SUSTAINABLE ENERGY TECHNOLOGIES FOR POVERTY ALLEVIATION AND ENVIRONMENTAL PROTECTION

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ABSTRACT

This paper examines the importance of sustainable energy technologies in addressing poverty eradication and environmental protection. The paper reveals the failure of conventional energy strategies in meeting the basic human needs of the poor majority. People living in poverty have benefited very little from conventional energy policies and their implementation. The lack of available energy services correlate closely with many poverty indicators. The use of unsustainable energy technologies has negative environmental effects and the people with low income are the most vulnerable. Limited income forced households to use traditional fuels and inefficient technologies. Various policies and measures that can improve the level of energy services for people living in poverty are discussed. Providing energy services to rural areas offers considerable opportunity for improving the lives of billions of people within a relatively short period. Promising approaches include decentralized rural electrification, appropriate technologies, modernized biomass and improved cookstove designs.

Keywords: Energy, poverty, environmental protection, technology

1.0 INTRODUCTION

Nigeria is currently being faced with energy crisis which is one of the most demanding crises in its modern history. Petroleum crude is the major energy resource in the national energy scene and the cost of petrol in the country has gravitated from 20 kobo per litre in 1987 to 6,500 kobo (₦ 65.00) per litre currently (Wabara, 2003; Ajueyitsi, 2005). The recurrent increases in the prices of petroleum products have a multiplier effect on other sectors of the economy and they have extraordinarily increased the cost of living of Nigerians. Transport, food, rent, healthcare, education, and indeed, virtually all social infrastructure are affected.

The increased dependence on non-renewable fossil fuels has a lot of negative implications on both people and environment. Jande (2005) reports that while energy is at the heart of economic and social development, its productions, transportation and use cause a wide range of major environmental problems at the local, national and global levels. It further concludes that in the face of continuous increase in demand for energy, energy systems developed so far to meet this rising demand are clearly unsuitable, as they lead directly or indirectly to health problems, pollution, acidification of ecosystems, land and water contamination, loss of bio-diversity and global warming. Beside these short comings, availability of these energy sources is largely limited to urban areas, especially in developing countries. It is usually very expensive and beyond the reach of most rural and urban inhabitants. This has encouraged the use and preference for fuel-wood as a major source of fuel for domestic activities.

It has been estimated that over 95% of Nigerian population especially in the savannah-region depends on fuel-wood as domestic source of energy (Adedire, 2002). Ladipo et al. (2002) noted that the scarcity and exhaustion of fuel-wood supply in these regions presents energy crisis, which threatens existence of most rural communities. With increasing population and urbanization, fuel-wood gathering has become very tedious, as longer distances have to be traveled before collection. The result is an ever-increasing price trend of fuel-wood which now constitutes a major drain on family incomes (Oboho, 1986). High initial investment costs of kerosene stoves, gas and electric cookers have discouraged the use of alternative fuels in favour of fuel-wood.

For people living in poverty, the most pressing priority is the satisfaction of basic human needs, which includes access to food, shelter, water supply and sanitation and other services that will improve their standard of living, such as health care, education, and better transport. Problems of poverty in all its dimensions can be addressed with the improved provision of energy services. It is significant that most of those without access to

modern energy services live in developing countries and belong to the segment of the human population that lives in poverty. While reliable and adequate energy supplies do not guarantee economic growth and employment generation, their absence typically limits growth. Although low energy consumption is not a cause of poverty, the lack of available energy services correlates closely with many poverty indicators. Moreover, the prospects for income generating activities that can help break the cycle of poverty often rely on the availability of energy. Nearly 2 billion people, constituting about a third of humanity, continue to rely on biomass fuels and traditional technologies for cooking and heating. About 1.5 to 2 billion people have no access to electricity (UNDP, 1998).

The link between poverty and energy should not, however, be construed simply in terms of inability of the poor to afford better energy services. Energy services constitute a sizeable share of total household expenditure in developing countries. People living in poverty often pay a higher price per unit of energy services than do the rich. They also spend more time obtaining these energy services and rely on resource-scarce and polluting ways of converting energy for services like cooking, drinking water, heating and lighting, all of which have associated health impacts. Often, it is the absence of institutional arrangements to widen the access to modern energy services that characterizes the condition of people living in poverty.

