Tanzania Association of Oil Marketing Companies **(LPG Committee)**

The True Cost of Charcoal: a rapid appraisal of the potential economic and environmental benefits of substituting LPG for charcoal as an urban fuel in Tanzania

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Norconsult Tanzania Limited, Dar es Salaam

Executive Summary

The true cost of charcoal is not the modest amount paid for a day's supply of cooking fuel. It is the price that Tanzanians unwittingly pay, or the value of benefits forgone, for the damage to their natural resources caused by charcoal making. Degradation of forests is reducing the water supply, making water scarce and more expensive. In effect, Tanzania is exchanging cheap fuel for expensive water.

Deforestation and woodland degradation also reduces agricultural productivity, damages habitat, diminishes biodiversity, emits pollution and reduces the sequestration of carbon in trees. The loss endured by the combination of those effects is equivalent to at least 2% of gross domestic product – and rising fast, with urban growth and forest retreat.

Until recently, charcoal production was probably still a sustainable use of the forest except in the drier regions. This is changing because the volume of charcoal produced has increased dramatically. The proportion of charcoal produced unsustainably is rising. If present trends continue, within eight years, it will *all* be unsustainable – even if every woodland and forest in the country is used.

Nowadays from 15000 to 20000 bags of charcoal enter Dar es Salaam every 24 hours, every day of the year, and an equal amount enters the other major Tanzanian towns combined. That adds up to nearly one million tonnes of charcoal per year, for which trees had to be cut from 3320 square kilometres of forest. Some of that forest will regenerate; but much of it never will because it is converted to farmland and/or is cut again for charcoal before it has fully recovered.

Tanzania is set on a dangerous course. Every year more people try to burn more charcoal taken from less woodland. That diminished and degraded woodland sends less water downstream except during storms.

LPG is easy to tax and charcoal difficult because of the nature of the two businesses. Charcoal is effectively subsidised by ineffective collection of dues while LPG is penalised by high import duties. In this situation, charcoal users are unwittingly externalising the negative impacts of their fuel choice to the environment.

Faced with the same problem, the Government of Senegal actively promoted the use of liquified petroleum gas (LPG), by adopting favourable fiscal, social and environmental policies and thereby succeeded in checking the pace of deforestation. Tanzania could do the same.

The True Cost of Charcoal

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Acronyms and Abbreviations used in this Report

AFPREN	African Energy Policy Research Network
CHAPOSA	Charcoal Potential for Southern Africa: regional research project
CIDA	Canadian International Development Agency
DFiD	Department for International Development (British Government aid)
EIA	environmental impact assessment
FAO	Food & Agriculture Organization (of the United Nations)
GDP	gross domestic product (total value of all goods and services produced within a country during a given year)
GNP	gross national product (GDP plus the net income earned from investments abroad minus similar payments made to non-residents who contribute to the domestic economy)
ha	hectares (one million hectares = 10000 km^2 = a square with 100 km sides)
LPG	liquefied petroleum gas
MEM	Ministry of Energy and Minerals
MNRT	Ministry of Natural Resources and Tourism
MNRT {FBD}	MNRT (Forestry & Beekeeping Division)
NEMC	National Environmental Management Council
NTz	Norconsult Tanzania Ltd
SEI	Stockholm Environmental Institute
t/ha	tonnes per hectare
TAOMC	Tanzania Association of Oil Marketing Companies
TASONABI	Tanzania Specialist Organisation on Community Natural Resources and Biodiversity Conservation
TaTEDO	Tanzania Traditional Energy Development & Environment Organisation
ToR	terms of reference
UDsm	University of Dar es Salaam
UNCHS	United Nations Centre for Human Settlements (Habitat)
USDC	Department of Commerce, of the Government of the United States
WCST	Wildlife Conservation Society of Tanzania
WLPGA	World Liquefied Petroleum Gas Association
www	World Wide Web (the Internet) – references listed in Table 22 on page 53

1. This Study

1.1 This Report

This report to the Tanzania Association of Oil Marketing Companies has been made in response to the instruction of the LPG Manager of the Addax & Oryx Group, Mr Malcolm B J Wigmore, on 15th February 2002. It has been done by the environmental section of Norconsult Tanzania Ltd[1], Dar es Salaam.

Copies of the report were distributed in April 2002 to 55 stakeholders of whom (so far) three have kindly responded in writing. Comments are individually acknowledged in Appendix Four below on page 43.

The report fulfils the Terms of Reference appended to this report, from page 55. As such, it is 'a clear, convincing and credible statement of the environmental benefits likely to accrue from increased consumption of liquefied petroleum gas (LPG) in Tanzania'. Admittedly it contains some qualified assertions based on partial data; but the possibility remains open at all times to update the figures in the light of better information. Assumptions are labelled as such and not disguised as facts; they are best current estimates based on available data.

In this context, 'environmental' encompasses ecological, social, health and safety considerations. The study area is Tanzania, specifically Dar es Salaam, and ten other large towns and Zanzibar, in respect of charcoal consumption, plus the rural areas from which charcoal is derived.

1.2 Hypothesis

Increased urban consumption of LPG would confer environmental benefit on Tanzania to the extent that LPG would be substituted for charcoal and not for kerosene or electricity. The value of the benefit would equal the cost of environmental degradation caused by the equivalent amount of charcoal production.

The scale of the benefit would be inelastic: two kg of LPG used would confer double the benefit of one kg of LPG used, with no diminishing or increasing return within any short-term scenario. Thus, in the short-term, the value of the benefit would be precisely the number of kilograms used multiplied by the benefit derived from the use of one kilogram. In the long-term, the environmental benefit of fuel-switching would increase, as environmental degradation renders remaining natural resources more valuable.

1.2.1 Discussion of the hypothesis

To quantify the benefit of substituting LPG for charcoal as an urban fuel, it is necessary to estimate:

- the nature and extent of tree loss and woodland degradation;
- the cost to Tanzania of tree loss and woodland degradation; and
- the proportion of that loss attributable to charcoal production.

That estimation is attempted in the following sections of this report. In keeping with the hypothesis, above, the benefit realised by substituting LPG for charcoal would be proportional to the market share achieved. The greater the share, the more the benefit.

1 team members are Stuart Stevenson (editor), Tuyeni Heita-Mwampamba, Winnie Mbaga and Dora Neema, all with Norconsult Tanzania Ltd. Claire Quinn, at the University of York, did the web-search.

1.3 Data

In Tanzania, research conducted by TaTEDO, CHAPOSA, AFREPREN, SEI, MNRT and MEM has been consulted. Literature reviewed is listed in the bibliography, from page 50.

Emmanuel Chidumayo has been researching charcoal in Zambia for twenty years. Much of his work has been published and is available on the Internet. Richard Hosier is another recognised authority who has researched and published on African energy issues also for twenty years. Some of their work, studied for this exercise, is cited in the bibliography.

Published research does contain results that can provide some the information needed for this analysis – but not all. It was necessary to conduct surveys (the questionnaires and field visits) to validate, update and/or supplement the data.

Experts and people knowledgeable about charcoal markets, consumption patterns, production methodologies, transportation and other charcoal-related issues have been consulted. Their names and organisations are listed on page 47. The team is grateful for their guidance and advice.

1.3.1 CHAPOSA

Charcoal Potential in Southern Africa, CHAPOSA, is a joint effort by the University of Zambia, Sokoine University of Agriculture in Morogoro, Eduardo Mondlane University in Maputo, the Institute of Energy Research at the University of Stuttgart and the Stockholm Environment Institute (SEI), co-ordinated by SEI. CHAPOSA's objective is 'to assess the extent of environmental degradation due to charcoal production, to identify indicators that can show where such degradation is taking place, and the conditions for it; and to identify policy alternatives that can address the issue of non-sustainable charcoal production while allowing production that is sustainable in the long-run'.

CHAPOSA is succeeding in the attainment of those objectives, but slowly in a thorough academic manner by undertaking careful verifiable research at specific sites. By this procedure, it will eventually produce defensible research results but it will not be able to generalise at national level about '.. the extent of environmental degradation due to charcoal production ..' anytime soon – yet this is what is needed now if LPG is to be helped to substitute for charcoal.

1.4 Policy

1.4.1 National priorities

The National Energy Policy in Tanzania includes the promotion of alternative energy sources. According to the World Bank[2], '… developing countries need to facilitate the substitution of charcoal with other fuels. At present LPG may be affordable for middle and upper wealth households but improvements need to be made to pricing and delivery to target poorer households as electricity is not a viable substitution'. The Tanzanian government's strategy regarding alternative energies supports initiatives that promote *'affordable and reliable energy supplies in the whole country;'* and *'reform the market for energy services and establish an adequate institutional framework, which facilitates investment, expansion of services, efficient pricing mechanisms and other financial incentives;'*[3]

Only in a very few of the poorest countries in the world is the derivation of >95% of the national energy supply from woodland deemed acceptable. Most countries seek a better balanced mix, with progress towards modernisation and conservation of forest.

2 (www.worldbank.org/html/fpd/energy/energynotes/energy01.html#end)

3 revised Energy Policy, in preparation, 2002

Dang (1993) found that 'Deforestation and decline in agricultural productivity are major concerns over large parts of sub-Saharan Africa. One of the principal causes for both these phenomena is the export of wood-fuels from rural agro-ecosystems to urban markets. This process is noteworthy because of the size of the trade. Wood fuels (fuelwood, charcoal, and agricultural residues) constitute the most important source of energy in these countries, varying from 60% to 95% of total energy consumption. In terms of the environmental impact of the fuelwood trade, solutions typically considered are the introduction of improved cook-stoves, fuelwood plantations, and fuel substitution by conventional fuels'.

1.4.2 Don't intervene – leave it to the market?

Economic theory posits that wood-fuel prices will rise in step with scarcity, driving consumers to other fuels. They do not. Chopping one more tree is always cheap, until there are no more trees. In 1993, one of the authors of this report saw pick-ups laden with wood leaving the desert of north-western Sudan, heading for the urban market. The wood came from the last woodland (only one-tree width on either bank, along a wadi[4]) for hundreds of miles in any direction.

Hosier and Milukas (1992) studied charcoal markets in two African cities: Mogadishu, Somalia, and Kigali, Rwanda. Although Rwanda and Somalia represent drastically different physical environments, both are wood-scarce. Yet neither market has demonstrated straightforward depletion effects. In Mogadishu, the price first rose and then fell in reaction to shifts in the structure of the charcoal market, relaxed regulations, and economic contraction. In Rwanda, the price began rising only after the closing of the Bugasera Region to charcoal producers.

Unrestrained market forces will always drive deforestation for charcoal production. Since forest governance is always expensive, and sometimes corrupt and ineffective, removal of discriminatory tariffs penalising other fuels is the only readily available way of relieving pressure on the forests. This is not a subsidy of modern fuels; rather, it is reduction of the subsidy enjoyed by charcoal in consequence of the charcoal's trade's externalisation of its adverse impacts. Tanzanian energy strategies[5] foresee ensuring that '*competition on fair and equitable conditions among independent actors shall form the basis for market efficiency*'

1.4.3 Energy pricing and the facilitation of transition to modern fuels

Barnes and Floor, 1996, wrote that the energy problems of the developing world are both serious and widespread. Lack of access to sufficient and sustainable supplies of energy affects as much as 90% of the population of many developing countries. Some two billion people are without electricity; a similar number remain dependent on fuels such as animal dung, crop residues, wood, and charcoal to cook their daily meals. Without efficient, clean energy, people are undermined in their efforts to engage effectively in productive activities or to improve their quality of life.

Developing countries face two crucial and related problems in the energy sector. The first is the widespread inefficient production and use of traditional energy sources, such as fuelwood and agricultural residues, which pose economic, environmental, and health threats. The second is the highly uneven distribution and use of modern energy sources, such as electricity, petroleum products, and liquefied or compressed natural gas, which pose important issues of economics, equity and quality of life.

Barnes and Floor evaluate some successful programmes and recommend that governments support market-oriented approaches that make the energy market equally accessible and attractive to local investors, communities and consumers. Such approaches ideally improve access to energy for rural and poor people by revision of energy pricing and by making the first costs of the transition to modem and more sustainable uses of energy more affordable.

4 Wadi Arab, near Haiya

5 revised Energy Policy, in preparation, 2002

1.5 Perceptions and Attitudes

Availability, convenience, familiarity and affordability affect public opinion in favour of charcoal. A charcoal stove (*jiko*) is cheap to buy or can be made with moderate skill from scrap metal.

The ordinary Tanzanian householder is likely to be powerfully discouraged by the investment cost in a stove to burn LPG, notwithstanding that the stove consists of no more than a metal ring (a ‘trivet’) on which to rest the cooking pot, a control knob and a nozzle to insert into the gas cylinder. The cost of the first gas cylinder is also substantial; thereafter the consumer simply trades in the empty cylinder for a full one, paying only for the gas. Regardless of the price of gas, the perception of an expensive initial investment will discourage many and tend to reinforce initial prejudice against gas as dangerous.

LPG stoves are easy to use but replacing the cylinder is inconvenient. It weighs 6 kg and sales outlets are still far apart in Dar es Salaam.

That gas is dangerous is a common presumption. Experience has shown that a small gas cooker, such as the Oryx Chap Chap, is much less dangerous than a charcoal *jiko*. However, people base their actions on beliefs rather than facts.

Eventually, the Tanzanian consumer is likely to profess similar enthusiasm for LPG as do new users in Brazil and Senegal; but it will take *all* of the available measures – price reduction, promotion and enhanced availability – to induce change. Price alone is not enough: in Nigeria, with subsidized official prices for kerosene, LPG and electricity, wood is more expensive on a net usable heat basis, but the high capital cost of stoves for these fuels prevents many households from switching (Hyman, 1994).

In 1988, LPG provided the Tanzanian consumer with five times as much cooking potential (measured as megajoules of useful heat per shilling) as charcoal (Leach and Mearns, 1988). The difference is much less now that charcoal has fallen in price relative to all other fuels, as may be seen in Table 4 on page 28.

1.6 Stakeholders

Everybody uses energy and everyone in the country has a stake in the future ability of the Tanzanian natural resource base to protect water catchment, conserve soil, ameliorate climatic extremes and provide woody biomass for a multiplicity of uses. Therefore everyone is a stakeholder – but may not be aware of that.

1.7 Public Disclosure and Follow-Up

Copies of this (draft final) report will be deposited with the Tanzanian environmental authorities (NEMC, the MNRT and the Vice-President’s Office) and the Tanzanian Government Ministries variously responsible for agriculture, forestry, energy and health, and with influential environmental NGOs, and with bilateral and multilateral agencies with energy and/or environmental programmes in Tanzania. The Consultant will solicit official written commentary on the report from all participants, and will append commentary to a further appendix to this report (section 5.6 on page 43).

2. Tanzanian Rural Trees Supply the Charcoal

2.1 Nature and Extent of Tree Loss and Woodland Degradation

2.1.1 Deforestation

Tanzanian forest was thought to cover half the country in 1993 – an area of 44 million hectares (Mwandosya and Luhanga, 1993). Everyone agrees that they are much reduced; but no-one knows by how much. Coincidentally, most current estimates of the national population and the hectarage of remaining woodland are the same: about 33 million. Each Tanzanian has one hectare of woodland now. 'How much each will the next generation have?' and 'Will they be able to meet their needs for woodland products?' are key questions.

