Smoke, health and household energy

Volume 1

Participatory methods for design, installation, monitoring and assessment of smoke alleviation technologies

Smoke, health and household energy

Volume 1

Participatory methods for design, installation, monitoring and assessment of smoke alleviation technologies

Written by the project team and compiled and edited by Liz Bates:

Smoke team

Kenya:	Daniel Theuri; Hellen Owala; Vincent Okello
Nepal:	Jun Hada; Min Bikram Malla: Top Kanta Parajuli; Rakesh Shrestha
Sudan:	Ahmed Hood; Afkar Osman; Mohamed Saleem
UK:	Liz Bates; Nigel Bruce; Daniel Pope

May 2005

Acknowledgements

This publication is part of a project funded by the UK Department for International Development[1]. The project team wish to express their thanks for both funding this project and the ongoing work, and for the positive encouragement and collaboration shown by DFID.

None of this work would be possible without the willingness and enthusiasm of the thirty households in each country who have welcomed the team into their homes and supported this work through their time and commitment. We hope that their generosity in time and effort to share their experiences with the project team will lead to many others benefiting from reduction in indoor air pollution.

This publication brings together a large amount of data. The authors have tried to ensure that everything presented is accurate, but would welcome any observations, corrections and additions - this programme is still 'work in progress'.

Finally, as project manager, I would like to thank the project teams both overseas and in the UK for their support and enthusiasm throughout this project.

Liz Bates

Front cover:
Mothers & children in:
Kenya (photo: ITDG)
Nepal (photo: Nigel Bruce / ITDG)
Sudan (photo: ITDG)

Rear Cover
Gatlang village (photo: Nigel Bruce / ITDG)

[1] Smoke, Health and Household Energy: funded by UK Department for International Development – R8021. The views expressed are not necessarily those of the DFID

Contents

Acknowledgements ii
Contents iii
Summary iv

Chapter 1: The problem of kitchen smoke 1
Why alleviate smoke? 1
Project background 2
Project aims and objectives 4

Chapter 2: Communities and collaborators 5
Social contexts of communities 5
Awareness- raising at local level 10

Chapter 3: Monitoring smoke alleviation 16
Outline of field methodology 16
Measuring levels of pollutant in a household 19

Chapter 4: Smoke-alleviating interventions 24
What is an intervention? 24
Interventions common to all three countries 25
Interventions in Kenya 26
Interventions in Nepal 27
Interventions in Sudan 28

Chapter 5: Methodology for data analysis 29
Baseline data on project households 29
Smoke data 30
Percentiles as a tool for examining impact of interventions on CO levels 32
Impact data 33

Chapter 6: Household data 35
Baseline data from project households 35

Chapter 7: Smoke data 40
7.1 Comparative tables of main pollutants for three countries 41
7.2 Time / activity data 48
7.3 Association between potential confounders, pollution and exposure 49
7.4 Percentiles 55

Chapter 8: Discussion and conclusions 58
Impact on smoke 58
Interventions and technologies 64
Cost of interventions 66
Overall project design 68
Monitoring 70
Ongoing and future work 72
Useful contacts 74

Bibliography 75
Glossary 76

Summary

More than two billion people cook using solid fuels; twigs, agricultural residues, dung, coal etc. (WHO, 2004) leading to over 1.6million people dying as a direct result of indoor air pollution (WHO, 2002). The technology to burn these fuels (three-stone fires or rudimentary stoves) results in poor combustion efficiency and high levels of indoor air pollution (IAP). Respirable particulates (small particles of smoke which get into the lungs) are considered to be the most dangerous pollutant, and carbon monoxide is another known hazard.

The purpose of this research project is to support large numbers of people living in poverty, especially women and children, to reduce the major health risks caused by smoke from kitchen fires, through awareness of the dangers of smoke and interventions to alleviate it. Interventions, in the context of this publication, mean any activities or technologies introduced by the project to alleviate smoke.

This publication describes a UK-Government funded research project done by ITDG in three very different communities under a Department for International Development (DFID) research grant. ITDG, an international NGO, has developed a framework to strengthen those living in poverty to work together, participating in all levels of the decision making process and leading to a sound redistribution and management of resources. Women in particular are supported through this approach. Ultimately, the process is intended to lead to a sustainable, commercially oriented approach and pro-poor policy action.

The success of earlier participatory work on this issue in Kenya raised two key issues:

- Could participatory methodology be applied to people living in very different situations?
- Could the research be developed such that instead of measuring 'the number of appliances introduced' it could seek ways to create a sustainable infrastructure, leading to long-term adoption, devoid of subsidy and not reliant on project resources?

The project has worked with around 30 households in each country, comprising:

- a peri-urban district in Kenya
- a village community in a high cold region in Nepal
- a community of displaced persons around Kassala in Sudan.

With a 'technology-neutral' starting point, the project worked with communities to identify, install and monitor sustainable interventions to alleviate smoke. This led to very different solutions in each country. In Kenya, a wide spectrum of options from very low cost 'fireless cookers' to metal smoke hoods was adopted. In Nepal, space heating is needed, and insulation, improved stoves and smoke hoods have been researched. Further research is currently under way on the smoke hoods, which were not so successful in Nepal as in the earlier studies in Kenya. In Sudan, LPG stoves were universally adopted, and the project has led to nearly 1000 households adopting this cleaner fuel.

