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Effects of Unsustainable Use of Biomass Energy for Cooking and Strategies for Their Reduction in Developing Countries

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Abstract

This paper analyses effects of biomass energy use for cooking in developing countries. The biomass use is harvested unsustainably and energy conversion technologies are inefficient. Unavailability and high prices of modern energy services has encouraged the use and preference for biomass as a major source of fuel for domestic activities. The use of biomass fuels for cooking has serious adverse consequences on the health of household members and on the environment. Women and children are traditionally responsible for cooking and other household chores, therefore, they suffer most from indoor air-pollution. Various measures and strategies for reducing the effects of unsustainable use of biomass for cooking are discussed. Promising approaches include the use of appropriate technologies, modern cooking fuel, modernized biomass and improved cook-stove designs for higher efficiency and good ventilation.

Keywords: Biomass, Cooking, Unsustainable, Energy, Health, Environment.

1. Introduction

One third of the world's population of six billion lives in developing countries. Many of these people lack access to modern energy services for economic and social development and some of their present energy systems are unsustainable (Brien et al., 2007). According to the WHO, energy-poverty, marked by lack of sustainable energy and access to modern cooking fuels, creates obstacles to achieving the Millennium Development Goals (MDGs), the global targets for reducing extreme poverty and improving health and welfare (WHO, 2007). The supply of affordable and reliable energy is essential for economic development and is a significant contributor to the alleviation of poverty, improved health, and better quality of life (Akinola and Bolaji, 2006).

According to Adeokun et al. (2003), energy consumption pattern and level in Nigeria have produced a serious exploitative and disruptive environmental stress. The exploitative stress is most obvious in the amount of fuel-wood harvested daily to support the energy needs. The rate at which the natural vegetation has been exploited to meet the exponential human demand for energy has become highly disruptive of the ecological system. 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. Beside these short comings, modern energy 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 (Adedire, 2002).

Wood has for long served as one of the energy sources known and used by mankind, for cooking in both urban and rural areas of developing countries. In Nigeria, fuel-wood is still the most utilized energy for cooking (Danshehu et al., 1992; Bolaji, 2005). Though fuel-wood is a renewable source of energy, several decades of fuel-wood exploitation over natural rates of regeneration has made fuel-wood availability more difficult. Several studies have established the fact that fuel-wood constitutes the bulk of energy used by rural households in Nigeria. Momoh and Soaga [1999] reported the work of Ogbona, who estimated that fuel-wood provided 60% and 92.3% of energy for cooking in urban and rural households respectively, in the Savannah areas of Nigeria. Akinbami et al. (2001), reveal in their study that fuel-wood use in Nigeria as of 1999 accounted for 65.9% of the overall energy used in the country. Ladipo et al. (2002) noted that the

scarcity and exhaustion of fuel-wood supply in Nigeria 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.

Use of biomass is not in itself a cause for concern. However, when resources are harvested unsustainably and energy conversion technologies are inefficient, there are serious adverse consequences for health, the environment and economic development. According to WHO (2006), about 1.5 million people (mostly women and children) die prematurely every year because of exposure to indoor air pollution from biomass. Therefore, this paper analyses the effects of unsustainable use of biomass energy for cooking in developing countries. Various policies and measures that can improve the level of household energy and reduce the effects of unsustainable use of biomass were also discussed.

2. Sources of household energy in developing countries

The main use of energy in households in developing countries is for cooking, followed by heating and lighting. Households generally use a combination of energy sources for cooking that can be categorized as traditional (such as dung, agricultural residues and fuel-wood), intermediate (such as charcoal and kerosene) or modern (such as LPG, biogas, ethanol gel, plant oils, dimethyl ether and electricity). Electricity is mainly used for lighting and small appliances, rather than cooking, and represents a small share of total household consumption in energy terms.

In sub-Saharan Africa larger proportion of the population relied on biomass as the major source of their household energy (Table 1). In many parts of this region, more than 90% of the rural population relies on fuel-wood and charcoal (World Bank, 2006). Many people use three-stone fires cook without ventilation and fuel-wood used is harvested at an unsustainable rate (UNDP, 2002). Heavy dependence on biomass is concentrated in, but not confined to, rural areas. Almost half a billion people in urban areas also rely on these resources. Although urbanisation is associated with lower dependence, the use of fuels such as liquefied petroleum gas (LPG) in towns and cities is not always widespread. In sub-Saharan Africa, well over half of all urban households rely on fuel-wood, charcoal or wood waste to meet their cooking needs. Over a third of urban households in some Asian countries also rely on these fuels. The share of biomass in household energy demand varies widely across countries and regions, primarily reflecting their resource endowments but also their levels of economic development and urbanization.