Forests in Tanzania are declining by 11.5% per year, 99.2% of which is for fuelwood and charcoal[6]. That is one of many published estimates of the scale of Tanzanian deforestation. Here are some more:-

- Forests in Tanzania have reduced from 44.3 million hectares to 33.5 million hectares. FAO estimates for deforestation range from 130,000 to 500,000 hectares per annum[7].
- UNCTAD reported 48% forest cover in 1980, 46% in 1989 and 37% in 1994 (UNCTAD, www).
- It is estimated that between 130,000 and 500,000 hectares of forest are lost annually, the permanent secretary in the Natural Resources and Tourism, Philemon Luhanjo, said; quoted by Panafrican News Agency (Blythe, www).
- Total annual wood fuel use in Tanzania is estimated at 32 million cubic metres (1999). Average wood fuel consumption is 1.5 cubic metres per capita. Conservative estimates suggest that 200,000 hectares of miombo woodland are required to produce 10 million cubic metres of wood fuel (UCCEE, www, 1999).
- On National Tree Planting Day, 2001, Vice President Omar Ali Juma compared the annual forest reduction by 130,000 to 500,000 hectares of forest a year with the mere 25000 ha planted annually (Mfugale, 2001).
- Tanzanian forests cover about 33.55 million hectares of forests and woodlands (Hurskainen[8], cited in Monela *et al*, 1999).
- The Ministry of Natural Resources and Tourism in a recent report (MNRT{FBD}, 2001) notes the reduction of national forest cover from 44 million ha in 1961 to 33.5 million ha in 1998. That represents an annual loss of 0.73% which, if sustained, would further reduce the forest to 28.4 million ha in 2020. In fact, the rate of deforestation is more likely to increase than simply to be sustained because, unless extraordinary change occurs, every year more people will take more wood from less forest.
- According to the National Geographic News (Donald Smith, 2000), Tanzania loses 400000 hectares of *woodland* per year. A recent figure for loss of *forest* was 91200 hectares per year (Ngotezi, 2002). Much depends on the definitions of *loss*, *woodland* and *forest*. Is a forest lost when half the trees have gone – or more or less than that? When does a forest become a woodland?

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6 (www.crwrc.org/teams/esamt/tanzania/profile/html)

7 (www.un.org/esa/agenda21/natlinfo/countr/Tanzania/)

8 Hurskainen, R. 1996. Privatization of public forest land. Towards solving the deforestation problem in Tanzania. Kansantaloiden suuntautumisvaintoehto, Helsingin Kauppa-korkeakoulu, Universtitas Economica Helsingiensis, 137 pp.

Mangrove forests are part of wider forest depletion estimated by the Tanzanian Wildlife Society at 300,000 and 400,000 hectares annually. There is a dispute about these figures, as the country office of the UN Food and Agriculture Organization (FAO) estimates deforestation at 140,000 hectares annually, at most (Blythe, 2000).

2.1.2 Charcoal's role in deforestation

Eleven to twenty per cent of deforestation in developing countries can be attributed to charcoal production[9]. Abundant evidence of the charcoal trade is visible throughout Tanzania: a visit to almost any forest reveals the presence of charcoal makers. Highways are lined with charcoal bags for sale in the production areas and on the outskirts of towns. Thousands of markets throughout the country offer charcoal for sale.

Clearly, charcoal production contributes to the deforestation of Tanzania but both processes are difficult to quantify: the extent of deforestation and the contribution to it by charcoal making. As stated by Monela *et al*, 1999, "Little is known about the actual extent of deforestation due to urban charcoal use". Van Aperen provides a useful formula: 50,000 tonnes of charcoal = 16,600 ha of forest = 26.7 million trees (van Asperen, 2000).

2.1.3 Sustainable and unsustainable forest use

According to CHAPOSA, "Average stand growth rate of 2.3 $m^3ha^{-1}year^{-1}$ has been recorded for the re-growth of miombo woodland" (Malimbwi *et al*, 199_). The annual national sustainable offtake has been estimated at 20 million m^2 based on regeneration estimates. Dar es Salaam's charcoal intake converts 2 million tonnes of wood per year and represents about half the national urban demand. It might appear to remain well within the sustainable limit – but it is not because that mean annual increment of 20 million m^2 has to satisfy *all* demands for wood, including firewood and building poles, and other forest products. Moreover, at least half of the miombo woodland lies in remote areas beyond the water catchment basins serving the cities and equally beyond the reach of most charcoal makers who need access by vehicle.

More wood for charcoal should mean less for other purposes, if the total were to be constrained within the sustainable offtake limit – which, of course, it isn't. The marginal cost to the wood-taker is effectively zero until (as in the Sahel) wood becomes hard to find. However, even when plenty of trees appear to remain, the marginal cost to society as a whole remains near zero within the sustainable limit but climbs steeply thereafter.

Now it appears that the sustainable limit has been exceeded in many parts of Tanzania and therefore the country is sacrificing its natural capital for charcoal production. Charcoal use today is being subsidised by future generations or even by the present generation in a few years to come. Charcoal is being produced at a cost to society in terms of its present and future ability to meet its needs for woody biomass for other purposes, food, water and medicinal products, and in the degradation of habitat and heritage held in trust (but, in fact, being exploited unsustainably) by the present generation of Tanzanians.

9 (www.ipcc.ch/pub/tar/wg2/318.htm)

2.2 Value of Tree Coverage

2.2.1 Useful roles performed

Forest loss reduces watershed moderation. That accelerates wet-season runoff and intensifies dry-season drought. Rapid run-off during storms induces soil destabilisation, erosion and land slips. The reduction in local microclimate attenuation which leads to forest drying and increased risk of fire. As a result forest loss leads to a decline in well-being of the local human population[10].

Forests perform an important role in the national economies of the riparian countries (of the Zambezi basin), contributing to the gross domestic product (GDP) and employing large numbers of people both directly and indirectly (Munyaradzi Saruchera, for IMERCSA, www). They also fulfil vital ecological functions such as providing habitat for wildlife, fertilising and nurturing the soil, cleaning the air by absorbing carbon dioxide and releasing oxygen.

Saruchera goes on to note that forest resources have a key role in rural economies and household production in the Zambezi basin. Forest products that are utilised include grass and leaves for grazing and browse, medicines, wild foods (honey, mushrooms, fruits), fuelwood and construction timber. The contribution of forest products and services (habitat and catchment area protection) to food security and the basic well-being of rural households is particularly significant among the poor households in rural areas.

Of Mainland Tanzania's allegedly remaining 33.5 million hectares of forest, 13 million are legally protected. Forest use employs around one million people *officially* and probably five to ten times that unofficially and part-time. The sector contributes heavily to the national economy with a 10% to 15% share of Tanzania's *registered* export earnings and about 2% of GDP for officially recorded forest products. Forests have the potential for tourism, and a diversity of interest to the pharmaceutical industry and carbon sequestration; but the major cash value is currently derived from timber, customary products and fuel. Trees provide around 75% of building materials, 100% of indigenous medicinal and supplementary food products and 95% of Tanzanian energy.

The cost to Tanzania of tree loss and woodland degradation need not include the value of timber converted to charcoal because the conversion has obvious economic benefits to the producer and the consumer. Whatever its other shortcomings, the charcoal trade is efficient. We assume that the value of wood used equals the value of charcoal produced.

It is the non-marketed values that have to be estimated. These are the roles of tree coverage in terms of:

- atmospheric cleansing and sequestration of carbon dioxide,
- water catchment and filtration,
- soil conservation, and
- habitat provision and conservation of biodiversity.

atmospheric values

Burning charcoal produces high volumes of carbon dioxide, carbon monoxide and CH_4. It adds to the load of atmospheric carbon dioxide[11]. International value of forests is estimated at $1500 per hectare in terms of recycling and carbon fixing[12]. Turpie (2000) attaches a still high, but less astonishing, figure of US$ 664 per hectare per year to the value of Tanzanian woodland in terms of carbon sequestration.

10 (www.newafrica.com/environment/output.asp?mainID=17749&cat=resources)

11 (www.worldbank.org/html/fpd/energy/energynotes/energy01.html#end)

12 (www.uccee.org/EconomicGHG/Tanzania.pdf)

water catchment, storage and filtration

Writing for CHAPOSA, Chidumayo[13] cautions that 'Deforestation caused by charcoal production in miombo woodland does not impair soil productivity and may actually enhance woodland regeneration and biodiversity through increased tree and species density. Deep soil moisture storage and rate of aquifer recharge are usually enhanced through reduction in evapotranspiration. However, woodland clearing may also increase overland runoff, erosion risk, flash floods in bottom areas and reservoir siltation'. The Tanzanian experience, and that of many other tropical countries, is that woodland clearance *does* increase overland runoff, erosion risk, flash floods in bottom areas and reservoir siltation. The experience of mud-slides is not confined to South America and The Philippines, as often portrayed on television. Less publicised but damaging slides also occur on Kilimanjaro, in the Eastern Arc Mountains and wherever in Tanzania tree cover is removed from steep slopes with shallow soil. Many formerly perennial Tanzanian rivers now desiccate for several months per year, a phenomenon more likely to be caused by deforestation of the catchment than by climate change.

Though Tanzania enjoys proximity to three enormous lakes, lake water is not readily available for urban use because it is low-lying and far from most large towns except Mwanza. Rainfall, in contrast, falls mainly on the wooded highlands and trickles by gravity to streams and rivers from which towns abstract their water supplies. These wooded highlands act as maintenance-free natural reservoirs, the replacement of which by engineered structures would be unrealistically expensive.

Tanzania receives an annual increment of 89 km^3 of fresh water on average, over the whole country. Most of that falls on wooded highlands, in a great arc encircling the dry north-central regions. Of that, much less than half remains available for lowland agriculture and urban consumption after deduction of losses to evaporation, evapotranspiration and direct outfall to the sea.

Per capita water availability is the total annual increment divided by the population. FAO calculated it at just over 11000 m^3 per person in 1950, from which it fell in step with population growth to around 3000 m^3 per person in 1995 (FAO, www). The UN's median projection has it falling to 1425 m^3 by 2025 and further down to 1000 m^3 per person by 2050. That predicts a major water crisis because the volume then available for urban consumption would have fallen below the critical level of one cubic metre per person per day which is reckoned by health authorities to be the threshold for attainment of a healthy and productive urban life.

The implication of this projection is that the value to Tanzania of natural water catchment and storage will rise rapidly over the coming decades. If, at the same time, the water catchment function is impaired, the crisis will be precipitated sooner and more severely.

soil conservation

Accounting for about half of GDP, Tanzanian agriculture depends largely on inherent soil fertility – the application of fertilisers being too expensive for most farmers. Tree loss on and around farmland deprives the soil of leaf-fall, thereby reducing fertility, and accelerates soil erosion by wind and water.

Soil erosion increases exponentially with removal of vegetative cover (IMERCSA, www). Typical erosion rates in this region are zero in mature woodland, wooded savanna 5 tonnes per hectare per year, maize fields 30 tonnes/ha/yr, and degraded land 50 to 100+ tonnes/ha/yr. Soil formation occurs at about one tonne per hectare per year in this region. Rapidly eroded soil is not replaced within a human generation.

Rainfall runs off soil that has been hardened by exposure much faster than before, removing humus and animal droppings, and carrying away the most fertile top layer of soil. The value of crops grown in what is effectively sub-soil, after serious erosion, is greatly reduced.

[13] EIA of charcoal production in Zambia

habitat provision and conservation of biodiversity.

Sustainable harvesting of miombo woodlands has been valued at $1050 per hectare (forest products and bee-keeping) and sustainable utilisation of national level forests at $750 per hectare, mostly from tourism[14]. Newmark (2002) quotes the TFAP's valuation of Tanzanian non-timber forest products at US$ 92.6 million in 1988 (Tanzania Forestry Action Plan, 1989) and mentions divergent valuations per hectare ranging from US$ 50 per hectare (Godoy *et al*, 1993) to US$ 2007 (Costanza *et al*, 1997) for the tropics generally.

Coastal forests in Tanzania are remnants of one of the world's oldest forests. They are rich in endemic species and important for many forest products[15].

Burgess, Mwasumbi, Hawthorne, Dickinson and Doggett, 1992, wrote that the lowland forests of coastal Tanzania comprise small and geographically isolated remnants of evergreen or semi-evergreen forest vegetation of the Zanzibar-Inhambane regional mosaic forest type. Most of these 'coastal forests' are located at less than 600 m attitude and within 50 km of the coast. They have been isolated from other forest blocks in Africa for perhaps the past 30 million years and have considerable biological importance, with high levels of endemism. Individual forests generally occupy less than 20 km^2, and the total area of forest remaining may be under 400 km^2.

Collectively these forests support many rare and poorly known plant species, including around 50 believed to be endemic to a single forest, seven bird species and subspecies of global conservation significance, several rare mammals, reptiles and amphibians, and an invertebrate fauna with many rare and undescribed species. All Tanzanian coastal forests are being destroyed by unsustainable human actions generally following the sequence (a) logging for timber and fuel; (b) pole-cutting to build houses; (c) wholesale burning for charcoal; (d) wholesale conversion to agriculture. At the present rate of destruction the Tanzanian coastal forests and their **globally important flora and fauna may be completely removed**.

2.3 Harmlessness or Harmfulness of Charcoal Production

Ten years ago, and earlier, researchers defended charcoal production against accusations of a role in deforestation. At four sites in central Zambia, Chidumayo (1993) found that charcoal production removed 50% of the total woody biomass but the woodland regenerated from a pool of stunted old seedlings and stumps of cut trees. Productivity was correlated to tree density before felling. Clearing of successive regrowth miombo did not appear to affect productivity.

Annual wood biomass increment in unmanaged regrowth miombo was estimated at 2 to 3 tonnes per hectare (t/ha) per year of which about 1.1 t was cord wood suitable for charcoal production. However, the charcoal spots within the deforested area were severely impacted by the carbonisation process which destroyed soil structure, seedlings and root stocks. Woodland regeneration on such spots is protracted. Fortunately, charcoal spots only covered 2 or 3% of the deforested area.

Dick Hosier made a similarly cheerful assessment in the same year. Examining tree harvesting for charcoal production to supply the urban areas in Tanzania, he found that woodlands appear to recover relatively well following harvesting for charcoal production. Selective harvesting, where the high quality, low-cost fuel production species and specimens are culled first from a piece of land, serves to maintain the viability of the woodland resource while providing charcoal.

14 (www.uccee.org/EconomicGHG/Tanzania.pdf)

15 (www.un.org/works/environment/environment3.html)

This recovery period can be prolonged by human activities, such as heavy grazing, multiple burns and extended cultivation periods. At the same time, post-harvest management techniques, such as coppice management, sprout protection and fertilization, can also improve the ability of woodlands to recover following harvesting. The environmental history of a given area determines why certain areas continue to be strong suppliers of wood-fuel while others are not. For example, Shinyanga started from a low productivity base and has been degraded by successive waves of tree harvesting compounded by heavy grazing pressure. It is this multiple complex of pressures over a long period of time on land which is intrinsically of low productivity, and not the harvesting of woodlands for fuels, which has led to the environmental degradation in these areas (Hosier, 1993).

Optimism about charcoal (which, even in 1993, was tempered by qualifications about techniques, pressure and exceptions) is being challenged by the evidence of degradation in woodlands conveniently near towns. Miombo woodland's 1.1 t/ha sustainable offtake of wood suitable for charcoal produces only 94 kg of charcoal per hectare. Tanzania's estimated present annual urban consumption of 926000 tonnes (Table 18 on page 40) therefore would need 9.85 million hectares (almost 100000 km^2) of miombo for sustainable production. Not all of Tanzania's remaining three hundred thousand km^2 of woodland is capable of such productivity; but the ratio still looks comfortable. However, project the demand upward by 5% per year and the usable woodland downward by 10%, both in keeping with current trends: the following result ensues.

