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The knowledge network on sustainable household energy
in Southern and Eastern Africa

Briefing paper:

Household energy & health: an introduction

Dr N G Bruce, 2002

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Household Energy and Public Health

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1.0 Introduction

Almost half the world's population, around 3000 million people, still rely on biomass fuel – i.e. wood, animal dung or crop wastes – and coal, for their everyday household energy needs (World Resources Institute 1999). Although accurate data are scarce, estimates suggest that wood provides around 15% of the energy needs in developing countries, and as much as 75% in tropical Africa. In more than 30 countries, wood provides more than 70% of the energy needs, and in 13 countries it is over 90% (World Energy Council 1999). Over the last 25 years, the trend in global biofuel use has changed little, and in some parts of the world where poverty and the prices of alternative fuels such as kerosene and bottled gas have increased, the use of biomass has increased (WHO 1997).

With development, there is generally a transition up the so-called 'energy-ladder' (Figure 1) to fuels which are progressively more efficient, cleaner, convenient and expensive. It is important to emphasize that households typically use a combination of fuels – for example, wood for cooking and heating, kerosene for lighting, and perhaps charcoal for making hot drinks. Thus, there is not a simple linear progression up this ladder, but it is nevertheless the case that households will tend to carry out more tasks with more modern fuels as their socio-economic circumstances improve. However, the problem remains that almost half of the world's population relies predominantly on fuels at the lower end of this energy ladder, and, for many, the prospects of moving up the ladder in the short term appear limited.

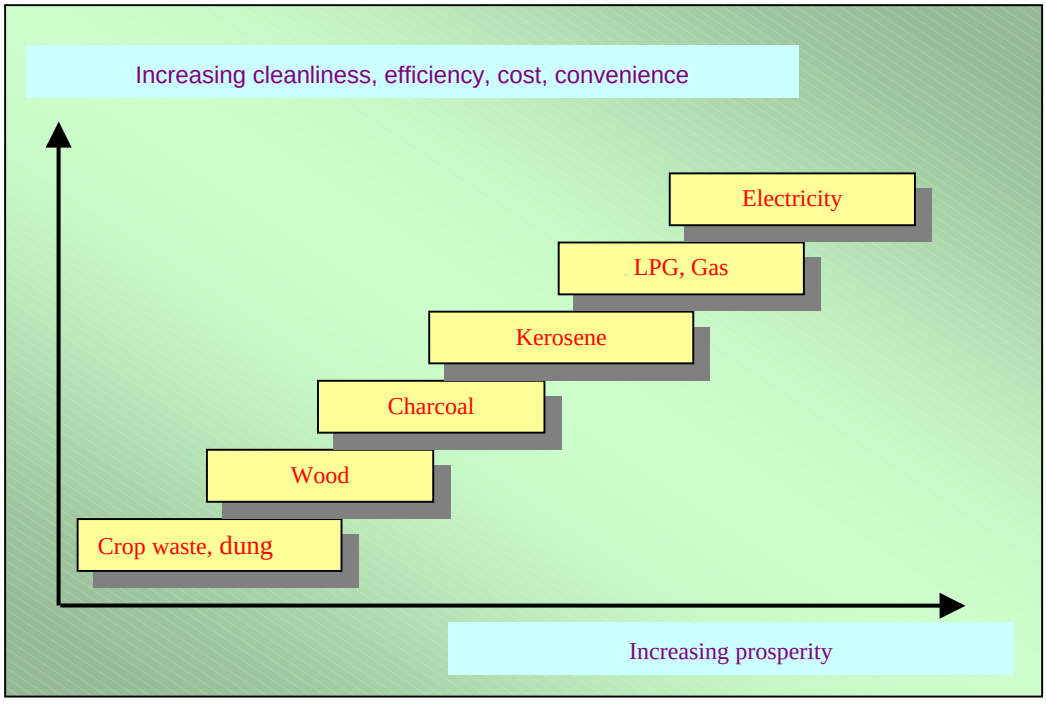


Figure 1: The 'Energy Ladder'

