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Improving Energy Efficiency and Green Economy in Africa: Have we lost the Poverty Argument?

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Abstract

There is no cheap renewable energy; majority of Africa economies exist below the poverty line and non-industrialized margin. How many Africans can afford the cost of a solar energy systems or wind energy station to burning local solid fuels, per se wood, for energy? In a green economy, growth in income and employment should be driven by public and private investments that reduce carbon emissions and pollution, enhance energy and resource efficiency, and prevent the loss of biodiversity and ecosystem services. Using secondary data to answer the questions, the IPAT (Environmental Impact, I, Population, P, Affluence, A, and Technology, T) formula African's position is unveiled by the index. There is imbalance among these four green economic factors. Discussed here are efforts to forestall improved energy efficiency which has not been empowered due to challenging factors from socio-economic, political and policy; Resource and efficient technology`s (RET) institutional framework and many others. Improving energy efficiency has much with making leverage as less effort is spent in exploitation, application and utilization of energy. The paper opines workable approaches to lift the welfare of many Africans in assessing and using energy, least we totally miss the poverty argument in the very near future.

Keywords: Energy efficiency, Green economy, Poverty.

1. Introduction

Green energy resources in Africa includes hydro, solar, wind, and biomass; while tidal and geothermal are far-fetched in Africa due to its compositeness with very hi-tech technology. Africa may have lost the poverty argument for enhancement of energy efficiency and green economy. There had been little leverage attained with enormous expenditure involved in the technology employed for exploitation, utilization and management of the green energies. Methods of harnessing renewable energy involve high technological and economic costs. Africa economics are below non-industrialized margin or low-technology. The continent is particularly susceptible to climate change because it includes some of the world's poorest nations [1]. Africa appropriately using green economy approaches can generate consistent and positive outcomes as increased wealth, productivity, decent employment, and reduced poverty. The Gross Domestic Product (GDP) assessment among African nation and employment level solely created or support by the green economic activities scored very low. Access to clean sources of energy is a function of mainly income[2]. Since most Sub Sahara is poor, incentives and subsidies are required to ensure green economy. What do existing data revel about African experiences and what actions are required? The answers are the objectives.

2. Methodology, data collection and analysis

The focus is Sub Saharan Africa. Secondary data was depended on the World Bank, the United Nation Conference on Trade and Development, UNCTAD, the United Nations Common Trade Statistics/database, IEA, International Development Association (IDA) and primary data are derived from energy studies in the department of Electrical Engineering in conjunction with the department of Economics & Demographic Studies, Federal University, Oye-Ekiti, Ekiti State, South-West, Nigeria.

Statistical, algebraic and a bit of stochastic analysis were used. Green economic index is highly dependent on IPAT formula used. The overall driver of human impact on

Earth systems is the destruction of biophysical resources, and especially, the Earth's ecosystems. The total environmental impact of a community or of humankind as a whole depends both on population and impact per person, which in turn depends in complex ways on what resources are being used, whether or not those resources are renewable, and the scale of the human activity relative to the carrying capacity of the ecosystems involved. Careful resource management can be applied at many scales, from economic sectors like agriculture, manufacturing and industry, to work organizations, the consumption patterns of households and individuals and to the resource demands of individual goods and services.

One of the initial attempts to express human impact mathematically was developed in the 1970s and is called the IPAT formula. This formulation attempts to explain human consumption in terms of three components: population numbers, levels of consumption (which it terms "affluence", although the usage is different), and impact per unit of resource use (which is termed "technology", because this impact depends on the technology used). The equation is expressed:

$$I = P \times A \times T \qquad (1)$$

Where: I = Environmental impact, P = Population, A = Affluence, T = Technology,[3]. Taking zero as a leverage point when ∂I (change in I) = ∂ K Q, Meaning that,

$$\int \partial I = K \int \partial Q, \qquad (2)$$

at $Kn = \partial I / \partial Q$, n is the year under assessment,(i.e. 1^{st} year, 2^{nd} year, etc). Integrating from the Year, *N* (year in study) to Year, *n* at zero. Where Q = PxAxT, and K is Integral constant(should be constant for the given period of years, *(N–n) years*, under assessment), K is for e.g environmental policies, regulation, powers/laws, etc And K cannot be numerically quantified since it is a ratio just as laws and policies are not numerically quantified). Probable conditions that can decide the integral value of *I* are: If $P > A > T$, then $I > 0$, the realization of green economy in low; if $P < A > T$, then $I = 0$, the green economy realization is moderately average; if $P<A<T$, then, $I < 0$, is high.