Table 1 woodland area required for sustainable charcoal production

year	urban charcoal consumption in tonnes	woodland area needed for sustainable production, in km^2	woodland remaining in km^2	woodland surplus or deficit in km^2
2002	926000	98511	300000	201489
2005	1071961	114038	218700	104662
2010	1368124	145545	129140	-16405
2015	1746111	185757	76256	-109501
2020	2228529	237078	45028	-192049

This table represents a projection, not a prediction. What is tabulated is not necessarily what will happen. What it does, though, is to illustrate what would happen if present trends were to continue. For them *not* to continue, changes have to be made – to woodland management at the supply end and to fuel pricing at the demand end. It would be hardly more difficult to make charcoal in the 129000 km^2 projected to remain in 2010 than in the existing forest estate; but doing so (if the figures are accurate) would take the process through an important threshold into depleting stock as well as charcoaling incremental growth. When consumption eats capital, as well as interest, accelerating decline should be expected. This situation appears to be merely eight years ahead.

The same woodlands have to provide firewood as well. By 2000, wood-fuel consumption in Tanzania was estimated to have exceeded 60 million cubic metres[16]. Moreover, the demand for charcoal is increasing, linked to an increasing urban population. Charcoal prices have declined or remained stable over the last 10 to 20 years because the resource is seen as 'free', depriving producers or users of incentives to become more efficient[17].

2.3.1 Sustainability of charcoal production

Sustainable charcoal production is unharmful to the environment except in the short-term. 'Sustainable' means that trees are cut to stumps (not to the ground) and they retain the ability to regenerate. The clearing for charcoal production is small and surrounded by healthy woodland or forest. The clearing is left fallow, to recover naturally – not converted to other purposes, notably cultivation. The kiln is well managed such that the woodland around it does not catch fire.

16 (www.un.org/esa/agenda21/natlinfo/countr/Tanzania/)

17 (www.worldbank.org/html/fpd/energy/energynotes/energy01.html#end)

Most Tanzanian charcoal production that was examined by researchers ten years ago, and earlier, fulfilled those requirements and, moreover, had generally been authorised by Village Councils on whose land the production occurred (Hosier and Kipondya, 1993). Exceptions occurred in Shinyanga and Singida Regions where it was noted (Hosier and Kipondya, 1993) that charcoal production often initiated further land use changes and was associated with environmental degradation. Those regions have poorer soils and lower mean annual rainfall than most of the country and, in consequence, the recovery of woodland is slower after disturbance.

Nowadays it is widely reported by Village Councils that itinerant charcoal makers operate without authorisation[18]. The volume of charcoal made has greatly increased. It seems certain that the proportion of unsustainable charcoal production – not meeting the above-listed criteria – has risen.

What has changed since the Stockholm Environmental Institute (SEI) found little permanent harm being done by Tanzanian charcoal making in the 1980s (and Zambian production in the 1990s, according to Chidumayo) is due to the multiplier effect of urbanisation and relative price changes on charcoal consumption. Hosier, Mwandosya and Luhanga, 1993, established that a 1% increase in urbanisation induced a 14% increase in charcoal consumption.

While no precise figures are available, it appears that the Tanzanian urban population has been growing by at least 3% per year since the detailed energy surveys were done in 1988, bringing about at least a 50% increase in urban population (in fact, a conservative figure). That change alone translates to a seven-fold increase in charcoal consumption. That charcoal has fallen in price relative to all other fuels since the 1980s has further promoted its use such that the level of consumption may now be more than seven times higher than in 1988 – possibly ten times, though reference must be made to the recent surveys (described below from page 25) to substantiate such an assertion.

At that level of production, charcoal making *is* unsustainable and environmentally damaging and therefore much cost to society is associated with charcoal use. That the size of that cost is difficult to quantify precisely in no way diminishes the reality – that there *is* a cost and therefore Tanzania would derive some environmental benefit from LPG use (which is environmentally benign) to the extent that gas would displace charcoal as a fuel.

In this situation, it is better to put an estimate, however rough, of the benefit into public debate than to deny that it exists simply because it cannot yet be precisely quantified and proven. Informed debate about the assumptions and conclusions will refine the estimate and render it progressively more suitable as a basis for decision-making by government. In the meantime, however, the best available estimate of the benefit of LPG substitution for charcoal in Tanzania is the one generated by this study (Table 3 on page 25).

2.3.2 Characteristics of charcoal production and use

deforestation

The direct environmental impact of charcoal production is caused by the felling of trees to produce charcoal. Since the trend has been that more and more people use charcoal (for all the reasons mentioned previously), the tendency to fell more trees has been and will continue to increase in the absence of any affordable alternative. The problems associated with felling trees that are not replaced by regeneration or reforestation activities are well known: depletion of water sources and water catchment areas; reduction of carbon sinks; erosion; and loss of habitat and biodiversity.

[18] NTz socio-economic and environmental baseline surveys for the Tulawaka gold mine EIA, 2002; Monduli District water project, 2001; Lindi and Mtwara water project, 2000; on-going socio-economic monitoring around Lower Kihansi hydropower station, 1997 to 2002.

Deforestation takes two forms: clearance and degradation. Clearance is conducted mainly for agricultural expansion and, to a lesser extent, logging, fuel procurement and urban expansion. Charcoal making, like procurement of sticks for wood-fuel, tends to damage the woodland selectively. Certain species are preferred and, by natural selection, growth of disfavoured species (especially *Acacia polyacantha*, locally called *muwindi*) is then favoured. "However, charcoal burners are lacking skills in sustainable tree harvesting and good forest management practices, which is the solution to the current unsustainable forest use in the country"(G.A Ngoo)

wood-fuel

Wood-fuel, which comprises firewood and charcoal (and, to a small extent, crop residues and sawdust) was overwhelmingly the fuel of choice domestically in Tanzania in 1981, accounting for 99% of domestic energy (DANIDA, 1989). Other surveys in the 1980s (Mnzava, E M, 1983; Vuai, 1986) painted the same picture. The proportion could be a little less now but most researchers believe it to be about the same, since the consumers are not significantly richer nor the other fuels cheaper than they were – rather the opposite.

Recent surveys under the CHAPOSA programme have confirmed the overwhelming preference of urban consumers for charcoal. Total consumption of wood-fuels has certainly increased, in step with population growth, and certainly now exceeds the estimated 20 million m^3 sustainable offtake of woody biomass – it may be double or even treble that.

transport

Some charcoal is transported long distances to urban markets, thereby increasing vehicle emissions. LPG also has to be transported long distances to urban markets except Dar es Salaam. That exception is significant because Dar es Salaam consumes at least half of all domestic fuels. LPG is imported to Dar es Salaam and about half of it is transported no more than ten kilometres to the point of sale.

Peri-urban production of charcoal imposes lower haulage costs and pollution than long-distance trade; but it is exceptionally damaging environmentally in that it degrades the protective tree cover on peri-urban hills, thereby inhibiting infiltration of rain water and provoking soil erosion where the land is already subject to pressure for urban expansion, waste disposal and market gardening. Reduction of peri-urban tree cover reduces the local supply of firewood, poles, medicinal plants, fruits, fodder, vegetables and mushrooms. By comparison of satellite imagery from 1991 with that of 1998, with ground-truthing by fieldwork, CHAPOSA, 2002, discovered that habitat degradation had accelerated greatly during in the 1990s in woodlands near Dar es Salaam. In that short period, more than half of the remaining closed woodland in the CHAPOSA study areas had been converted to open woodland, bush or cultivated fields. Charcoal production was a cause and/or associated factor in most of this transformation.

employment

Charcoal production employs many people for whom paid employment is scarcely possible. Fuel-switching from charcoal to LPG would reduce the labour requirement. However, the charcoal business is so vast and the LPG business so small that the loss of employment would be small even if LPG consumption increased ten times, or more. Current energy demands for charcoal in Tanzania are 394.09 TOE (tonnes of oil equivalent) compared to 4.19 TOE for LPG[19]. Trebling or quadrupling the sales of LPG would hardly be noticeable in terms of the demand for charcoal.

Nevertheless, for there to be any appreciable environmental benefit from a switch to LPG, *eventually* there would have to be a measurable reduction in charcoal production and therefore charcoal-related employment. In the long-term, beneficial economic effects of checking environmental degradation caused by deforestation would more than offset the loss of charcoal-related employment. Such gains would reverberate throughout the entire economy and would enhance the well-being of all Tanzanians.

technology

Most charcoal production causes much more degradation than is necessary because of the technologies that are commonly used:

[19] (www.uccee.org/EconomicsGHG/Tanzania.pdf)

- The efficiency of the production kilns used in many parts of Tanzania is a mere 19% (conversion of calorific value in the wood to that remaining in the charcoal) and adoption of more efficient methods is often very low[20]. Adopting better kiln preparation methods could increase efficiency to 30% or more.
- Often trees are cut to the ground, thus, rather than regenerating, the trees die (Ngoo, personal communication, 2002).

The major health effects of charcoal production are associated with wood cutting and preparation of kilns. Cuts, strains and back problems are common. Severe burns during kiln management are less common but may be fatal.

resource-related conflict

The Tanzanian Ministry of Natural Resources and Tourism as recently as last year, 2001, noted that '*the scope and magnitude of natural resource conflicts have increased and intensified due to increasing population with declining forest resources* (MNRT{FBD}, 2001). In this context, it is prudent to recall that the countries to the north of Tanzania that experience recurrent drought and hunger are also those where environmental degradation is far advanced. Having lost a high proportion of their forest, Kenya and Sudan suffer chronic water shortages. Right across the Sahel, competition for access to a diminishing natural resource base is concurrent with and related to civil unrest.

Summarising the foregoing, these risks are associated with forest and woodland loss and degradation.

Table 2 risks associated with forest loss and degradation

function	process	implication
climatic amelioration	Rainfall diminishes over unwooded land; but not greatly.	prejudicial to agricultural and pastoral production
soil protection	Unprotected tropical soil loses fertility and/or rapidly erodes to a near-worthless condition.	highly prejudicial to agricultural production
water catchment	deforested slopes release water rapidly	water loss during rains; shortage during dry season.
habitat conservation	Heavy offtake of wood converts closed forest to open forest, and open forest to scrubland or savanna.	With less woodland, Tanzania would lose much of its wildlife and many rare species of plants
cultural values	Traditional culture depends heavily of forest products.	Medicinal herbs and wood for carving would be hard to find.
subsistence	Most rural dwellers augment their food supply with forest products.	Wild fruits and honey would be hard to find.
civil disorder	Competition for scarce resources.	Diversion of government funds to security and public order.

[20] According to the World Bank, efficiency in energy conversion from wood to charcoal is even lower than that, merely 8-20% (www.worldbank.org/html/fpd/energy/energynotes/energy01.html#end)

3. Tanzanian Urban Growth Drives the Demand for the Charcoal

3.1 Tanzanian Urban Population and Growth

The present population of Tanzania is generally estimated to be around 33 million; but some sources put it as high as 36 million (CIDA, www). The UNCHS predicts that it will be 44 million by 2010 and 56 million by 2020 (UNCHS, www). Population projections are, of course, often proved wrong; but the extreme youthfulness of the Tanzanian population (average age about 14 years) does guarantee rapid growth.

The urban population of Tanzania is also unknown but various researchers and international agencies have estimated it to be 12 million – almost one third of the total population. UNCHS predicts that it will exceed 12 million in 2005, will exceed 15 million in 2010 and will exceed 23 million in 2020 (UNCHS, www). Over that period the urbanisation level would have risen from 30% now to over 40% in 2020. Concomitantly the area of woodland per capita would have fallen substantially even *without* deforestation. UNCHS estimates that the area of woodland and forest per capita fell from 1.91 hectares per person in 1985 to 1.12 ha/person in 1995.

Of the present total, Dar es Salaam is said to accommodate three million people and the next ten or a dozen largest towns another three million together. About one million households in the large towns and cities seems about right.

Since national average population growth is believed to be at least 2% per year, urban growth may conservatively be estimated at 3% per year. That rate sustained to 2020 would produce 1.7 million households in Dar es Salaam plus the next ±10 large towns.

3.2 Tanzanian Urban Charcoal Consumption

3.2.1 Ten years ago

Ten years ago, Monela studied charcoal making along the Dar-es-Salaam to Morogoro highway. This is typically a miombo woodland area. Data collection was done during a one year period designed to cover both rainy and dry seasons. The methodology included field observation, monitoring at a selected forest-products checkpoint and interviewing charcoal makers, traders and consumers. Some parameters used in the calculation of the area cleared to meet the charcoal consumption were taken from related past studies. Household income from charcoal was TShs 34200 per year (when US$1 was worth TShs 193/=) and income redistribution flowing from Dar es Salaam, the capital city, to the rural areas along the highway was TShs 40 253 400/= in one year.

The total area of miombo forest cleared annually for producing charcoal was 4354 ha per year or 1524 km^2 in 35 years. Such a huge area was cleared as a consequence of the fact that energy from charcoal is the most affordable and efficient fuel for most poor urban dwellers in the area of study. Therefore, charcoal consumption near a growing city such as Dar es Salaam promotes lucrative business with a positive economic impact on households. However, this is realized at the expense of environmental protection (Monela, 1993).

3.2.2 Now

Now, every 24 hours, from 15000 to 20000 bags of charcoal enter the city of Dar-es-Salaam. The bags are deposited in the outskirts of the city, with most of the charcoal coming from the coast region (Blythe, 2000, www).

More than 85 percent of the population of Dar es Salaam depends on charcoal as a source of energy for cooking purposes. Due to the scarcity of trees in the nearby villages, charcoal is now obtained from more than 150 km when transported by road, and is transported to the city by lorries; some also arrives from other country regions as far as Kigoma and Tabora by train.

Charcoal consumption in Dar es Salaam is about 50% of the total charcoal consumed in the country. Dar es Salaam with 3 million inhabitants[21] consumes about 360,000 tons per year; the average household consumption is 1080 kg charcoal a year[22] or 36 bags of 30 kg each (van Asperen, 2000). The survey for this report generated a slightly lower figure (Table 18 on page 16).

3.2.3 Environmental impacts of charcoal and LPG consumption

The thermal efficiency of LPG combustion is high and that of charcoal very low. A gas cooker reaches the desired temperature for cooking immediately whereas a charcoal stove is slow to reach a cooking heat – yet it must be supervised if small children are nearby, as usually they are. As significantly, a gas stove may be switched off whereas a charcoal stove (or electric hot-plate) cools slowly, wasting heat.

LPG consumption

Subsidy of LPG in Brazil dramatically increased its use in place of charcoal and kerosene. According to a study by the World Bank: "Increased LP Gas use has resulted in significant improvements in health and safety, and has reduced deforestation in many parts of the country."

Contrary to the widespread perception of gas as dangerous, the gas ring is much safer to use than a charcoal stove[23]. The flame can be extinguished instantly whereas a charcoal stove cannot. The gas stove emits no detectable fumes and no smoke at all.

LPG is a clean burning fuel because of its simple chemical makeup. It produces virtually no particulates and low levels of CO, hydrocarbons and nitrogen oxides, which are the precursors of ozone (smog)[24]. Conversion to LPG from wood fuels would lead to a 50 to >90% reduction in particulates[25].