2.0 The problem of indoor air pollution

In these poor rural and urban homes, biomass fuels and coal are typically burnt in open fires or poorly functioning stoves, often indoors inadequate ventilation for the smoke. This leads to very high levels of pollution in the homes where especially women and young children are exposed on a daily basis. Smoke from these fuels contain many health-damaging pollutants, including particulates, carbon monoxide, nitrogen oxides, benzo[a]pyrene, benzene, and many others. Together, these pollutants are known to be capable of irritating the airways and lungs, reducing the resistance to infection, and increasing the risk of cancer. Studies from a number of countries in Asia, Africa and the Americas have measured the levels of indoor air pollution associated with cooking on biomass fuels (Smith 1987, Bruce et al. 2000). Most of these studies have measured particles – complex mixtures of chemicals in solid form and droplets. These particles are thought to be the most health-damaging component of smoke pollution, especially the smaller ones which are able to penetrate deep into the lungs. Particles are therefore usually described by size or their effective (aerodynamic) diameter, which is measured in microns (millionths of a metre).

Particles of up to 10 microns in diameter (PM_{10}) have been most commonly measured, although some have looked at the total (i.e. all) suspended particles (TSP), which tends to include dust from sources other than combustion. More recently, in line with recent evidence that the very smallest particles are the most dangerous, some studies have measured particles up to 2.5 microns in diameter ($PM_{2.5}$). Concentrations of particles are expressed as the weight of particles (in micrograms, μg) per cubic metre (m^3) of air, thus $\mu g/m^3$. For consistency, only results for PM_{10} will be discussed here. Typical 24-hour mean levels of PM_{10} in homes using biofuels range from 300 to >3000 $\mu g/m^3$, and during use of an open fire, the PM_{10} level can reach 20 000 $\mu g/m^3$ or more. By comparison, the US-EPA standard for daily (24-hour) average PM_{10} is 150 $\mu g/m^3$ (this concentration should be exceeded only in one per 100 days), while the annual average should not exceed 50 $\mu g/m^3$ (US-EPA 1997). Most 'western' cities rarely exceed these standards, whereas in rural homes in developing countries, they are exceeded on a daily basis by a factor of 10, 20, and sometimes more. Levels of carbon monoxide and other pollutants also often exceed the standard guidelines.

3.0 Health impacts

Health is influenced by a wide range of physical, social and environmental factors. In addition to the production of toxic pollution, the supply and use of household energy in conditions of poverty and scarcity affects health – particularly of women and young children – in a variety of ways that encompass physical injury, lost opportunity for income generation, environmental stress, and many other issues. These are now briefly reviewed.

3.1 Health impacts of indoor air pollution.

Indoor air pollution is the clearest and most direct physical health risk, and there is now fairly consistent evidence that biomass smoke exposure increases the risk of a range of common and serious diseases of both children and adults (Bruce et al, 2000). Chief among these is childhood acute lower respiratory infections (ALRI), particularly pneumonia (Smith et al, 2000). Association of exposure with chronic bronchitis (long-term cough and phlegm) and chronic obstructive lung disease (narrowing of airways in the lung, which is progressive and can be only partially reversed) is quite well established, particularly among women. There is also evidence, mainly from China, that exposure to coal smoke in the home markedly increases the risk of lung cancer, particularly in women.

In recent years, new evidence has emerged which suggests that indoor air pollution (IAP) in developing countries may also increase the risk of other important child and adult health problems, such as low birth weight, perinatal mortality (stillbirths and deaths in the first week of life), asthma, and middle ear infection in children, tuberculosis, nasopharyngeal and laryngeal cancer, and cataract in adults (Bruce et al, 2000). Table 1 summarises the evidence currently available linking indoor air pollution from biomass (and coal) smoke in developing countries with these health conditions:

Table 1: Summary of amount and quality of epidemiological and other evidence on the risk of various health outcomes associated with indoor air pollution exposure in developing countries.