Energy is directly related to the most pressing social, environmental, economic and security issues which affect sustainable development. These include: poverty, jobs and income levels, access to social services, the situation of women, population growth, agricultural production and food scarcity, health, land degradation, climate change and environmental quality, and economic and security issues. Energy challenges should be tackled in ways such that these social, environmental, economic and security problems are ameliorated-not aggravated - as is typically the case with conventional energy strategies, which either ignore these global problems or do not deal with them adequately.

Energy interventions can help in the challenges of poverty alleviation and environmental protection. The conventional belief has been that poverty and environment are linked in a "downward spiral" in which people living in poverty, forced to overuse environmental resources for their daily survival, are further impoverished by the degradation of these resources. Increasingly, however, it has become evident that people living in poverty are capable of creating arrangements that protect the environment while sustaining their livelihoods, to the extent that they are provided access to superior technology and finance. Thus, improved energy services will increase their satisfaction of basic needs, and in the process, reduce their adverse impacts on the environment. Nevertheless, realising this dual potential requires institutional as much as technological innovation. Primarily, the level of energy services, rather than energy consumption, needs to be taken as the indicator of development. Energy strategies, policies, programmes and projects should be consistent with, and contribute to, the solutions of the major national and global problems. The national goal for energy should be to make energy an instrument to help realize the broader goal of sustainable development. This paper analyses the relationship of energy with poverty and environmental degradation. It also examines ways of improving on the use of renewable energy sources in order to increase energy services which are essential for meeting basic human needs and in the process alleviating poverty and protecting environment.

2.0 EFFECT OF THE USE OF UNSUSTAINABLE ENERGY

2.1 The Use of Inefficient and Environmentally Harmful Energy

The fuels and devices available to people living in poverty are typically less efficient, more hazardous to users and more damaging to the environment than those enjoyed by the better-off. The use of traditional fuels has a negative impact on the health of household members, especially women and children, when burned indoors without either a proper stove to help control the generation of smoke or a chimney to vent the smoke outside (Smith, 1987). According to Hosier and Dowd (1987), the cook stove efficiencies of firewood, kerosene and gas are roughly 15%, 50%, and 65%, respectively. Similarly, kerosene used in household lamps is a poison and a major fire hazard. Lighting with kerosene can be twice as expensive and up to 19 times less efficient per lumen of output than fluorescent lights using electricity as the energy carrier (Reddy and Reddy, 1994). Moreover, inefficient lighting services in the home and in public areas are directly related to poor safety and personal security.

It is estimated that more than half of the world's households use wood, crop residues and untreated coal for their cooking needs. In most developing countries, the household sector is the largest single energy consumer and cooking constitutes the dominant energy need. In the under-developing countries, the household sector accounts for more than 90% of total energy consumption. The reliance on biomass fuels results in reduced agricultural productivity by depriving the soil of recycled nutrients that would have been available from tree, crop and animal residues and could be a cause of deforestation and desertification in some areas (Cecelski, 1995).

Traditional cookstoves cause indoor concentrations of important pollutants, such as small particles less than 10 microns in diameter, known as PM10, carbon monoxide, benzene and formaldehyde, to be excessive compared to health-based standards or even to other common thermal applications. Such exposures are linked to acute respiratory infections, chronic obstructive lung diseases, low birth weights, lung cancer and eye problems, primarily, among women and children (Smith, 1990).

Solid fuels such as biomass are quite difficult to burn completely in simple household-sized stoves. Therefore, although biomass does not contain many non-combustible contaminants, the emissions of health-damaging pollutants in the form of incomplete combustion products are quite high per unit of energy. Households that use coal and biomass generally have poor ventilation and because occupants are usually indoors when they use these fuels, they tend to be exposed to significant amounts of particulate pollution, as indicated in Fig. 1. In addition, indirect health impacts from lack of fuel for proper cooking (malnutrition) and boiling water (diarrhea and parasites) may be significant.

