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RESEARCH ARTICLE

DOES ACCESS TO ELECTRICITY REDUCE BIOMASS USE FOR ENERGY PURPOSES IN PEDDIE?

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ABSTRACT

In Peddie, the households use electricity and biomass for energy purposes. While some households use both, others use only biomass. This study investigates whether access to electricity has an effect on biomass use or not. There are social, economic and environmental factors that influence the effect that access to electricity has on biomass use. The study uses linear regression, ANOVA and Chi square tests to analyze the data. The results indicate that household income, employment status and education of household head are the factors that influence biomass use in Peddie. Investment in research in order to develop efficient technologies and the establishment of rural electricity generating plants based on solar, wind and hydro-power together with the community environmental education programs should be considered in order to rescue the situation.

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INTRODUCTION

The condition of global warming has worsened due to increased emissions of harmful gases from the industries, automobiles and households into the atmosphere and these have negative effects on the environmental, economic and social welfare (Bastianoni *et al.*, 2004). All these threats have forced people to seek alternative resources that are less environmentally, socially and economically threatening. Biomass, which is all the matter obtained from various materials such as wood, crop residues, grasses and animal wastes has been identified as an alternative energy resource (Tenenbaum, 2002). Biomass has been the main source of energy especially in developing countries with the rural population being the major consumer (World Energy Organisation, 2002).

Energy forms part of the basic needs of life and, to satisfy the requirements for energy, several sources are exploited such as fossil fuels, electricity and renewable energy resources that include biomass (United States of America Department of Energy, 2007). Peddie is endowed with biomass resources since the vegetation is mainly composed of trees, shrubs and grass species. Livestock farming is one of the livelihood activities, which imply relative abundance of biomass resources that can be used for energy purposes.

In Peddie, the residents depend on biomass resources for energy purposes and the commonly used resources include fuel wood and animal wastes (dung). These are used mainly for cooking and heating purposes. There are proportions of the population that use electricity to satisfy their energy needs, and a common practice has been the concurrent use of electricity and biomass to meet energy requirements (Ngqushwa Municipality, 2007).

Despite the endowment of biomass energy resources and the improved access to electricity there has been an increase in the rate of land degradation. Also, there has been a decline in biomass supply for energy use, particularly fuel wood supply. People are faced with costly processes of cooking and heating. These conditions have led to little improvement in the standards of living in the district (Ngqushwa Municipality, 2007). The evident predicament among the population has led to the study seeking to find answers to the following questions namely: How does electricity affect the use of biomass for energy provision? What influences people to use biomass for energy purposes? Which factors affect use of electricity in Peddie?

Access to energy is an underlying component linked to the achievement of the global goals of poverty reduction, improved living standards and environmental protection. People realised that improved conventional access to power supply could be realised by utilising modern energy sources such as electricity and renewable energy sources such as biomass (WEO, 2002). This intended improved access has led to the implementation of electrification programmes together

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with other programs that promote use of renewable energy resources (World Bank, 2006: WEO, 2002). There have been high rates of electrification in the world with variations between and within countries. Environmental Protection Agency (2007) stated that access to electricity is essential for sustainable development through environmental protection by replacing or reducing pressure on biomass as a source of energy for rural households. However, various factors determine the transition from biomass use to dependence on electricity for energy needs satisfaction. These factors are availability, affordability and preferences that are driven by economic, environmental and social aspects of the community (Volti, 1998) which are examined in turn below.

Economic Aspects

Income has an influence on the extent to which the access to electricity affects the use of biomass for energy purposes since it has direct relationship with fuel affordability and choice (Henderson, 1991). Volti (1998) indicated that in the developed countries as well as in transition economies, households have relatively higher incomes and therefore, are able to use electricity as the provider of almost all their energy requirements. These households can afford electrical energy-using appliances together with associated electricity bills. Labour availability has an influence on the households' energy consumption patterns in various households. In the rural households of the developing countries, there have been low schooling and employment rates, which imply less costly biomass gathering due to the low opportunity cost of collecting biomass (Boulding, 1993 and Pingali, 2006). The low levels of schooling rate evident in rural areas have also contributed to the availability of labour for biomass collecting, and consequently increased biomass consumption (WEO, 2002).

Social Aspects

Boulding (1993) and WEO (2002) stated that there are various social aspects that determine the extent to which electricity contributes towards the goal of providing energy in an environmentally-friendly manner and cost-effective way. These aspects influence the energy consumption patterns among households and the aspects include changing lifestyles and the level of development. The changing lifestyles of the modern human being have led to increased interest and investment in recreation and entertainment. There has been increased investment in comfort such as air conditioners and entertainment like television and radios, particularly in urban and high-income rural households.