LPG is transported and stored in strong sealed containers which do not leak. If somehow LPG is spilled, it evaporates and disperses rapidly to the air, without polluting soil or water and with little risk of igniting unless trapped in a confined space. In each of those respects, LPG has major environmental, health and safety advantages compared with kerosene, which is a popular household fuel in Tanzania but a main cause of house fires and other domestic accidents.

charcoal consumption

The efficiency of charcoal stoves is very low. Charcoal stoves have an efficiency of 20-35% energy conversion compared to LPG stoves at 45-65%[26].

Adoption of energy-efficient stoves has not been as widespread as had been hoped, despite promotion by NGOs. This means that most people use a lot more charcoal than would have been the case if they had more efficient stoves. This is especially the case for businesses that do a lot of cooking, such as restaurants and food vendors who rarely use energy efficient stoves. That charcoal is cheap means that such consumers do not feel the need to invest in better methodologies.

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21 Planning Commission, 2000

22 Tanzania Woodfuel Forestry Project, Joint UNDP/ World Bank Energy Sector Management Assistance Program, 1988

23 one co-author of this report observed the cooking members of his household recoil in fear when an Oryx Chap Chap was brought home and lit for the first time; but after two days, LPG became the much preferred fuel, displacing charcoal entirely and electricity almost entirely except for the use of an electric kettle. This experience may not be universal but it has been a powerful demonstration in one instance, at least. The speed, efficiency and user-control of the Chap Chap are now much admired by the household users. No disadvantages have been found in two months of daily use other than the necessity to be careful when extinguishing the flame after prolonged use – everything gets quite hot.

24 (http://worldlpgas.com/mainpages/aboutlpgas/benefits.php)

25 (www.cct-freiburg.de/who/cross_sectoral/documents/CMEH.pdf)

26 (www.worldbank.org/html/fpd/energy/energynotes/energy01.html#end)

Charcoal combustion emits carbon monoxide and nitrogen oxides. Unlike LPG it is neither safe nor comfortable to use inside the home. In extreme cases, carbon monoxide poisoning leads to brain damage and even death. Nitrogen oxides emissions react with sunlight to produce dangerous air pollution. Fumes from charcoal burning augment those from diesel engines and industrial chimneys.

The association between exposure to air pollution from cooking fuels and health aspects was studied in Maputo, Mozambique (Ellegard, 1996). Almost 1200 randomly selected women residing in the suburbs of Maputo were interviewed and 218 were monitored for air pollution. The fuels most commonly used were wood, charcoal, electricity and liquified petroleum gas (LPG). Wood users were exposed to significantly higher levels of particulate pollution during cooking time (1200 $\mu g/m^3$) than charcoal users (540 $\mu g/m^3$) and users of modern fuels (LPG and electricity – 200 to 380 $\mu g/m^3$).

Charcoal consumption makes a small – but not negligible – contribution to climate change. Brocard, Lacaux and Eva, 1998, compared emissions from domestic fires with those of savanna fires, the dominant form of biomass burning in tropical Africa, and found that the relative contribution of fuel wood and charcoal combustion is important for CH_4 (46%), CO (42%), and non-methane hydrocarbons (NMHC) (44%), but less so for CO_2 (32%). This source of biomass burning has a different spatial and temporal distribution than that of savanna fires and represents an atmospheric background noise throughout the year, whereas the savanna fires occur during a limited season.

Health impacts of using charcoal and firewood affect the household economy. Smoke includes particulates, CO, NO_2, formaldehyde and carcinogens. Indoor air pollution may be many times the standards in industrialised countries. The 24 hour mean levels of particulates have been recorded in the range PM_{10} 300-3000 μgm^{-3} (PM_{10} includes all particles smaller than 10µm). Exposure can cause acute lower respiratory infections (e.g. pneumonia) in children (2 million deaths in under 5s world wide) and chronic bronchitis or chronic obstructive pulmonary disease in women. Smoke from wood fuels has also been linked to other conditions such as low birth weights, perinatal mortality, asthma, tuberculosis and laryngeal cancer[27].

The burden on sub-Saharan countries of wood fuel use in the 1990s has been estimated at 429,027 deaths, 350,703,204 illnesses and 14,323,188 DALYs (disability adjusted life years). The World Bank estimates gains of $150-200 per DALY saved by the conversion to LPG and kerosene. Interventions are considered cost effective if they produce greater than $150 per DALY saved[28]. Most of that damage, however, relates to firewood rather than charcoal.

4. Main Findings

The environmental damage caused by charcoal production in Tanzania annually is comparable to a reduction of GNP by not less than 2%. That cost is not paid in cash but it is real nonetheless because it represents a reduction in the capital of Tanzania’s natural resource base plus an opportunity cost expressed in terms of crops not grown, water not delivered to consumers, biomass not available for other purposes, and cultural heritage degraded.

Totally substituting LPG for charcoal would confer an annual environmental benefit on Tanzania worth somewhere between US$ 12 million and US$600 million per year (Table 3 on page 25 below) with US$ 160 million as the most likely estimate. Total substitution is, of course, only theoretical; but the value of partial substitution can be calculated on a *pro rata* basis in keeping with the hypothesis above (page 7).

[27] (www.cct-freiburg.de/who/cross_sectoral/documents/CMEH.pdf)

[28] (www.ccf-freiburg.de/who/cross_sectoral/documents/CMEH.pdf)

4.1 Sectoral Analysis

4.1.1 Water supply

No-one doubts the *value* of water; but the *cost* of water varies enormously between different Tanzanian consumers (IIED, www). Urban households pay from as little as one shilling per litre to as much as TShs 300/- per litre depending on availability, situation and willingness-to-pay. Many peri-urban households exchange labour for water much as rural households do, with little in the way of cash expenditure. Someone still has to pay for maintenance of the water-point, however, and a shadow price has to be attributed to the labour. Taking into account IIED's findings and the many recent surveys done by NTz on water supplies, a working figure of US$100 is proposed as the average cost (including shadow pricing of unmarketed services) of water for domestic use per urban household per year, suggesting US$100 million as the conservatively estimated current annual value of Tanzanian urban water supplies. By international standards, that remains extremely low but over-estimating the cost would invalidate the argument whereas underestimating may weaken, but would not invalidate, it.

In step with the inevitable reduction in water availability *per capita*, discussed in section 2.2.1 at page 14 above purely on the basis of population growth, the cost of maintaining the same volume of urban water supply to each household as now is likely to double, at least, by 2020. That cost would be payable by the consumer.

The predicted reduction of woodland coverage by 2020 (in section 2.1 at page 7, above) would impair the water catchment (interception, retention and slow release) function by an estimated 50%, thereby quadrupling the cost of water in 2020. Impairment of the catchment function will therefore impose a cost rising to US$300 million per year by 2020, also payable by urban consumers.

If they had to finance engineered replacements of the lost natural storage of water in catchment basins, the cost would spiral to absurd figures, 1000 times higher at least; but such infrastructure would be unaffordable. It is more likely than Tanzanian town dwellers will pay more for less water and will forgo the development, health and convenience benefits of an adequate water supply for the foreseeable future – if upland deforestation continues.

What proportion of the estimated US$300 million per year can be attributed to charcoal production? Conservatively, a tenth – say US$30 million per year. In fact, charcoal production and clearance for cultivation are so intimately related in the process of deforestation that no precise calculation would ever be possible. Representing the charcoal-related cost as 10% of the whole is, in the light of the increasing role of clearance for charcoal, a modest estimate – so that the argument is not weakened by exaggeration.

4.1.2 Soil conservation

Deforestation allows the cultivated area to be moved – but not expanded. Clearance of miombo for cultivation is futile because nearly all the fertility is in the standing biomass (Weischet and Caviedes, 1993). The exposed soil, without leaf-fall, rapidly becomes not worth cultivating. The cleared portion then has to be abandoned to revert, slowly, to woodland – too slowly to re-enter the charcoal supply chain within a human generation, during which period a whole sequence of clearings may have been made.

Tree loss on established farmland reduces agricultural productivity due to increased wind erosion, reduced shade, soil heating and desiccation, and loss of leaf-fall. Whereas many pests can live in the crop fields, most predators of those pests need shady woody refuges to breed and raise young. Both seed and harvest losses would increase dramatically without helpful predation of pests.

Total tree loss, on-farm and in the forests is unimaginable but would, should it occur, diminish agricultural productivity so drastically that a 50% reduction in output could easily ensue, equivalent to a 25% reduction of GDP. *Pro rata* losses may be calculated for less than total tree loss.

4.1.3 Habitat provision and conservation of biodiversity.

The local effects of forest loss lead to a reduction in animal habitat and so animal diversity and abundance. Apart from the scientific and cultural loss, rural dwellers lose access to forest products which are thought to be worth, in nutritional and medicinal value, at least US$100 per rural dweller per year: US$200 million per annum for Tanzania. *Potential* values cited above, in section 2.2.1 on page 15, would put it far higher; but the calculations in this report try to adhere to actual current local values.

4.2 Implications of the Findings

The report spells out the implications of fuel-switching (principally from charcoal) to LPG at various levels of future consumption, from the zero option (no more LPG than at present) to the greatest feasible adoption of the technology within an 18-year time horizon (to 2020, in other words).

In so doing, the study forecasts the environmental impacts of further increased demand for charcoal and contrasts them with the effects of reducing demand by fuel-switching. Such effects impact on water catchment, conservation of habitat and wildlife, availability of timber for other purposes, soil conservation, micro-climate and aesthetics.

4.2.1 Pessimistic scenario: sustained urban consumption of charcoal

Events likely to induce realisation of this scenario are:

- no change in the price of LPG; and
- ineffective regulation of charcoal production;

This is the 'business-as-usual' scenario which, by default, is what will happen without deliberate and effective measures by government to change the course of events. Eventually the evident cost of deforestation to society would become so severe and apparent that public opinion would demand change; but, by then, great damage would have been done and much of it would be irretrievable.

In this scenario, the demand for charcoal would continue to grow and would be satisfied by accelerated conversion of trees to charcoal. As formerly felled areas failed to regenerate in time to be used again, so charcoal makers would constantly clear new areas. Closed forest would degenerate to open woodland, and woodland to secondary scrub. As the extent of forest and woodland suitable for charcoal production diminished, the penetration of new areas would accelerate and the rate of deforestation would increase. Adverse environmental and economic impacts, that are already apparent but which would increase, are that:

- the supply of water to streams and rivers would become more erratic, with run-off greatly accelerating during storms;
- soil erosion would increase, and watercourses would become sedimented with soil;
- less woody biomass would be available for all other uses and traditional forest products would become scarce;
- more land would be opened for cultivation but agricultural productivity would fall; and
- the price of charcoal would eventually rise.

4.2.2 Median scenario: slightly reduced urban consumption of charcoal

In this scenario, a reduced retail price for LPG combines with somewhat more effective regulation of forest depletion for charcoal. The result is that the growth of charcoal consumption is restrained, then halted and finally the volume of consumption is slightly reduced as urban households switch to other fuels, LPG included.

Charcoal-making would revert to being a sustainable forest use except in the dry central regions. Cleared portions would regenerate in time to be used again.

4.2.3 Optimistic scenario: greatly reduced urban consumption of charcoal

Realisation of this scenario depends on a desirable but improbable combination of Government and NGOs lending full support to a campaign by the TAOMC to promote the use of LPG, plus vigorous suppression of illegal charcoal making backed up by effective checks on vehicles incoming to towns, especially Dar es Salaam, followed by fines for over-loading and penalties for carriage of charcoal not certified as legitimate by Forestry Officers. The outcome of success of those measures would be that:

- the supply of water to streams and rivers would become constant throughout the year, as healthy woodlands prevented sudden run-off of surface flows;
- soil erosion would reduce, and watercourses would become clearer;
- more woody biomass would be available for all other uses and traditional forest products would become abundant;
- less land would have to be cleared for cultivation and agricultural productivity would rise; and
- the price of charcoal would probably remain low.

4.3 Valuation of Tree Coverage

Widely divergent values can be attached to the risks described above; but their divergence does not mean that they should be disregarded until shown to be precise.

Table 3 opportunity cost of charcoal production in Tanzania

area of forest and woodland, km^2	330000	330000	330000
	lower estimate	**upper estimate**	**working estimate**
current annual increment of forest affected by deforestation or serious degradation	5 %	15 %	10 %
of which percentage, proportion attributable to charcoal production	10 %	30 %	20 %

	lower estimate (GDP)	**upper estimate (GDP)**	**working estimate (GDP)**
value of forest and woodland products and services	2 %	20 %	10 %
GDP in US$ million	6000	10000	8000
cost of current annual loss to deforestation and degradation in US$ million	120	2000	800
of which, attributable to annual charcoal production in US$ million	12	600	**160**

Within those divergent estimates and derivations therefrom, the best available estimate for the cost to Tanzania of charcoal production now is US$ 160 million or 2% of GDP.

Rising by 8% per year, it would reach 8% of GDP in 2020 as urban population rises and woodland cover falls.

note on the estimation of GDP

Tanzanian GNP per capita was estimated to be US$210 in 1997 (WB, often quoted by others). Notwithstanding the evidence of widespread poverty, that seems low. Though most Tanzanians are poor, few starve – as many would on an income of US$0.55 per day. Some allowance has to be made for the value of subsistence and to bring the figure into line with visible evidence.

According to another source, Tanzanian GDP was US$ 5300 million in 1998 and 1999, well up from the previous decade but lower than the US$ 5862 million GDP for 1997 (US Dept. of Commerce, www). UNCTAD put it much higher – US$ 7607 million in 1997 (UNCTAD, www). These discrepancies are characteristic of Tanzanian macroeconomic statistics, and result from divergent estimates of the population and the value of unrecorded transactions. GDP growth denominated in shillings has been sustained but recent deterioration of the exchange rate puts it into negative terms, expressed in dollars.

5. Appendices

5.1 Appendix One - LPG

5.2 LPG production

LPG is a derivative of two large energy industries: natural gas processing and crude oil refining[29]. As a result, its production alone does not add to atmospheric pollution, although atmospheric pollution and marine pollution are both associated with natural gas and oil refining industries[30]. It is transported by sea to Dar es Salaam and the ships do probably emit some marine pollution during that process.

Production of LPG along with natural gas processing reduces the need for flaring of natural gas during oil drilling and as such reduces the atmospheric pollution of the oil drilling industry (ICLEI, www).

5.3 LPG consumption

5.3.1 LPG consumption worldwide

LP Gas has been the fastest growing fossil energy source with a recent growth rate of 5% a year. The total world primary output has been growing recently at a trend rate of 2½ to 3% a year. The total use of LPG is expected to reach some 200 million tonnes a year early in this century. The fastest growth rates for the use of LPG are in the developing countries with, for example, China growing from 300 tonnes a year to 3,000,000 tonnes a year (TAOMC, 2001).

5.3.2 LPG consumption in Tanzania

The Tanzanian LPG market in the 1990s was characterised by shortages and disruptions in supply, high cost of gas and lack of investment in infrastructure, packaging and safety. Those shortcomings together with inertia by the gas marketing companies led to a decline in consumption from over 6500 tonnes in 1996 to just 3500 tonnes in 2001 (TAOMC, 2001).

