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The effect of environmental change on sustainable energy in Olkaria geothermal and Kenya power station, Nakuru County, Kenya

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ABSTRACT

Energy is one of the most important resources in the growth of an economy. The generation of power is key to the effectiveness of sustainable energy management. Energy production warrants production hence connected to economic development. Environmental change has an impact on the sustainability of renewable energy. The objective of this study was to analyze the effect of environmental change on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The study was informed by two theories namely; Socio-technical Transitions Approach Theory and Co-evolutionary Approach to Transitions. The study adopted a descriptive research design. The target population was 359 employees with a stratified sample design. The sample frame was 108 employees being 30% of the total population. Data were analyzed using the Statistical Package for Social Science (SPSS). The preliminary data was analysed using descriptive statistics and presented in the form of tables. Inferential statistics were employed through Pearson's Correlation analysis and regression analysis was used to test the study hypothesis at a 5% significance level. The findings indicated that was a statistically significant relationship between environmental change and sustainable energy (r=0.286; p=0.005). Further, the study revealed that environmental change has a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya (p<0.05). The study recommends that institutional environmental changes should be examined and their influence on sustainable energy management.

Introduction

Energy management is one of the main key driving factors that help in achieving the economic growth of any country. Hák, Janoušková, and Moldan (2016) highlight that global climatic changes happen frequently but socio-economic and environmental factors have to be coordinated, monitored, and modelled so that the climatic changes can be addressed effectively. Having a Clean Development Mechanism (CDM) becomes important to create a more powerful incentive for geothermal projects. In the future, a clean atmosphere will be achieved when the present mitigating factors are put in place to ensure that air pollution has been minimized. Carbon dioxide has to be reduced in the atmosphere.

Renewable energy sources such as geothermal power assist in the elimination of atmospheric problems leading to access to sustainable energy. Globally, geothermal energy is among the most common renewable energy sources. In countries such as New Zealand, Italy, Mexico, Japan, the USA, Iceland, Philippines and Turkey, geothermal power is widely used (Tubei, 2019). Completing a geothermal plant project takes 5 to 10 years. Geothermal energy requires high capital to be able to meet technology that taps thermal energy into electricity generation with minimal environmental impact due to its exploitation

Kenya has several energy sources and does not rely on just one source of power and the use of geothermal energy is seen to provide an alternative to the sources of energy in the country. With a high demand for electric power, expansion of the sources of power is key to meet the energy needs of the people. Kenya is the first African nation to produce geothermal energy from the earth's crust in an efficient and significant manner. Kenya needs well-manageable energy that will lead to the realization of Vision 2030. Geothermal

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energy is ranked third among the renewable energy sources in the category of MWe produced. Over 5.5% of Kenya's electricity is produced through geothermal energy (Dalla Longa, & van der Zwaan, 2017).

Geothermal projects in Kenya have to undergo economic and financial feasibility studies to ensure that the projects are viable in the long run. This is because of the high capacity intensity required for the geothermal projects. The Kenyan government has continued to set up geothermal stations in various areas of the country which has increased the geothermal power tapped in the country (Kiruja, 2017).

Over the years, sources of power have been misused which has led to negative environmental impact such as emission of greenhouse gases and land biodegradation among others. In Kenya, the main source of energy is hydroelectricity which is harnessed using water. The overexploitation of the water resources has led to a shortage of power in the country. Climatic changes have led to erratic rainfall and other environmental changes in the country. There has been low food production leading to overexploitation of water resources.

This has led to the need for stable energy supply to ensure stable economic growth. There is a need for the government to tap different sources of energy to reduce over-reliance on one source of energy. Climatic changes are as a result of pollution from example emission of carbon dioxide in the atmosphere. This has been proven by the availability of acid rains in industrial areas which leads to less vegetation as well as reduced soil productivity.

Hák, Janoušková, and Moldan (2016) show that global coordination, monitoring, and modelling of socio-economic and environmental factors can effectively address climatic changes. The future clean atmosphere relies on the present mitigating factors that are put in place to ensure carbon dioxide reduction in the atmosphere. The renewable energy sources such as geothermal power help in eliminating many atmosphere problems offering sustainable energy sources. This study, therefore, aimed to gain an understanding of how environmental changes affect sustainable energy. The objective of the study was to analyze the effects of environmental change on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. From this objective, the following hypothesis was derived;

H_{01}: Environment Change does not have a statistically significant relationship on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

Literature Review

Theoretical Review

This study was pegged on the Socio-technical transition approach theory and the co-evolutionary approach to transition. The socio-technical transition approach was developed in 2007 by Shove and Walker and it focused on sustainable energy development. The approached has been developed by various scholars over the years. The approach presents a change mechanism from a socio-technical system that is relatively stable to another. The transition focuses on the invention of new technologies and how to and how to achieve results sustainably to ensure the continuity of the systems (Shove & Walker, 2014).