These items require electrical energy to function therefore the consumption of electrical energy has increased in these households compared with biomass energy consumption (Townsend, 2000). Goldsmith *et al.* (2004) indicated that the rate of urbanisation is steadily increasing in the developing world. This has led to increases in the size of human settlements that have an influence on the energy consumption patterns in the households. In areas where the rate of urbanisation has been high, the biomass resources have been removed to create space for settlements, and the rate of electrification has been high. There has been an increased need for food and as a result, more land has been required for food

production that has led to forestland being cleared to create space for food production. These conditions have limited the household's choice of energy source hence relatively high use of electrical energy in these areas (Stern *et al.*, 1996).

Environmental Aspects

Several conditions within the environment have an influence on the energy consumption patterns in the households and these conditions include location of energy sources and weather conditions. Location of the energy resources has an influence on the way households consume energy. In the households where biomass energy resources are located within short distance from the homestead, the consumption of biomass has been relatively higher than that of electricity. In the households where biomass resources are located far away from the homestead, consumption of biomass has been relatively low and more electrical energy has been utilised (Fergus, 1993). Temperature has played a significant role in influencing the households' energy consumption patterns in various regions within and among countries. In the cold regions, there has been high consumption of biomass particularly fuel wood for heating purposes since people tried to avoid excessive costs of other relatively expensive sources of energy such as electricity (Kgathi *et al.*, 1997).

MATERIALS AND METHODS

Data Collection

In Peddie, there are households that rely on electricity and biomass for energy purposes and others that rely solely on biomass for energy purposes. The proportion of households that have access to electricity equals 24% (Ngqushwa Municipality, 2007). The stratified sampling technique was employed. The strata consist of those with and those without access to electricity. In each stratum, twenty-five households were randomly selected.

Data analysis

How Electricity Affects Biomass use for Energy Provision

Analysis of variance (ANOVA) is used in the estimation of the significance in the relationship between biomass use and access to electricity, the dependent variable is biomass use and the independent variable is electricity use. The measurement of the estimated change in the dependent variable because of a change in the independent variable is carried out. This technique is appropriate and effective in the analysis of the relationship between numerical and categorical variables.

Factors Influencing People to use Biomass for Energy Purposes

Analysis of variance (ANOVA) is also used to analyse the relationship between biomass use and categorical variables including gender, education level and employment status of the household head. It assesses the effects of the categorical variables on the dependent variable. The dependent variable is biomass use and independent variables are gender, education level and employment status of household head.

Linear Regression

Linear regression is expressed and used to analyse the relationship between biomass use and the variables including household income, number of household head's dependents and the number of children attending school. This model provides better results when used to analyse relationships between ordinal scale variables (Bodhlyera, 2007).

The regression model can be expressed as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3$$

Where:

Y= biomass use (kgs)

a = Constant

X1= Household income (Rands)

X2= number of household head's dependents (person)

X3= number of children attending school (person)

b_1, b_2, b_3 = Coefficients

The model presumes that biomass use is affected by a set of factors including household income, household size and number of children attending school. The biomass use is the dependent variable and the independent variables include household income, number of household head's dependents and number of children attending school. Central to this model is the significance of each independent variable and dependent variable's relationship while other independent variables are held constant.

Factors Influencing Electricity Use

The chi square tests are used in the analysis of the association between electricity use and household income, gender, education level, employment status, number of household head's dependents and the number of children attending school. These tests are used since both the dependent and independent variables are categorical variables.

RESULTS AND DISCUSSION

The Socio-Economic Features of the Respondents

Analysis on the socio-economic features revealed that majority 60% of the households heads were males while the remaining were females. The level of education was low with only 2% achieving post-secondary education, secondary education being achieved by 27% of the respondents. Unemployment was very high as majority (62%) were without jobs, about 8% held informal jobs, only 5% indicated self-employment while the remaining were formally employed in various sectors. About 60% of the respondents received monthly income of less than M400.00, between M401.00 and M800.00 was received by 25%, about 5% received between M801.00 and M1200.00 while the rest received between M1201.00 and M2000.00. About 30% of the households had less than four members, 35% were between five and eight members big while more than eight members were found in the other 35% of the households. The schooling rate was about 70% in this community of Peddie. The entire households used fuel wood for cooking and heating purposes though at varying rates and

only 3% indicated the use of cow dung for these purposes. Half of the households had access to electricity and used it mainly for lighting though cooking and heating were mentioned as other uses. About 50% used paraffin and candles for lighting purposes. Those who used paraffin indicated occasional use of paraffin for cooking and heating purposes.