Monitoring has been a major part of the work; to ensure that what is being promoted is having a positive effect. Smoke reduction has been the key factor for the project team, but it has been found that increased prestige and confidence, time saving and cost savings have been reported as important by those households involved in the project.

The project is now in a second phase, developing the interventions that have proved popular but have not shown the levels of smoke reduction required, and scaling up those that have been successful through commercial routes. Partnerships and collaboration have been vital to the project, and as the work enters a 'scaling up' phase, these early relationships are proving to be even more valuable. Promotion has been through radio and TV, through theatre and drama, through house-to-house visits, through exchange visits, and through Smoke Alleviation Forums, set up nationally in each country. ITDG has also campaigned successfully to raise awareness of this issue at international level.

Chapter 1: The problem of kitchen smoke

Why alleviate smoke?

More than two billion people cook using solid fuels; twigs, agricultural residues, dung, coal etc. (WHO,2004). The technology to burn these fuels (three-stone fires or rudimentary stoves) results in poor combustion efficiency and high levels of indoor air pollution (IAP). Respirable particulates (small particles of smoke which get into the lungs) are considered to be the most dangerous pollutant, and carbon monoxide is another known hazard.

The World Health Organization's 'World Health Report 2002', indicates that over 1.6million people die as a direct result of IAP, mainly caused by cooking fires in their homes (WHO, 2002). This is approximately double the global death toll resulting from global urban air pollution (around 800 thousand people). Children are the most at risk, so the 'years of life lost' are even more extreme – 35 000years lost as a result of IAP compared with 6400 years for those affected by atmospheric pollution in urban areas.

There are a multitude of reasons why this situation has not received more attention:

- The people concerned are very poor and often biomass can be obtained at no monetary cost – and time cost is often not considered
- A lack of recognition of the scale of the problem by policy-makers until very recently
- Lack of funds, at government level, to address the scale of the problem
- The low status of women and children in many poor communities
- A failure to recognise that fuel-efficient stoves do not always alleviate smoke (Ballard-Tremeer, G.,1997).
- Rural electrification is seen as the key to poverty alleviation, though non-grid systems seldom produce enough power for cooking, people who are very poor cannot afford it for anything more than basic lighting. The many household enterprises that use biomass are often overlooked, in development circles, in favour of electrification.

Cooking *kisra* using traditional stove Sudan
(photo: Nigel Bruce)

Participatory methods

ITDG has developed a framework to strengthen those living in poverty to work together, participating in all levels of the decision making process and leading to a sound redistribution and management of resources. Women in particular are supported through this approach.

A participatory approach has well-defined features that engage the project communities at all levels.

ITDG / Practical Action

ITDG is a non-governmental organization (NGO) whose vision is of a world free of poverty and injustice in which technology is used to the benefit of all. Its mission is to eradicate poverty in developing countries by developing and using technology, and by demonstrating results, sharing knowledge and influencing others. The organization believes that the best way to alleviate poverty and suffering in a country can be found within people themselves. **ITDG has recently changed its name to 'Practical Action'**

Common themes and principles in participatory development (PTD) practice include:

- That the community is the main actor in any development initiative
- That the outsider's role is basically supportive to the local efforts
- That the development activities should be oriented towards needs as perceived by the community
- That indigenous knowledge has an important role to play as a basis for action, support and strengthening
- The challenge is to tap the potential interaction between indigenous knowledge and that of outsiders.

Details of a Participatory Technology Development Training meeting (one of several participatory activities) are shown in Annex 1.

Consulting with a women's group, Kisumu, Kenya (photo: ITDG – EA)

Informed international policy action

If there is to be a major step change, an international concerted effort, and the involvement of governments and international bodies such as the World Health Organization and the World Bank, is needed to identify affordable and appropriate means to enable people to get rid of kitchen smoke. Over the recent past, these key organizations have become active in this field and knowledge of successful interventions is urgently needed to support the policy agenda (Warwick, H. Doig, A. 2004).

Project background

In 1998, ITDG ran a successful pilot project in two communities in Kenya, alleviating smoke in rural kitchens (Bruce, N. et al, 2002, Bates, E. et al 2002). The participatory approach produced very positive outcomes, both in terms of smoke alleviation, and in other indicators, such as time-saving, prestige and improved hygiene. What emerged was a methodology, working with people on very low incomes, which dealt with the issue of smoke alleviation in a way that suggested that it could be developed to be both replicable and sustainable.

Key to this approach was a technology-neutral starting point – a process of consultation with the community on their wishes, coupled with a baseline assessment of resources and skills, leading to appropriate and effective technologies being introduced.
The success of this pilot work raised two key issues:

- Could this methodology apply to people living in very different situations?
- Could the research be developed such that instead of measuring 'the number of appliances introduced' it could seek ways to create a sustainable infrastructure, leading to long-term adoption, devoid of subsidy and not reliant on project resources?