2.2 Energy Consumption Patterns and Poverty Status

Household survey data reveal the connection between energy consumption patterns and poverty status. Figure 2 compares energy consumption and fuel sources of extremely low-income households (those in the lowest income quintile) with much wealthier households. The energy carriers evaluated are biomass, kerosene, electricity, and gas; and the household activities examined are cooking and lighting. As shown in Fig. 2, the poor household use biomass rather than gas or electricity for cooking, and they are more inclined to use kerosene rather than electricity for lighting.

Since they cannot afford the initial costs of more efficient and cleaner devices and systems for cooking, lighting, etc., people living in poverty are often locked into a vicious cycle. They rely on patterns of energy use that contribute to depleting their resource base or they expose themselves to environmental harm and thereby deepening their misery. They deplete nearby fuel-wood resources for cooking, and harm their habitat while further increasing their poverty.

2.3 Inordinate Expenditure on Energy

People living in poverty spend inordinate personal and family resources of time and effort to gather fuel and acquire their essential energy services. Most estimates of household expenditures on fuel are substantially understated for very low income households because people living in poverty devote a larger portion of their most important asset, their time, to the production of energy services. In general, people living in poverty expend more time and effort to obtain energy services that tend to be of lower quality than the energy services available to the rich. Poor women and children, in particular, bear the burden of having to carry water and firewood across long distances, while the better-off typically enjoy the convenience of having piped water and cooking gas delivered to their homes.

Poor women spend far more time and effort than men on energy-related activities. This gender bias is a further reflection of energy's largely non-monetized attributes among the poor, since much of women's work is characteristically unpaid work. Poor women are also disproportionately the victims of energy scarcity. The consequences are found in their poor nutritional status, poor health due to indoor air pollution, and even low literacy rates, which could be attributed to the fact that girls are more likely than boys to spend about 5 hours a day gathering fuel-wood or drinking water, Fig. 3, (UNDP, 2002).

2.4 Energy use and Climate Change

In 1995, the Intergovernmental Panel on Climate Change (IPCC), a panel of experts assembled by the United Nations, concluded after detailed scientific reviews that "the balance of evidence suggests a discernible human influence on global climate" (IPCC, 1996). This human influence on the climate is mainly due to the emissions of three greenhouse gases (GHG) - carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), of which CO_2 is the most significant. Energy production and use is responsible for 80% of all anthropogenic GHG emissions and even in fairly optimistic scenarios, carbon emissions from burning fossil fuels (in the form of CO_2) are predicted to increase quite dramatically. Indeed, according to the most likely IPCC scenarios, they will double from a total of 6.5 Gigatons of carbon today to 13.8 Gigatons by 2050 (IPCC. 1996). Current patterns of land-use and energy have been deemed responsible for the net atmospheric increases in greenhouse gases, which are predicted to result in moderate to severe changes in regional and global temperature, precipitation, soil moisture and sea level.

3.0 SUSTAINABLE ENERGY POLICIES FOR POVERTY ALLEVIATION AND ENVIRONMENTAL PROTECTION

Sustainable energy is defined as those energy interventions that support sustainable development. The central priority for people living in poverty is the satisfaction of basic needs, which could be addressed by increasing the level of energy services. In fact, one of the ways in which energy strategies could be sustainable, that is, meet sustainable development goals, is by introducing specific technologies that would increase energy services for people living in poverty (e.g., efficient lighting technologies, water pumping technologies, efficient cookstoves, modern energy carriers for cooking). Such strategies could also promote job creation in rural areas and thereby help those currently living in poverty acquire the capability to free themselves from poverty. Moreover, the emphasis given to promoting the wide availability of modern energy carriers and inherently clean energy technologies would help improve their nutritional status and reduce their risks of ill-health and resource depletion, while also addressing global and regional environmental concerns.

Policies to promote the implementation of sustainable energy strategies must be sufficiently resourceful, and yet adaptable to local situations, to be able to address the numerous institutional and other challenges. The following are some guidelines for the development of policy measures, which can promote sustainable energy technologies for poverty alleviation and environmental protection.