3. Effects of biomass energy use for cooking in developing countries

3.1 Health Effects of the Use of Biomass as Cooking Fuels

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, but the emissions of pollutants in the form of incomplete combustion products are quite high per unit of energy. Incomplete combustion of solid fuels and poor ventilation result in high indoor concentrations of health-damaging pollutants including particulate matter and carbon monoxide (Jetter and Kariher, 2009; MacCarty et al., 2010). 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 Figure 1. In addition, indirect health impacts such as malnutrition, diarrhea and parasites may be significant due to lack of fuel for proper cooking (Smith, 2007).

The World Health Organization (WHO) estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels. That is more than 4 000 deaths per day, more than half of them are children under five years of age. More than 85% of these deaths are due to biomass use, the rest due to coal. This means that indoor air pollution associated with biomass use is directly responsible for more deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS (Figure 2) (WHO, 2006). Just as the extent of dependence on polluting fuels and inefficient stoves varies widely around the world, so does the death toll due to indoor smoke. Women and children

suffer most from indoor air pollution because they are traditionally responsible for cooking and other household chores, which involve spending hours by the cooking fire exposed to smoke. Young children are particularly susceptible to disease, which accounts for their predominance in the statistics for premature deaths due to the use of biomass for cooking.

Traditional cook-stoves cause indoor concentrations of important pollutants, such as small particles less than 10 microns in diameter, known as PM10, carbon monoxide, benzene and formaldehyde, which are 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 (WHO, 2007).

3.2 Environmental effects of the use of biomass

The increased dependence on the use of wood, crop residues and untreated coal for cooking in developing countries has a lot of negative implications on both people and environment. Fuel-wood, roots, agricultural residues and animal dung all produce high emissions of carbon monoxide, hydrocarbons and particulate matter. Hydrocarbon emissions are highest from the burning of dung for fuel, while particulate emissions are highest from agricultural residues (WHO, 2007).

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 (Akinola and Bolaji, 2006).

3.3 The burden of biomass collection

In developing regions, women and children are responsible for fuel collection, a time-consuming and exhausting task. The average fuel-wood load in sub-Saharan Africa is around 38 kg loads. Women can suffer serious long term physical damage from strenuous work without sufficient recuperation. Collection time has a significant opportunity cost, limiting the opportunity for women and children to improve their education and engage in income-generating activities. Many children, especially girls, are withdrawn from school to attend to domestic chores related to biomass use, reducing their literacy and restricting their economic development by enhancing the productivity of labour and capital.

4. Strategies for reducing the effects of unsustainable use of biomass

4.1 Conversion of biomass to less polluting fuel

For many households, switching away from traditional biomass is not feasible in the short term. Improving the way biomass is supplied and used for cooking is, therefore, an important way of reducing its harmful effects. This can be achieved either through transformation of biomass into less polluting forms. Charcoal and agricultural residue briquettes which have higher energy content and less polluting can be used for cooking.

4.2 Uses of modern cooking fuels

In the long run, and even today in areas where sustainable biomass use is not possible, a modern cooking fuel solution is the most appropriate way to reduce the health risks and time-loss suffered by women and children. There are a range of fuels that can substitute for, or supplement the use of, biomass for household energy in developing countries. Liquefied petroleum gas (LPG) is already quite well established in some countries. Ethanol gel is also potentially very important, particularly in sugar-producing countries, because

of its low cost. Biogas has considerable potential in many rural communities, though the capital costs are not directly comparable to those of liquid fuels.

4.3 Improving the cook-stoves

Since cooking using traditional biomass fuels is both the dominant energy activity in developing countries and is the source of undue hardship to people, the dissemination of more efficient cook-stoves using traditional or modern fuels is an essential sustainable energy intervention (Adkins et al., 2010). Cook-stove design can be improved to maximize combustion of fuel, maximize radiative heat transfer from the fire to the pot, maximize convection from the fire to the pot, and maximize 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, example of such improved stoves is the sawdust briquette cooking stove (Bolaji, 2005). Another approach is to improve the efficiency of biomass use by adding chimneys to stoves, example is the improved coal stove (Bolaji and Olalusi, 2009). 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.

4.4 Developing 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.

4.5 Expanding the use of modern fuels through the help of microfinance institutions

One of the principal barriers to the penetration of modern cooking fuels is the high initial cost of the cylinder purchase (in the case of LPG) and the stove. An option to overcome up-front costs is for a bank or financial institution to offer financing for the cooking stove, cylinder and appliance over a year or more. There are strong arguments for using the community as a vehicle for this financing and making it jointly and individually responsible for repayment. Energy service companies can assist with cost barriers by providing energy to customers on a fee-for-service basis, retaining ownership of some or all of the energy equipment, pooling subsidies and investment incentives and amortizing over time the balance of equipment costs in the fees charged to customers.

