	
3	EPNR	**β3**	NA		NA		NA		0.520			
4	EPOR	**β4**	0.006		0.089***		-0.156		0.041		-0.058**	
5	EPGR	**β5**	0.041		-0.524***		-0.127		NA		0.032*	
6	EAP	**β6**	-0.374***		-0.182***		0.540***		-0.131**		-0.133**	
7	LF	**β7**	-0.047	-0.119	0.086**	0.016	-0.170**	0.060	-0.152**	-0.325***	0.015	-0.119***
8	AL	**β8**	-0.00005***		0.0001***		0.00001		-0.0001***		-0.0001***	
9	GDP	**β9**	0.0001	-0.002***	-0.002***	-0.002***	-0.003***	-0.003***	0.0001	-0.001	-0.003**	-0.009***
10	PD	**β10**	-0.579***	0.425***	0.004	0.017*	-0.197***	-0.295***	-0.467**	0.282***	0.011	-0.004
11	TP	**β11**	-0.00000***	0.00000***	0.00000***	0.00000***	0.00000***	0.00000***	0.00000	-0.00000***	0.00000***	0.00000***
12	TOT	**β12**	-0.0004		0.276***		0.154***		0.147***		-0.025	
13	EG	**β13**	0.038**	0.008	0.043	0.115	-0.015	-0.163**	0.030	-0.044	-0.065	0.078
14	ALR	**β14**	0.085	0.264**	0.062	0.292***	-0.381***	-0.827***	-0.115	0.095	-0.082*	-0.085*
15	RDC	**β15**	10.958***		11.978***		3.941		1.442		-4.860***	
16	PPEI	**β16**	0.000*		0.000		0.000***		-0.000		-0.000	
17	NRU	**β17**	0.070		-0.177***		-0.533***		-0.109		0.068	
18	TO	**β18**	-0.068**		-0.029*		0.030		0.061		0.051	
19	GP	**β19**	1.006		3.447***		-8.098***		-0.757		4.845***	
20	CA	**β20**	0.000**	0.000***	0.000***	-0.000	-0.000***	-0.000***	-0.000	0.000	-0.000***	-0.000**
21	CE	**β21**	0.0001***		-0.001***		-0.0002***		-0.00000		-0.0005***	
22	DU	**β22**	-3.579***		-0.253**		-0.030		-0.588***		-0.945***	
23	EI	**β23**	0.033***		0.008***		0.005**		-0.183		-0.330***	
24	LE	**β24**	4.683***	-6.919***	-1.668***	-2.043***	-0.620	1.771***	0.239	-0.252*	-0.220*	-1.393***
25	II	**β25**	-0.075	-0.390	**-0.407*** **	-0.313*	0.026	-0.752*	-0.178	-0.412***	-0.307***	-0.064
	Constant		**-19.338**	**505.121*** **	**142.528*** **	**172.141*** **	**135.525*** **	**81.399*** **	**102.642*** **	**81.173*** **	**138.463*** **	**161.327*** **
	Observations		**120**	120	**360**	**360**	**160**	**160**	**100**	**100**	**100**	**300**
	R2		**0.593**	0.896	**0.895**	**0.552**	**0.924**	**0.806**	**0.970**	**0.934**	**0.899**	**0.693**
	Adjusted R2		**0.591**	0.887	**0.887**	**0.541**	**0.924**	**0.794**	**0.961**	**0.928**	**0.890**	**0.684**
	F Statistic		**566.282*** **	**104.956*** **	**118.983*** **	**47.964*** **	**72.367*** **	**69.247*** **	**102.520*** **	**142.635*** **	**101.952*** **	**72.902*** **
	Significance Level: *p<0.1; **p<0.05; ***p<0.01											

Source: Author's Own Compilation 2022

If the TP has been increased by 1,00,000 then renewable energy consumption will be reduced by 1 percent, it is it is statistically significant at 1 percent level. If the economic growth has been increased by 10 percent, renewable energy consumption will be increased by 0.38 percent. If the Research and development expenditure (% of GDP) has been increased by 1 percent, then renewable energy consumption will be increased by 10 percent, it is statistically significant at 1 percent level. If the PPEI (private Investment in energy sector) has been increased by 1000 US$, then renewable energy consumption will be increased by significant rate. If the Trade (% of GDP) has been increased by 100 percent, then renewable energy consumption will be reduced by 6.8 percent,