- ***Improvements in commercial energy services*:** There is sufficient evidence that small improvements in the level of energy services available to people living in poverty could generate dramatic changes in their quality of life. Cross-country comparisons by UNDP (2002) indicate a positive correlation between access to energy and electricity services and educational attainment and literacy among both the rural and urban poor. This may be because families lacking adequate energy supplies will tend to limit children's time spent on schoolwork and reading; in extreme cases, families may withdraw children, especially girls, from school to spend time on fuel-wood and dung collection.
- ***Promote the creation of favourable legal, institutional and regulatory climates for sustainable energy development and increased involvement of private sector*:** Privatisation policies must be designed explicitly to improve the access to energy services for people living in poverty, with incentives offered to private power developers to make use of the best suited technology options. In some cases, where grid access is convenient and cost-effective, flat rate, yet low cost, billing can overcome barriers related to costly metering. Similarly, many conventional problems of theft can be avoided by encouraging local, self-governing institutions to manage distribution of energy services, for instance, through bulk sales to co-operatives.
- ***Promote initiatives to overcome high first costs and risks associated with sustainable energy technologies*:** This could be done by developing innovative financing mechanisms for extending credit to non-conventional borrowers. This is particularly important for people living in poverty because they think primarily in terms of the first cost, rather than the life-cycle cost, which would ultimately result in lower energy prices and improved energy services. Early penetration of such advanced technologies as household lighting systems using photovoltaic technology or efficient biomass or gas stoves will also help bring down costs, thus widening the market even further to encourage new entrants. In many cases, the high initial cost of renewable energy systems requires financial mechanisms to make them affordable to consumers. Because most renewable energy technologies are small and modular, their manufacture can benefit from the economies of producing large numbers of identical units.
- ***Promote the development of productive uses for energy services*:** This could include developing strategies to fully utilise natural resources in order to create additional economic benefits and possibly the establishment of new industries (e.g. food processing industries). New urban industries can be created in value added energy generation activities. Such measures may persuade development aid agencies, governments and entrepreneurs to perceive the direct value in promoting sustainable energy policies. In addition, well-designed demonstration projects may also cause governments to revise obsolete laws and regulations that hinder the development of renewable energy or energy efficient technologies.
- ***Support measures to develop indigenous capacity in the area of sustainable energy*:** This could include training and education to create local manufacturing capabilities, sales, and service industries related to sustainable energy, thus creating new jobs and economic activity. It will be essential to consider both value-added activities directly related to the delivery of energy services (e.g., battery charging stations, bottled gas distribution) and those that are indirectly related (e.g., food processing industry, trade and small scale manufacturing). Training will help build awareness of sustainable energy opportunities, widen skill levels and create a new manufacturing class that could eventually form new lobbies for sustainable energy. Training for government officials and development workers is also essential to help build organisational capability for

creating and sustaining energy programmes that promote renewable energy and energy efficiency technologies.

- ***Promote various means to improve the utilisation of modern energy services*:** This will help to improve the living conditions of people living in poverty and promote the delivery of more energy efficient municipal services for urban areas. This might include improved stoves, better ventilation, improved sanitation, etc. Retrofitting existing structures for energy efficiency improvements would also improve energy services for people living in poverty. Similarly, consideration could be given to the energy services required to provide adequate street lighting, cleaner public transportation, communication infrastructure, water pumping and delivery etc. All such measures would help mainstream sustainable energy strategies by including them in other development initiatives considered by governments, donors and nongovernmental organisations.

4.0 MEASURES THAT WILL IMPROVE ENERGY SERVICES TO THE POOR

The following are some measures that will directly improve the level of energy services to those living in poverty and thereby improve the environment:

4.1 Improved Cookstoves and Modern Fuels

Since cooking using traditional biomass fuels is both the dominant energy activity in developing countries and is the source of undue hardship to people living in poverty, the dissemination of more efficient cookstoves using traditional or modern fuels is an essential sustainable energy intervention. Cookstove design can be improved to maximise combustion of fuel, maximise radiative heat transfer from the fire to the pot, maximise convection from the fire to the pot, and maximise conduction to the pot. This improved design will maximize users satisfaction by making the stoves convenient to use (with local fuels, cooking pots and utensils) and able to easily prepare local dishes well primarily, the end-users (mainly women) will find the improved stoves easy to use and fuel efficient under a variety of conditions. The improved stoves will also perform robustly in the environmental and practical constraints of indoor or outdoor kitchens.