Assuming that A = Affluence is GDP results (as Technological Export) shown in Table 3. Assuming that T=Technology is Energy Consumption level as shown in Table 2, and P = Population, which is evidently known. And there could be possibilities of interactions among the factors. The outcome would reveal the basis of our assessment in this context. However, we have to note that for all these: $K \ \forall \ f\{P,A,T\}$, K is not an element of P, A and T. T = f {*T`, E,M, I`,R..n*}, (Technology is a function of Technical-know-how, Energy Consumption level, Industrialization level, Innovative power, Raw-material, etc). A = f {*G, F,F`,H,..m}* *(*Affluence is a function of GDP, Foreign/diplomatic relationships and Influence, Fiscal power, Hi-technical-aid, *m* stands for other factors). P = f{ *B,D,M,…l*} (Population is a function of Birth rate, death rate, migration rate, etc). Continental Population figure are: Africa total population 1,072 billion, Northern Africa 213 million Western Africa 324 million, Middle Africa (Central Africa) 134 million, Eastern 342 and Southern Africa 59 million[4].

A. African performance relative to others

During the period 1990–1997, manufacturing value added in sub-Saharan Africa, without South Africa, amounted to only 0.1% per annum. Sub-Saharan Africa's share of global manufacturing value added has remained constant since 1980, at under 0.4 per cent [5]. Even this low level of activity is highly concentrated. In 1998, only South Africa accounted for 55% of sub-Saharan Africa's total manufacturing value added, and seven countries for another 22%. The relationship between carbon emissions, income, energy and total employment in some countries which included African OPEC members was investigated [6]. Table 1 shows regional concentrations of manufactures exporters among developing countries. Almost two-thirds up from only a third in 1980 of total manufactured exports by developing countries in 2000 came from Asia. The Latin American region maintained its 20 per cent share during this period. Sub-Saharan African lost ground in its world market shares of manufactured exports in every category, even in resource-based exports. The dynamics of export growth and technological upgrading seem to be bypassing the region. Primary products mainly agricultural dominated exports of sub-Saharan Africa. Apart from the Middle East and North Africa (MENA) and its huge oil-exporting base, Africa is the region with the highest reliance on primary products. At the other extreme is East Asia, with the share falling from 15 to 4 per cent. Latin America having maintained its one-fifth shares between 1980 and 2000. Therefore, it would seem that Africa has yet to break away from the tradition of exporting unprocessed materials, which is not only the slowest growing segment of world trade but also the least stimulating in terms of structural, entrepreneurial, skill and technology growth.

B. Energy Consumption Level

Energy consumption level can be used to represent the level of technology T and application of hi-tech activities which could be resulting to high emission of green house gases. According to various regions of Africa, technology level is presented as shown below;

Examples of Resource-based include Agro-forest based, LT is Textile, clothing, footwear, MT is Automotive, Process engineering, and HT is Electronic/electrical and other high technology. Energy consumption level can be used to represent the level of technology, T and application of hi-tech activities which could be resulting to high greenhouse gases.

Table 1: Percent share of regions in developing countries' exports, 1980 and 2000.

Regions / Year	Total Manufactures		Resource-Based		Low Technology		Medium Technology		High Technology	
	1980	2000	1980	2000	1980	2000	1980	2000	1980	2000
Latin America & Caribbean	20.5	20.4	33.5	25.8	14.9	12.5	33.1	26.1	22.0	13.1
Middle-East & North Africa	32.7	12.4	18.0	13.8	9.1	7.0	8.7	4.1	2.9	0.8
ASIA	*2.6*	62.8	37.6	54.5	73.1	79.1	52.8	67.4	73.8	85.9
South Asia	*16.2*	*3.7*	2.6	6.1	*8.9*	*9.3*	*3.1*	2.0	1.4	0.6
East Asia	*13.9*	*35.2*	9.9	22.0	*57.4*	*55.3*	*35.0*	*45.3*	43.5	43.1
South East Asia	11.6	*23.9*	25.1	26.5	*6.7*	*14.5*	*14.7*	*20.2*	28.9	42.2
Sub-Saharan AFRICA	*5.9*	4.4	10.9	5.9	3.0	1.4	5.4	*2.4*	1.3	0.3
Southern	*0.6*	*1.9*	6.2	4.0	*2.5*	*1.2*	*4.5*	2.2	0.9	0.3
East	*5.9*	*0.2*	1.0	0.2	0.2	0.1	*0.1*	*0.0*	0.2	0.0
West	*4.1*	*2.0*	2.9	1.1	*0.3*	*0.1*	*0.8*	*0.1*	0.2	0.0
Central	*1.0*	*0.3*	0.8	0.5	*0.0*	*0.0*	*0.0*	*0.0*	0.0	0.0

