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Full Length Research Paper

Role of fuel efficient stoves in achieving the millennium development goals: case of Ethiopia

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World leaders set far-sighted eight goals to free a major portion of humanity, particularly in developing nations, by the year 2015 from extreme poverty, hunger, illiteracy and disease; established targets for achieving gender equality and the empowerment of women, environmental sustainability and a global partnership for development. The objective of this paper is to critically examine the role of fuel-efficient stoves in realizing these goals based on secondary sources. Access to fuel efficient cooking stoves has a paramount contribution for the struggle to achieve the Millennium Development Goals. It is vital in minimizing the incidence of indoor air pollution and related deaths; reduces the rate of green house gas emission; enables to reduce the demand for fuel (so as to decrease the rate of deforestation and utilization of animal dung and crop residues for fuel-which again enables to increase the productivity of the land); it also plays great role in minimizing the amount of time and effort women and young girls spend in gathering fuels which otherwise will be used for education and income generating activities. Developing countries should disseminate appropriate fuel saving stoves especially for the rural areas whereby the majority of their population are dependent in traditional open fire system.

Key words: Ethiopia, MDGs, fuel efficient stoves, Indoor air pollution

INTRODUCTION

Human survival and prosperity are highly dependent on the environment. Complex ecosystems ensure a continuous supply of food and fresh water and provide wood and other natural resources for our use. They regulate our climate and protect us from floods and other natural disasters. Ecosystems have shown a remarkable capacity to accommodate more and more of our needs, yet, these very foundations of our existence are now endangered by population growth and the unsustainable use of natural resources (Barrow, 2005). More than 2.4 billion people burn biomass fuels on a daily basis mainly for cooking food. As a result 2 million tones of biomass are going up in smoke every day.

This may not pose a problem where the growth of new trees surpasses human demand. However, with increasing of demand of wood through time, wood collection can put considerable pressure on forests. Spending money on large quantities of inefficient fuels, where fuel is purchase, places severe constraints on household budgets. Poor households tend to spend a larger percentage of their income on energy than well-off households. Women and children spend many hours a week searching for fuel wood. Fuel collection is not necessarily a daily task, as the duration and frequency of collection varies depending on the

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availability of wood for use as a fuel (Gill, 1985; FAO, 2003; UNDP, 2005b; Barnes et al., 2012 and Ekouevi and Tuntivate, 2012).

According to UNDP (2005b) and World Health Organization (WHO) (2006), energy is essential to meet our basic needs mainly for cooking, boiling water, lighting and heating. Worldwide, more than three billon people are dependent on burning wood, dung, and other traditional fuels inside their homes which results indoor air pollution. Due to this, more than 1.5 million deaths are occurred mostly of young children and their mothers. Millions more are suffering every day with difficulties in breathing, stinging eyes and chronic respiratory diseases (WHO, 2006). Some studies have linked exposure to indoor smoke to asthma, cataracts, tuberculosis, adverse pregnancy outcomes (particularly low birth weight), heart disease, interstitial lung disease, and nasopharyngeal and laryngeal cancers.

The millennium declaration promotes a comprehensive approach that overcomes a broad range of problems simultaneously. By 2015, the world aims to have achieved eight goals for combating poverty, hunger, disease, illiteracy, environmental degradation and discrimination against women (UNDP, 2005b). But there are no MDGs on energy (UNDP, 2005a and World vision, 2011) though energy poverty is one of the many manifestations of poverty and a widespread feature of deprived rural and urban households in developing countries.

The ambitious goals around poverty eradication will not be realized without overcoming the challenge of energy provision for the poor. Lack of access to modern cooking fuels and electricity, already represents a bottleneck, holding back progress towards achieving the goals. To that end, United Nation (UN) highly recommended that without increased investment in the energy sector, the MDGs will not be achieved in the poorest countries (Modi et al., 2006). UNDP (2005a) also underlined the fundamental role of affordable, reliable and environmentally benign energy in underpinning efforts to achieve the MDGs and improving the living standards of the poor.

The use of biomass fuels and coal for cooking and heating accounts for the greater proportion of global energy use. Yet household use of these fuels does not feature prominently in discussions on global warming and climate change. The burning of biomass fuels in poor homes in the developing world does not convert all fuel carbon into CO_2. Open fires and traditional stoves tend to be highly inefficient and lose a large percentage of the fuel energy as so-called products of incomplete combustion (Owsianowski and Barry, ND; WHO, 2006). Introducing household energy practices can make paramount contributions in achieving MDGs. Improved stoves, if adequately designed, installed and maintained, can lower indoor smoke levels considerably. For example, cheap wood-burning stoves in East Africa have lowered pollution by 50%; and plancha stoves in Latin America reduce indoor smoke levels by as much as 90% harmful pollutants by optimizing combustion, venting smoke to the outside through a flue and chimney and, in some cases, reducing cooking times (WHO, 2006). For developing countries, where the great proportion of their populations depends primarily on biomass fuels, technical advances in energy efficiency are crucial (Owsianowski and Barry, ND). Overuse of these fuels depletes resources and degrades local environments, multiplies the time needed to collect fuel, and creates indoor pollution that threatens the well-being of the most vulnerable members of households (Douglas and et al, 1994 and Singh et al., 2012).