5. Conclusion

Biomass has for long served as one of the energy sources known and used by mankind, for cooking in both urban and rural areas of developing countries. The majority of people in these countries lack access to modern energy services for economic and social development and some of their present energy system is unsustainable. Where modern energy is available, is usually very expensive and beyond the reach of most people. This has encouraged the use and preference for biomass as a major source of fuel for domestic activities. The increased dependence on biomass has a lot of negative implications on both people and

environment. Heavy dependence on biomass is concentrated in, but not confined to, rural areas. Substantial number of people in urban areas also relies on these resources. Although urbanization is associated with lower dependence, the use of fuels such as liquefied petroleum gas (LPG) in towns and cities is not always widespread.

Analyzed in this paper, are various effects of biomass energy use for cooking in developing countries. Indoor air pollution associated with biomass use is directly responsible for deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS. Women and children are traditionally responsible for cooking and other household chores, therefore, they suffer most from indoor air pollution. Various measures and strategies for reducing the effects of unsustainable use of biomass in developing countries are discussed. Current approaches to energy are not sustainable and will, in fact, make energy a barrier to socio-economic development, especially for people in rural areas of developing countries. What is needed now is a major reorientation toward sustainable energy technologies. Promising approaches include the use of appropriate technologies, modern cooking fuels, modernized biomass and improved cook-stove designs for higher efficiency and good ventilation.

References

Adedire, M.O. (2002). Environment implications of tropical deforestation. *The International Journal of Sustainable Development and World Ecology*, Vol. 9, pp. 33-40.

Adeokun, O. A., Adekoya, A. E. & Oloruntoba, A. (2003). Energy generation from livestock manure as a means of reducing Environmental pollution. *Proceedings of 11th Annual Conference of Environment and Behaviour Association of Nigeria (EBAN)*, pp. 274-278.

Adkins, E., Tyler, E., Wang, J., Siriri, D. & Modi, V. (2010). Field testing and survey evaluation of household biomass cookstoves in rural sub-Saharan Africa. *Energy for Sustainable Development*, Vol. 14, No. 2, pp. 172-185.

Akinbami, J.F.K., Ilori, M.O. Oyebisi, T.O., Akinwumi, I.O. & Adeoti, O. (2001). Biogas energy use in Nigeria – Current Status, Future Prospects and Policy Implications. *Renewable and Sustainable Energy Reviews*, Vol. 5, pp. 97-112.

Akinola, O.A. & Bolaji, B.O. (2006). Sustainable Energy Technologies for Poverty Alleviation and Environmental Protection. *1st National Conference of Faculty of Science*, University of Abuja, Nigeria, 18th – 20th July, pp. 53-63.

Bolaji, B.O. (2005). The use of sawdust as an alternative source of energy for domestic cooking and as a means of reducing deforestation. *Global Journal of Environmental Sciences*, Vol. 4, No. 1, pp. 73-76.

Bolaji, B.O. & Olalusi, A.P. (2009). Development of an Improved Coal Stove for Cooking in Developing Countries. *AU Journal of Technology*, Vol. 12, No. 3, pp. 182-187.

Brien, G. O. Keefe, P. O. & Rose, J. (2007). Energy, poverty and governance. *International Journal of Environmental Studies*, 64, 605-616.

Danshehu, B. G., Sambo, A. S. & Musa, M. (1992). Comparative performance of sawdust and wood burning stove. *Nigerian Journal of Renewable Energy*, Vol. 3, No. 1, 50-55.

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), pp. 43-47.

Jetter, J. & Kariher, P. (2009). Solid-fuel household cook stoves: characterization of performance and emissions. *Biomass Bioenergy*, Vol. 33, No. 2, pp. 294-305.

Ladipo, D. O. Adebisi, A. A. & 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*, pp. 240-251.

MacCarty, N., Still, D. & Ogle, D. (2010). fuel use and emissions performance of fifty cooking stoves in the laboratory and related benchmarks of performance. *Energy for Sustainable Development*, Vol. 14, No. 1, pp. 161-71.

Momoh, S. & Soaga, J. (1999). Biomass energy consumption in Nigeria: Integrating demand and supply. *Nigerian Journal of Renewable Energy*, Vol. 7, No. 1, pp. 78-82.

Smith, K., Dutta, K., Chengappa, C., Gusain, P.P.S., Masera, O. & Berrueta, V. (2007). Monitoring and evaluation of improved biomass cookstove programs for indoor air quality and stove performance. *Energy for Sustainable Development*, Vol. 12, No. 2, pp. 5-18.