it is statistically significant at 5 percent level. If the CA has been increased by 1000 US$, then renewable energy consumption will be increased. If the carbon emission has been increased by 10,000 KT, including all agro and non-agro product burning, then then renewable energy consumption will be increased by 1 percent, it is statistically significant at 1 percent level. If the density of urban population in total population has been increased by 1 percent, then renewable energy consumption will be decreased by 3.5 percent, it is statistically significant rate 1 percent level. If the Energy imports, in net (% of energy use) has been increased by 10 percent, then then then renewable energy consumption will be increased by 0.33 percent, it is statistically significant at 1 percent level. If the LE has been increased by 1 year, people will be willing to search alternative energy to fulfil their daily demand, renewable energy will be increased by 8.6 percent, it is statistically significant at 1 percent level.

Table 4 – Interacted Multiple Regression Analysis in Zonal-wise

Interacted Variable: Adult Literacy Rate (ALR)* Economic growth (EG)								
Dependent Variable: Renewable energy consumption (% of total final energy consumption)								
Variable Name	Model 11 IRM_NAZ	Model 12 IRM_EAZ	Model 13 IRM_MAZ	Model 14 IRM_SAZ	Model 15 IRM_WAZ	Maximum Positive Effect	Maximum Negative Effect	Comparative Analysis with EAZ (Referred Zone)
EPRR	0.000	-0.000***	0.000	-0.000	-0.000	0.000	-0.000	None of the zone possesses good position to consume renewable energy
EPCR	0.101	0.149**		-0.034	-0.217***			
EPNR				0.341				
EPOR	0.002	0.083***	-0.167	0.035	-0.065**			
EPGR	0.030	-0.494***	-0.127		0.029*			
EAP	-0.377***	-0.151**	0.549***	-0.136**	-0.138**	0.549***	-0.377***	Only MAZ affect positively on REC. When huge population demand more electricity, the authority
LF	-0.043	0.091**	-0.166**	-0.154**	0.013	0.091***	-0.166**-	No zones does not able to create positive impact to consume renewable energy compared to EAZ
AL	-0.00005***	0.0001***	0.00001	-0.0001***	-0.0001***	0.0001***	-0.00005***	When AL usage increases, developing countries will take initiatives to produce more renewable energy to fulfil local demand of households. Except EAZ, no other zone grabs good position
GDP	0.0001	-0.002***	-0.003***	0.0002	-0.003**	0.0002	-0.003***	Generally, if GDP level create positive effect to consume renewable energy, it will be optimistic approach for these developing economics. No one the country belongs healthy position.
PD	-0.581***	0.005	-0.192***	-0.465**	0.009	0.005	-0.581***	EAZ create positive impact of REC but it is not statistically significant to affect model.
TP	-0.00000***	0.00000***	0.00000***	0.00000	0.00000***	0.00000***	-0.00000***	Except NAZ, all zone affects the model but SAZ does not create effect on model.
TOT	0.003	0.262***	0.159***	0.145***	-0.022	0.262***	0.003	Compared to EAZ, MAZ and SAZ affect nearly 10% and 11% less in model.
EG	0.415	-0.934***	-0.281	1.704	0.253	0.415	-0.934***	No of the Zone belongs in good position to create positive impact on REC
Interacted Variable: Adult Literacy Rate (ALR)* Economic growth (EG)								
Dependent Variable: Renewable energy consumption (% of total final energy consumption)								
Variable Name	Model 11 IRM_NAZ	Model 12 IRM_EAZ	Model 13 IRM_MAZ	Model 14 IRM_SAZ	Model 15 IRM_WAZ	Maximum Positive Effect	Maximum Negative Effect	Comparative Analysis with EAZ (Referred Zone)
ALR	0.106	0.014	-0.387***	-0.023	-0.056	0.106	-0.387***	No of the Zone belongs in good position to create positive impact on REC
RDC	11.060***	9.863***	3.885	1.457	-4.960***	11.060***	-4.960***	Compared to EAZ, NAZ creates nearly 1% more positive effect to REC
PPEI	0.000*	0.000	0.000***	-0.000	-0.000	0.000*	-0.000	Compared to EAZ, NAZ and MAZ creates more positive effect to REC
NRU	0.045	-0.131***	-0.543***	-0.056	0.059	0.059	-0.543***	If this variable affects REC positively, it may be optimistic for a specific zone. No zone belongs healthy position.
TO	-0.056	-0.033**	0.032	0.060	0.050	0.060	-0.056	Trade openness does not affect the REC positively.
GP	0.822	2.415**	-8.011***	-0.936	5.189***	5.189***	-8.011***	Compared to EAZ, WAZ affects 5.5% more and positive effect on REC. Only EAZ and WAZ affect and influence the model positively.
CA	0.000*	0.000***	-0.000***	-0.000	-0.000***	0.000***	-0.000***	Except SAZ, all zones create positive effect on REC.
CE	0.0001***	-0.001***	-0.0002***	0.00000	-0.0005***	0.0001***	-0.0002***	Only NAZ zone affect positively on REC. No their zone affect REC positively.
DU	-3.555***	-0.244**	-0.007	-0.588**	-0.927***			No zone does not create positive effect on REC.
EI	0.032***	0.007***	0.005*	-0.203	-0.330***	0.032***	0.005*	Compared to EAZ, NAZ affect 2.5% more REC and affect positively on model.
LE	4.691***	-1.693***	-0.704	0.247	-0.200	4.691***	-1.693***	Compared to EAZ, NAZ affect positively on model on consume REC.
II	-0.078	**-0.392*** **	0.044	-0.202	-0.293***	0.044	**-0.392*** **	No zone does not create positive effect on REC.
ALR*EG	0.006	**0.017*** **	0.003	-0.020	-0.008	0.017***	-0.006	Only the EAZ create positive and significant approach on REC.
Constant	**-22.955**	**148.235*** **	**137.543*** **	**97.781*** **	135.720***			
Observations	120	**360**	**160**	**100**	300			
R2	0.993	**0.893**	**0.925**	**0.971**	0.900			
Adjusted R2	0.991	**0.900**	**0.911**	**0.961**	0.891			
F Statistic	**542.585*** **	**120.744*** **	**69.117*** **	**97.569*** **	98.327***			
*Significance Level: *p<0.1; **p<0.05; ***p<0.01*								