The socio-technical transition approach captures energy development and how it can be used to protect and care for the environment by ensuring that there is sustainable power management. The transition is a complex process and structure as it includes different dimensions such as politics, technology, industry and society. Through the transitions, new technological changes are made which can fully or partially replace the existing technology. For this study, the socio-technical transitions approach was used as it explains the various transitions that can be made in the society to embrace to new energy sources from a community level to a societal level to achieve effective energy management (Verbong and Loorbach, 2012).

The co-evolutionary approach to transition was developed by Foxon (2011) and it was aimed at solving the high carbon energy system challenges by transitioning the high carbon energy system to a low carbon energy system. There are innovative technologies that use different sources of energy such as solar, wind and geothermal. Contrary to the socio-technical transition approach, the co-evolutionary approach to transitions deems that energy change management depends on the institutional regulatory framework and organizational standards. Activities and strategies in the organization define its sources of energy and its capability to co-evolve innovations on energy in society.

The co-evolutionary approach to transitions brings together different elements and players in the energy management system where new energy innovations are discovered and adopted. There are techniques developed to ensure low carbon energy use in the environment. This brings about sustainable energy management which boosts a nation's as well as global economic sustainability (Foxon, 2011). In this study, the co-evolutionary approach to transitions helps to understand the transitions that the country needs to make to ensure that more advanced energy technology that is sustainable and manageable is adopted.

Empirical Review and Hyptohesis Development

Environmental Change and Sustainable Energy Management

In a review on the energy sector, Sarkodie and Owusu (2016) present that over the years, climatic change has increased globally which has increased carbon dioxide emission in the atmosphere. The weather patterns have changed drastically leading to negative

environmental conditions such as global warming. In the UN framework convention on climatic changes, there are indications that human activities have created the variance in the natural environment where, globally, the composition of the atmosphere has been altered as compared to the earlier years.

Sustainable development is at the centre of recent national policies, strategies, and development plans of many countries. Through renewable energy technologies, climatic changes can be curbed through the mitigation of greenhouse gases emission, global warming and the reduction of complications in the environment that are associated with pollutants found in fossil fuels energy sources. According to Johansson et al. (2012), high climatic changes lead to a reduction of natural resources lead to depletion of natural resources which creates conflict and over-exploitation of natural resources.

Sustainable energy development has become the goal of every nation across the globe and hence measures need to be put to achieve sustainable energy which is in line with the set climatic standards which helps in conserving the environment. In the recent past environment, conservation has been the backbone that ensures future sustainable energy. Global warming has increased in the recent past leading to land degradation which has over the years led to food shortages, loss of both marine and wildlife.

The great contributor of pollution being carbon dioxide and is emitted in the atmosphere during energy production and usage of fossil fuels. In many industrial areas, climatic changes have been experienced over the years this is because they are the main areas which emit a lot of carbon dioxide in the atmosphere. This has been proven by the availability of acid rains in industrial areas which leads to less vegetation as well as reduced soil productivity. Hák et al. (2016) show that global coordination, monitoring, and modelling of socio-economic and environmental factors can effectively address climatic changes. The future clean atmosphere relies on the present mitigating factors that are put in place to ensure carbon dioxide reduction in the atmosphere.

Based on the theoretical and empirical review, the following hypothesis was derived;

H_{01}: Environment Change does not have a statistically significant relationship on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

Conceptual Framework

From the literature review, the conceptual framework was drawn. The independent variable was environmental change. This variable was operationalized as global warming, depletion of resources and greenhouse gases. The dependent variable was sustainable energy which was operationalized as alternative sources, biodegradable sources, affordability and management of clean energy.