MATERIALS AND METHODS

Intent of the paper

Despite the problems associated with traditional use of wood fuels (like energy inefficiency, deforestation, increasing use of time for collection of fuel, and deleterious health and environmental effects), hundreds of millions of people, mainly in developing countries, rely on wood fuels for most of their energy needs (Gill, 1985; FAO, 2003; Ahmed et al., 2005; UNDP, 2005b; Barnes et al., 2012 and Ekouevi and Tuntivate, 2012). Open fires and traditional stoves tend to be highly inefficient and lose a large percentage of the fuel energy due to incomplete combustion. Introducing household energy practices that, in addition to decreasing levels of indoor smoke, save fuel and reduce greenhouse gas emissions can make an important contribution to achieving MDGs but the its role is not well studied. Therefore, this paper tried to look at the contribution of fuel efficient cooking stoves in achieving the Millennium

Development Goals based on intensive review literature. In doing so, different theoretical and empirical evidences (both form Ethiopia and aboard) regarding the significance of fuel efficient stoves in achieving the different targeted objectives of the MDGs have been examined.

Fuel efficient stove-world context

Worldwide, 3 billion people are dependent on burning biomass fuels for cooking (World Vision, 2011; Anhalt and Holanda, 2009; Sepp and Mann, 2009). In Sub-Saharan Africa (SSA), wood-based biomass is the dominant source of energy where about 81% of rural households and 60% of urban dwellers depend on it for cooking-far more than in any other region in the world (Modi et al., 2006; IBRD, 2011; World Vision, 2011 and Ekouevi and Tuntivate, 2012). According to ESCAP (ND), wood fuel, agricultural residues and animal waste account for 65 to 70 per cent of the energy used in rural areas of Asia and more than 25 per cent in urban areas.

Given current trends of population growth, urbanization, economic growth, and relative price developments of other energy sources, it is likely that wood-based biomass will remain an important source of energy for the coming many decades. Over 95% of the population in countries such as Burundi, Central African Republic, Chad, Liberia, Rwanda, The Gambia and Sierra Leone lack access to modern energy, with the rural population relying almost exclusively on wood-based biomass energy for cooking. Wood-based biomass as the main source of energy is reported at 68% in Kenya, 95% in Eritrea, 94% in Ethiopia, while Zambia and Uganda indicated 70% and 92%, respectively (Duflo and Greenstone, 2008 and UNDP, 2009 as cited by IBRD, 2011). Projections suggest that the consumption of wood-based biomass by SSA households will increase in relative terms over the next 30 years as demographic growth continues to outstrip access to other modern fuels (IBRD, 2011).

Efforts to improve the efficiency of biomass cooking stoves date back to the 1940s. In recent decades, urban areas in developing nations have experienced higher dissemination rates of improved stoves; indeed, many urban households have made the switch to cleaner fuels like liquid petroleum gas (LPG) or kerosene for cooking. On the contrary, most rural households in these countries are not endowed with the necessary infrastructure that could bring them cleaner fuels, nor do they have the adequate income to pay for the fuels. Low-income communities located in rural areas without accesses to markets or energy infrastructures are most likely to benefit from improved cooking stove projects.

The dissemination of efficient stoves in these households can be a step taken toward minimizing indoor air pollution, decreasing time and money spent on fuel wood, and can prevent the rate of deforestation substantially (Anhalt and Holanda, 2009). Anhalt and Holanda (2009) added that, the goal of any improved cook stove program is to develop more efficient, energy-saving, and affordable biomass cook stoves that can help overcome local pressure on wood resources, cut down the walking time required to collect the fuel, reduce cash outlays necessary for purchasing fuel wood or charcoal, and reduce the indoor-air pollution.

One of the first improved fuel efficient stoves was the “Magan Chula”, introduced in India in 1947. A publication called “Smokeless Kitchens for the Millions” advocating the health and convenience benefits of efficient burning of biomass, stimulated the promotion of improved cooking stoves. The initial wave of stove programs focused on health aspects rather than reduction of fuel wood. Consequently, attention shifted to the potential of fuel efficient stoves in saving biomass fuels and limiting deforestation. Currently, paired focus on fuel wood reduction and health impact of improved cook stove utilization is agreed to. Recently stressed aspects on climate change and carbon emissions in conjunction with the preoccupation of increasing respiratory infections are the key issues incorporated into program proposals (Anhalt and Holanda, 2009).

Fuel saving stove in ethiopia

In Ethiopia, fuel wood is the major energy source and over 90 percent of the country’s total energy for household cooking comes from biomass fuels, of which wood provides 78 percent. Deforestation is a major problem and many peasants have switched from fuel wood to dung for cooking and

heating purposes. Such burning of dung and crop residues that were sources of soil humus and fertility has brought about a decline in land quality, reduction of soil fertility and agricultural productivity (FAO, 2003; Tsegaye, 2006 and Zenebe et al., 2006). Regarding this issue, Woldegabreil (2003) has indicated that "firewood and dung cakes are the major sources of fuel in most parts of the country and absence of alternative source of energy force local communities to deplete the scanty wood resources of the forest." This high biomass energy consumption, according to FAO (2003) and EPAE (2004), has aggravated the rate of deforestation, biodiversity loss and land degradation.