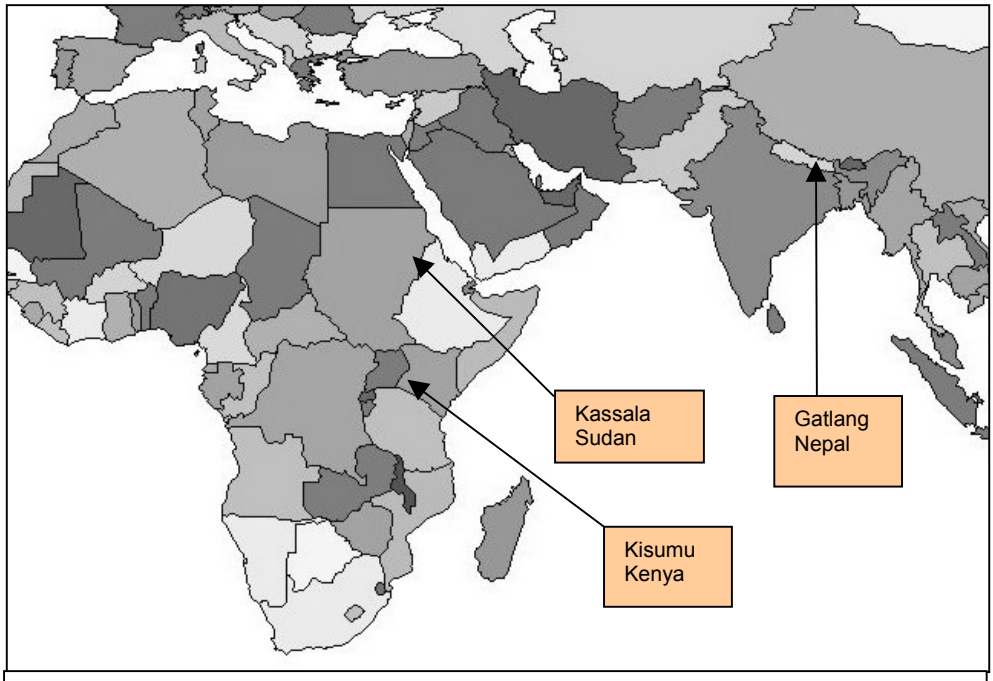
If people have very low incomes, the technologies must work well or the expense will merely lead to greater poverty; if the technologies are to be effective, people must want to use them. This publication describes a UK-Government funded research project done by ITDG in three very different communities under a Department for International Development (DFID) research grant. A second project, developing and evaluating methods for scaling-up, is currently ongoing (2005) and will form Part 2 of this publication.

The project has worked with around 30 households in each country, comprising:

- a peri-urban district in Kenya
- a village community in a high cold region in Nepal
- a community of displaced persons around Kassala in Sudan.

Project locations

Within those countries where ITDG has offices, the project areas were selected to reflect a range of settings and challenges for developing and testing the participatory methodology. Working with local teams ensured that ITDG was already known, and the socio-cultural aspects of working within a household could be sensitively handled.



Project locations in Kenya, Nepal and Sudan

Kenya
Two communities, close to the town of Kisumu in West Kenya, were selected; Kajulu in North-eastern Kisumu, and Otonglo, in West Kisumu. By selecting two separate areas of the town, scaling up and wider dissemination would be more effective
(photo: ITDG-EA)

Nepal
A rural community was chosen in Gatlang, which lies 148 Km north of Kathmandu, close to the border with China, at the altitude of 2200 meters above sea level. An earthen road that is intended to be all-weather reaches it, but during the wet season, landslides blocking the road from Kathmandu to Gatlang make travelling hazardous.
(photo: ITDG)

Sudan
Displacement, due to civil war, conflict in neighbouring countries, and drought, has been identified as the main causes of sudden growth of urban areas and consequent severe biomass shortages. A poor household residential area (Wau Nur), part of Kassala (Eastern Sudan), was selected for project implementation. The community of Wau Nur is situated just outside the town walls of Kassala, in the east of the country.
(photo: ITDG)

Project aims and objectives

The purpose of the project is ultimately to help poor people, especially women and children, to reduce the major health risks caused by smoke from kitchen fires, through awareness of the dangers of smoke and interventions to alleviate it. *Interventions*, in the context of this publication, mean any activities or technologies introduced by the project to alleviate smoke.

The project planned to achieve this goal through empowering people living in poverty to reduce the major health risks, especially to women and children, through a participatory process that:

- Engaged the communities involved in a dialogue on the dangers of smoke
- Engaged other key actors in the project at both practitioner and policy level
- Identified appropriate ways to alleviate smoke
- Tested whether those methods were effective both in terms of the amount of smoke removed and other indicators of positive impact identified by both the community and the project team
- Disseminated those findings at community level and at national and international level
- From the outset, the concept of the project was that it would ultimately be scaled up so that interventions could reach hundreds of households. For this, all approaches were around affordable interventions that could be sourced, installed and maintained by each community. This sustainable infrastructure is the basis of the second project currently taking place (2005).