Effect of Electricity on Biomass use for Energy Provision

For cooking purposes, access to electricity does not have a significant effect on the use of biomass. The significance level is 0.621, which indicates that there is insufficient evidence to believe that change in access to electricity will affect the use of biomass for cooking. The possible explanation is that electric appliances are expensive and consume large quantities of power, and therefore, are not affordable to the households. In terms of heating, biomass use is not affected by access to electricity and this is revealed by the poor level of significance of 0.773. The possible reason for this situation is that the electric heaters have high consumption of power and are relatively expensive. The level of significance recorded for lighting purposes is 0.000, which indicates that a change in access to electricity will affect significantly biomass use for lighting purposes (Table 1). Access to electricity affects biomass use for lighting purposes negatively because consumption of power for lighting is low and electrical lamps and bulbs are relatively cheap therefore households can afford their purchase and use. These results agree with the hypothesised influence of access to electricity on biomass use.

Factors Influencing Biomass use for Energy Purpose

The study's expectation is that in households with relatively higher income, the consumption of biomass will be lower than in the low-income households and this agrees with the study's expected influence of income on biomass use for energy purposes. The negative coefficient of regression shows that increase in household income results in less biomass use. There is sufficient evidence that increase in household income will reduce biomass use for energy purposes ($P < 0.000$). The expectation in this study was that household heads with large number of dependents would use more biomass as a means of avoiding costs associated with electricity use and that such households would have enough labour for gathering biomass for energy purposes.

The positive coefficient for the household size supports the study's a priori expectation that biomass use increases with larger households. However, the P-value for the relationship between biomass use and number of household head's dependents is equal to 0.364, which means that there is insufficient evidence to believe that change in the number of dependents will have an effect on the household's use of biomass (Table 2). In the study, it was expected that the number of children attending school will affect the use of biomass in that, the larger the number of children attending school the greater the share of income spent on school fees. Hence, financial inability to purchase electricity therefore conversion to biomass for energy purposes. However, the negative regression coefficient shows that an increase in the number of school-going children results in less use of biomass. One possible explanation is that where children are school-going there is less labour for collecting fuel wood.

Table 1. ANOVA analysis of the effect of access to electricity on biomass use for energy purposes

Purpose of energy	Scenario	Sum of squares	d.f.	Mean square	F	Significance (P-value)
Cooking	Between groups	5.128E-02	1	5.128E-02	0.247	0.621
	Within group	9.949	48	0.207		
	TOTAL	10.000	49			
Heating	Between groups	2.513E-02	1	2.513E-02	0.084	0.773
	Within group	14.295	48	0.298		
	TOTAL	14.320	49			
Lighting	Between groups	106.634	1	106.634	2772.48	0.000*
	Within group	1.846	48	3.846E-02		
	TOTAL	108.480	49			

*Statistically significant at 5% significance level

Table 2. Linear regression analysis of the relationship between biomass use and socio-economic variables

Model	B	Standard error	Beta	T	Significance (P-value)
Constant	4.192	0.246	-0.570	15.903	0.000*
Household income	-0.217	0.051	0.149	-4.287	0.000*
Household head's dependents	7.401E-02	0.081	-0.214	0.917	0.364
Children attending school	-0.106	0.022		-1.299	0.200

* Statistically significant at 0.05 significance level

Table 3. ANOVA analysis of the relationship between biomass use and gender, education level and employment status of head of household

Predictor	Scenario	Sum of squares	df	Mean square	F	Significance (P-value)
Gender	Between groups	0.208	1	0.208	1.019	0.318
	Within group	9.792	48	0.204		
	TOTAL	10.000	49			
Education level	Between groups	0.458	1	0.153	0.735	0.536
	Within group	9.542	48	0.207		
	TOTAL	10.000	49			
Employment	Between groups	1.690	1	0.563	3.119	0.035*
	Within group	8.310	48	0.181		
	TOTAL	10.000	49			

*Statistically significant at 5% significance level

Table 4. Chi square analysis of the associations between electricity use and independent variables

Predictor	Value	d.f.	Asymptotic Sig (2-sided)	
Gender	Likelihood ratio	0.551	3	0.907
Education level	Likelihood ratio	21.506	9	0.011*
Employment status	Pearson-chi-square	22.211	9	0.000*
Household income	Pearson-chi-square	70.176	15	0.000*
Household dependents	Pearson-chi-square	8.603	9	0.475
Children attending school	Pearson-chi-square	3.855	9	0.921

*confidence level equals 5%

The result 0.200 of P-value however indicates that there is insufficient evidence to believe that this factor has an influence on biomass use in Peddie. Further, the P-value of 0.318 suggests that there is insufficient evidence that gender has an effect on biomass use for energy purposes (Table 3). It was however expected that consumption of biomass in female-headed households would be higher since most jobs in rural areas are for male hence, less income accumulation opportunities for females due to the lack of employment opportunities, and was expected to result in high biomass use in female-headed households. However, the results contradicted with this expectation. The possible explanation here is that the rate of unemployment is high to an extent that even males are unemployed and those employed may be poorly paid. Hence, little effect on their biomass use. In terms of the association between education level of household head and biomass use, the significance level is 0.536, which means that change in the level of education does not effect change in the use of biomass. The study expected the households headed by people with high level of education to have relatively low consumption of biomass for energy purposes.