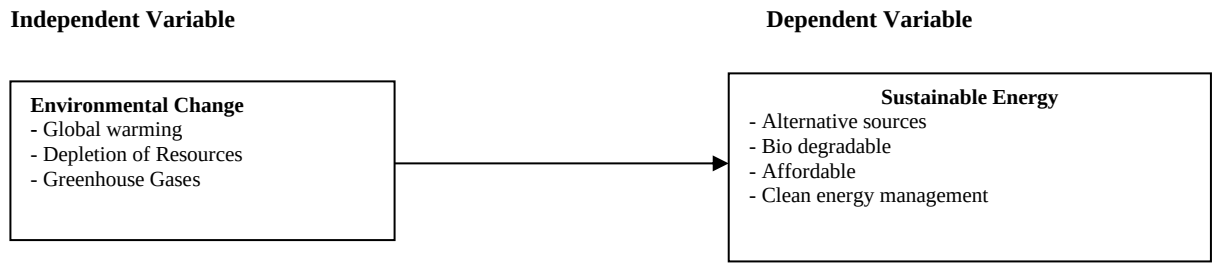

Figure 1: Conceptual Framework

Research and Methodology

The study adopted a descriptive survey design which helped the researcher to collect information and evaluate the existing relationship between the study variables. The target population comprised of 359 employees from Kenya Power station and Olkaria Geothermal in Nakuru County. A stratified proportionate sampling method was used to select the respondents. A sample frame of 30% was drawn from the total population allowing the researcher to attain a sample that was representative of each stratum (Mugenda and Mugenda, 2003). The strata comprised of engineers, management, electricians, and support staff. A sample of 108 respondents was selected to participate in the study.

Primary data was collected using a self-administered questionnaire which entailed a combination of open and closed-ended questions. This enabled easier analysis as they were in a directly usable form while the unstructured questions were used to encourage the respondent to give an in-depth and felt response without feeling thought back in revealing any information. To ascertain the validity of the questionnaire, content and criterion validity tests were used. The content validity test was achieved by cross-checking that all items reflected and were accurate. The criterion validity was achieved by carrying out a pilot test to examine language accuracy and meaning comprehension to establish whether the respondents understood the instruments. After establishing the reliability and

validity of the questionnaire, the respondents were given the questionnaire to answer and ample time given for them to give their responses.

The answered questionnaires were edited and coded to ensure their completeness and accuracy. Using the Statistical Package for Social Science, the data were analyzed through descriptive and inferential statistics. A Pearson Correlation and regression analysis were used to test the study hypotheses at a 5% significance level. The analyzed data was presented in the form of tables. The formula for the regression analysis was;

$$y = \alpha + \beta_1 X_{1_2} + \varepsilon$$

Where;

Y= Sustainable Energy Management
α =constant
β_1= parameter estimates
X_1 = Environment change effects
ε = the error of prediction.

Research Findings

The objective of this study was to analyze the effects of environmental change on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya. The data were analyzed and the findings were recorded in Table 1.

Table 1: Environmental Change

	Environmental Change	**SD (%)**	**D (%)**	**U (%)**	**A (%)**	**SA (%)**
1.	Environment change has a very little negative impact on the sustainability of renewable energy	15.8	45.3	0	37.9	**1.1**
2.	Pollution of the environment has nothing to do with sustainable energy management.	14.7	42.1	11.6	27.4	**4.2**
3.	Fossils fuel have been the main cause of unsustainable energy management.	16.8	23.2	24.2	31.6	**4.2**
4.	Geothermal and other renewable sources offer clean energy in the environment	2.1	23.2	5.3	51.6	**17.9**
5.	Renewable energy sources help in eliminating the competition of energy sources.	7.4	28.2	7.4	46.3	**10.5**
6.	The use of renewable energy sources contributes to energy conservation and protection of the environment.	4.2	21.1	3.2	49.5	**22.1**
7.	The future of the safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy.	5.3	14.7	12.6	51.6	**15.8**
8.	**Exploration of geothermal power affects sustainable energy management.**	**6.3**	**13.7**	**11.6**	**51.6**	**16.8**

SA= Strongly agree A= Agree U= Uncertain D= Disagree SD= Strongly Disagree

As indicated in Table 1, 45.3% of the respondents disagreed that environmental change has a very little negative impact on the sustainability of renewable energy. There was also an indication that 42.1% of the respondents disagreed that pollution of the environment has nothing to do with sustainable energy management. Among the respondents, 31.6% agreed that fossils fuel has been the main cause of unsustainable energy management. Majority of the respondents (51.6%) agreed that geothermal and other renewable sources offer clean energy in the environment. There was also a 46.3% agreement that renewable energy sources help in eliminating the competition of energy sources. Over 60% of the respondents believed that the future of a safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy. The results also indicate that 51.6% of the respondents agreed that the exploration of geothermal power affects sustainable energy management.