Chapter 2: Communities and collaborators

Social contexts of communities

Project locations in Kenya

Kisumu town comprises many communities, and criteria were used to identify the most appropriate for the project. The Kenya team identified the following criteria:

- Not in the centre of Kisumu, where most people use some form of 'clean' fuel, so the indoor air pollution is not so great a problem
- Not in houses rented to the very poor – it was felt that any improvement in these houses would make the homes more desirable, and therefore the owners would increase the rental, and they would be evicted – the risk of an adverse effect on this group needed to be avoided. Further, it would inhibit the types of structural interventions that could be installed without the owner's consent. Finally, the potential for people leaving would be greater during the project than in they own the houses.
- The households selected should live in areas where the occupants use mainly biomass but live within the money economy of the town.

Kenya households: Most households in this district have metal roofs, but some still have thatch (photo: ITDG-EA)

The two communities, Kajulu and Otonglo, with whom the project is working, are located in Winam and Kadibo divisions of Kisumu district. Within the two communities, the majority of householders are small entrepreneurs; in Otonglo, many women sell fish for their income, whilst in Kajulu, they mainly sell agricultural produce. Some of this produce may be cooked before sale, e.g. maize, so this aspect of energy use must be taken into account. Other aspects of the lifestyle include:

- The families in these areas tend to be large
- There is a mix of styles; most houses have metal roofs, but some still have thatch. Some of the kitchens are integral with the main house, some are separate.

Many people in the community are poor in terms of both income and assets. Within the project there are households on a range of monthly incomes. Some of this income is 'in kind' – mainly foodstuffs – as well as cash.

- Upper range (e.g. husband is a primary school teacher); Ks5000 – 7000
- Middle range (owner of a small enterprise) ; Ks 2000 – 5000
- Very poor (unemployed or casual labour); Ks < 2000 ***(Ks1000~£6.90)***

Weather in Kisumu town	
Wet months	March → June
Variable	July → September
Dry months	November → February

The area receives average rainfall that amounts to 500mm in long rains and 200mm in short rains. Geographically, Kadibo has a gentle contours, making the area flood-prone due to poorly drained soils, basically clay with a bit of sand in some isolated parts. Winam has more urban settlements clustered around Kisumu town.

The major crop enterprises are maize, sorghum, cowpeas, green-grams, and irrigated horticultural crops e.g., tomatoes, kale and rice, cotton, onions and some arrowroot in the swampy areas. The livestock enterprises include local poultry, cattle, sheep and goats.

The community is involved in various other development activities e.g., opening drainage channels, de-silting rivers of water-pans to harness water for agricultural use in Kadibo division. Floods and droughts are the main problems affecting food production in the community, and flood control and water harvesting for agricultural production is one of the coping strategies being advocated. The food security issues tend to overshadow all other efforts, and form a central part of any developmental effort that seeks sustainability.

Fuel use

Fuel is both gathered and bought in this region. There is insufficient fuel for gathering because people own little more than the land on which their homes are built. Some wood fuel and wood shavings (low cost) are bought and charcoal is bought for speed of cooking. Kerosene is used for lighting, but there is very little fossil fuel used for cooking.

Community organizations in Kisumu

The CBO's (Community Based Organisations) are social networks and gatherings that exist to serve several purposes. The most common are the 'merry go rounds' that function primarily as a savings mechanism for women that are involved in largely similar pico-economic activities. Some are purely commercial - meaning that the women meet at the market place where they sell their goods, and put a specific amount of money in a common kitty. The money goes to individuals, and lots are drawn in advance to determine the times in the month when each woman draws her funds. The membership is mostly female, except in the market groups where some men are members.

Most women belong to three or more merry go rounds. The social welfare groups meet in members houses/homes at specific times, but the merry go round principle operates here as well, with the added flavour of sympathy, support, prayers and other expressions of social networking - meals, purchases of gift items, celebrations. The groups are registered with the ministry of culture and social services, and exist in the thousands. Leadership is well structured, with the chairlady, secretary and treasurer's offices well recognized.

From anecdotal evidence, these groups have bought land, furniture, capital goods, livestock, household goods and so on. They also lease land for agricultural production and till it as members and support members in raising money for paying school fees, traveling distant places, etc.

The group types are varied - levels of income determine membership in certain groups, but almost all women belong to one group or other, even the salaried women living in the urban centres and having formal jobs. The meetings are important for sustainability, and the regular ‘donations’ (participation in which guarantees members support for the diverse social needs that arise from time to time), assures group longevity.

Some groups are clan oriented, i.e., women married into a certain clan form a group, women who come from the same geographical area and get married in the same sub-location or village form others. Others are formed by widows, farmer-groups types, agency groups - groups initiated by other NGO's or agencies for the purpose of propagating their work, such as planting trees or fruits.

The community in Nepal

The criteria used to select the project site in Nepal required that the site was to be in the high hills area where the community use biomass as an energy source for room heating as well as cooking. It was agreed that it would be better to select a region where there were not already household energy programmes taking place. Finally, because of the need to take smoke measurements and characterise the community with whom the project was working, the location had to be reasonably accessible.

Gatlang village – view from elevated ground (photo: Nigel Bruce)

The site selection team held detailed discussions with women's groups, local bodies representatives, non-governmental organisations (NGOs), school teachers, health post staff etc. in the villages. Based on these activities, the team recommended Gatlang village for project implementation.