Nature and extent of evidence	Health outcomes
Around 20 studies from developing countries (including two from Navajo communities), fairly consistent across studies, but confounding[1] not dealt with in a substantial minority. Evidence is supported by studies of ambient air pollution and environmental tobacco smoke and to some extent by animal studies.	• ALRI (young children) • Chronic bronchitis and COPD • Lung cancer (coal only)
Only a few (2–3) studies from developing countries, consistent across studies; supported by evidence from smoking and animal studies	• Cancer of nasopharynx and larynx • Cataract • Tuberculosis
Only one study from a developing country; but, supported by studies of ambient air pollution and environmental tobacco smoke	• Perinatal mortality • Reduced birth weight
No studies from developing countries, but an association may be expected from studies of ambient air pollution and/or studies of wood smoke in developed countries	• Acute middle ear infections (otitis media) • Cardiovascular disease
Several studies from developing countries, but inconsistent. Some support from studies of ambient air pollution	• Asthma

3.2 Other direct health impacts on child health.

The health and well-being of the mother and child are inextricably linked. Women normally continue their usual work during pregnancy, so the unborn child is exposed as the mother continues her activities in the polluted kitchen. After birth, the young child typically stays very close to its mother until s/he is able to walk, so being exposed directly and increasing the risk of a range of serious health problems. Once the child is mobile, open fires, stoves and lamps all pose a significant risk of burns for children who are at serious risk of falling into the hearth (Courtright et al. 1993). Kerosene, although a cleaner fuel, carries the risk of fire if the stove or lamp is knocked over. Another risk from kerosene is poisoning if it is stored in soft drink and similar bottles and a child accidentally drinks it (Yach 1994, Gupta et al. 1998).

3.3 Social and economic impacts on health

Lack of access to more modern fuels and appliances limits the quality of life and opportunities for income generation in a variety of ways. For example, in many poor rural homes, lighting may be very restricted and provided only by the fire, candles, or simple kerosene wick lamps which can be a significant source of pollution. The lack of light restricts activities in the home, including children's homework, reading and opportunities for income-generating activities. Lack of access to electricity further restricts the use of a wide

[1] Confounding variables are factors - such as overcrowding and malnutrition, in the case of childhood respiratory infections - which are (a) known to increase the risk of ALRI and (b) also associated with the type of fuel and stove used in the home. Thus, poor homes are more likely to use smoky biomass stoves than better-off ones, ***and*** more likely to suffer overcrowding and malnutrition. If studies do not adequately deal with these confounding factors (which requires that the factors are both measured to begin with, and adjusted for in the analysis), it may be very difficult to know whether an apparent increase in risk of the disease (e.g. ALRI) is due to the smoke, or to one or more of these other factors, or indeed (as is probably most common) a little of both.

range of appliances that can contribute to food safety (refrigerators), communication/education, leisure (radio, TV), and economic activity.

Dependence on biomass fuels can affect the wellbeing of children in other ways. For example, it is not uncommon for older children to help their mothers in collecting fuel, thus missing school attendance and also being exposed to the risk of physical injury.

3.4 Gender, household energy and health

In almost all developing countries it is women who provide fuel for the family and carry out cooking and many other tasks that require energy use in the home. Studies show that fuel collection takes, on average, from 30 minutes to 2 hours a day, although this can be longer when fuel is scarce. The time spent in collecting wood and other fuels has an 'opportunity cost' for women, especially during busy agricultural periods (World Energy Council 1999). Carrying heavy loads of wood exposes women to injury from falls (bruises and fractures) and the risk of miscarriage; in areas of war and civil unrest the women may be exposed to violence as well as injury from land mines (WHO 1992). Because of their work in the kitchen, often close to the fire, women have more exposure to pollution than other family members, which has been estimated at between 4 and 7 hours per day in rural Guatemala, for example (Engel et al. 1997), although in the coldest highland areas of Asia and South America it may be considerably longer.