Source: UN Common Trade (COMTRADE) Statistics data base

Table 2: Energy Consumption by Sector in Regional Africa ('000 toe), 2001

Region	Industrial (000'toe)	Transport ('000 toe)	Other Sectors ('000 toe)1	Non-Energy uses ('000 toe)2
North Africa	26,421	18,903	27,608	2,504
Sub-Saharan Africa*	24,432	18,944	158,281	1,395
South Africa	26,023	13,593	16,256	556

*Sub Saharan Africa Comprising *of West Africa and Central Africa excluding South Africa East Africa.* 1. Other sectors comprise of Agriculture, Communication and Publication Services, Residential and other non specified uses. 2. Non energy uses chiefly constitute electricity generation. (toe = tonne of oil equivalent) *Sources: IEA, 2003, 2002*

3. Correlations, Other Results and Discussions

The feasible conditions are recalled; If $P > A > T$, then $I > 0$, the realization of green economy is low, If $P < A > T$, the $I = 0$, It is moderately average. And if $P<A<T$, then $I < 0$, it is high. The total estimated

Table 3: Share of Technological Export (%)

Regions	RB	LT	MT	HT
Middle East & North Africa	13.8	7.0	4.1	0.8
Sub-Sahara Africa	5.9	1.4	2.4	0.3

Resource-based is *Agro-forest based*, RB, LT is *Textile, clothing, footwear*, MT is *Automotive, Process Engineering*, and HT= Electronics*/electrical & Other high technology.* Source: Authors Calculation

energy consumption in Africa is 334,916 toe The share and percentage for North Africa are 75,436 toe and 22.52% while Sub-Sahara's share are 203,052 toe and 60.63%; South Arica`s share are 56,428 toe and 16.85%. The percentage shares, Technological Export are in lieu of GDP.

Comparing Tables 2 and 3 the results shows that most African regions experiences occur at $P > A < T$, which is not a good or smooth analysis of attainment of less impact, I and greener economy. Under the judging parameters; is $P > A < T$ an invariable condition considering all the African regions? Recall Africa population discussed above. Sub-Sahara African, merging Western, Central Africa and South Africa, will have a population 517 millions and the Technological Export came to 10, and Northern and Eastern Africa altogether were 555 millions in population which the total technological export was 25.7 (having to consider only core African states). Energy consumptions were 22.52 %, 60.63% and 16.85% for North, Sub-Sahara, and South Africa regions respectively. Satisfying this condition $P > A < T$ may affirms the notion that the African states have not scaled off the poverty judgment. Based on the World Bank criterion for poverty assessment among nations, Experts at the World Bank use so-called development diamonds to portray relationships among four socio-economic indicators for a given country relative to the averages for that country's income group. Development diamonds, human development Index, Gross National Income among other factors are used in affirming each nation`s level of development and poverty level.

However, envisaging the value of environmental impact, *I,* amongst contemporary nations supported the analysis. It is found that Environmental Impact Assessment (EIA) figures of developed countries are very different to that of the less developed or developing countries [7]. EIA in developing economies is not feasible because of inability to store data, financing assessment projects and unwillingness to embark on the legal implication of policies supporting EIA. Table 4 shows the dominance of African nations on global ranking in environmental impact assessment score, judging the African positions here poses a question that had Africans not the technological power or affluence to acquire renewable energy facilities and embark on green economy policies, still own 50%(of global figure) of the safest environmental base [8].

Table 4: Twenty top-ranked countries by proportional composite environmental (pENV) rank (higher ranks=lower negative impact).