29 (http://worldlpgas.com/mainpages/aboutlpgas/wherefrom.php)

30 (http://www.ipcc.ch/pub/tar/wg3/363.htm)

The True Cost of Charcoal

Investment in the petroleum industry in Tanzania currently ensure that the infrastructure to support access to and distribution of petroleum fuels, including LPG, is in place by virtue of the service station network. Furthermore the modern processing and bottling plant in Dar es Salaam has the capacity to ensure sustainable supply.

The very recent increase in electricity cost is likely to drive up demand for charcoal and, to a lesser degree, LPG. The comparisons, overleaf, of fuel efficiency per unit cost is taken from the TAOMC's recent presentation to the Ministry of Finance. The exchange rate at the time was US$ 1 = TShs 970.75. Stove efficiency for both calculations was taken as follows:

fire wood	10 to 25%
charcoal	20 to 35%
kerosene	34 to 50%
LPG	45 to 65%
electricity	75 to 85%

Table 4 fuel efficiency of various fuels per unit cost at current prices including tax

FUEL	RETAIL PRICE	UNIT	CALORIFIC VALUE MJ/UNIT	CALORIFIC VALUE KWH/UNIT	EFFICIENCY %	KWH PER UNIT	UNIT COST PER KWH TSH	UNIT COST PER KWH USD
LPG 15KG								
DAR	1100	KG	48.4	13.7	55	7.5	**146**	0.15
MOSHI	1200	KG	48.4	13.7	55	7.5	**159**	0.16
MWANZA	1267	KG	48.4	13.7	55	7.5	**168**	0.17
ZANZIBAR	1500	KG	48.4	13.7	55	7.5	**199**	0.20
KEROSENE LITRE BOTTLE	420	LIT	37.5	10.6	35	3.7	**113**	0.12
ELECTRICITY (LUKU)	97	KWH	3.53	1.0	80	0.8	**121**	0.12
CHARCOAL								
LOW EFFICIENCY	120	KG	20.1	5.7	20	1.1	**105**	0.11
HIGH EFFICIENCY	120	KG	20.1	5.7	35	2.0	**60**	0.06
FIRE WOOD BUNDLE	75	KG	14.8	4.2	17	0.7	**105**	0.11

The True Cost of Charcoal

Table 5 fuel efficiency of various fuels per unit cost at current prices excluding import duty

FUEL	RETAIL PRICE	UNIT	CALORIFIC VALUE MJ/UNIT	CALORIFIC VALUE KWH/UNIT	EFFICIENCY %	KWH PER UNIT	UNIT COST PER KWH TSH	UNIT COST PER KWH USD
LPG 15KG								
DAR	872	KG	48.4	13.7	55	7.5	**116**	0.12
MOSHI	972	KG	48.4	13.7	55	7.5	**129**	0.13
MWANZA	1039	KG	48.4	13.7	55	7.5	**138**	0.14
ZANZIBAR	1272	KG	48.4	13.7	55	7.5	**169**	0.17
KEROSENE LITRE BOTTLE	420	LIT	37.5	10.6	35	3.7	**113**	0.12
ELECTRICITY (LUKU)	97	KWH	3.53	1.0	80	0.8	**121**	0.12
CHARCOAL								
LOW EFFICIENCY	120	KG	20.1	5.7	20	1.1	**105**	0.11
HIGH EFFICIENCY	120	KG	20.1	5.7	35	2.0	**60**	0.06
FIRE WOOD BUNDLE	75	KG	14.8	4.2	17	0.7	**105**	0.11

Although the above calculation assumes zero import duty, it still allows for 20% VAT.

5.4 Appendix Two – the Survey

5.4.1 Methodology

To determine how much charcoal is being consumed (and therefore produced) in urban Tanzanian centres, several approaches have been used. Investigations have been made of both supply and demand.

charcoal entering Dar es Salaam survey

The amount of charcoal coming into Dar es Salaam has been surveyed. Enumerators were posted at six points past which it is known that charcoal enters. The MNRT's revenue-collecting checkpoints were used since they provided shelter and security necessary for the 24-hour shifts. The survey took place over two days: a Saturday and a Wednesday[31].

Every charcoal-carrying vehicle and bicycle crossing the post and heading towards the city was noted, as was its carrying capacity. Unlike in the MNRT's own surveys, the vehicles were not stopped. Counting continued throughout the night and into the following day (24 hours). The counts were used to determine the amount of charcoal that entered the city on those particular days and to extrapolate the weekly, monthly and annual amounts.

urban charcoal consumption surveys

Informal interviews were conducted in all urban areas visited to determine a base figure of how much charcoal is being consumed by households and food-vending businesses. By obtaining municipality population figures and determining average household sizes, it was possible to determine household charcoal consumption. Municipality figures on the number of registered hotels that sell food were also obtained and their charcoal consumption rate determined. Furthermore, estimates of how many non-registered food-vending businesses were made.

5.4.2 Sites

Dar es Salaam

Several studies have been done to estimate the amount of charcoal that is being consumed in Tanzania's largest city. In 1993 Hosier and Kipondya showed that average household consumption was at 72.5 kg/month. This is equivalent to about 1.4 sacks of charcoal per month per household, if it is taken that 1 sack is 53 kg as determined by the CHAPOSA 2002 study.

Taking into account population increase, the Hosier & Kipondya study suggests that 5,784,906 sacks per year are consumed by Dar-es-Salaam households alone. The CHAPOSA study however, concludes that about 300,000 additional sacks are actually consumed, the difference being attributed largely to the fact that users other than households also utilise charcoal. According to household and other sector charcoal consumption patterns, the estimated number of sacks consumed in Dar es Salaam per day is at about 24,000 (CHAPOSA 2002). This indicates that two million tonnes of wood are required annually to meet this demand (CHAPOSA 2002).

[31] during March 2002 when the wet weather may have reduced the volume of charcoal traded; this timing was unfortunate and ought to be supplemented by similar surveys during dry weather

Table 6 estimated charcoal consumption in Dar es Salaam

description	bags per year	tonnes[32]	[33] m^3	ha[34]
MNRT official figures of charcoal entering the town in 2001	1,655,090			
estimated household consumption [35]	6,862,000			
estimated enterprise and institution consumption [36]	1,898,000			
total estimated annual consumption	**8.760,000**	**438,000**	**5,089,560**	**145,417**

NTz's incoming-charcoal road survey revealed that 15,396 sacks of charcoal enter the city per day, a good percentage of which enters at night and is thus never charged revenue at the MNRT checkpoints, which close at 1800 hrs. As in Hosier and Kipondya's earlier study, the NTz 24h-survey revealed that at least five and half million sacks enter the city per year. In the above table, however, CHAPOSA's higher estimate is used, to factor in the substantial amount brought by train plus that missed by concealment within (as opposed to open display on) vehicles plus the shortfall implicit in counting during a very rainy week when traffic is somewhat reduced by muddy conditions and vehicle failure.

32 Although the Forest Rules indicates that one bag of charcoal weighs 28kg, most other recent studies have shown that more often than not, one sack consists of much beyond 35kg and even as much as 70kg. For the purpose of this study, a gross median has been used instead, suggesting that one sack of charcoal weighs 50kg.

33 Conversion from tonnes to cubic metres based on the assumption that 50,000 tonnes are equivalent to 16.600 ha of forest and 26.7 million trees, and where 35 cubic metres of wood produce 3000kg of charcoal (van Aspen, S. A., 2001 'Improvement of Production and Management Processes of Metal-Ceramic Charcoal Stoves in Dar-es-Salaam' Research Project from collaboration of TaTEDO and the University of Twente).

34 as previous footnote

35 CHAPOSA, 2002

36 as previous

Charcoal into Dar es Salaam by Road in March 2002

Table 7 carriage of charcoal in Dar es Salaam by road in March 2002

road name	date	week day	pickups	light truck (3-5 tonnes)	medium truck (6-10 t)	heavy truck (>= 11 tonnes)	other vehicles (e.g. tractors)	bicycles	
								carrying one sack	carrying two sacks
Kilwa Road	09-03-02	Saturday	35	66	18	0	1	89	254
	13-03-02	Wednesday	36	44	13	2	0	72	277
Pugu Road	09-03-02	Saturday	7	35	5	0	0	64	90
	13-03-02	Wednesday	5	38	3	0	0	73	192
Charambe Road	09-03-02	Saturday	1	3	0	0	0	20	36
	13-03-02	Wednesday	0	0	0	0	0	21	41
Morogoro Road	09-03-02	Saturday	9	30	23	0	0	16	98
	13-03-02	Wednesday	12	31	17	0	0	29	218
Bagamoyo Road	09-03-02	Saturday	1	17	2	0	0	84	3
	13-03-02	Wednesday	1	13	0	0	0	83	8
Total			**107**	**277**	**81**	**2**	**1**	**551**	**1217**
Average per day			54	139	41	1	1	276	609
Average number of sacks per day			**1238**	**7916**	**3969**	**150**	**23**	**276**	**1521**

Morogoro

No previous study has been done of the amount of charcoal consumed in Morogoro Municipality. It has thus been necessary to do a quick reconnaissance and questionnaire survey to provide an indication of household and hotel-business consumption. Representatives from all sections of society were interviewed as were licensed and unlicensed hotels/kiosks. By these means, it has been possible to extrapolate total municipality charcoal consumption.

There are no compiled data on the amount of charcoal entering the municipality. The District Forest Catchment Office has no records of how many registration licences they have issued for charcoal production, transportation and/or marketing in the last years. Nor does any report summarise district revenue generated from charcoal business.

Charcoal used in Morogoro Municipality originates from within the region, and mostly from public lands: Lukobe, Mkundi, Sokoine, Ranch, Melela, Doma, Mikese, Newland and Ngerengere. Some registered charcoal businesses in the municipality own charcoal production sites or otherwise buy charcoal directly from the producers. Charcoal is brought into the town centre mainly by lorries but also by pick-ups and bicycles. It is resold to small retailers who sell the charcoal in measurements of tins, buckets and small sacks (*virobas*).

The price of charcoal in Morogoro varies slightly depending on the season. During the rains, a sack may cost TShs 4000/=. In the dry season, a similar sack costs around TShs 3000/= to 3500/=. A four-litre tin of charcoal varies from TShs 100/= to 150/=, while a bucket may be TShs 500/= to 600/= depending on the size of the bucket. *Virobas* are about TShs 1000/= but are less common measurements, preferred mostly by people living in the town centre.

The current population of Morogoro Municipality is about 207,000 people consisting of about 48,140 households. These are extrapolations made from the 1997 estimate of the population at a rate of 2.8% rate of (regional) increase. The average household size provided by the Municipality does not seem indicative of the real situation; the household charcoal consumption survey showed that the average household size is six rather than four. The municipality has 42 licensed restaurants/hotels. These exclude the scores of *chips-mayai* kiosks all over the town centre and suburbs.

Analysis of the questionnaire shows that, on average, Morogoro households consume 192,552 sacks of charcoal per month. That is equivalent to 2,310,624 sacks per year.

The amount of charcoal consumed by licensed hotels is on average 1113 sacks per month, equivalent to 13,356 sacks per year. Seeing, during reconnaissance, that there are at least 200 *chips-mayai* kiosks in the municipality (probably there are many more), then the total amount of charcoal that they consume would be not less than 12,480 sacks per year.

The amount that other service industries use cannot readily be determined. The government and private hospitals, boarding schools, the university, missions, and other institutions also use charcoal for their cooking activities, but many also use firewood. Assuming that most use firewood, then just households and businesses alone use 2,336,460 sacks of charcoal per year.

Table 8 estimated charcoal consumption in Morogoro

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	unavailable			
estimated household consumption	2,310,624			
estimated enterprise and institution consumption	25,836			
estimated total annual consumption	2,336,460	**116,823**	**1,357,483**	**38,785**

Tanga

Much of the existing forest in Tanga Region is under public ordinance and therefore not reserved. Much of the charcoal generated from these forests comes from Handeni and Muheza Districts, and often consists of *Muhoho* and *Mikarambati* species. Although mangrove trees grow along the coast of Tanga Municipality, these are rarely burnt for charcoal production – being too cumbersome to work with and yielding less for more work (Dengo, 2002 *pers.comm*.). Mangroves are, however, harvested for building poles and for firewood. The continued abundance of *Muhoho* and *Mikarambati* have, up to now, prevented mangroves from being harvested more vigorously for the purpose of producing charcoal.

As in Morogoro, Zanzibar, Mtwara and Lindi, no studies have been conducted to determine charcoal consumption in the regions' headquarters. All the same, estimations have been conjectured based on known charcoal coming into the towns and those derived from the charcoal survey administered by the consultant.

Two MNRT checkpoints monitor incoming charcoal and whether or not all royalties due to the central and local governments have been paid. According to these checkpoints, a total of 119,465 and 116,085 sacks paid royalties at the checkpoints in 2000 and 2001 respectively. The amount of charcoal that entered Tanga Municipality but paid royalties elsewhere amounted to about 10,000 suggesting that some 130,000 sacks of charcoal enter Tanga per year. The NTz survey revealed that some 1,012,231 sacks are required per year to meet the consumption needs of Tanga households and service sectors. That is almost eight times more than what is recorded at the checkpoints, and there is never a shortage of charcoal in Tanga (or any other town visited).

The price of charcoal in Tanga is at about TShs 2500/sack, but some pay as much as 6000/sack only because they buy charcoal in smaller quantities (often as a *kapu* which is equivalent to 2 four-litre tins of charcoal and costs between TShs 200 and 300/=).

Charcoal originating from within Tanga and Muheza Districts makes its way into the town mostly by bicycle. Many paths bypass the checkpoints and so a lot of the charcoal goes by unnoticed. That charcoal prices range between TShs 2000 and 3000/= per sack suggests that those who sell cheaper often are those who have evaded paying royalties. Officially, as much as TShs 1000/= goes to paying royalties and some vendors have to rent a bicycle. If the seller has had to buy the charcoal rather than produce it himself, profit ranges from TShs 400 to 1000/= per bag, often on the lower scale, according to interviews with charcoal vendors who make a living by bringing charcoal into town by bicycle.

Table 9 estimated charcoal consumption in Tanga

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	130,000			
estimated household consumption	992,895			
estimated enterprise and institution consumption	19,336			
estimated total annual consumption	1,012,231	**50,612**	**588,106**	**16,803**

Dodoma

Previous studies show that charcoal consumption in Dodoma Municipality was at about 19 kg/household/month (MNRT {FBD} 2001). This indicates that a total of 451,041 sacks are consumed by households alone. Depending on which sack-to-kg values are used, this is equivalent to either 12,630 tonnes/year (at 28 kg/sack) or 25,710 tonnes/year (at 57 kg/sack as stated in the MNRT {FBD} 2001b study). The total number of sacks consumed per year by restaurants and kiosks is 58,648. That consumed by other service sectors has to be derived from total wood-fuel (as opposed to just charcoal) consumption; but since most urban services prefer charcoal to firewood, then consumption is about 43,652 sacks per year, bring the entire consumption of charcoal for Dodoma Municipality, according to the figures from this study to 553,341 sacks per year.

This means either 15,493 tonnes (using government figures) or 31,540 tonnes of charcoal were harvested to meet this demand. The total revenue collected by Dodoma from charcoal business (i.e. either the TShs 50,000/year fee or the TShs 400/sack fee) for the year ending 2001 is a mere TShs 852,750. If every sack that entered Dodoma was to pay the TShs 400/sack fee, a revenue of TShs 221,336,400 could have been generated.