The houses in Gatlang are of thick, well-constructed dry-stone walls, mainly comprising an open ground floor for cattle and fuel storage etc., a living area on the first floor, and a storage area above. The quality of floorboards, doors, window frames etc. is exceptionally high – often including fine carving. The roof is made of long wood tiles, which are replaced regularly and, it is said by some, depend on the smoke for their strength and resilience. There are about 250 houses in the project village, with other Tamang villages nearby. Although the village houses are well built, there is very little provision for water and sanitation, no provision for evacuating smoke, and food security is a major problem. Respiratory illnesses are reported (by local health department) to be the main source of ill-health in the community.

The major crop is potatoes, and beans, millet, buckwheat, apples, and a small amount of rice are also grown. During the monsoon season, the land appears rich and fruitful, but there is a glut in potatoes at this time, so local prices are very low, and transporting them is difficult due to landslides that isolate the village from the nearby town of Dhunche. At other times, the weather is bitterly cold, or there is drought, and food security is a major problem. Beer is brewed on the same stove as that used for meals. This is a design constraint as the brewing pot is about 0.5m across, and 0.75m high.

The community in Gatlang is almost completely Tamang, with their own culture and language. A few households, considered a lower caste (Bishwokama), live in harmony within the community. Festivals, mainly occurring in October and November, are a large part of cultural life, and many of the usual cooking activities are disrupted at this time. Festivals also use much of the surplus income that people earn - people really value them and they are an important part of community life.
The climate falls into three distinct categories, with mixed periods between:

Weather in Gatlang	
Winter; snow – mainly dry	December – February
Dry	March – May
Wet	July– September
The months of June, October and November are mixed.	

Fuel use

Fuel is used for cooking, space heating, brewing beer, drying crops etc. The fuel is one of two types only: pine wood - both twigs and large cut branches, and crop residues. Use of these

fuels is seasonal; During the rainy season, stored chopped up logs will be used (gathered by the men from the far forests) , whereas during the dry periods, residues and twigs collected locally by women will be used. Space heating is needed for six months of the year.

There is a ban on gathering live wood, so none of the wood is 'green'. This has a bad impact on the only other fuel source, charcoal, which is used solely by the blacksmith. Charcoal is more easily made from 'green' timber.

Due to pressures on resources, women find it increasingly difficult to gather wood locally, and men find it takes longer to gather larger pieces of wood legally from the high hills. Food, mainly of potatoes, is cooked using a three-stone fire and a tripod. Although electricity has reached the village, mainly for lighting, only a fraction of households are connected, the electricity supply is unreliable, and lighting is mainly by kerosene wick-lamp.

The Sudan communities

The main target groups of the project are Internally Displaced Peoples [IDPs] from Southern Sudan, Nuba mountains region and local displaced population from eastern region (Beja and Beni Amir) living in the peripheral zones of Kassala city. The estimated number of households is around 3500. This community lives around Kassala town (Wau Nur, Kadugli) and Gedarif town (Jebel Marco).The settlements have recently been legalised, with people receiving formal documents for their plots. However people are poor and are not able to build their homes with robust building materials, and they lack the basic infrastructure services, mainly heath, education and security.

Originally these displaced people were rural peasants and pastoralists who have been evicted from their environmentally productive functions that are structurally tied to the provision of essential livelihood resources. The main coping mechanism at their disposal depends on family labour including the children.

The presence of about 95 000 refugees has further reduced labour opportunities for the vulnerable IDPs. This environmental insecurity for the displaced people has been further aggravated by ethnicity, religious problems, and social exclusion. Women's Development Associations were set up by ITDG to help resolve these problems.

Women have been traditionally restricted to domestic and reproductive roles in most Sudanese societies. The long-term fighting in Sudan has left many women without fathers or husbands, struggling to keep their families going. In the Kassala region over 85% of the women in the project are widows, divorced or household heads. In towns dominated by poor people and those displaced by drought and war, women tend to be burdened by all household needs including income. In addition, the areas are annually exposed to floods.

Weather in Kassala	
Dry	October – June
Wet – prone to flooding	July – August / September

Women lack access to basic services and resources including health, employment, education and skills. They live in deteriorating household environments, and since they are at home most of the time, smoke affects them more than the men who are often away from the home. There is discrimination against women in the formal sector and they lack the necessary skills relevant for competition in the urban environment job market, so they are left with no opportunity other than seeking informal sector employment. In addition, due to lack of legal recognition and lack of access to capital or credit, women are particularly vulnerable to discriminatory legislative attitudes, low wages and hostile public attitudes including harassment and oppression.

Houses in Wau Nur, Kassala (photos:ITDG)

Women's Development Associations (WDAs) were created by ITDG and since their inception, in 1994, over 13 000 women have been trained in marketing skills for both food security and now selling household energy products. The decision to train women is based on their status, their traditional role in society and their knowledge. ITDG looked at the needs of the poor, the potential to expand the productive sector, and the chances for intervention. They were set up with the following criteria:

- That women were able to organise themselves into productive groups.
- That each group is able to manage the training and ensure that members benefit practically
- That training given is suitable to the needs and resources of the groups and their local areas.