The basis for this was that such people are more likely to know threats posed by biomass use such as acute respiratory diseases. They are more likely to know about the better lifestyles in other parts of the world, which could lead to a move away from biomass use. The possible argument for education level having no significance in explaining biomass use is that the general level of education is low thus, no significant differences by education found among households. On the contrary, employment status of the household head is a significant factor influencing biomass use in Peddie. The P-value is 0.035, which means that change in employment status has a significant effect on the use of biomass for energy purposes (Table 3). This agrees with the expectation of the study, which believed that employed people would use less biomass compared to those who are unemployed since they have more income to purchase other energy sources.

Factors Influencing Electricity use in Peddie

Out of the six examined predictors, only three were significant at the 5% confidence level (Table 4). These include education

level, employment status of the household head and household income. It was expected that an improvement in the level of education of household head would indicate the association with the consumption of electricity in the household. The results agree with this expectation since p-value equals 0.011. Thus, there is sufficient evidence that an improvement in the level of education is positively associated with electricity use. In households headed by people with high level of education, the consumption of electricity is likely to be higher than in those headed by the less educated. The P-value equals 0.000 for the estimation of the association between electricity use and the employment status of household head, and this finding supports the study's *a priori* expectation that a change in employment status will cause a change in energy use in the household. The study's expectation was that in a household headed by an employed person, the consumption of electricity is likely to be higher than in a household headed by an unemployed person.

In the study, it was stated that if a household has higher income, the household is more likely to use more electricity and that if a household has low income; the household is more likely to use less electricity. In support of this, the results show that household income has significant association with the level of use of electricity. The number of household head's dependents was expected to be one of the factors that are associated with electricity use. It was expected that if the number of dependents were high the use of electricity would be low. However, the results do not agree with this expectation. The possible explanation is that the large sized households may have sufficient income to purchase electricity and the small sized households may have insufficient income therefore their consumption of this energy source may be low.

It was expected that the number of children attending school would have association with the use of electricity in the households; however, the results reveal that this factor does not have a significant association with the use of electricity. The p-value equals 0.921, and that shows lack of evidence to believe that the number of children attending school is associated with the use of electricity. Finally, the expectation was that maleness would have significant influence on the use of electricity in the households. It was expected that in female-headed households, the electricity use would be lower than in the male-headed households. The basis for this expectation was that employment opportunities in the Peddie area are mostly for males. Therefore, higher income is anticipated in male-headed households that can be used for purchasing electricity. However, the results contradict this expectation. The possible explanation is that unemployment is high among both females and males in the study area.

Conclusion and Recommendations

The study shows that access to electricity does not have an effect on biomass use for energy purposes since the biomass use for energy purpose is high among all households in Peddie. People use biomass to satisfy their cooking and heating requirements irrespective of access to electricity and more energy is required for these processes. Many people continue to use biomass particularly fuel wood and continuous harvesting of firewood can have a negative impact on the socioeconomic and environmental sustainability through

deforestation and soil erosion. These problems could be solved by increased investment in research in order to develop technologies that efficiently use biomass, and hence, improved sustainability of biomass use through reduced exploitation of the environment for energy resources. The local communities should be encouraged to grow tree species that are fast maturing to guarantee supply and satisfy demand. There should be community environmental education programmes that teach people about safer and sustainable ways of using natural resources in order to make sure that use of biomass is socio-economically and environmentally sustainable.

The study indicates that employment status and household income are all significant factors influencing biomass use. The explanatory factors for electricity use were found to be household income, education level and the employment status. All these factors have led to the situation whereby use of electricity is low since they influence affordability of electricity. These could be solved by establishing rural electricity generating plants because extending electricity grid to remote villages is expensive and the cost of electricity is relatively high. Therefore, electricity from local rural grids will be relatively cheaper, and as such more affordable. Electricity companies that run these local grids should provide connection and services on credit to the poorer people, thereby allowing customers to pay back the costs in small monthly instalments over a specific period. The predicament of Peddie could be overcome by adoption of technologies such as solar, wind and small-scale hydropower. These renewable technologies have significant environmental advantages and the costs of many renewable technologies are relatively low. The fore-going suggestions should ensure that all people have access to energy, and hence, better living standards as well as ensure that the process of development is achieved in a socio-economically and environmentally sustainable manner.

Disclosure of Conflict of Interest

The study was influenced by the high level of environmental degradation because of high use of biomass for energy purposes despite increased rural electrification levels.

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