Source: Author's Own Compilation 2022

5.1.1.2 Multiple Regression Result of Socio-economic Variables in NAZ

The author only considers socio-economic variables in this section. If the GDP level has been increased by 1000 US$, then renewable energy will be reduced by 2 percent. GDP level does not

create positive impact on renewable energy consumption level in Northern African. If the Population density (people per sq. km of land area) has been increased by 10 percent, then renewable energy consumption will be increased by 4.25 percent, it is statistically significant at 1 percent level. If the Average Literacy Rate (LR) has been increased by 10 percent, then renewable energy consumption will be increased by 2.64 percent, it is statistically significant at 5 percent level. A Literate people will be eager to find out new and green energy sources with their existing knowledge. If the LE has been increased by 1-year, renewable energy consumption will be decreased by 6.91 percent, it is statistically significant at 1 percent level.

5.1.2 Multiple Regression Result of Eastern African Zone

5.1.2.1 Multiple Regression Result of General Variables (EAZ)

If the Electricity production from renewable sources, excluding hydroelectric (kWh) has been increased, then renewable energy consumption will be reduced. People will not be conscious to usage alternative energy. But in the long run, it will hamper their renewable energy storage in future. If the Electricity production from coal sources (% of total) has been increased 10 percent, then renewable energy consumption will be increased by 1.54 percent, it is statistically significant at 5 percent level. If the Electricity production from oil sources (% of total) has been increased by 10 percent, renewable energy consumption will be increased by 0.891 percent, it is statistically significant at 1 percent level. If the Electricity production from natural gas sources (% of total) has been increased by 10 percent, renewable energy consumption will be decreased by 5.24 percent, it is statistically significant at 1 percent level. If the Access to electricity (% of population) has been increased by 1 percent, renewable energy consumption will be decreased by 1.82 percent, it is statistically significant at 1 percent level. If the labour force participation rate for ages 15-24 has been increased by 100 percent, renewable energy consumption will be decreased by 8.6 percent, it is statistically significant at 5 percent level. If the AL has been increased by 10,000 square kilometres, then renewable energy consumption will be increased by 1 percent, it is statistically significant at 1 percent level. Conversely, if the GDP level has been increased by 1000 US$, renewable energy consumption has been reduced by 2 percent, it is statistically significant at 1 percent level. If the TP has been increased by 1,00,000 then renewable energy consumption will be reduced, it is it is statistically significant at 1 percent level. The terms of trade (TOT) has positive connection with renewable energy consumption. If the Research and development expenditure (% of GDP) has been increased by 1 percent, then renewable energy consumption will be increased by nearly 12 percent, it is statistically significant at 1 percent level. If the Pump price for gasoline (US$ per liter) has been increased, renewable energy consumption will be increased by 3.44 percent. When the gasoline price will be increasing at continuous rate, then people will take important steps to usage renewable energy. Renewable energy might be the important source to fulfil daily energy demand as well as to ensure energy security. If the CA has been increased by 1000 US$, then renewable energy consumption will be increased at significant rate. If the carbon emission has been increased by 1,000 KT, including all agro and non-agro product burning, then then renewable energy consumption will be decreased by 1 percent, it is statistically significant at 1 percent level. If the density of urban population in total population has been increased by 10 percent, then renewable energy consumption will be decreased by 2.53 percent, it is statistically significant rate 1 percent level.