Table 10 estimated charcoal consumption in Dodoma

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	2,131			
estimated household consumption	484,276			
estimated enterprise and institution consumption	100,206			
estimated total annual consumption	**584,482**	**29,224**	**339,584**	**9702**

The consultants' study was much less exhaustive than that of MNRT but came up with a similar figure: 539,882 sacks of charcoal per year are consumed by Dodoma Municipality. A study conducted by Dodoma Environmental Network (DONET) in 1997, however, indicates that the figure could be double that derived by NTz and the MNRT {FBD} 2001 studies, i.e. a staggering 1,396,560 sacks per year (DONET, 1997).

Tabora

Charcoal consumption in Tabora is unusual in that it is a town completely surrounded by public forests and so both firewood and charcoal are easily accessible. Despite the town's historic significance and large number of institutions, Tabora still remains fairly small, mainly due to poor communication networks that sometimes leave it inaccessible during the rainy season when even the airfield and railway are inoperable. Coupled with the slow population increase of the town at 3.3% per annum, the demand for charcoal within the town has not increased significantly. Notwithstanding, per capita consumption of charcoal in Tabora is still high and unlikely to be sustainable in the national context. Moreover, most household consumption of charcoal is not exclusive and institutions tend to use firewood with only a few coupling it with charcoal.

Estimating the amount of charcoal coming into the town is hindered because no MNRT checkpoints monitor in-coming charcoal and the only policing that is done concerns purchased licences. Most charcoal coming into Tabora is produced from forests on the periphery of the town boundaries with the furthest being some 30 km away.

The main markets for charcoal are charcoal yards spread out in residential and industrial areas of the town. These yards are the delivery, storage and sale points for the traders. Some traders who have been in the charcoal business for a while noted that even though charcoal is available, they now have to spend longer stretches of time in the villages to fill up a single lorry because the productive forests are further away than before. They contrasted this to a time, less than a decade ago, when charcoal was produced in forests that existed within the town suburbs.

Charcoal originates from different villages surrounding Tabora such as Igalagala and Ujerumani and is dependent largely on its accessibility and availability in a particular village. Some arrives on lorries and smaller motor vehicles, the rest by bicycle. Charcoal traders tend to sell their wares directly to households before they enter the Town.

Table 11 estimated charcoal consumption in Tabora

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	29,228			
estimated household consumption	366,703			

description	bags per year	tonnes	m^3	ha
estimated enterprise and institution consumption	21,900			
estimated total annual consumption	**388,603**	**19,430**	**225,778**	**6451**

The official figures from MNRT showing how much charcoal enters the Town are less than a tenth of what the consultant has been able to deduce from the household and business sector survey. The difference is enormous, highlighting the unpaid royalties. Of equal importance, they indicate the gap between the perceived and the true environmental cost of charcoal production at the current rate of extraction.

Shinyanga

Due to time constraints, observations and interviews that were made in Shinyanga were not as profound as those made in other regions. It is well known, however, that this region suffers from deforestation caused mainly by the tsetse fly eradication programme that wiped out a large section of the Region's forests. As a result, most of the Shinyanga's charcoal needs are met by neighbouring districts of Kahama and Bukombe.

Table 12 estimated charcoal consumption in Shinyanga town

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town 1999	40,468			
estimated household consumption	442,386			
estimated enterprise and institution consumption	35,405			
estimated total annual consumption	**477,791**	**23,890**	**277,597**	**7931**

Mwanza

Charcoal in Mwanza originates from numerous sources and is sold in town in designated charcoal yards that are not within the vicinity of the main market, but rather are spread out in various locations around the town. The main entry point for charcoal into the town is via the Kigongo and Kamanga ferries from various surrounding districts. Use of charcoal is high in Mwanza Town both at household and enterprise level although some households do use it in combination with another type of energy.

Charcoal coming into Mwanza originates from Biharamulo (Kagera Region); Bukombe (Shinyanga Region) and Geita, Sengerema and Misungwi in Mwanza Region. All charcoal entering into the city must come in via the Kamanga or Kigongo ferry and there are MNRT checkpoints at both of these entry points

There is a substantial amount of bicycle trade into the town, which was estimated by a regional forestry and beekeeping office spot-check in 2001 to consist of about 130 bicycles daily.

Table 13 estimated charcoal consumption in Mwanza

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	279,490			
estimated household consumption	535,231			
estimated enterprise and institution consumption	87,053			

description	bags per year	tonnes	m^3	ha
estimated total annual consumption	**901,774**	**45,088**	**523,021**	**14,943**

Kigoma

Charcoal consumption in urban Kigoma is relatively high with majority of households using charcoal either in combination or exclusively. The sources of charcoal are neighbouring villages all of which have public forests.

Charcoal enters Kigoma town from four points (Simbo from the south; Mlelea from KIDEA; Kwaga and in boats from the lakeshore villages) all of which have MNRT checkpoints. Sources of production are getting to be further away from the town, however, and moving into villages in neighbouring Kasulu District responding to incremental demand for charcoal.

A visit to one of the pioneer charcoal villages, Nyamoli, which is 18km from Kigoma town centre, showed that this village now has no public forest left apparently due to charcoal production. A source in the village alleged that charcoal production was introduced to the village around 1986 by charcoal producers from neighbouring Burundi who would make pyres in the Nyamoli Forest and sell the charcoal in large consignments to traders in the town and sometimes even to traders from Burundi. The local youths picked up the skill and also started making charcoal as an income-earning activity – which according to a former charcoal producer – at the time could earn them between TShs 40,000 to 100,000/= per month. Producers claim that now they can only make about TShs 20,000/= per month because of the scarcity and difficulty of finding trees. They now have to travel several kilometres to reach viable trees.

Presently the main sources of supply to the market are Kidea forest[37] and Kasengezi (Kasulu district). Some charcoal comes to Kigoma on boats from various villages on the southern shores of the lake. The boats bring in about 300 big sacks called *'ushenga'* (one *'ushenga'* holds about 1.5 times more charcoal than the ordinary sack) on a daily basis. The main sources of supply to the lake are the villages to the south of the lake (Suruka, Karago, Kirando, Sonagambele, Erembe and Sigunga).

As in all towns, bicycle vendors occupy a niche of their own in the charcoal affairs, loading 1 to 2 sacks upon their bicycles and taking them to customers. In some cases, these vendors produce the charcoal themselves whilst clearing their land for cultivation but more often than not, this is a daily business consisting of going further into the interior to villages with dense forest cover, buying the charcoal from small scale producers and then carrying it into town.

Table 14 estimated charcoal consumption in Kigoma

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	27,140			
estimated household consumption	485,890			
estimated enterprise and institution consumption	48,007			
estimated total annual consumption	**533, 897**	**26,695**	**310,194**	**8868**

37 Kigoma Development Association (KIDEA) is the legal owner of an area of forested land that was gazetted for large scale agricultural activity in the 1980s by the regional commissioner then, but extensive agriculture never took off and so the area has been steadily depleted for charcoal and the deforested parts are being cultivated on a small scale.

Mtwara

Almost all the charcoal that enters Mtwara Town does so on the back of a bicycle. Being surrounded by rural settings, most of the charcoal consumed in the town originates from less than 30 km away and often from within the municipal boundary. Unlike towns and cities located further away from rural surroundings, many of the town's residents live in or close enough to the four villages that are part of the Municipality to be able to collect firewood to meet their energy demands rather than having to buy charcoal. As a result, the percentage of people using charcoal as a main source of fuel for cooking is much less than in other towns (some 65%).

According to the survey conducted by NTz, Mtwara Town consumes some 460,300 sacks of charcoal per year, mostly by households, which on average use two sacks per month. An interview with the Forest Officer for the Municipality however, revealed that a poverty alleviation survey conducted in 2000 concluded that about 470 sacks of charcoal are required per day to meet the energy needs of Mtwara Town. This means that some 171,550 bags of charcoal are required per year, a third of what was derived from the consultant's surveys. Last year, TShs 1,496,750 were collected as revenue from charcoal, indicating that a mere 3750 bags were charged royalties (at TShs 400/sack).

Table 15 estimated charcoal consumption in Mtwara

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	171,550			
estimated household consumption	433,123			
estimated enterprise and institution consumption	17,550			
estimated total annual consumption	**460,298**	**23,015**	**267,433**	**7641**

In addition to charcoal consumed within Mtwara Town, charcoal is also exported to Zanzibar. About 100 sacks/month are transported there from the harbour. The number of bags that leave from other places along the coastline headed for Zanzibar is unknown.

Lindi

Lindi being a much smaller town than Mtwara, much less charcoal is consumed. It is however, a much more centralised town and about 75% of the population use charcoal. Lindi's consumption, according to the Municipality Forest Officer, is 100 to 150 sacks per day, much of it being produced from within the municipal boundary.

As with Mtwara, the only form of transporting charcoal is by bicycle. Vendors begin to bring charcoal to the town from first light and continue until late afternoon. Being a region with the largest public forest (beyond 3,500,000 ha) (MNRT {FBD} 2001) forests are everywhere, including within the town boundaries and charcoal is plentiful. Although there are fees and licences for producing charcoal, many of these are not paid because there are no fees for clearing land for agriculture. Last year TShs 1,200,000/= were collected by the Municipality from charcoal vendors. This amount indicates that about 6000 sacks were consumed in 2001.

The survey conducted in Lindi shows that about 236,000 sacks of charcoal are consumed per year by all sectors of the municipality. This does not include institutes such as the hospital and the missions but in any case, these tend to use firewood rather than charcoal. Considering that the current Lindi population is at about 72,000, some 3.3 sacks/capita/year are consumed.

Table 16 estimated charcoal consumption in Lindi

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	54,750			
estimated household consumption	229,151			

description	bags per year	tonnes	m^3	ha
estimated enterprise and institution consumption	6,720			
estimated total annual consumption	**235,871**	**11,794**	**137,041**	**3915**

Zanzibar

The case of Zanzibar is interesting because there is seemingly a ban on 'exporting' charcoal to the island from the mainland. Neither is Pemba or Mafia allowed to bring any charcoal to Zanzibar. All the same, charcoal does cross the sea to Zanzibar and is well received at the harbour and levied just as all other incoming goods. Visits to Mtwara and Lindi towns confirmed that charcoal does leave their ports headed for Zanzibar.

Not all in-coming charcoal lands in Zanzibar legally however; many *mashuas* and *ngalawas* anchor along the shore at night to deposit their charcoal. According to the harbour Natural Resource documents provided by the Cash Crop, Fruits and Forestry Revenue Department, some 32,000 sacks of charcoal entered Zanzibar Town port from the Mainland. This is almost equal to the number of bags recorded to have entered Zanzibar Town through the Natural Resource checkpoints in 2001 (31,000 sacks). According to the Director of the Forestry Department, the Ministry captures less than 50% of what really enters the City. In fact, it only captures 8% of what is consumed per year by Zanzibar Town residents and businesses; a total of 813,000 sacks per year are required to meet the charcoal demand of Zanzibar Town according to the NTz survey.

Despite that fact that all Zanzibari districts produce charcoal, the forests and woodland within Zanzibar are unlikely to be capable of meeting such a high demand, hence the need for 'imported' charcoal. Against this backdrop, it is very likely that charcoal smuggling will continue to occur between the Mainland and Unguja as long as the current trend of charcoal consumption continues.

Much of the charcoal produced in Zanzibar is from mangroves, harvest of which is prohibited in theory. Other species are terrestrial indigenous hardwoods which produce much preferred charcoal as well as planted exotics such as mango and cashewnut. The environmental effect of producing charcoal from mangroves is difficult to determine because mangroves are also harvested for building poles.

Table 17 estimated charcoal consumption in Zanzibar

description	bags per year	tonnes	m^3	ha
MNRT official figures of charcoal entering the town in 2001	321,000			
estimated household consumption	775,389			
estimated enterprise and institution consumption	37,392			
estimated total annual consumption	**812,781**	**40,639**	**472,226**	**13,492**

Figure 1 charcoal from the mainland arriving at Zanzibar Port

national summary

Table 18 urban Tanzanian charcoal consumption, 2002

town	bags per year	tonnes per year	m^3 per year
Dar es Salaam	5615940	280797	3262861
Morogoro	2336460	116823	1357483
Tanga	1012231	50612	588106
Zanzibar	812781	40639	472226
Dodoma	584482	29224	339584
Mwanza	535231	26762	310969
Kigoma	533897	26695	310194

Shinyanga	477791	23890	277597
Mtwara	460298	23015	267433
Tabora	388603	19430	225778
Lindi	235871	11794	137041
surveyed towns	12993585	649681	7549272
unsurveyed towns[38], say 75% of above towns except Dar es Salaam	5533234	276663	3214808
total	18526819	926343	10764081

In this national context, the figures for Morogoro look high. Probably some of it is in transit to Dar es Salaam, for which these figures probably are under-estimates (compare Van Asperen's estimate of 360000 tonnes per year, cited above in section 3.2 on page 7).

5.5 Appendix Three – the Charcoal Trade in Tanzania

5.5.1 transport

The most common way that charcoal is transported from production areas to points of consumption is by carriage on lorries and trucks. Lorries carrying sacks of charcoal that are piled much above the safe capacity of the vehicles are common even in remote areas of Tanzania. Such lorries are used by business-people who deal specifically in charcoal, providing it to urban centres. While most of these lorries have old registrations, some vehicles with recent registration numbers have been seen in Morogoro, Dar es Salaam and deeper into the hinterland (CHAPOSA 2002 & Mwaijele, 2002 *pers. comm*). The bulk of charcoal requires that vehicles with large carrying capacities be used, so that a profitable amount is acquired on each trip.

For other business-people, trading much smaller amounts, the bicycle is a reliable and common form of transporting charcoal. The distances covered and amounts that can be transported are, naturally, less. Bicycle-based charcoal trade is most common in areas where charcoal production sites are less than 30 km from potential market sources. This is the case in Dar es Salaam, for instance, where there are charcoal production sites along the road to Bagamoyo, in the Pugu Hills area, and between Kigamboni and the city. Bicycles are used to transport charcoal within the city from areas where in-coming trucks from the interior offload. At Mbagala, for example, up to 300 bicycles wait to load two to three sacks of charcoal each that they then carry off for retail around the city.

5.5.2 sale

Most charcoal is first sold at production sites (CHAPOSA, 2002) where the sack measurement is used. Sacks vary in size, however, and the weight of the charcoal contained also varies, depending on the type of wood used. Charcoal prices often take all these factors into consideration. A common tendency, however, is for sacks to be much bigger at the points of production and for charcoal to be transferred into smaller sacks as they enter the urban market (CHAPOSA, 2002). Other than making greater profit, this is a way of reducing the amount of tax paid since tax is charged by the sack, early in the process, irrespective of its weight and/or volume.

Other than by the sack, charcoal is also sold in smaller quantities: quarter-sacks known as '*viroba*', in tin buckets known as '*debe*', or in former four-litre paint tins known as '*vikopo*'. The common translation of these measures is that about five *viroba*, six *debes* and 30 *vikopo* make what is understood as one sack (*gunia*) of charcoal. Across the country, these vary slightly. Some sacks are bigger (containing eight *debe* as opposed to six), but these tend to come directly from the production sites, before reduction to smaller parcels. In towns, these are naturally more expensive.

[38] mainly Bukoba, Musoma, Arusha, Moshi, Tabora, Singida, Sumbawanga, Mbeya, Iringa, Ifakara, Songea and Kilwa.