These technologies are preferred for their convenience, comfort, cleanliness, ease of operation, speed, efficiency, and other attributes. Depending on relative fuel and stove prices, substantial reductions in both operating costs and energy use can be obtained from switching from traditional stoves using commercially purchased fuel-wood to improved biomass, gas, or kerosene stoves.

4.2 Decentralised Rural Electrification

Decentralised sustainable energy can contribute significantly to improving the living conditions of rural populations by bringing energy services to outlying areas that cannot be quickly connected to electricity grids. Improved access to electricity in rural areas need not take place only through grid extension. In recent years, technological developments in small hydropower, biomass utilisation, wind energy and solar photovoltaic systems have created new opportunities for rural development, so that Decentralised Rural Electrification (DRE) is a proven competitor to grid extension. Renewable energy sources are the only ones capable of assuring access of rural populations to essential energy-based services (health, education, etc.) in the near term. Several renewable energy technologies provide cost effective energy alternatives to grid extension or isolated diesel mini grids in rural areas. This is not only by itself extremely important, but by reducing the exodus from rural regions also reduces some of the development problems of cities.

Access to energy services can help the people living in poverty to remedy two of the pervasive problems that keep them in poverty - their low productivity and their limited range of productive options. Many rural enterprises can become viable only once there is access to a reliable modern energy source -mechanical power, electricity, process heat, transport fuel. In fact, decentralised generation and distribution of electricity creates more employment in rural areas than central generation. An energy system can create a net profit by displacing current energy costs, freeing time that can be put to more productive use and by increasing the efficiency of income generating activities. Furthermore, biomass production for energy could be a major source of jobs and revenues for rural populations. Advanced small-scale biomass energy technologies could generate electricity cost-effectively and justify extending power lines to rural areas, with electricity flowing from the rural areas to the cities, thereby, generating rural income.

4.3 Modernized Biomass

To assist in providing improved energy services in rural areas, modernised biomass utilisation shows great promise. The widespread use of modernised biomass for cooking and combined heat and power (CHP) generation in rural areas can address multiple social, economic and environmental bottlenecks which now constrain local development. The availability of low-cost biomass power in rural areas could be helpful in

providing cleaner, more energy efficient rural energy services to support local development, promote environmental protection, and stem the use of coal as a home fuel. It can also help improve the living conditions of rural people, especially women and children who currently face indoor air pollution associated with open burning of agricultural residues.

5.0 CONCLUSION

Energy plays a substantial role in the everyday lives of people, and poverty describes the condition of people who are denied the opportunities for a tolerable existence. There are multiple links between energy, poverty and the environment. People living in poverty use inefficient and relatively more polluting energy carriers and systems than those who are better off. Also, they engage in hazardous or ecologically disruptive activities to obtain energy services.

Conventional energy strategies for the most part have failed to help meet the basic human needs of the poor majority. Yet numerous opportunities are available for meeting basic needs at much lower energy consumption levels than has traditionally been the case. By using the most efficient technologies available today, and focusing increasingly on renewable sources of energy, the level of energy services can be increased considerably. Those increased services are essential for meeting basic human needs and in the process alleviating poverty and protecting the environment.

The first priority of the people with low income is the satisfaction of basic human needs and energy plays an important role in providing for these needs. Analyzed in this paper, are various concrete policies and measures designed to promote energy services that will lead to poverty eradication and environmental regeneration. Current approaches to energy are not sustainable and will, in fact, make energy a barrier to socio-economic development, especially for people living in poverty. What is needed now is a major reorientation toward sustainable energy technologies, including renewable energy, energy efficiency, and cleaner conventional fuels. The availability of new energy technologies offers the prospect of low-cost, localized solutions to national energy concerns.