Consistent with these results, Ockwell and Byrne (2016) indicate that environmental changes negatively impact renewable energy sustainability. The environmental changes are mainly climatic and in instances of aridity, production of hydropower becomes difficult. Renewable energy sustainability is highly dependent on climatic changes. Renewable energy sources eliminate carbon pathways transmissions brought about by fossil fuels which pollute the air and bring about rapid and unpredictable climatic changes.

Similarly, Gollwitzer et al. (2018) found out that environmental changes bring about seasonality which affects the supply side of renewable energy. For instance, in Kenya, the provision of solar energy is dependent on sunshine variations while wind energy is dependent on wind speed, and hydropower is dependent on rainy seasons. These variations determine the sustainability of renewable energy.

Correlation Test Results

A Pearson correlation test was conducted using the independent and dependent variables and the results are recorded in Table 2.

Table 2: *Correlation Test*

		Sustainable Energy	Environmental change
Sustainable Energy	Pearson Correlation	1	
	Sig. (2-tailed)		
	N	95	
Envrionmentalchange1	Pearson Correlation	.286**	1
	Sig. (2-tailed)	.005	
	N	95	

**. Correlation is significant at the 0.01 level (2-tailed).

The results show that there was a positive correlation relationship between environmental change and sustainable energy (r=0.286; p=0.005). Correspondingly, findings by Merem et al. (2019) indicate that there is a positive relationship between environmental change and sustainable energy. This is because, in the Kenyan energy landscape, there has been a concentration on renewable energy which is highly dependent on climatic variation.

Regression Test Results

A regression analysis was conducted to test the hypotheses of the study which are;

H_{01}: Environment Change does not have a statistically significant relationship on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

The model summary, ANOVA and Coefficient results are presented subsequently.

Table 3: *Model Summary*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.363[a]	.132	.093	4.363
a. Predictors: (Constant), Environmental change				

Results in Table 3 shows that the R^2 value is 0.132 which means that the variance proportion in sustainable energy can be explained by 13.2% of the determinants of energy production in this study. This is an indication that other variables should be indicated in the study and this presents a chance for further studies to be conducted including other predictable variables.

The Analysis of Variance (ANOVA) was conducted in this study to establish whether the predictor variable influences the dependent variable. The results were recorded in Table 4.

Table 4: *ANOVA Test*

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	161.309	1	161.309	8.278	.005[b]
	Residual	1812.227	93	19.486		
	Total	1973.537	94			

a. Dependent Variable: Sustainable Energy

b. Predictors: (Constant), Environmental change

The ANOVA model shows an F-statistic is 8.278 and the significance is 0.005. This is an indication that the regression model is significant. In other words, environmental change has a significant effect on sustainable energy.

Table 5: *Coefficient Table*

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	20.679	2.089		9.898	.000
	Environmental change	2.275	.791	.286	2.877	.005

a. Dependent Variable: Sustainable Energy

In this study, the regression formula used was;

$$y = \alpha + \beta_1 + \varepsilon$$

Where;

Y= Sustainable Energy Management
α =constant
β_1= parameter estimates
X_1 = Environment change effects
ε = the error of prediction.

The findings in Table 5 show that the regression equation can be estimated as:

Sustainable energy=20.679+2.275*environmental change+ε

Finally, the findings of this study show that when all factors are held constant, there is a unit change of environmental change which increases sustainable energy (β= 2.275, p =0.005). Since p<0.05, the relationship between environmental change and sustainable energy is significant. This leads to the rejection of the null hypothesis which states that environmental change does not have a statistically significant effect on sustainable energy in Olkaria Geothermal and Kenya Power Station, Nakuru County, Kenya.

Conclusions

The study findings indicated that environmental change has an impact on the sustainability of renewable energy. Global warming has contributed to climatic changes and inevitably environmental changes. This has led to the need for alternative sources of energy. Additionally, the need for alternative sources of energy is driven by the fact that fossils fuels lead to pollution which affects sustainable energy management. To attain clean energy in the environment, the alternative sources of energy such as geothermal energy should be considered. The future of the safe environment depends on the effectiveness of migrating from fossil fuels and embracing renewable energy.

The study concludes that there is a statistically significant relationship between environmental change and sustainable energy. In particular, environmental change influences the achievement of sustainable energy in Kenya. For the organizations under this study, there should be consideration of the effectiveness of migrating from fossil fuels to renewable energy production. The focus on renewable energy sources should ensure that renewable sources are not over-exploited in a bid to ensure energy production as well as ensure that the resources can be available for future generations. Furthermore, mechanisms should be put in place in mitigating drastic climatic changes which may affect different renewable energy sources. Therefore, this study recommends that institutional environmental changes should be examined and their influence on sustainable energy management.

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