Initial training was based on sustainability, Training of Trainers (TOT) who then went on to train other women in their area and recruit new members to their WDA. The women were also encouraged to work as a group to access funding by legalizing their organizations and looking for funds and loans to implement further development activities. ITDG's initial input was providing training in technology and management, a revolving fund to buy materials, agricultural support and marketing support. From that start, WDAs have been required to manage their own growth.

Fuel use

Within the community, charcoal and wood are normally used in combination: charcoal for making tea, meat and soup (eaten with *kisra* – a staple 'pancake' made from sorghum) and wood for cooking the kisra and porridge. Almost all the fuel is bought due to the scarcity of biomass. Both firewood and charcoal are burned on traditional inefficient stoves; firewood on three-stone fires and charcoal on metal stoves. For the size of family described above, a survey showed that the monthly costs were between SDD5000 - charcoal - SDD1500 and wood - SDD3500; and SDD5500 -charcoal - SDD1750 and wood SDD3750 **(500SDD~£1)**.

Households are aware of Government policy that aims at increasing the use of LPG by the domestic sector in order to reduce environment degradation caused by heavy pressure on forest resources. The newly established Khartoum refinery produces LPG at a rate of 650 tonnes/day. Policy measures were announced to promote widespread local use of LPG, particularly in the household sector. However, although this action facilitated the widespread accessibility of LPG appliances, it did not support a large proportion of the household sector that does not have access to credit. In particular it prevented urban poor households living on the peripheries of the cities and towns benefiting from this fuel.

Selection criteria for project households

The selection criteria for households in all three countries were: the family was interested in the aims; the house structure should be typical; there was one or more children less than five years; the family was prepared to accept the questionnaires and pollution monitoring over the three years of the study; and they should be keen to implement changes to the homes in consultation with ITDG staff.

Selecting participants

It was decided, for reasons discussed in Chapter 8, to involve around 30 households per community, and use a before-and-after design, with careful attention given to the assessment of factors other than the intervention that might affect pollution, exposure and other outcomes of interest, and change over the course of the study. The assessment and adjustment for these possible 'confounding' factors is described fully in later sections of this report.

Kenya

The community members together with ITDG and household owners were given a clear understanding of the monitoring process, which involved interviews and measurement of smoke and personal exposure. The community itself selected each of the project households, through the women's groups, perceiving each selected household as their representative household from whom they are to learn. The selected household owners expressed their willingness to work with ITDG for the project duration. Finally, a schedule was agreed between the team and the households involved, giving the households time to prepare for the activity.

Nepal

A survey team visited *Gatlang* village to identify the participants, their homes, location and other local collaborators. The survey team held meetings with the local saving and credit groups, Health Empowerment Committee, and community group members. At the meetings the team informed them about the participants selection criteria and project activities. The criteria for household selection were that they were to belong to a poor community with the majority from disadvantaged groups (occupational, ethnic and minority groups). The community had to be willing to participate in the project and make the necessary contribution to the project in terms of time and commitment. A mass meeting of the community members selected 31 households who fulfilled the criteria. All the selected households made a formal commitment that they would support to the project.

Sudan

The Wau Nur development committee organised the selection of the 30 women from those expressing an interest. Initially they were a little reluctant to participate because they felt that holding such strange [monitoring] equipment was a risk. Rumours had spread that this equipment might transfer disease or cause them trouble. This concern was short-lived, and when it came to implementation of interventions, the women were very collaborative, making the final choice of intervention (LPG and kitchen modification), and selecting repayment method for the distributed cookers, cylinders and hot plates used for cooking *kisra*.

In all three countries, this approach to sampling was judged more likely to lead to success of the project than if a random sample was chosen. Information on the household, house (windows, doors, ventilation), stove type, fuels, and cooking (food types cooked, numbers cooked for) during the 24 hour periods of air sampling, was collected by interview using a questionnaire developed for the purpose.

Awareness- raising at local level

The participatory process

Kenya

Community groups elected community representatives, using a set of criteria provided by ITDG Kisumu staff. These representatives (not necessarily project households) acted as key informants for the group, creating an interface between the group and ITDG through which ideas could be channelled. The representatives were trained to help in baseline information gathering; they assisted in mobilizing the households to carry out project activities (such as regular meetings) and during the installation of interventions. Kajulu has more than 20 000 households, grouped in villages. Each of the household representatives was selected for 1-2 villages.

(photo: Nigel Bruce/ITDG)

Case study: Technology selection - Nepal

Selection of appropriate technology for indoor smoke alleviation was an interesting issue for all the villagers. This issue was discussed many times in the community meetings. They even formed a "Technology Development Support Committee" having five members to provide input in technology development.

A community meeting was held in the village on 22nd Saturday 2003 to select best technological solution for indoor smoke alleviation.

Most of the project participants, school teachers, local health workers and one member of Search-Nepal (partner NGO) were present at the meeting. ITDG Nepal staff helped the participants to aware with available intervention options, using models to illustrate the two main ideas (smoke hood and improved cooking stove). The participants were informed about the benefit of plastering the walls. An active discussion was held. The participants expressed the wish to try out both types for while, before deciding which was best. The community pointed out that smoke has positive effects such as preserving wood and reducing insects in grain and beetles in wood, which need to be regarded during technology development. Despite this, the community are eager to install smoke alleviation solutions.