Rank	Country	Code	PD	PGR	GOV	GNI	NFL	HBC	MC	FER	WTP	PTHR	CO2	pENV
179	Cape Verde	CPV	69	54	76	20	**128**	**214**	**113**	**157**	-	-	-	148.5
178	Cent Afr Rep	CAF	199	67	188	29	**76**	**172**	**176.5**	**174**	-	**175**	**131**	144.8
177	Swaziland	SWZ	116	96	142	31	**201**	**192**	**176.5**	**113**	**67**	**167**	**148**	143.9
176	Antig & Barb	ATG	50	85	52	9	**128**	**148**	**119**	-	-	**176**	-	141.1
175	Niger	NER	191	10	143	46	**80**	**178**	**176.5**	**173**	**109**	**128**	**145**	136.4
174	Grenada	GRD	30	164	66	6	**128**	**214**	**115**	-	-	**109**	-	136.1
173	Samoa	WSM	117	150	65	14	**196**	**214**	**95**	**96**	-	-	**116**	134.7
172	Tonga	TON	66	185	109	8	**128**	**214**	**132**	-	-	-	**88**	133.6
171	Djibouti	DJI	153	53	151	19	**128**	**184**	**152**	-	-	**98**	**109**	130.8
170	Tajikistan	TJK	137	119	182	38	**161**	**124**	**176.5**	**111**	-	**93.5**	-	129.6
169	Bhutan	BTN	183	143	81	-	**198**	**85**	**176.5**	**169**	-	**53**	**142**	124.8
168	Chad	TCD	197	12	181	41	**70**	**112**	**176.5**	**148**	-	**125**	**144**	124.3
167	Vanuatu	VUT	172	48	88	4	**128**	**165**	**81**	-	-	-	**139**	124.2
166	Mali	MLI	193	29	103	50	**65**	**114**	**176.5**	**137**	-	**148**	**137**	124.0
165	Kazakhstan	KAZ	200	207	146	114	**157**	**107**	**176.5**	**152**	-	**57**	-	120.8
164	Gabon	GAB	201	63	125	39	**81**	**161**	**86**	**163**	**110**	**144**	**124**	120.0
163	Turkmenistan	TKM	192	91	189	70	**128**	**182**	**176.5**	**90**	-	**66**	-	119.6
162	Lesotho	LSO	114	116	102	34	**128**	**126**	**176.5**	**120**	**46**	**157**	**138**	119.1
161	Suriname	SUR	208	152	94	22	**128**	**181**	**66**	**73**	-	**183**	**136**	118.6
160	Eritrea	ERI	148	52	168	27	**77**	**117**	**148**	**133**	-	**132**	-	118.5

Shown are country names and codes, population density (PD) rank, population growth rate (PGR) rank, governance quality (GOV) rank, Gross National Income (GNI) rank, natural forest loss (NFL) rank, natural habitat conversion (HBC) rank, marine captures (MC) rank, fertilizer use (FER) rank, water pollution (WTP) rank, proportion of threatened species (PTHR) rank, and carbon emissions (CO2) rank. Constituent variables used to create the pENV are in boldface. See text for details. Missing values denoted by '-'.

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Source: Plos-One Journals: *Evaluating the Relative Environmental Impact of Countries*. Bradshaw,C.*et al*, (2010).

And this stands that it will require fewer finances to clean the economy and foster it greenish. Can we still claim a position above the poverty level since we have negative environmental impact?

Finally, Figures deduced from our observation in the former discussion go along with the motion that higher proportion of African is still living below the poverty line. Interpolation of the energy consumption level, the population sizes and the export expresses their regional gross domestic product. We would come to the arrival of result seemingly as we have above; the results were able to buttress the inference which was earlier stated, about the feasible conditions of the African regions. From the later discussion, buttressed by Table 4, are having all parameters of environmental impact assessment pointing the competency of African region to possess a good attributes of leveraging green economy in the area of low impact on the environment.

4. Further Information

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5. Conclusion and Recommendations

Understanding the individual contributions of the constituents of the Impact formula and the general effect of the integrated output of each resulting to an economic change for a given period, was shown here as a guide to aid green economists and energy users in Africa and global. It was also shown that laws and policies are to be considered at an instant while analyzing the Impact level of a region or country. However, Due to challenging issues of energy loss in Africa, some approaches to be adopted to improve the energy efficiency in Africa are:

A. Cost by source

Large energy subsidies are present in many countries [9]. Economic theory indicates that the optimal policy would be to remove coal mining and burning subsidies and replace them with optimal taxes. Global studies indicate that even without introducing taxes, subsidy and trade barrier removal at a sectoral level would improve efficiency and reduce environmental damage. Removal of these subsidies would substantially reduce GHG emissions and stimulate economic growth.
Evaluating the cost-effectiveness of energy efficiency is essential to identifying how much of our country’s potential for energy efficiency resources will be captured[10].