According to EPAE (2004), improved charcoal stove (Lakech) and biomass closed Enjera stove (Gounzie) can save up to 25 percent and 47 percent over traditional stove and open fire stove respectively. Improved fuel efficient stoves, therefore, help to reduce pressure on the biomass resources including forests; increase land productivity by reducing crop residue and dung usage for fuel wood and improve family health (FAO, 2003 and EPAE, 2004).

According to the climate resilient green economy (CRGE) strategy of the country (FDRE, 2011:24), despite their economic and environmental value, Ethiopian forests are under threat due to:

"The growing population requires more fuel wood and more agricultural production, in turn creating needs for new farmland-both of which accelerate deforestation and forest degradation. Projections indicate that unless action is taken to change the traditional development path, an area of 9 million hectare shall be deforested between 2010 and 2030. Over the same period, annual fuelwood consumption will rise by 65%-leading to forest degradation of more than 22 million tones of woody biomass."

Furthermore, the document emphasized that deforestation and forest degradation should be checked to support the continued provision of economic and ecosystem services and growth in GDP. Fuelwood accounts for more than 80% of households' energy supply particularly in rural areas. Furthermore, forests contribute an estimated 4% to GDP through the production of honey, forest coffee, and timber. They also provide significant and valuable ecosystem services like protecting soil and water resources by controlling the discharge of water to streams and rivers, preserve biodiversity, function as a carbon sink, clean the air to create important health benefits, and boost land fertility. In order to minimize the rate of deforestation, the document forwarded reduction of the demand for fuelwood through the dissemination and usage of fuel-efficient stoves and/or alternative fuel cooking and baking techniques (MoFED, 2010 and FDRE, 2011).

Using fuelwood saving stoves also enables to reduce green house gas (GHG) emission offering a potential of almost 35 Mt CO_2e reductions (FDRE, 2011: 30). Introducing efficient stoves has two distinct effects on GHG emissions "it reduces forest degradation, with an impact of around 0.9 tonnes biomass/year per households; and woody biomass acts as carbon sink amounting to 2.1 tonnes per year per household (if it is not burned)" (FDRE, 2011).

In Ethiopia, wood is the most important energy source for cooking in households and its consumption is particularly high in rural areas, where alternative sources of fuel are either unavailable or unaffordable for the majority of consumers. Inefficient open fires used to cook household meals waste wood and worsen health problems associated with indoor air pollution and resulted in high depletion of the forest resources (World Vision, 2011; Abebe and Koch, 2011). Rural Ethiopian households have been dependent for centuries on woody biomass and dung. Use of woody biomass and dung as energy sources has contributed to forest degradation, deforestation, and land degradation which are among the severe environmental problems in Ethiopia. Burning dung as a fuel source makes it unavailable as manure to increase agricultural productivity (FAO, 2003; Tsegaye, 2006:26 and Alemu and Kohlin, 2008).

According to EPAE (2004), in Ethiopia the high biomass energy consumption has created deforestation, biodiversity loss and land degradation. Sisay (2008) on his study has confirmed similar findings that biomass energy at the national level provides more than 96.9 percent of the total domestic energy consumption: 78 percent from woody biomass, 8 percent from crop residue, 11 percent from animal dung and 3.1 percent from modern energy. Ministry of mines and energy issued an energy policy in May 1994 and the general content of the policy focused on

energy development, energy supply, energy saving and utilization capacity, major cross sectoral policies and improvement of organizational structure of the energy sector.

According to EPAE (2004), the wood consumed for fuel and construction purposes comes from high forests and wood lands as well as trees planted on farms and plantations. Open fire stoves require large amounts of wood which has led to deforestation and soil erosion because they have 80% heat loss rate, needing more wood to cook food. Their use also further marginalizes women and girls as they must collect hard-to-find fuel wood and are exposed to the smoke and fumes. By providing energy saving stoves that efficiently burn wood and reduce heat wastage, it is possible to improve conservation and women's health.

Population growth in Ethiopia has led to agricultural land expansion and an increased need for firewood ultimately causing deforestation. The lack of accessible wood impacts local women who are burdened with collecting or paying for expensive firewood and cooking over inefficient and smoky traditional stoves. The EPAE (2004) estimates that if all rural and urban households in Ethiopia shift to the improved Lakech and Mirt stoves, a savings of about 7,778,800 tons of fuel wood (requiring the clear-cutting of 137,192.24 ha of forest) will be achieved on an annual basis.

Considering its multifaceted role of fuel efficient stoves, dissemination of rural energy efficient stoves is among the major objectives of CRGE strategy of Ethiopia and its rationale as mentioned in the document (FDRE, 2011) are fuelwood usage is the largest source of rural energy supply and one of the largest contributors to GHG emissions; and efficient stoves can have massive benefits by increasing rural household income by 10%, health, women's empowerment, and education while decreasing emissions by around 50 Mt CO_2e in 2030. As a result there is ambitions plan to distribute fuelwood efficient stoves to 80% of the rural and 5% of the urban households; and electric stove to 5% of the rural and 62% of urban; biogas stove to 5% of rural and 1% of urban as well as Liquefied Petroleum Gas (LPG) to 5% of the urban households starting from the first quarter of 2012 to the end of 2014.