Sudan

The project worked with sixty women, organised into five groups according to their settlement and each group formed a focal point for reduction of indoor pollution. From the groups thirty were selected for the research. The organisational capacity of the Women's Development Association was strengthened by the formation of a sub-group; the Women's Group involved in the Reduction of Indoor Pollution(WGRIP) especially on advocacy, lobbying and networking for their basic needs in heath, education housing and energy

Making the process inclusive

The team in Kisumu have collated various ways to alleviate smoke and set them in a table for 'short, medium and long' term' for those who cannot afford smoke hoods right away (Table 2.1) – some of them are 'for free' like keeping themselves and their small children away from the fire as it lights up – through to the installation of a smoke hood. Whatever a person's circumstances, the team ensure that there is something that they can do to improve their situation so that they take on the information and make it their own. This key approach is described by one of the team members as follows;

> **Awareness creates an immediate desire to take up an intervention and apply the new knowledge. It is a time where all things are possible and the magic of new knowledge creates a momentum.**
>
> **If this is not expressed in the short term the momentum is lost, and the [no-cost and low-cost] interventions available in this period serve to keep the beneficiaries 'warm' - they are engaging in the process of technology uptake and making a commitment, and this is important to us, as we work with them with reference to the long-term interventions.**

Table 2.1: Time / technology matrix for adoption of smoke-alleviating interventions - example from Kenya			
User/ context	***Kitchen***	***Fuel***	***User***
Immediate term	Cooking outside on a shielded fire (see Glossary)	Better fuel preparation such as drying	Cooking to conserve techniques Behavioural interventions User education
Medium term	Using a portable improved stove	Fuel combinations such as fireless cooker (see Glossary)	Behavioural interventions such as identifying a safe place for an infant to stay away from the cooking fire
Long term	Building an improved kitchen, including a smoke hood (see Glossary) and inbuilt stove	Fuel switching Use of gas, solar cookers, and other clean energy technologies.	Spending less time in the kitchen, made possible by better fuel burning techniques

Stakeholder involvement

Table 2.2 indicates the roles of the various stakeholders involved in the three countries of the study. Meetings have been held since the early stages of the project with potential collaborators including District Officials (Social Services Development, Cultural Services, Public Health, Divisional Officers, Planning Office) and NGOs. These meetings ensure the participation and assistance in project implementation, and further disseminate and transfer experience to other communities and localities. The formation of partnerships is key in creating a sustainable infrastructure for smoke alleviation. Partnerships varied with country.

Table 2.2: Role of collaborators	
Type of collaborator organisation	**Their role**
Women's (and other) community-based organisations	Acting as a focus within the community for all the activities within the project. Support in community mobilization, awareness creation, dissemination
International NGOs	Building capacity and supporting the organisation of national workshops on smoke alleviation
National Forums for Indoor Air Pollution and Health	Created during the project but with the intention of it becoming autonomous in each country
Local government offices & officials	May be required to give permission for the project to take place and can be very supportive in community mobilisation and awareness-raising
Environmental groups	Creating awareness on the dangers of smoke and fuel use in general
Local entrepreneurs and private enterprise	Manufacture and development of technologies
Health practitioners and Ministry of Health	Awareness-raising on dangers of smoke
Private firms	Supply of capital equipment such as LPG stoves – useful to involve as they may provide credit
Local universities	Support in data entry and (in Kenya), laboratory analysis
National Bureau of Standards	Laboratory analysis for particulate pollution measurement (in Nepal and Sudan)

Case study – report on role of partners in Sudan
The project partners have a great role to play for the success of the scaling-up of the project. The State Ministry of Health, FNC, Environment Conservation Society, and the Civil Defense will continue their original role in training and awareness.

The partner NGOs will be encouraged to participate in funding some of the project activities in order to cover all the WDAs' branches in Kassala and Gedarif. ACCORD has already started co-operation with the project and is willing to continue. Its participation is highly appreciated, but the project has to consolidate this cooperation through a signed agreement clearly stating the roles, activities and work-plan.

The private sector and particularly the Nile Petroleum Company will approached to further cooperate with the project. An important message is that profit resides in ongoing LPG sales rather than initial purchase of cylinders. Beside that the company has to accept selling the cylinders on instalments rather than paying 50% in advance and 50% on instalments (6 months). Also the Nile Petroleum can play a role in providing the LPG appliances (gas cooker and kisra plate) at lower prices than presently available in the market. Nile Petroleum provides a package comprising of cylinder, gas burner and kisra plate.

Involving local entrepreneurs
Local entrepreneurs have knowledge of availability of raw materials and manufacturing skills. They have a vested interest in 'getting it right' as they will be the ones for whom any technologies add extra products to their range. They also have a good understanding of the affordability of products and how cost reductions in manufacturing can be implemented. If they are regarded as partners, rather than beneficiaries of a manufacturing methodology, their local knowledge can be important.

Role and effect of government

Local government
The relationship between this project and local government has been very positive, with support from health, development and energy departments in terms of active collaboration having a very positive effect.