If the Energy imports, in net (% of energy use) has been increased by 100 percent, then then then renewable energy consumption will be increased by 0.80 percent, it is statistically significant at 1 percent level. When a country bears huge burden of cost for importing energy from abroad, those country will be optimistic to introduce renewable energy. If the LE has been increased by 1 year, people will be willing to search alternative energy to fulfil their daily demand, renewable energy will be decreased by 1.68 percent, it is statistically significant at 1 percent level.

5.1.2.2 Multiple Regression Result of Socio-economic Variables in EAZ

If the GDP level has been increased by 1000 US$, then renewable energy will be reduced by 2 percent. GDP level does not create positive impact on renewable energy consumption level in Eastern African zone. If the Population density (people per sq. km of land area) has been increased by 10 percent, then renewable energy consumption will be increased by 0.17 percent, it is statistically significant at 1 percent level. If the Average Literacy Rate (LR) has been increased by 10 percent, then renewable energy consumption will be increased by 2.92 percent, it is statistically significant at 1 percent level. In addition, literacy rate in eastern African zone create positive impact to consume renewable energy. If the LE has been increased by 1 year, renewable energy consumption will be decreased by 2.043 percent, it is statistically significant at 1 percent level. Moreover, income inequality has negative connection with renewable energy consumption, if the income inequality increases by 10 units, then renewable energy consumption will be decreased by 3.13 percent, it is statistically significant rate 10 percent level. When there are inequality exists between poorer and rich class, the government will not take any positive initiative to introduce renewable energy consumption in general people in Eastern Africa.

5.1.3 Multiple Regression Result of Middle African Zone

5.1.3.1 Multiple Regression Result of General Variables (MAZ)

In this area, EAP has positive connectivity with renewable energy usage, if the electricity access has been increased by 10 percent, then renewable energy usage will be increased by 5.4 percent, that is 1 percent level of statistically significant.

If the labour force participation rate for ages 15-24 has been increased by 10 percent, renewable energy consumption will be decreased by 1.7 percent, it is statistically significant at 5 percent level. Conversely, if the GDP level has been increased by 1000 US$, renewable energy consumption has been reduced by 3 percent, it is statistically significant at 1 percent level. If the Population density (people per sq. km of land area) has been increased by 10 percent, then renewable energy consumption will be increased by 1.97 percent, it is statistically significant at 1 percent level. The terms of trade (TOT) has positive connection with renewable energy consumption. When the export exceeds than import, TOT stands positive, if the TOT increases by 10 percent, REC will be increased by 1.54%, it is statistically significant at 1 % level. If the average literacy rate has been increased by 10 percent, renewable energy consumption will be increased by 0.38 percent, it is statistically significant at 1 % level. If the investment on PPEI has been increased, then REC will be increased significantly. If the NRU has been increased by 10 percent, REC will be decreased by 5.33%, it is statistically significant at 1 % level. If the Pump price for gasoline (US$ per litre) has been increased by 1 %, renewable energy consumption will be decreased by 8.098 percent. Adversely, CA and CE have negative and significant connectivity with REC. If the energy import cost has been increased by 1000 dollar, renewable energy consumption will be increased by 5 percent.

5.1.3.2 Multiple Regression Result of Socio-economic Variables in MAZ

If the GDP level has been increased by 1000 US$, then renewable energy will be reduced by 3 percent. GDP level does not create positive impact on renewable energy consumption level in Eastern African zone. If the Population density (people per sq. km of land area) has been increased by 10 percent, then renewable energy consumption will be increased by 2.95 percent, it is statistically significant at 1 percent level. If the economic growth has been increased by 10 percent, renewable energy consumption will be decreased by 1.63 percent, it is statistically significant at 5 percent level.