According to MoFED (2010), awareness within communities will be created and promoted; demand for alternative energy technologies will be improved and loans arranged for manufacturers and consumers to install alternative technologies.

Currently, the government's efforts are concentrated in improving household energy utilization efficiency and in promoting wider use of commercial fuels such as electricity, kerosene and LPG. In addition to the efforts of the government, the GTZ (now GIZ) "Household Energy/Protection of Natural Resources Project" is promoting improved stoves that can reduce the fuel consumption by 50 % with an objective of producing and disseminating improved Mirt stoves for Injera baking to the farming communities as part of the national strategy for the conservation of forest resources. The project is involved in the training of stove producers and in the establishment of stove production facilities. Till the end of 2001, for instance, the project has helped to produce 3114 Mirt stoves in Amhara region, 5 257 in Oromia, 2 746 in Southern Nations and 286 in Tigray region (FAO, 2003).

The roles of fuel saving stove

Though energy is a basic need for survival and a key input to social and economic development, about 2.4 billion people in developing countries still lack access to clean, affordable and reliable sources of modern energy. Two crucial aspects to which traditional energy policies have paid inadequate attention are the role of energy as an input to development and the crucial role that women play in energy systems (ESCAP, ND and IBRD, 2011). Noticeably, traditional biomass fuel use in rural areas by the poorest sectors makes it clear that the majority of people in many countries have not been able to access better energy carriers to meet their needs, and few institutions have taken the lead in providing energy services to these sectors (ESCAP, ND). The global focus on improved cook-stoves and clean fuels has increased because of their potential for delivering all rounded benefits in household health, local environmental quality, and regional climate benefits (Lewis and Pattanayak, 2012). Even though, the benefits of introducing more fuel-efficient stoves are all rounded and cut across many development sectors, it is often hard to quantify or assign monetary value to these benefits, because many of them are indirect and fluctuate depending on a wide range of different factors (World Vision, 2011).

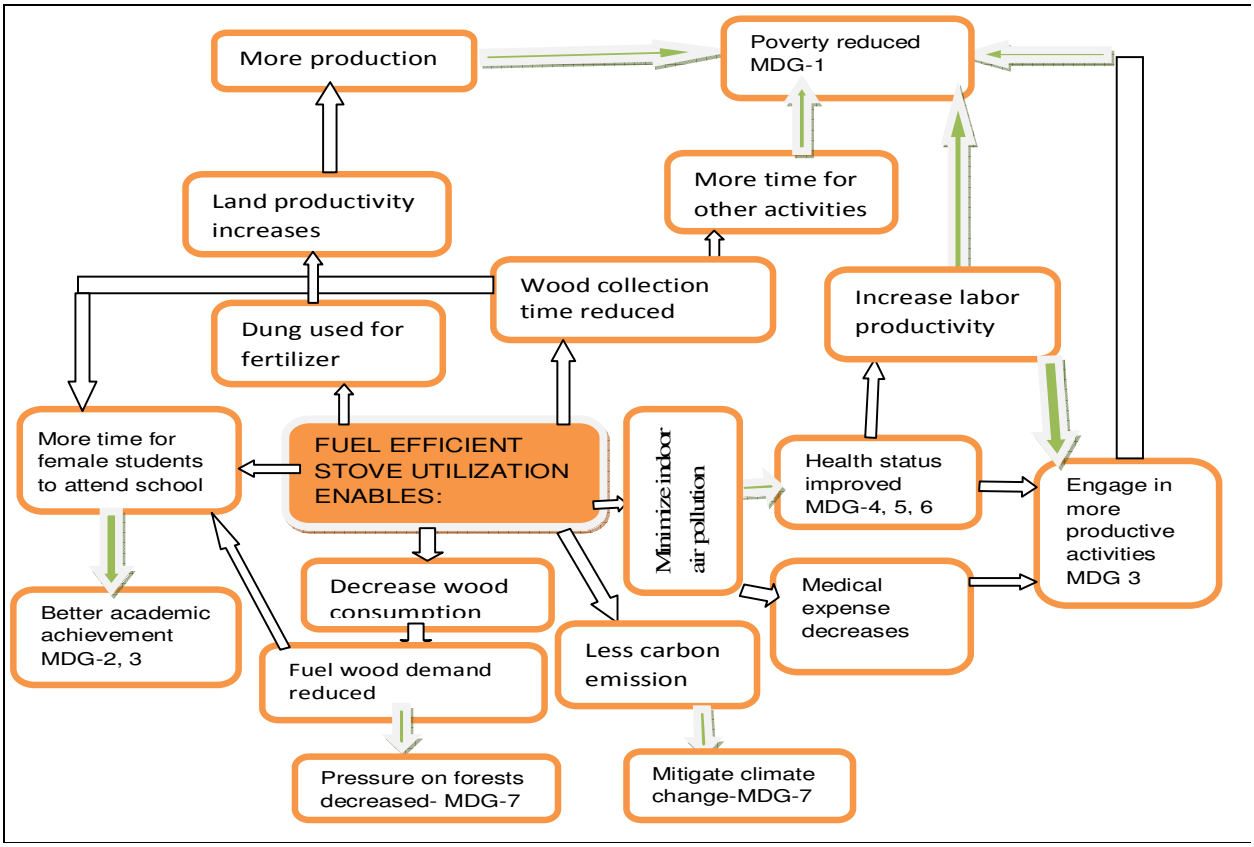

Figure 1: Benefits of Fuel Efficient Stoves in achieving MDGs Adapted from UNDESA (2005), UNDP (2005b), WHO (2006), Modi et al. (2006), Ekouevi &Tuntivate (2012)