3.5 Local and global environments

The damage to the environment can impact on health in a wide variety of ways, from increasing pressure on food production, water shortages, etc., in the local setting, to the potentially widespread and major impacts that global warming may have – particularly on the countries of sub-Saharan Africa. Household energy supply and use in sub-Saharan Africa has impacts on both local and global environments, although the latter are small relative to industrialised countries, and in general environmental impacts should be viewed in the wider context of poverty, population pressures, and political factors.

Local environment

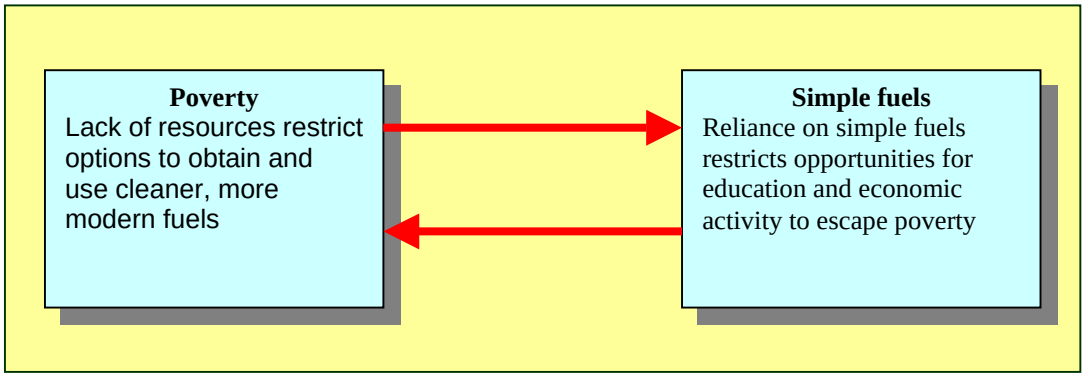
It has often been assumed that, in many areas, the use of wood fuel is the major cause of deforestation and environmental damage that results from this. However, it is generally the case that, in rural areas, wood fuel is gathered rather than cut from the trees; agricultural practices and the need for building materials, combined with population pressure, are therefore the most important factors in deforestation. Nevertheless, pressure on forests from the use of wood fuel is a problem. In peri-urban and urban areas, the use of wood requires transport over longer distances, so increasing the demand for charcoal which is leading to forest depletion in rural areas providing fuel to cities. Charcoal is an important fuel for many poor peri-urban and urban populations in sub-Saharan Africa.

Global environment

The burning of biomass, like all combustion of carbon fuels, produces carbon dioxide and other gases which contribute to global warming, which is expected to increase the risk of vector borne disease, food and water shortage, population dislocation, etc. However, the low energy use of homes in countries such as those in sub-Saharan Africa means that their contribution to the global output of greenhouse gases is relatively small. In 1995, per capita CO_2 production was estimated at less than 2 tonnes for developing countries, compared to 12 tonnes for developed countries and 20 tonnes for the USA (Reddy et al. 1997). That said, it is nonetheless a contributory factor and one that can be expected to grow. Furthermore, although it might be assumed that since biomass is renewable, the replacement of wood burned should result in a neutral carbon balance – the CO_2 released from burning being taken up as new trees grow. However, since the stoves used in developing country homes have a low efficiency of around 15%, with (for example) nearly 10% of the energy of wood being lost as products of incomplete combustion (PICs). These PICs include methane, which has a greenhouse effect many times greater than CO_2. As a result, the two main factors that influence the global warming effect of biomass use are the combustion efficiency of the stove and the effectiveness of energy forest management.