Academic studies focus more on the weight of charcoal than on its volume. Several studies have attempted to put a kilogram-value to a sack. Such values have ranged from 28 kg/sack to 58 kg/sack, the upper scale being the most common for many of the calculations used in their reports. The government, however, asserts that a sack contains 28 kg (*Third Schedule to the Forests (Amendment) Rules, 2001, Item 5 for Charcoal: "Fees for charcoal shall be charged at the rate of Shs. 400.00 per bag for which purpose the weight of a bag will be considered to be 28 kg"*). Variable sack sizes introduce to charcoal research much scope for misunderstanding about actual quantities made, transported and sold.

5.5.3 consumption

Several studies have attempted to calculate charcoal consumption in Tanzanian towns. The Agenda-21 web-site (UN, 199_) states 'estimated charcoal consumption in Tanzania is 392,000 tonnes per annum' but all other investigations cite or project much higher figures.

All estimates and figures obtained are rendered imprecise by lack of sure and recent information on the population of the municipalities, the number of restaurants and kiosks, the number of households, and the number of other facilities that operate charcoal-requiring activities. That many kiosks and smaller restaurants operate without being registered means that often their numbers, for the sake of calculating consumption, are best estimations from a limited visual sample.

All earlier attempts to find out how much charcoal enters urban centres have also largely failed, mainly because of the nature of charcoal business. For charcoal, one may safely conclude that production is equal to consumption. No warehouses store surplus charcoal for future consumption and charcoal exports from Tanzania are prohibited by law[39].

Hence, a study that would be able to monitor all charcoal entering an urban area through legal and illegal entry-points, at day and at night, by road and railway, during the dry and the rainy seasons should reach a realistic figure of how much charcoal is being consumed in that urban area. No study has ever approached that level of dependability.

The CHAPOSA 2002 study found that in order for a charcoal business to make any profit on charcoal, taxes have to be avoided. Many of the businesses are not registered, making it equally difficult to approach charcoal business-people for information.

In a few towns, however, consumption has been measured. By conducting supplementary household and the service sector questionnaires, it has been possible to obtain some reasonably safe figures for consumption (as tabulated above).

taxes and fees

Fees for obtaining a licence to produce charcoal varies from village to village, and may be as much as TShs 10,000/= per month in some areas (*pers.comm*., Laurent Gabriel, village secretary, Mavota Village, Shinyanga). Moreover, some fees are payable to the local government and some to the central government. Those due to the latter are the requirements stated in The Forests Ordinance (Cap. 389) as 'Rules'.

In the case of charcoal produced from non-plantation forest, the licence to remove charcoal from its source of production is TShs 400/sack (assumed to be 28 kg). In the case of plantation forest, fees vary depending on the tree species felled and/or whether it is a hard or soft wood. For most charcoal however, one may safely conclude that it hardly ever originates legally from plantations or forest reserves. No revenue is collected from such charcoal.

[39] (www.ustr.gov/html/2001_tanzania.pdf)

Apart from the fees incurred (but rarely paid) by the producer, fees are charged to charcoal dealers and traders: TShs 50,000/= for each financial year. This fee is the one that all registered charcoal dealers pay, and it seems to waive the obligation to pay the TShs 400/sack fee that is charged by the MNRT. The checkpoints erected on highways along the main charcoal-trading routes are specifically for ensuring that the business is registered and/or the sack fee has been paid. This, in fact, is what makes the data from these checkpoints invalid for the determining urban consumption: only incoming charcoal with incomplete payment records enters the database; all else remains unrecorded.

5.5.4 trends

Charcoal consumption is on an upward trend. Everyone who is doing research on charcoal deduces this for the following reasons:

- charcoal prices have remained constant in the last decade making it increasingly affordable for most urban dwellers;
- electricity is unaffordable to most urban dwellers; more people move from electricity to charcoal and/or kerosene than go the opposite way;
- kerosene prices tend also to rise, making kerosene unaffordable to many as a source of cooking energy, although it is the most popular source of light energy; and
- urban growth.

Charcoal prices have not changed significantly in the last ten years. This is because the producer expends very little cash to obtain the raw materials. Charcoal at the source is very cheap (sometimes as low as TShs 500/sack). Considering how the cost of living has increased, the producer has to produce more to keep up with expenses. The need to clear more land at a faster rate is inevitable.

Woodland degradation caused by charcoal production is on the increase. Satellite imagery in areas that are well known as major charcoal producing areas, display much closed woodland turned into open woodland, thicket and farmland in the past decade. Not all of that degradation was caused by charcoal production. Sometimes charcoal production is a by-product of intended clearance for agricultural purposes.

5.6 Appendix Four – Commentary Received

5.6.1 brief comments

This section summarises comments received after circulation of the draft final report.

Table 19 brief comments received from recipients of the draft final report

commentator	post or role	institution	comment
Mr. Mwihava	Acting assistant commissioner for renewable energy	MEM	The report was well received and thorough with a good number of facts. Based on the report and internal discussions, the minister has endorsed the recommendation reduction of tax on LPG, coupled with better policing by MNRT to the Minister of Finance.
Mr.Ngereja	Principal environmental management officer	NEMC	The report was satisfactory and received a positive response from the council. Further more technical comments and recommendation swill be released after further verification research in June, but they are comfortable enough to endorse the report to the Ministry of Finance as per their attached statement.
Richard Hosier	Chief Technical Adviser	UNDP	reproduced below
Paul Y Nnyiti		WCST	reproduced below
G.A Ngoo	Environmental section coordinator	TATEDO	a good report for the clients benefit with extensive literature review by the consultant. Total substitution of LPG for charcoal should be treated with caution though because of the economic effects and emphasis should be more on sustainable management and skills transfer in the charcoal industry at all levels.
Bright Naiman		AFREPEN	reproduced below
Bariki K Kaale	Chairman	TASONABI	reproduced below

5.6.2 detailed commentary

comment by the Wildlife Conservation Society of Tanzania

We acknowledge with many thanks the receipt of a copy of your report titled “The True Cost of Charcoal” Having read through the report I should say that it is one of the best reports with enough information to set a direction for those who care about the well being of our country. In fact as you correctly pointed out we are jeopardizing our coming generations life. In other words we are digging graves for our future generation by commercialising charcoal. Charcoal burning is under normal standards an unsustainable activity. Taking into consideration the number of year the indigenous trees take to reach a reasonable maturity and size for charcoal burning and the price offered for charcoal it is obvious that such trees are not given their true value. As you pointed out charcoal is cheap because tree are taken from the woodland or forest as a free resource. This coupled with unlicensed operations and evading of all taxes makes the trading parties to give charcoal at a throw away price and therefore reducing the use of other fuels. I would think that if charcoal was given its proper price let alone its handling during cooking being a fairly dirty operation many people would prefer kerosene or even gas or electricity.

Charcoal burning is extremely wasteful. It is estimated that the conversion rate is one tone of charcoal from 10 tonnes of green wood. If that is the case how many trees die to make one tone of charcoal?

On the alternative use we are held back by the initial high costs of the gadgets required such as gas cylinders, cookers, kerosene stoves etc. before you buy the fuel or electricity. If there could be some way of subsidizing the costs of these gadgets it would encourage the use of these cleaner and environment friendly fuels.

By the way have you made any comparisons of the costs for importing LPG and charcoal even though the damage left on the ground after converting the forest into charcoal is unbearable?

Let me conclude my remarks by congratulating you for this good work which needs to be pushed further jointly by different sections be them government or otherwise if we are serious with the present devastation which is actually on the increase.

Problems associated with excessive exploitation of charcoal.

1. Poor enforcement of existing laws
2. Inadequate number of staff in the Ministry responsible for Forestry issues.
3. Undervaluing the trees and therefore charcoal sold at throw away prices.
4. Low awareness by the public in terms of laws for the protection and conservation of natural recourses.
5. Wrong notion by a section of town dwellers to prefer charcoal for cooking certain kinds of foods.
6. Fairly high prices of other fuels and their associated pieces of equipment.
7. Uncontrolled issuing of licenses for charcoal.
8. Exclusion of local communities in the protection of natural resources being important and immediate stakeholders. Locals do not see ownership of the woodlands/forests.
9. Commercialising charcoal. At domestic household levels in the rural areas it could be sustainable.
10. Poor/inefficient charcoal making methods i.e. lost calorific value too high. However efficient (process) methods could be more damaging to the forests as well.
11. Some local councils take an advantage of charcoal making to collect revenue and this practice encourages charcoal production instead of such institutions helping to control the wanton destruction of our natural heritage.
12. Lack of cooperation among the government departments in fighting these wrong doings. These leave the work of controlling the charcoal business to only one ministry (Maliasili) several ministries and in fact everybody benefits if a country is covered by a reasonable forest cover which ensures enough and permanent water flow climate amelioration, protection and maintenance of soil fertility etc.

Problems are endless. May I encourage you to go ahead with your plans for press release, conference and if possible a seminar involving all key stakeholders.

Best of luck for your efforts to serve the country.

Yours truly,

Paul Y. Nnyiti

For: Coordinator

comment by TASONABI

General comments

The report is excellent backed up with intensive literature review and consultation with various key stakeholders in natural resources management and the energy sector.

The report provides excellent illustration on the effects of degradation and deforestation in Tanzania and their impact to the country socio-economic development. Charcoal production is considered with other forest products and land uses leading to integrated analysis of development issues for urban and rural areas.

Monetary values resulting from loss of forests are well documented. Many decision-makers in Tanzania are not aware of the direct and indirect costs of loosing forests. Increased awareness will intensify policy makers’ support to up-ward fuel switch.

Specific comments

(*These were report specific and have been incorporated into the report)*

Weight of a bag of charcoal

Observations have shown that bags used for selling charcoal differ in size. Species and moisture content also influence weight of charcoal. The average weight of 50 Kg adopted by the study could be reasonable.

Follow-up activities

You can acknowledge comments and quote my name.

Findings of the study should be discussed in a brief seminar. Key stakeholders including media representatives should be invited. Conclusions of the seminar should form part of the press release.

I will appreciate to participate in the seminar. I am also prepared to provide assistance in preparing and conducting the mini seminar if required.

Sincerely

Bariki K. Kaale

TASONABI – Chairman

comment by AFREPREN

HEALTH & SAFETY ASPECT;

Referring to TOR paragraph 1, it is also expected that Safety Concern on use of Gas at household level get substantial coverage. On page 10 to 11 about Perception and Altitude, it is only mentioned that LPG stove is safer than charcoal. No fact / figures presented to support this statement. Hence is difficult to believe above statement. May be you could research on accidents caused by Gas and compare those caused by charcoal usage. To my experience fear on safety aspect of gas is among the major hindrance to fuel switch from charcoal to gas. Or you could show or mention some ways to increase confidence for potential gas user on Health & safety aspects.

FUEL SWITCH;

About switching or selection of cooking fuel at household level, not only price and efficiency that matters, but there is social/cultural value attached to it as well. In fact efficiency and price only matter to the elite minority, while larger majority other factors determine their choices.
a) Example; meat grill in charcoal stove taste (better!!!) differently than that cooked in electric or kerosene stove.
b) Type of food also determine what kind of fuel is needed to cook it.
Above factor are very important as far as women are concern, since they are responsible in food preparation at household level.

NB; To improve quality appearance of the report justify full the text in all pages.

End of my comments

Bright Naiman

comment by Richard Hosier (in his personal capacity, as an author quoted in the report)

> Greetings from Dhaka.
>
> I did manage to read the Tz Charcoal report on the way out. It seemed
> to me to be a fairly good account of what may be the outlines of the
> problem. I was glad that you included the terms of reference as there
> are a lot of other questions that I had which are actually precluded by
> the ToR.
>
> Your hypothesis that the charcoal supply system may have turned from a

> benign state to a malignant state over the past decade may well be the
> case--I would have a rough time arguing firmly either way. Our earlier
> conclusion also was based upon the understanding that the land in the
> rural areas was basically controlled--either by communities or by
> authorities or by both. If that is becoming more problematic and the
> "hit-and-run" producers are taking over, then the value of the economic
> damage function probably would increase as you see it.

5.7 Appendix Five – Other Sources of Information

5.7.1 stakeholders and other key informants

That the following people were consulted during the preparation of this report does not imply any endorsement on their part of what it contains. They might agree with some, none or all of what is written. The consultants are grateful for their advice and willingness to share their knowledge.

Table 20 persons consulted during the preparation of this report

person	post or role	institution	comment
Mr Muyungi	Assistant Director -EIA	VPO-DOE	
Mr Peter Sarawat	Project administrator	UNICEF Kigoma	
Mr Musa Uwesu	Project Manager	UNICEF Kigoma	
Mr. Julius Kiza	Forest Officer	District Forest Office for Dodoma Rural	
Ms Ruaihwa	Geologist	Ministry of Energy and Minerals	
Ms Gisella Ngoo	Renewable energy researcher	TaTEDO	
Mr. Frank Mongi	Municipal Forest Officer	Dodoma Municipality – Natural Resource Department	
Mr. Katemana	Treasurer	DONET (Dodoma Environment Network)	
Mr Sawe	Executive Director	TATEDO	
Mr Sago	Renewable energy expert	TaTEDO	report on consumption levels being compiled
Mr Kaale	Chairman	TASONABI	
	Acting Director	Tanga Town Municipality	
Mr Dengo	Forest Officer	Tanga Town Municipality	
Ms. Lusabi	Planning Officer	Tanga Town Municipality	
Mr Katyega		TANESCO	
Mr Kashula	Project Forester	TACARE Kigoma	
MrMtiti	Project Manager	TACARE Kigoma	
	District Forestry Officer	Tabora District Office	
Mr Qorro	Journalist	Sunday/Daily News	Wrote article: How cities chop down rural trees.
Dr Mbilinyi	lecturer	SUA GIS & Remote Sensing Laboratory	
Mohamed Mvita	Statistics Officer	Office of Statistics, Zanzibar Town Municipality	

person	post or role	institution	comment
	Headmaster	Nyamoli primary school, Kigoma	
Mr Mheto	Director environmental research and planning	NEMC	
Mr Mmasi	Regional Forestry Officer	Mwanza regional forestry office	
Mohamed Makaa	Charcoal vendor	Muhogo Market, Zanzibar Town	
Mr Licholonjo	Town Natural Resource Officer	Mtwara Town Municipality	
Mr Chimgugu	Town Treasurer	Mtwara Town Municipality	
Mr Shausi	Census Officer	Morogoro Municipality Census Office	
Mr Mackenzie	MNRT forestry products checkpoint officer	MNRT Mwanza	
MrSiulapwa	District Forestry Officer Kigoma	MNRT Kigoma	
Mr Mbonde	Asst. Director Forestry and Bee keeping	MNRT	
Prof. Saidi Iddi	Director of Forestry and Beekeeping	MNRT	
Mr Lyimo	Forestry Officer	MNRT	
Hadija Ramadhani	Principal Forestry Officer	MNRT	
Mr Babu Matunda	Assistant project manager	Misitu Yetu project, CARE	Gave permission to use information that Mr Kaale is processing for them
Mr Mkeya	Forest Officer	Ministry of Natural Resource and Tourism, Dar es Salaam	Provided information on levies and taxes over forestry products
Mr Mwihava	Acting assistant commissioner for renewable energy	MEM	
Mr John Paulo	Forest Officer	Maweni Natural Resource Checkpoint - Tanga	
	Acting Director	Lindi Town Municipality	
Mohamed A Chimbuli	Forest Officer	Lindi Town Municipality	
Mr Albert Jimwaga	Project Manager	IUCN –Rufiji Environ-ment Management Program	
Dr Kauzeni	Professor	IRA, UDsm	conducted research on bioenergy options for Tanzania with SEI in 1998: deals with rural areas
Dr Jambiya	Professor	Geography Dept, UDsm & CHAPOSA	socio-economic aspects of charcoal consumption
Dr Misana	Professor	Geography Department, U-Dsm & CHAPOSA	long-term resident – key informant
Mr Mwaijele	Acting District Forest Catchment Officer	District Forest Catchment Office	
Alawi Haji Hija	Officer	Department of Environment, Zanzibar	
Bakari S Asseid	Director	Department of Commercial Crops, Fruits and Forestry, Zanzibar	

person	post or role	institution	comment
Mwalimu Juma Mohamed	Forestry Officer	Department of Commercial Crops, Fruits and Forestry, Zanzibar	
Mr Kibwero	Revenue Officer - Harbour	Department of Commercial Crops, Fruits and Forestry, Zanzibar	
Dr Malimbwi	Professor and country coordinator	CHAPOSA & SUA	ecological aspects of charcoal production
Mr Iza Mziray	Forest Officer	Amboni Natural Resource Checkpoint - Tanga	
Mr Msolwa	Project Administrator	AFRICARE Tabora	
Mr Mlingana	Project Forester	AFRICARE Tabora	
Mr Mawe	Project Manager	AFRICARE Tabora	
Mr Mialla	Forest Officer		