Health and indoor air pollution related role

There is increasing evidence that the burning of solid biomass fuels for cooking in indoor environments, mainly using traditional stoves in inadequately ventilated spaces, can lead to an increased disease burden (UNDP, 2005b). According to WHO, the impact of indoor air pollution on morbidity and premature deaths of women and children is the number one public health issue in many developing countries predominantly for the poorest segments of the population (Modi et al., 2006). Cooking and heating with solid fuels on open fires or on traditional stoves generates high levels of health-damaging pollutants, such as particulates and carbon monoxide.

As a result, indoor air pollution is a major contributing factor for ill health in rural communities due to inefficient burning of inferior fuels such as cow dung, agricultural residue, coal and fuel wood, along with poor ventilation systems inside houses. Women, children and older persons, who spend most of their time indoors, are severely affected. Acute respiratory infection, chronic obstructive lung disease, pregnancy complications, daily discomfort in women from coughs, headaches, stinging eyes and backaches, low birth weight, increased infant and peri-natal mortality, pulmonary tuberculosis, nasopharyngeal and laryngeal cancer, and cataract are some of the critical health problems associated with exposure to indoor air pollution.

The supply of alternative energy services could positively benefit maternal health and reduce child mortality (see figure 1 for the role of fuel efficient stove in achieving MDGs). In addition, users of solid fuels in developing countries tend to be poor

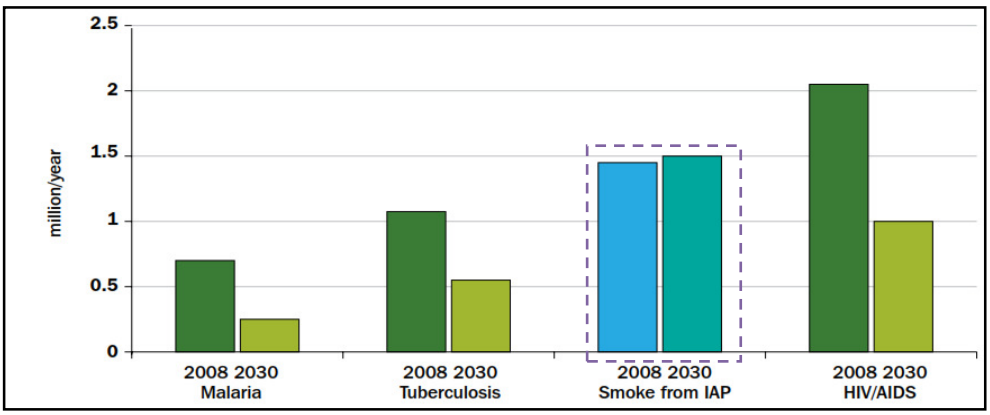

Figure 2: Number of deaths from indoor air pollution (IAP)-related health complications
Source: WHO (2009) as cited in IBRD, 2011

and, especially in rural areas, are unlikely to live in the vicinity of health care facilities. Their ability to afford medical treatment and to seek medical care for themselves and their sick children is limited. Consequently, trying to reduce the number of deaths from pneumonia through treatment may not benefit the poorest of the poor (ESCAP, ND; Bruce et al 2000; Duflo and Greenstone, 2008; Anhalt and Holanda, 2009; MoFED, 2010; USAID, 2010; IBRD, 2011; Abebe and Koch, 2011; Ekouevi and Tuntivate, 2012; Barnes et al., 2012 and Singh et al, 2012).

According to Lewis and Pattanayak (2012), worldwide, indoor air pollution emitted by burning solid fuel indoors in poorly ventilated conditions is responsible for 2 million premature deaths per year, or 3.3% of the global burden of disease, particularly women and children. Globally 36 percent of all lower respiratory infections, 22 percent of chronic obstructive pulmonary disease and 1.5 percent of trachea, bronchus, and lung cancer are related to IAP (Ahmed et al., 2005).

In Nepal, over 76.9% of the population burns solid biomass fuels (such as wood, dung, and agriculture residues) in unvented, open-fire cook stoves for their daily cooking activities. As a result, indoor air pollution is a major cause for key respiratory disorders and nearly 2.7% of Nepal's national burden of disease is attributed to indoor air pollution (Singh et al, 2012). A study in rural Guatemala also confirmed that, babies born to women using wood fuel were 63gram lighter than those born to women using gas and electricity (Bruce et al, 2000). Children are especially vulnerable since they spend much time indoors close to their mothers who are cooking.