B. Informed energy management through awareness

Majority of the African are rural dwellers and possesses less educational background to administer nascent electric energy management at the household level. As a result of this, large sum of Kilowatts of electric energy are wasted unutilized for null purposes. For instance, Between the hours of 0800 and 1500 are less peak consumption range for most of the West African electric energy consumers and it is found that 80% of the lightning lamps are always left on, spending energy through over-heads. Accrued reasons were that consumers do not get thoroughly informed about the shed-down time and supply time so as to switch off their appliances and lamps before leaving home for their respective offices. Poor billing and little tariffs placed per consumed watts could as well be attributed to this. Peak hours range from 1600 to 2100 and this is when maximal draw of energy is saddened on the power supply lines which sometimes results in transformer break-down or surging technical failures at distribution stations.

Also, campaign on agricultural practices that encourage Carbon burial as a better adopted farm practices could go a long way in aiding the fight against Green House Gas and ubiquitous emissions across Africa. This has been severally challenged by the fact that few Farmers are moderately literate in Carbon sequestration methods, and government`s effort on such campaign is still low.

C. Increased energy efficiency

A chase to acquire improved energy efficiency can be realizable through modern innovation and re-modification of technologies used in RET. A source disclosed that Energy efficiency is increasing by about 2% a year, and absorbs most of the requirements for energy development. New technology makes better use of already available energy through improved efficiency, such as more efficient fluorescent lamps (e.g. energy-savers), engines and insulation. New designs for buildings may incorporate techniques like passive solar; Light-emitting diodes are gradually replacing the remaining uses of Light bulbs. Note that none of these methods allows continuous motion as some energy is always lost to heat.

Mass transportation increases energy efficiency compared to widespread conventional automobile use while air travel is regarded as inefficient. Conventional combustion engine automobiles have continually improved their efficiency and may continue to do so in the future, for example by reducing weight with new materials. Hybrid vehicles can save energy by allowing the engine to run more efficiently, regaining energy from braking, turning off the motor when idling in traffic, etc. Electric Vehicles and PHEVs are more efficient during use (but maybe not if doing a life cycle analysis) than similar current combustion based vehicles, reducing their energy consumption during use by 1/2 to 1/4. Micro-cars or motorcycles may replace automobiles carrying only one or two people. Transportation efficiency may also be improved by in other ways, see automated highway routes.

Distribution of electricity may change in the future by the adoption of Smart grid in Africa. New small scale energy sources may be placed closer to the consumers so that less energy is lost during electricity distribution. Like in Nigeria electricity power grid, approximately 25% of generated power is lost in transmission and close to 22% lost along distribution line giving a landing lost of about 47% of generated wattage lost wholly.

However, new technology like superconductivity or improved power factor correction will help minimize energy lost. Distributed Generation permits electricity "consumers," who are generating electricity for their own needs, to send their surplus electrical power back into the power grid.

On the other hand, agricultural waste and post-harvest yields e.g corn chaff, maize heaves, rice bran, saw-dust, coconut-husk and so on , are convert to solid briquette(by moulding) which is made for home cooking as solid fuels as an alternative to household-kerosene. The combustion energy value of that agro-waste from farms is high and the raw-materials are cheap. Also, modern house sewage collection system has to be encouraged in rural as well as urban areas so that human faeces and all waste of human metabolic process would be collected in a central point of large community, for further processing into bio-gas which is a useful bio-energy. No more latrine or pit system in our homes or the traditional `shot-put common to the lowest African.

D. Subsidies and incentives

Subsidies for small scale entrepreneurs such as farmers and other micro players who will need such due financial constraints to adopt energy efficient practices. While the incentives such as tax holidays can be given to companies who want to invest in this area. The list includes reduced interest or interest free credit that can motivate both small and large scale entrepreneur respectively.

6. Summary

African regions are still battling to escape from poverty and the major challenge deals with the hurdles of acquiring technology which would harness efficient energy for the purpose of supporting the hope of realization of green economy. The most known routes to green energies are rigorous, expensive, intricate in technology, and requires to some extent a technological assistance to Africa to improve capacity.

On the contrary, the majority of African nations are operating at negative impact level, meaning that environmental impact in majority of African countries is low. This ranking of our region still encourages the fact that we are not far from Green economy attainment.

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