UNDP, (2002). Energy for sustainable development. [Online] Available: http://www.undp.org/seed/eap/activities/wea (June 14, 2006).

WHO, (2006). *Statistical information system*. World Health Organization. [Online] Available: http://www.who.int/whosis. (August 9, 2007).

WHO. (2007). *Indoor air pollution: national burden of disease estimates*. World Health Organization Geneva, Switzerland: WHO Press; 2007.

World Bank, (2006). *Rural energy and development*: Improving energy supplies for two billion people. Washington, DC.

Table 1. People relying on biomass resources as their primary fuel for cooking

Developing regions	Population			People relying on biomass					
	Rural	Urban	Total	Rural		Urban		Total	
	(Million)	(Million)	(Million)	(Million)	(%)	(Million)	(%)	(Million)	(%)
Sub-Saharan Africa	444.0	280.0	724.0	413.0	93	162.0	58	575.0	79
North Africa	67.0	100.0	167.0	4.0	6	0.2	0.2	4.2	3
India	762.0	308.0	1070.0	663.0	87	77.0	25	740.0	69
China	780.0	520.0	1300.0	428.0	55	52.0	10	480.0	37
Indonesia	116.0	102.0	218.0	110.0	95	46.0	45	157.0	72
Rest of Asia	489.0	263.0	752.0	455.0	93	92.0	35	547.0	73
Brazil	30.0	160.0	190.0	15.0	50	8.0	5	23.0	12
Rest of Latin America	95.0	278.0	373.0	59.0	62	25.0	9	84.0	23
Total	2783.0	2011.0	4794.0	2147.0	77	462.2	23	2609.2	54

(Source: World Bank, 2006)

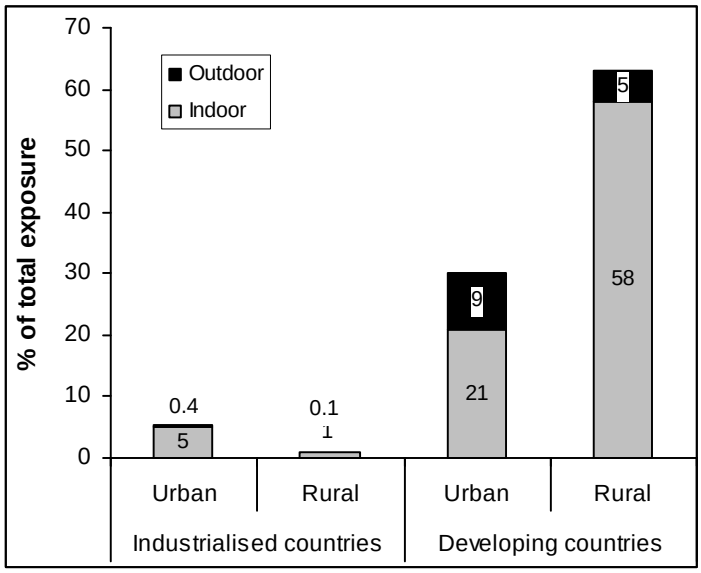

Figure 1. Approximate distribution of human exposure to particulate pollution (Source: WHO, 2007)

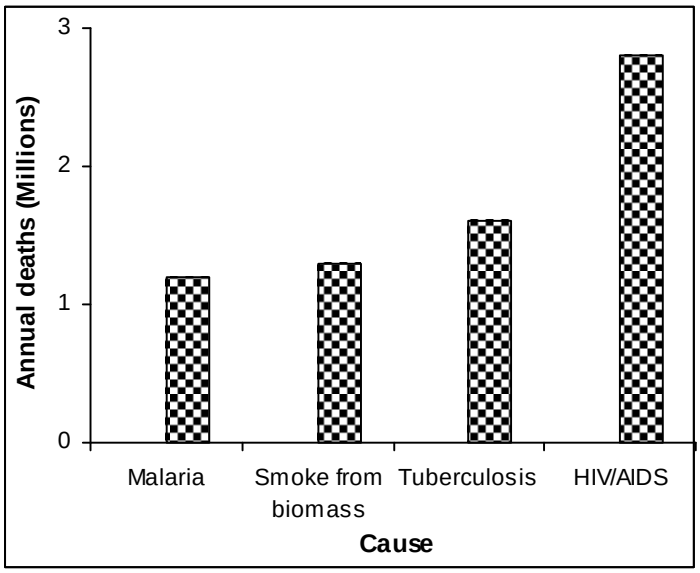

Figure 2. Annual deaths worldwide by cause (Source: WHO, 2006)