A study by World Bank in Gambia, which examined the health of 500 children below the age of 5, found that girls carried on the backs of mothers (see figure 3) who were cooking in smoke-filled huts were six times more likely to develop acute respiratory illness than other children. A meta-analysis of all global studies indicates that the risk of acute respiratory infection for children exposed to indoor smoke is 2.3 times higher than for other children (Barnes et al., 2012). Studies in Nicaragua have shown that acute respiratory infections, in many cases linked to fuelwood smoke exposure, are the second leading cause of death among infants, after diarrhea (Ahmed et al., 2005:11).

According to World Vision (2011), children are especially vulnerable to exposure from pollutants, which can adversely affects the development of their organs and immune systems. As a result, exposure to biomass smoke is a significant risk factor for acute lower respiratory infections in children, including pneumonia, which remains one of the most common causes of death in children under five globally. As indicated in figure 2, worldwide the death prevalence due to indoor air pollution is expected to increases in 2030 while the number will decrease for malaria, tuberculosis and HIV/AIDs. In addition to the respiratory health burden posed by the use of traditional fuels, women also face health dangers such as

Figure 3: Traditional firewood stove (World Vision, 2011)

vulnerability to cuts, animal bites, falls, sexual attack, and back injuries as they travel long distances to collect and carry traditional fuels for home use (Modi et al., 2006).

More efficient cooking stoves can reduce smoke inhalation with significant health benefits, as well as reducing greenhouse gas emissions, slowing deforestation and providing plenty of social benefits. A field trial of fuel-efficient stoves in Mexico has shown that stoves can reduce indoor air pollution by 70 percent, reducing the risk of a range of health impacts. This would also have secondary effects, such as reducing household expenditure on healthcare (World vision, 2011). Anhalt and Holanda (2009) also explained the impact of indoor air pollution on child health as "…..in many rural settings, women cook with their children strapped on their backs or the children are always around in the kitchen. Any reduction in pollutants emitted from cook stoves will be beneficial for children's as well as for women's health." Cleaner fuels and cook stoves that facilitate lower smoke exposures, as well as improved ventilation of cooking areas, can reduce the disease burden from smoke, lower child mortality rates, and improve maternal health (UNDP, 2005b and Modi et al., 2006). In Kenya, for instance, dissemination of improved cook stoves has enabled to reduce indoor pollution by 60% and contributed to a 65% reduction in acute respiratory infection among mothers and children (UNDP, 2005b).

In Ethiopia, use of dung as manure is also limited partly because of a significant level of dung consumption as a source of household fuel. Use of dung as fuel is also an important cause of health problems, mainly through indoor air pollution (Alemu and Kohlin, 2008). The great majority (95 percent) of households in Ethiopia primarily use solid fuel for cooking which include charcoal, wood, straw, shrubs, grass, agricultural crops, and animal dung. The practice is nearly universal in with rural households, at 99 percent, and very common in urban households (80 percent) as well. Wood is the main type of cooking fuel, used by 77 percent of households-46 percent of urban households and 86 of rural households (CSA, 2012).

Land productivity and environment related role

The way energy is produced, distributed, and consumed affects the environment at different scales through land degradation, local air pollution, acidification of water and soils, or greenhouse gas emission (Modi et al., 2006). In many cases, cutting trees, shrubs, and roots for fuel can lead to the depletion of forests and environmental degradation. Fuel-saving stoves can slow the degradation and help ease tensions over the use of, and access to, these natural resources (USAID, 2010; MoFED, 2010 and Barnes et al., 2012).

The reliance on fuelwood for cooking and heating is increasingly being associated with climate change. There are claims that reducing

black carbon emitted from the burning of open biomass with the use of improved stoves may provide quick gains in slowing down global warming (Barnes et al., 2012 and Ekouevi and Tuntivate, 2012). Cooking with unsustainably harvested biomass can affect climate because inefficient fuel combustion releases products of incomplete combustion with a higher global warming potential than carbon dioxide, such as methane and carbon monoxide (Sagar and Kartha, 2007as cited in Lewis and Pattanayak, 2012).

As pointed out by Ramanathan and Carmichael (2008), cited in Lewis and Pattanayak (2012), biomass and fossil fuel cook stoves emit 22% and 7% of global black carbon emissions, respectively, which is the second strongest contributor to current global warming. In line with this, World Vision (2011), underlined that meeting the energy needs of growing populations in developing countries is contributing to widespread deforestation, which reduces carbon sinks, contributes to erosion, and results in the overall deterioration of natural systems on which rural communities depend. With respect to environmental sustainability, poor communities are often more vulnerable to global warming because they lack the resources to cope with crises resulting from climate change.

Development and environmental opportunities for following a clean energy path help to alleviate global warming by reducing greenhouse gas emissions. The local environment may also be improved with modern energy services as the use of biomass can contribute to land degradation, reducing soil fertility and contributing to desertification (Dessalegn, 2001; ESCAP, ND; Anhalt and Holanda, 2009; IBRD, 2011; Abebe and Koch, 2011and Barnes et al., 2012).

Given the continuing importance of wood-based biomass to satisfy energy needs, a sustainable wood energy sector could reduce GHG emissions throughout its entire value chain and thus taking a key role for implementing low-carbon growth strategies in SSA. At present, cooking with traditional biomass fuels may account for approximately 18% of current global GHG emissions if forest degradation and deforestation are included in the equation (Anhalt and Holanda, 2009; IBRD, 2011and Barnes et al., 2012). Therefore, improved cooking stoves are vital for reducing GHG emissions: they could improve the efficiency of the fuel, reduce GHG emissions through an enhanced combustion process, and lower air pollution that affects the health of mainly women and children (Barnes et al., 2012 and IBRD, 2011).