REFERENCES

Adedire, M.O. 2002. Environment implications of tropical deforestation. The International Journal of Sustainable Development and World Ecology .Vol. 9, No.1, pp. 33 – 40.

Ajueyitsi, O. A. 2005. Coal resources development environment. In: Environmental Sustainability and Conservation in Nigeria, Okoko, E., Adekunle, V. J. A. and Adeduntan, S. A. (Eds); Environmental Conservation and Research Team (ECRT). Federal University of Technology Akure, Nigeria, pp. 43 – 47.

Cecelski, E. 1995. From Rio to Beijing: Engendering the Energy Debate. Energy Policy, Vol. 23, No. 6, July.

Hosier, R. H. and Dowd, J. 1987. Household fuel choice in Zimbabwe: An empirical test of the Energy Ladder Hypothesis. Resources and Energy, Vol. 13, No. 9, pp. 347 – 361.

IPCC (Intergovernmental Panel on Climate Change). 1996. Impacts, adaptations and mitigation of climate change: Scientific-Technical Analyses. In: Watson, R.T., M.C. Zinyowera, and R.H. Moss (Eds). Cambridge University Press, Cambridge and New York.

Jande, J. A. 2005. Analysis of fuel wood consumption among the residents of Makurdi suburbs, Nigeria. In: Environmental Sustainability and Conservation in Nigeria, Okoko, E., Adekunle, V. J. A. and Adeduntan, S. A. (Eds); Environmental Conservation and Research Team (ECRT). Federal University of Technology Akure, Nigeria, pp. 43 – 47.

Ladipo, D. O, Adebisi, A. A and Adewusi, A. G. 2002. Domestic energy and conservation needs for indigenous forest species in Nigeria. Proceedings of the 28th annual conferences at forestry association of Nigeria 4th - 8th Nov, 2002. pp. 240 – 251.

Oboho, E. G. 1986. The use of fuel wood and alternative energy sources in sokoto Metropolis. Journal of Tropical Forest Resources. Vol. 2, No. 1, pp. 28 – 34.

Reddy, A. K. N. and Reddy, B. S. 1994: Substitution of energy carriers for cooking in Bangalore. Energy, Vol. 19, No. 5, pp. 561 – 571.

Smith, K. R. 1987. Biofuels, Air Pollution and Health-A Global Review. Plenum Press, New York.

Smith, K. R. 1990. Health effects in developing countries in. Janos, P. and Kristoferson, P. (Eds.) Bioenergy and the Environment, Westview, Colorado.

Smith, K. R. 1993. Fuel combustion: Air pollution exposures and health in developing countries. Annual Review of Energy and Environment, Vol. 18, No. 1, pp. 529 – 566.

UNDP, 1998. Human Development Report 1998, Oxford University Press.

UNDP, 2002. Energy for sustainable development. http://www.undp.org/seed/eap/activities/wea.

Wabara, E. 2003. Endless energy crises in Nigeria. The Daily Sun. Vol. 1, No. 136. December 24, p. 7.