3.6 Poverty

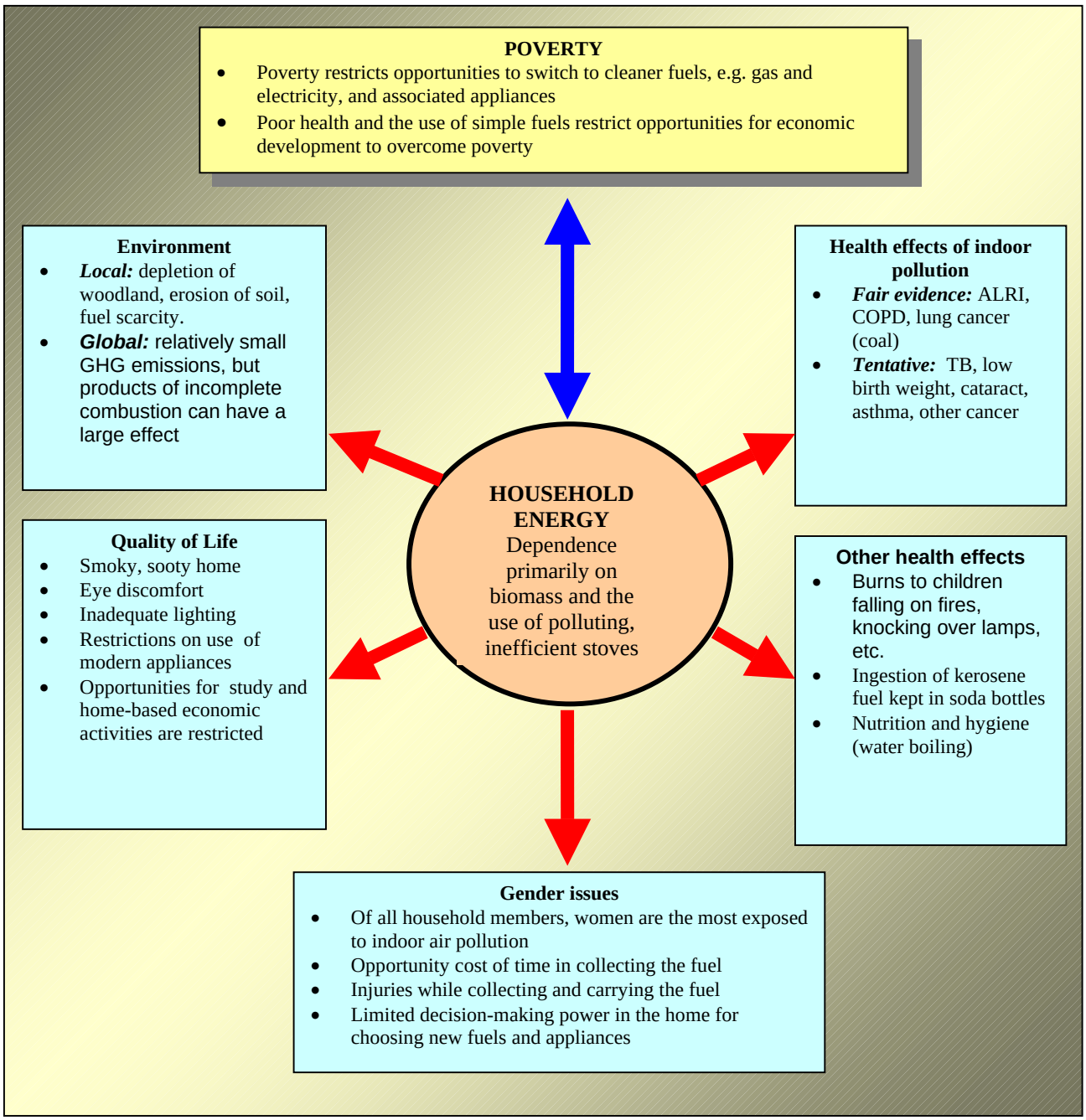
Poverty remains a very important, probably the most important, determinant of health, underlying all other issues discussed so far – and this is clearly demonstrated by the close inter-relationship between household energy, poverty and health. Reliance on simple biomass fuels holds back development because it impairs health and restricts opportunities for education and income generation, while poverty prevents households breaking out of this reliance because poor families cannot afford the higher cost of cleaner fuels and the appliances required.