One of the four pillars of the green economy plan of Ethiopia is protecting and reestablishing forests for their economic and ecosystem services, including as carbon stocks and in doing so large scale promotion of advanced rural cooking technologies is taken as a prominent option (FDRE, 2011). Burning of dung and crop residues which were sources of soil humus and fertility has brought about a progressive decline in land quality and agricultural productivity. This implies that, in addition to minimizing GHG emission and rate of deforestation, using fuel efficient stoves also enable to enhance productivity of land.

Save time (women and children)

In most rural societies, where solid fuels are used for cooking and heating, women are generally the ones who devote most of their time to collect and transport. In times of fuelwood scarcity, the distance they have to go to find wood increases and requires more time (Ekouevi and Tuntivate, 2012). Women in rural areas usually spend long hours collecting wood-based biomass-time that would carry higher value-added to the household if it could be used for child care, agricultural production, education and other activities (UNDP, 2005b and Barnes et al., 2012).

While the distances traveled to collect fuel wood vary greatly depending on region and area of the country, distances in a Tanzania case study were up to 10 miles. This demonstrates that gathering fuel wood can be physically demanding and also accompanied by other negative attributes, such as sexual assaults and snake bites (IBRD, 2011). A more serious and long-term implication of fuel shortages is that as the daily search for fuel wood, fodder and water becomes more difficult, children are taken out of school to help their mothers (UNDP, 2005b).

In most instances it is the girls who are deprived of education in order to look after younger siblings and assist their mothers, perpetuating the cycle of illiteracy and poverty. In the southern State of Tamil Nadu in India, a major reason for keeping

girls aged 10 to 12 out of school is to help the mothers collect cow dung. Access to a reliable modern energy supply will free women and girls from this chore, providing time for activities such as education and income generation (ESCAP, ND; MoFED, 2010).

According to ESCAP (ND), Anhalt and Holanda (2009) and Barnes et al., (2012), the most obvious burden is that as fuel resources become increasingly scarce, women must walk longer distances and invest a greater portion of time each day in gathering fuel wood and water. As expressed by Lewis and Pattanayak (2012), inefficient stoves require more time to cook and gather fuel, a burden usually borne by women and children, which diverts their time from education and income-producing activities.

For example, in the Himalayan foothills of Nepal, a journey to gather firewood and fodder which took an hour or two a generation ago now takes a whole day. An increase in time spent in fuel wood collection implies that women may have less time for other livelihood activities. Fuel efficient stoves can have many positive impacts: save energy, reduce the time and burden of collecting firewood and limit the associated exposure for collectors to physical attack and/or gender based violence (USAID, 2010; MoFED, 2010).

If traditional biomass energy use in SSA is modernized, it could bring far-reaching benefits in both the short and long term and raise household living standards. According to women using improved cook stoves in Kenya, time gained from faster cooking was used for farming, income-generating activities, girls' education and women's participation in community life (GTZ, 2009 as cited in IBRD, 2011; USAID, 2010). Greater wood stove efficiency, combined with enhancements in biomass fuel availability through such programs as agro-forestry, can also reduce the time and transport burden of women and young girls who collect biomass, thereby increasing opportunities for education and income-generating work. These and other improvements can all lessen the pressure on fragile ecosystems (Modi et al., 2006 and Barnes et al., 2012).

In short, when fuel efficient stoves are widely used, the disproportionate amount of daily time and effort women and young girls spend gathering solid fuels and water for household chores could be used for other income-producing activities, family subsistence, or education (World Vision, 2011; Modi et al., 2006; MoFED, 2010).

Factors affecting the adoption of fuel saving stove

People rarely adopt innovations without good reason (Barnes et al., 1994). While energy services are directly associated with the quality of life and level of development, the amount and quality of energy consumption has a co-relation with poverty, deprivation, social seclusion, access to knowledge and achievements, health, livelihood and security (ESCAP, ND). Modi et al. (2006) also stressed that progress toward providing greater access to modern energy services has been slow, due to a combination of interrelated circumstances.

These include low income levels among the unserved population; lack of financial resources for service providers to build the necessary infrastructure and reduce first-cost barriers to access; weak institutional, financial, and legal structures that could otherwise encourage private investment; and lack of long-term vision and political commitment to scale up services (Modi et al., 2006). The most important factor worth mentioned by different scholars is poverty and lack of access. Households at lower levels of income and development tend to be at the bottom of the energy ladder, using fuel that is cheap and locally available but not very clean nor efficient.

According to the WHO for example, over three billion people worldwide are at these lower rungs, depending on biomass fuels-crop waste, dung, wood, leaves and coal to meet their energy needs (Duflo and Greenstone, 2008). Economic determinants of fuel choice, as stressed by Barnes et al. (1994), UNDP (2005b), Manyo-Plange (2011) and Inayat (2011), is by large the most widely covered driver of fuel choice. There are several components to economic factors which include household income, cost of equipment and fuel, and noneconomic costs such as time and access to fuels. Barnes et al. (1994) emphasized that "the price of stoves can be a significant barrier to their adoption. Improved wood fuel stoves are typically about twice as expensive as the local traditional stoves.