5.7.2 documentation

Table 21 bibliography of documents consulted during the preparation of this report

author	date	title	published (in or by)	comment
Barnes, D F, and W M Floor	1996	Rural energy in developing countries: a challenge for economic development	*Annual Review of Energy and the Environment* 21 (497-530)	
Barnes, Douglas	1995	Consequences of energy policies for the urban poor	The World Bank Group	FPD Energy Note No. 7
Boberg J.	1993	Competition in Tanzanian wood-fuel markets.	*Energy Policy* 21:5 (474-490)	
Brocard, D, J P Lacaux and H Eva	1998	Domestic biomass combustion and associated atmospheric emissions in West Africa	*Global Biogeochemical Cycles* 12:1 (127-139)	
Burgess, N D, L B Mwasumbi, W J Hawthorne, A Dickinson and R A Doggett	1992	Preliminary Assessment of the Distribution, Status and Biological Importance of Coastal Forests in Tanzania	*Biological Conservation* 62:3 (205-218)	
Chidumayo, E N	1993	Zambian Charcoal Production - Miombo Woodland Recovery	*Energy Policy* 21: 5 (586-597)	
Costanza, R *et al*	1997	The value of the world's ecosystem services and natural capital	*Nature* 387 (253-260)	
Dang, H	1993	Fuel Substitution in Sub-Saharan Africa	*Environmental Management* 17:3 (283-288)	
DANIDA	1989	Environmental Profile: Tanzania. Country Strategy for Strengthening Environmental Considerations in Danish Development Assistance to Tanzania	DANIDA Department of Development Co-operation, Copenhagen	
Ellegard, A	1996	Cooking fuel smoke and respiratory symptoms among women in low-income areas in Maputo	*Environmental Health Perspectives* 104: 9 (980-985)	
ffolliot, P F, and J L Thames	1983	*Environmentally Sound Small-Scale Forestry Projects. Guidelines for Planning*	Codel Inc., NY, for VITA Publication Services	
Godoy, R, R Lubowski and A Markanya	1993	A method for the economic valuation of non-timber tropical forest products	*Economic Botany* 47 (220-233)	
Hifab & TaTEDO	1998	Tanzania Rural Energy Study Final Report, Dar-es-Salaam		
Hosier, R H	1993	Charcoal Production and Environmental Degradation - Environmental History, Selective Harvesting, and Post harvest Management	*Energy Policy* 21:5 (491-509)	
Hosier, R H	1993	Urban energy systems in Tanzania: a tale of three cities.	*Energy Policy* 21:5 (510-523)	

author	date	title	published (in or by)	comment
Hosier, R H, and M V Milukas	1992	African Woodfuel Markets - Urban Demand, Resource Depletion and Environmental Degradation	*Biomass & Bioenergy* 3:1 (9-24)	
Hosier, R H, and W Kipodya	1993	Urban household energy use in Tanzania: Prices, substitutes and poverty.	*Energy Policy* 21:5 (454-473)	
Hosier, R H, M. J Mwandosya and M L Luhanga	1993	Future energy development in Tanzania: the energy costs of urbanization.	*Energy Policy* 21:5, (524-542)	
Hyman, E L	1994	Fuel Substitution and Efficient Woodstoves - Are They the Answers to the Fuelwood Supply Problem in Northern Nigeria?	*Environmental Management* 18:1 (23-32)	
ICS	2002	Strategic Approaches to the LPG Lobby	ICS	report to Oryx, Dar es Salaam
Jambiya, George L K and Beatrice Mchome	1999	Dar es Salaam Charcoal Consumer's Study	University of Dar es Salaam	CHAPOSA
Leach G and R Mearns	1988	*Beyond the Woodfuel Crisis. People, Land & Trees in Africa*	Earthscan, London	
Malimbwi, R E, S Misana, G C Monela, G Jambiya and E Zahabu	199_	Impact of charcoal extraction to the forest resources of Tanzania: the case of Kitulangalo area, Tanzania	Sokoine University, Morogoro	CHAPOSA
Mfugale, Deodatus	2001	Indiscriminate tree felling attracts desert in Tanzania	Panafrican News Agency	press report
MNRT {FBD}	2001	Tanzania National Forest Programme 2001-2010		
MNRT {FBD}	2001	Wood-fuel consumption in selected urban areas of Tanzania.	report requested by Strategic Analysis and Planning Unit (SAPU), Dar-es-Salaam	final report
MNRT {FBD}	2001	Wood-fuel strategy options. Support to formulation of national forest programme in Tanzania		programme supported by DFiD and Finnish Ministry of Foreign Affairs
Mnzava, E M	1983	Tree planting in Tanzania. A voice from villagers	Forestry Division, MLNRT	
Monela, G C, A Ktingati and P M Kiwele	1993	Socio-economic Aspects of Charcoal Consumption and Environmental Consequences along the Dar-es-Salaam Morogoro Highway, Tanzania	*Forest Ecology and Management* 58:3-4 (249-258)	
Monela, G C, E Zahabu, R E Malimbwi, G Jambiya and S Misana	1999	Socio-economics of charcoal extraction in Tanzania: a case of eastern part of Tanzania	University of Dar es Salaam	
Mwandosya, M J, and M L Luhanga	1993	Energy and development in Tanzania, issues and perspectives.	*Energy Policy* 21:5 (441-453)	

author	date	title	published (in or by)	comment
Newmark, William D	2002	*Conserving Biodiversity in East African Forests. A Study of the Eastern Arc Mountains*	*Ecological Studies*, Vol. 155. Springer Verlag, Berlin	
Ngotezi, Alfred	2002	Tanzania losing 91200 hectares of forest a year	*The East African*, 18th March 2002	report on the Second International Workshop on Participatory Forestry in Africa, held in Arusha, March 2002
Norconsult	1991	Strategy & Action Plan for Environmentally Sound & Sustainable Development in Tanzania 1992-1997. Environmental Profile of Tanzania. Final Report to NORAD, Dar es Salaam	NORAD	
Oryx		Oryx Chap Chap	Oryx Oil Company, Dar es Salaam	promotional leaflet
Pereira, Carla R *et al*	2000	Supplying Maputo City with Firewood and Charcoal: production areas, actors and markets	Eduardo Mondlane University, Maputo	CHAPOSA
Serenje, W, E N Chidumayo, J H Chpuwa, H Egnéus and A Ellegård	1994	Environmental Impact Assessment of the Charcoal Production and Utilization System in Zambia	EE&D Series No. 32	
TANZANIA	2001	The Forests (Amendment) Rules	Government Notice 29 of 2001	
TAOMC	2001	Proposal for Change in LP Gas Tax Policy for Consideration by the Ministry of Finance, Task Force on Tax Reform, for Inclusion in the Year 2002-2003 Budget	Tanzania Association of Oil Marketing Companies	
TFAP	1989	Tanzania Forestry Action Plan 1990/91-2007/8	Ministry of Lands, Natural Resources and Tourism, Dar es Salaam	
The Addax & Oryx Group	2000	Energy for the New Millennium	Oryx Oil Company, Dar es Salaam	promotional leaflet
Total	199_	Case Study Eleven. Total in Senegal	Total	promotional leaflet
Turpie, Jane K	2000	The use and value of natural resources of the Rufiji floodplain and delta, Rufiji District, Tanzania	Rufiji Environment Management Project, Dar es Salaam	Technical Report No. 17
van Asperen, S A	2000	Improvement of Production and Management Processes of Metal-Ceramic Charcoal Stoves in Dar es Salaam	University of Twente	TaTEDO Research project
Vuai, Anne	1986	Energy Policy in Tanzania	Economic Development Institute of the World Bank	
Weischet, Wolfgang, and Cesar N Caviedes	1993	*The Persisting Ecological Constraints of Tropical Agriculture*	Longman, Harlow	
World LP Gas Association	199_	LP Gas, a Clean and Multi-Purpose Energy for All	WLPGA	promotional leaflet

5.7.3 World-Wide-Web

Table 22 list of web-sites visited during preparation of this report

Web-sites used as references once only in the report, and cited in footnotes, are not reproduced here.

author	date	title	URL	comment
Blythe	2000	Deforestation in Tanzania alarming	http://www.blythe.org/nytransfer-subs/2000af/	TOMRIC Agency via Africa News Service
Blythe	2000	Illegal Logging Cuts a Swathe across Tanzania	http://www.blythe.org/nytransfer-subs/2000af/	
CIDA	2002	Tanzania profile	http://www.acdi-cida.gc.ca/cidaweb/webcountry.nsf/	
Donald Smith	2000	When Green Earth Turns to Sand	news.nationalgeographic.com/news/2000/12/1219_tanzania.html	National Geographic News
FAO	2002	Tanzania profile – water resources	http://popplanet.org/PopPlanet/issue.cfm?countryid=3&iid=5	
ICLEI	2002		http://www.iclei.org/efacts/natgas.htm	
IIED	2002	cost of water	http://www.iied.org/agri/dowrv-truecostofwater.html	IIED home page
IMERCSA	2002	CEP Factsheet Series No. 1: soil erosion	http://www.sardc.net/imercsa/Programs/CEP/Pubs/CEPFS/CEPFS01.htm	
LEAT	199_	Environmental Law Handbook for Businesses	http://www.leat.or.tz/publications/env.handbook/	
New African	2002	Tanzania health and population	http://www.newafrica.com/profiles/Healthpopulation.asp?CountryID=49	
Oryx		Addax and Oryx in Tanzania	http://www.addax-oryx.com/news7a.html	background information
Saruchera, Munyaradzi	2000	Forests shrinking in most basin states	http://www.sardc.net/imercsa/zambezi/ZNewsletter/issue1of2/forest.htm	IMERCSA web-site
SEI		CHAPOSA – charcoal potential in southern Africa	http://www.sei.se/chaposa/chaposaresources.html	portal site
SEI		Tanzania	http://www.sei.se/chaposa/pres_tanzania.html	
TaTEDO		Increased Production and use of Improved Charcoal Stoves and Ovens for Improved Energy Services, Environmental Conservation and Income Generation, Tanzania	http://www.undp.org/sgp/cty/AFRICA/TANZANIA/pfs3998.htm	
UCCEE	2002		www.uccee.org/economicsGHG/Tanzania.pdf	
UN	199_	Agenda 21	www.un.org/esa/agenda21/natlinfo/countr/tanzania/	
UNCHS	2002	Tanzania profile	http://www.unchs.org/habrdd/conditions/eafrica/tanzania.htm	
UNCTAD	2002	Tanzania profile	http://www.unctad.org/en/subsites/ldcs/country/profiles/tanzania.htm	

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author	date	title	URL	comment
USDC	2002	US Dept. of Commerce statistics on Tanzania	http://strategis.ic.gc.ca/SSG/da91845e.html	
WLPGO		Recommendations to Policy Makers	http://worldlpgas.org/sustdev/mainpages/recommendations/casestudies.php	case studies from Brazil and West Africa
World Bank	2002	Energy Notes	www.worldbank.org/html/fpd/energy/energynotes/energy01.html#end	

6. Terms of Reference

6.1 Main Points

The Tanzania Association of Oil Marketing Companies requires a clear, convincing and credible statement of the environmental benefits likely to accrue from increased consumption of liquefied petroleum gas (LPG) in Tanzania. The purpose is to lend weight to the argument for reducing Tanzanian import duties on LPG. Notwithstanding that intention, however, the study is wholly independent and should not be biased for or against fuel-switching from charcoal to LPG. Any risks or potentially adverse impacts tending to diminish foreseen benefits should also be mentioned and evaluated.

While the consultant should be aware of the fiscal and regulatory aspects of LPG importation and use, this report is focussed upon the environmental aspects. In this context, 'environmental' should be understood to encompass ecological, social, and health and safety considerations.

The study area is Tanzania, specifically the urban areas of Dar es Salaam, Morogoro, Tanga, Dodoma, Arusha and Mwanza, plus Zanzibar, in respect of charcoal consumption, plus the rural areas from which charcoal is derived. In the time available, charcoal production and trade cannot be documented comprehensively; but sufficient examples should be given to permit reliable deductions for the purposes of this study.

A thorough search should be made for existing documentation on the environmental aspects of charcoal production, trade and use. Time available does not allow for extensive field research. Nevertheless reconnaissance visits should be made to three, at least, principal sources of charcoal supplying urban areas. Environmental observation in those areas should complement deductions made from data available in published sources and research reports.

6.2 Specifics

At present the volume of charcoal consumed is increasing annually, an unsustainable trend with adverse environmental consequences. It has been estimated that the offtake of wood-fuel, for direct consumption and as charcoal, is already double the sustainable yield of the Tanzanian forests. Insofar as possible, this assertion should be checked and the ramifications clarified.

The report should spell out the implications of fuel-switching (principally from charcoal) to LPG at various levels of future consumption, from the zero option (no more LPG than at present) to the greatest feasible adoption of the technology within an 18-year time horizon (to 2020, in other words).

In so doing, the study will forecast the environmental impacts of further increased demand for charcoal and contrast them with the effects of reducing demand by fuel-switching. Such effects impact on water catchment, conservation of habitat and wildlife, availability of timber for other purposes, soil conservation, micro-climate and aesthetics.

6.3 Outputs

The draft final and final reports will comprise clear text, appropriately supported by maps, tables and other illustrations. Sources of information will be acknowledged; documents and web-sites consulted will be listed in a bibliography.

The draft final report should be submitted to the Client, electronically and in four identical copies on paper, within eight weeks of the signature of the Contract. Within three days of comments, if any, being received from the Client, and appropriate adjustments made to the report if need be, copies of the report should be deposited with the Tanzanian environmental regulatory authorities (NEMC and the Vice-President's Office) and the Tanzanian Government Ministries variously responsible for agriculture, forestry, natural resources, energy and health, and with influential environmental NGOs, and with bilateral and multilateral agencies with energy and/or environmental programmes in Tanzania. The Consultant will solicit official written commentary on the report from all participants but most particularly and diligently from the Tanzanian environmental regulatory authorities.

The final report will be submitted eleven weeks after signature of the Contract and will contain a summary of the comments received plus, where appropriate, copies of the actual responses. At no further cost to the Client, the Consultant will supply to the Client copies of comments received after submission of the final report.