Furthermore, there is evidence that, over time, the cost of using cleaner fuels is not necessarily higher, but poverty prevents people from taking advantage of this fact. The reason is that poor families have very limited financial assets and generally find it difficult to invest money 'up-front' to obtain the appliances needed for burning kerosene cleanly (with pressurized stoves), for gas or electricity, or to buy the fuel in sufficient quantity to benefit from lower unit prices. As a result, poor people may spend a higher proportion of income on fuel for cooking and heating than those who are better off, in addition to the time lost in collecting and using these less convenient fuels (Reddy et al. 1997).

Figure 2 summarizes the wide range of factors that both influence and result from dependence on biomass fuels and inefficient, polluting stoves. There are of course many inter-relationships that are not indicated in the diagram. The important message, however, is that patterns of household energy use in poor communities impact on a very wide range of key health, social, gender, economic and environmental issues, and that action therefore has the potential for considerable benefits in terms of development and health improvement

Figure 2:



4.0 Burden of disease

The review of the health effects of indoor air pollution discussed in Section 3 above provides information on the risk to individuals associated with exposure to smoke from biomass fuels (and coal). It has been noted that very large numbers of people, mainly women and young children, are exposed to this pollution in a wide range of rural as well as peri-urban and urban settings. This implies that a very substantial public health impact can be expected. While acknowledging the uncertainty that exists in the estimates of health risk, levels of personal exposure, numbers of people exposed and disease rates, it is nevertheless possible to combine this information – so long as this is done cautiously – to derive an estimate of the overall 'public

health burden' resulting from indoor air pollution in these settings. This approach is encapsulated in the global burden of disease (GBD) project (Murray et al).

Current estimates indicate that in developing countries indoor air pollution is responsible for around 1.8 million extra deaths and the loss of just over 50 million DALYs[2] (Smith and Mehta 2000). These figures are equivalent to 4.7% of total deaths and around 4% of DALYs lost for these areas of the world (Table 2). For sub-Saharan Africa, some 420 thousand deaths and 14 million DALYs are accounted for. Most of this burden is due to acute respiratory infections, especially in poor rural populations..

Table 2. **Percentage of total burden in listed regions attributable to solid fuel use**

Region	Deaths	ARI (%)	DALYs	ARI (%)
India	**5.3%**	81	**5.5%**	87
China	**5.8%**	25	**4.5%**	50
Other Asia & Pacific Islands	**3.8%**	75	**3.7%**	85
Sub-Saharan Africa	**5.2%**	85	**4.9%**	90
Latin America	**1.0%**	71	**0.9%**	82
Middle East and North Africa	**3.6%**	89	**3.7%**	93
Total	**4.7%**	**67**	**4.3%**	**81**

These are fairly conservative estimates based on disease conditions for which there is moderately good evidence (ARI, COLD and Ca lung – the latter for coal use). The evidence for other health impacts such as TB, low birth weight, etc., is not thought sufficiently robust for inclusion at this time. Furthermore, these estimates account only for the health effects of indoor air pollution, and do not yet take account of the wider health impacts of household energy use in poor countries discussed in sections 3.2-3.5.

5.0 Conclusions

Household energy has substantial impact in health of rural poor: globally 1.8 million excess deaths and around 4% of the burden of disease in terms of DALYs lost that are attributable to indoor air pollution – most of which falls on the rural poor. Health impacts are mediated through a wide range of inter-related mechanisms from direct (indoor air pollution, burns) to social, economic and environmental issues such as women's time, opportunities for income generation, children's education, environmental stress, etc. The majority of this health burden falls on women and children, with acute respiratory infections being the major disease consequence.

A marked change in policy on household energy is required to improve this situation in short to medium term for the majority of rural poor in many countries. A broad public health framework for understanding and documenting the many and varied health impacts is needed, together with new research to strengthen the evidence base. Although further research on health risks and impacts will help galvanise action and inform decisions about resource allocation for health development, the evidence we currently have shoes that improving access to cleaner and more efficient household energy use among rural poor will deliver marked improvements in health and wellbeing for many millions of families.

6.0 References

Available at www.sparknet.info.

[2] DALYs: disability adjusted life years lost – a measure of burden of disease now in common use.