Although in the long run improved stoves save money, the initial cash outlay required may

prevent poorer people from affording the stove." Ergeneman (2003) also underlined that the incidence of rural poverty is an important determinant for the adoption of improved cook stoves. He added that "it is hard to imagine a rural household which is barely meeting its subsistence needs being able to afford the whole cost of an improved cook stove." Bruce et al (2000), on their part, stressed the impact of poverty on fuel stove adoption as "the types of fuel used become cleaner and more convenient, efficient and costly as people move up the energy ladder." Improved stoves are more attractive to those households that experience a scarcity in biomass resources since they will benefit significantly (be it in terms of time saved from collecting firewood or money saved from the purchase of firewood) from the increased efficiency of the stoves. In an evaluation done on the Mirt stove in the Amhara National Regional State (ANRS), a large percentage of households indicated that the price was too high (Ibdi.).

According to Barnes et al. (1994) and Manyo-Plange (2011) women's choices of fuel efficient stoves also depend upon existing environmental factors and culture. The cultural factor has particular significance because it can form the basis through which individual decisions are made. It comprises not only the local traditions specific to tribes, but also of a woman's beliefs and understanding like age and education. A study in determining barriers to fuel switching in Sri Lanka by Wijayatunga and Attalage (2003) as cited in Manyo-Plange (2011) confirmed that cultural factors play an important role in cooking fuel decision-making and should not be overlooked.

The study identified that an attachment to past practices and the belief that food cooked on clay stoves tasted better than food cooked on other stoves, as two main reasons for not switching from biomass to cleaner fuels. Manyo-Plange (2011) also pointed out that the design of equipment, its size, perceived safety and even the type of existing cooking utensils are technical aspects which have their own impact in stove adoption. Educational status also plays a significant role in determining fuel choice; a reason for this may be the implication that a higher education level is the result of higher wealth which in turn could lead to better economic prospects and the potential to afford clean energy sources. In addition, the higher education leads to better knowledge regarding modern fuels which could result in a greater likelihood of fuel-switching (Manyo-Plange, 2011 and Inayat, 2011). High wood prices or scarce supplies of wood are also factors which increase the likelihood of stove adoption (Barnes et al., 1994).

As far as fuel saving stove adoption is concerned, social capital (diffusion of information) has its own impact of the adoption of fuel efficient stoves. A study in northern Peruvian Andes by Adrianzén (2011), confirmed that information diffusion during the adoption of new cooking technologies is essential, and highlights the importance of having an appropriate understanding of the village social structure, as this structure influences the degree in which local generated information will be shared and diffused. It also pointed out the relevance of high quality monitoring and extension services in stove adoption because bad news about the performance of the new technology can have adverse effects in terms of the adoption processes. Information about a new technology is more intensively diffused in villages which are likely to have strong levels of bonding social capital.

If the initial success in improved stove usage at the village level is relatively low, it negatively influences the individual decision to effectively use the improved stoves. This implies that bonding social capital played a crucial role facilitating social learning during the adoption process of improved stoves. Another factor which determines the adoption of fuel efficient stoves according to Bruce et al (2000) and World Vision (2011) is alternative purposes of an open fire. Indoor fires that cook food often also serve other purposes, such as heating indoor areas, preserving food through smoking, keeping thatched roofs dry, repelling mosquitoes and lighting. A study in Ghana pointed out that open firewood is required to smoke fish (Manyo-Plange, 2011). Failure to effectively address these issues almost guarantees that the improved stove will not be adopted.

SUMMARY

Technical advances in energy efficiency are fundamental for developing countries, mainly for

those countries whose populations depend principally on biomass fuels such as wood, charcoal, and agricultural residues. Better stoves have several benefits. They reduce the amount of indoor pollution in a home and, therefore, can improve a family's health. They can also reduce the money spent to purchase fuel because they require less fuel than traditional stoves. In most rural economies, biomass fuels are collected from the local environment. Therefore, most of the benefits of having better stoves involve reducing the fuel collection time for household members, especially for women. In general, improved cooking stoves improve cooking efficiency compared with a traditional stove; can reduce the amount of fuel required, fuel gathering time, and cooking time—all of which have the potential to improve health and increase household income.

In addition, these efficiencies can benefit the local environment and global climate because of reductions in fuelwood harvesting and particulate emissions. Fuel efficient stoves play significant importance in the process of achieving most of the MDGs. The majority of Ethiopians are highly dependent on traditional open fire system for cooking and wood, dung and crop residues are the primary source of fuel. As a result the rate of deforestation is among the highest and there is a shift to use dung and crop residue for fuel than augmenting the land.

Given the importance of the improved stoves in saving biomass resources and reducing indoor air pollution, the government planned to disseminate fuel efficient stoves. Even though there are some efforts done by the government and Non-governmental organizations so far, its overall performance is not satisfactory. Therefore, the concerned bodies should work more to disseminate appropriate fuel efficient technologies which are vital in realizing most of the Millennium Development Goals.

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