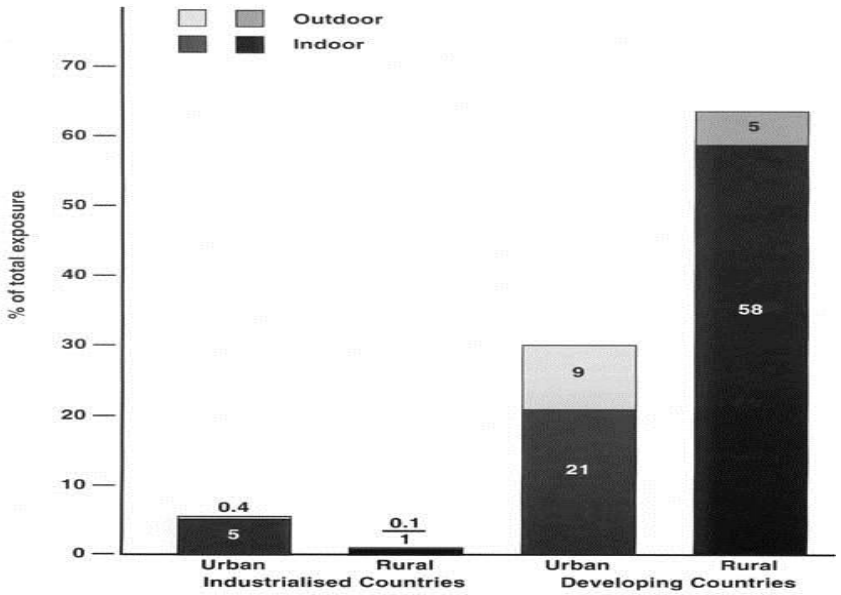

Fig. 1: Approximate distribution of human exposure to particulate pollution.
Source: Smith, 1993.

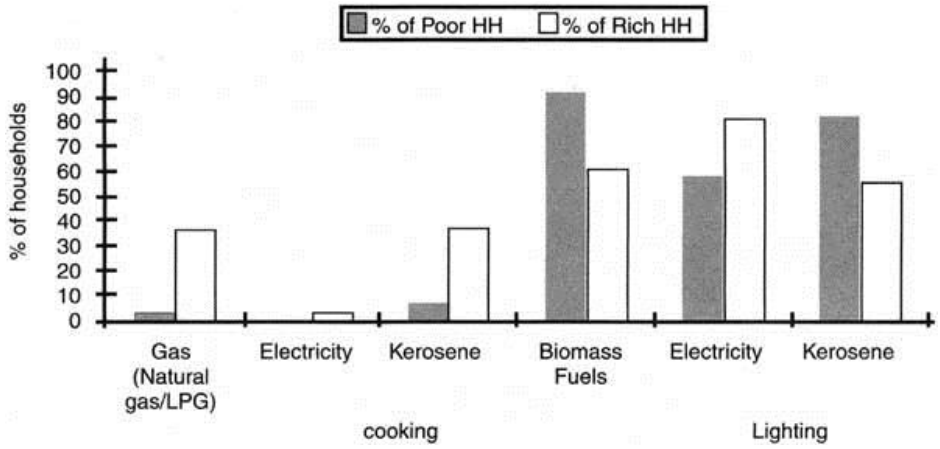

Fig. 2: Household energy consumption and poverty status
Source: UNDP, 2002.

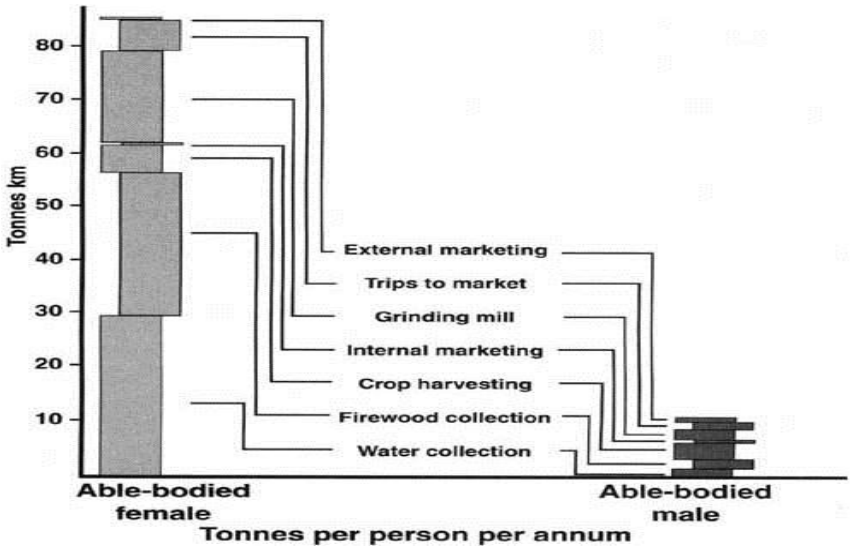

Fig. 3: Rural transport activities by males and females
Source: UNDP, 2002.