If the Average Literacy Rate (LR) has been increased by 10 percent, then renewable energy consumption will be decreased by 8.27 percent, it is statistically significant at 1 percent level. In

addition, literacy rate in eastern African zone create positive impact to consume renewable energy. If the LE has been increased by 1 year, renewable energy consumption will be increased by 1.77 percent, it is statistically significant at 1 percent level. Moreover, income inequality has negative connection with renewable energy consumption, if the income inequality increases by 10 units, then renewable energy consumption will be decreased by 7.52 percent, it is statistically significant rate 10 percent level.

5.1.4 Multiple Regression Result of Southern African Zone

5.1.4.1 Multiple Regression Result of General Variables (SAZ)

In this area, EAP has negative connectivity with renewable energy usage, if the electricity access has been increased by 10 percent, then renewable energy usage will be decreased by 1.31 percent, that is 5 percent level of statistically significant.

If the labour force participation rate for ages 15-24 has been increased by 10 percent, renewable energy consumption will be decreased by 1.52 percent, it is statistically significant at 5 percent level. If the Population density (people per sq. km of land area) has been increased by 10 percent, then renewable energy consumption will be decreased by 4.67 percent, it is statistically significant at 5 percent level. The terms of trade (TOT) has positive connection with renewable energy consumption. When the export exceeds than import, TOT stands positive, if the TOT increases by 10 percent, REC will be increased by 1.47%, it is statistically significant at 1 % level. If the urban density has been increased, then renewable energy consumption will be decreased by 5.88 percent.

5.1.4.2 Multiple Regression Result of Socio-economic Variables in SAZ

If the labour force (LR) has been increased by 10 percent, then renewable energy consumption will be decreased by 3.25 percent, it is statistically significant at 1 percent level.
If the Population density (people per sq. km of land area) has been increased by 10 percent, then renewable energy consumption will be increased by 2.82 percent, it is statistically significant at 1 percent level. If the economic growth has been increased by 10 percent, renewable energy consumption will be decreased by 1.63 percent, it is statistically significant at 5 percent level.

If the LE has been increased by 10 years, renewable energy consumption will be decreased by 2.52 percent, it is statistically significant at 10 percent level. Moreover, income inequality has negative connection with renewable energy consumption, if the income inequality increases by 10 units, then renewable energy consumption will be decreased by 4.12 percent, it is statistically significant rate 1 percent level.

5.1.5 Multiple Regression Result of Western African Zone

5.1.5.1 Multiple Regression Result of General Variables (WAZ)

In this area, if energy production from coal resources has been increased by 10 percent, renewable energy consumption will be reduced at 2.1%, that is 1 percent level of statistically significant. Similarly, if energy production from oil resources has been increased by 10 percent, renewable energy consumption will be reduced at 0.58%, that is 1 percent level of statistically significant. Conversely, energy production from gas resources has positive and significant connectivity with REC. If the electricity access has been increased by 10 percent, then renewable energy usage will be decreased by 1.33 percent, that is 5 percent level of statistically significant. Agro-land has negative connectivity with REC, if the agro-land has been increased by 10,000 Sq, then REC will be reduced by 1 percent, it is statistically significant at 1 percent level. Moreover, if the GDP level has been increased by 1000 US$, renewable energy consumption has been.

If the average literacy rate has been increased by 10 percent, renewable energy consumption will be decreased by 0.82 percent, it is statistically significant at 10 % level. If the research and development cost (RDC) has been increased by 1 percent, renewable energy consumption will be decreased by 4.86 percent, it is statistically significant at 1 % level. If the Pump price for gasoline (US$ per litre) has been increased by 1 %, renewable energy consumption will be increased by 4.85 percent, it is statistically significant at 1 % level. When the gasoline price is rising, people will try to find alternative energy sources to fulfil their demand. Adversely, CA, CE, DU, EI, LE and II has negative and significant connectivity with REC.

5.1.5.2 Multiple Regression Result of Socio-economic Variables in WAZ

If the labour force (LR) has been increased by 10 percent, then renewable energy consumption will be decreased by 1.19 percent, it is statistically significant at 1 percent level. If the GDP level has been increased by 1000 US$, then renewable energy will be reduced by 9 percent, it is statistically significant at 1 percent level.

If the average literacy rate has been increased by 10 percent, renewable energy consumption will be decreased by 1.39 percent, it is statistically significant at 1 % level. If the LE has been increased by 1 year, renewable energy consumption will be decreased by 1.39 percent, it is statistically significant at 1 percent level.

5.2 Multiple Regression Result Interacted or Joint Variables

In this multiple, the author considers economic growth and average literacy rate as joint variable and measure their joint effect on renewable energy consumption. In the zone EAZ, the joint effect of economic growth average literacy rate affects positively on renewable energy consuming level. If the joint variable value increase by 10 units, the renewable energy consuming level will be increased by 1.7%.

5.3 Hypothesis Testing

From the restricted and unrestricted regression, the author tries to find out whether there are any effect of economic growth (EG) and average literacy rate (ALR) on the model or not.

Null Hypothesis: EG =ALR = 0

Alternative Hypothesis: EG ≠ ALR ≠ 0

Model 1: Restricted Model

REC ~ EAP + LF + AL + GDP + PD + TP + TOT + RDC + PPEI + NRU + TO + GP + CA + CE + +UPD + EI + LE + II

Model 2: Unrestricted Model

REC ~ EAP + LF + AL + GDP + PD + TP + TOT + EG + ALR + RDC + PPEI + NRU + TO + GP + +CA + CE + UPD + EI + LE + II

Hypothesis Testing for NAZ						
	Res.Df	RSS	Degree of Freedom	Sum of Square	F Statistics	Pr(>F)
1	*101*	*587.45*				
2	*99*	*543.87*	*2*	*43.582*	*3.9666*	*0.02202 **
Hypothesis Testing for EAZ						
	Res.Df	RSS	Degree of Freedom	Sum of Square	F Statistics	Pr(>F)
1	*341*	*46635*				
2	*339*	*45251*	*2*	*1384.2*	*5.1848*	*0.006054 ***
Hypothesis Testing for MAZ						
	Res.Df	RSS	Degree of Freedom	Sum of Square	F Statistics	Pr(>F)
1	*141*	*7650.6*				
2	*139*	*7213.9*	*2*	*436.71*	*4.2073*	*0.01682 **

Hypothesis Testing for SAZ						
	Res.Df	RSS	Degree of Freedom	Sum of Square	F Statistics	Pr(>F)
1	*81*	*971.94*				
2	*79*	*965.47*	*2*	*6.4733*	*0.2648*	*0.768*
	Hypothesis Testing for WAZ					
	Res.Df	RSS	Degree of Freedom	Sum of Square	F Statistics	Pr(>F)
1	*281*	*22187*				
2	*279*	*22125*	*2*	*62.623*	*0.3948*	*0.6742*
*Significance Level: '***' 0.001 '**' 0.01 '*' 0.05*						

Source Author's Own Compilation 2022

From the above table, it is observed that there are statistically significant effect of economic growth and literacy rate on NAZ economy, it is statistically significant at 5 percent level. For EAZ, the value of economic growth and literacy rate are statistically significant at 1 percent level. Furthermore, for the zone MAZ, values are statistically significant at 5 percent level. Conversely, there are no statistically impact of EG and ALR on SAZ and WAZ.

6. Policy Recommendation

In this research, the author wants to focus mainly two major variables named economic growth and average literacy rate, where these values differ from zonal-wise because of general and socio-economical changes. The government of some zones named MAZ, SAZ, WAZ should introduce adult school and stipend policies due to attending the classes compulsory, cash transfer polices or food for work program (FFW) to enhance the interest among them. From economic growth perspective (EG), except the NAZ, none of the region does not able to produce positive and significant impact on REC. Economic growth can be improved with changing the pattern of fiscal and monetary policies, when the bank and non-bank sectors should provide loan in flexible-condition and make the easier repayment systems. Renewable energy consumption is not only the issues of households or consumer, if the government and non-government institutions provide monetary support to set up solar-plant for each households, and those households will not get all electricity, because households need to change their behaviour on using renewable energy. Example: In rural areas, most of the households have Cattel and housing wastage that may be used to produce biogas, the households may use the biogas to produce renewable energy in daily basis. Firstly, it can lessen their daily cost to consume electricity and convert their mentality to consume renewable energy.

7. Conclusions

Renewable energy is one of the foundations for modern economies because it is mandatory factor economic development, life-standard. Access and use of renewable energy are one of the major issues in SDGs, which should be grabbed within 2030. Therefore, renewable energy technologies offer reasonable and sustainable energy usages for millions of people who are affected in energy-poverty. Policy-makers should consider different policies and planning in different zone.

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9. Competing interests

The authors declare that they have no competing interests.

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