In Kenya, the health department has encouraged the team to disseminate smoke alleviation to a very wide region around Kisumu. It has pledged support for many of the initiatives, including radio broadcasting and involvement of the teams who visit households and discuss health issues.

Nepal has a policy whereby each project has to be approved at local level before it can go ahead. The local government has been highly supportive of the project.

In Sudan, the Ministry of Health and the Civil Guard have been active in the field of safety demonstrations and household visits to ensure that the LPG is used safely.

National government
A project can only be successful in the longer term if successful interventions can be disseminated widely within the region and country as a whole.
In Nepal, the Forum set up by the project team has benefited from government personnel as part of the team. In Sudan, the national Government encourages LPG use as an alternative to biomass fuels**.** Incentives set by the Government are in terms of LPG price reduction and exemption of LPG appliances from custom.

Workshops
In each country, awareness-raising workshops for participating households were held on:

- The negative impacts of smoke on health of women and child (under 5 years).

- Alternative household energies as substitutes for wood and charcoal.
- The best ways and means to supply alternative energies for household as substitutes for wood and charcoal.

Table 2.3 shows the workshops held in Sudan in 2003 on dangers of indoor air pollution and possible means of reducing smoke:

Case study: Table 2.3: Report on awareness raising workshops - Sudan		
3 mobilization sessions for raising the level of social and cultural awareness about heath hazards associated with biomass fuel	The first three weeks of January. [2003]	3 awareness meetings for 45 women were held it discussed the fuels types and usage (wood, charcoal & agricultural residue)
One-day workshop about heath risk caused smoke for women and infant children.	8/1/2003	Ministry of health considering as a main partner for the project it was curried one-day workshop about the negative impact of smoke in the women health and children less than 5yaers.
One-day workshop for alternative fuels options.	30/1/2003	Sudanese environment conservation society and solar project were curried one- day workshop about alternative energy (solar energy, improve stoves, electricity & LPG)
One day workshop : Types of smoke reduction interventions	5/2/2003	The staff project were held one – day workshop for the participants women & partners to prioritise the areas of interventions and to formulate the work plan (Participatory approach).
One-day workshop on safety measures.	24/2/2003	One-day workshop for demonstration of safety measures regarding the usage of LPG # of women who were participated is 45.
One day workshop with the participants on costs.		To discuss the finding of the market survey [discussed later in the book] for the cost of alternative household energy. Introduction of LPG and improved stove for the poor, especially for IDPs where average income per month ranged between SD7500 toSD12000 will improve their livelihood and create new jobs for the future

Rallies and meetings

Large gatherings of people can provide a good forum for highlighting the dangers of smoke, especially if the target group is right; an example from Kenya was at the International Women's Day. The team in Kenya has worked with around fifteen women's groups in putting together drama, dance and song that is presented at local and regional meetings, providing a powerful message. Objectives, attendance, plans were recorded, as in Annex 2. A record of each community meeting was used to contribute to reporting, accounting, and determining the cost-effectiveness of each activity.

Media

A typical set of programmes, devised by the ITDG Kenya staff, is given in Annex 3. This type of public awareness should not be overlooked, as it can be highly cost-effective. It also improves morale of the community and the field team if they see that the work they are doing is reaching a large audience. In Kenya, the households working with ITDG were very enthusiastic in recognising they were pioneers in the search for ways to reduce indoor air pollution.

As a follow-up to a set of radio broadcasts, a question and answer programme had callers as many as 15 to 18 on queue at a time, and calling almost exclusively out of the district - Migori, Eldoret, Bomet and Iten, with almost no callers from Kisumu district, on the KBC slot between 9 and 10pm. The callers wanted to know largely about how to remove kitchen smoke from

their kitchens, and also where to get more information on the same. One asked about cigarette smoke, and another about smoke from burning textiles.
The team realised that there is a deeper interest created by the program than even they had thought likely, extending to outside the province to Rift Valley province. The radio section that was used was selected on a cost basis to reach as many people as possible as cheaply as possible, but may have failed to reach a lot of listeners within the district, who are strong adherents to another station that is a bit more costly. Further efforts will be made, as this method of dissemination is proving highly effective.

Solar Cookers International (SCI), who promote the Solar Cookit, having listened to the radio broadcasts, took the theme of smoke reduction as a rider for promoting their solar cooker as a zero smoke technology. The programme lasted 30 minutes and they had a live call-in session with specific preference to women callers, whose questions received first attention. Nevertheless, the bulk of the callers were men. The reduced smoke is for SCI a selling point, with some general reference to improved health. It is a sign of the good collaboration between the organizations that the project officer sent a message to inform the team of the broadcast.

Exchange visits

Exchange visits involve transporting members of the participant community to a different village where interventions have already been installed. This has proved extremely effective in Kenya – a case study is provided in detail in Annex 4.

Case study – Kenya
Both men and women from the community households were taken to see kitchens improved during earlier projects, when smoke alleviation and other cleanliness improvements had been undertaken. Men were involved because kitchen building and maintenance is their responsibility and they are part of the decision making within these communities. These exchange visits sensitized the community members to possibilities.

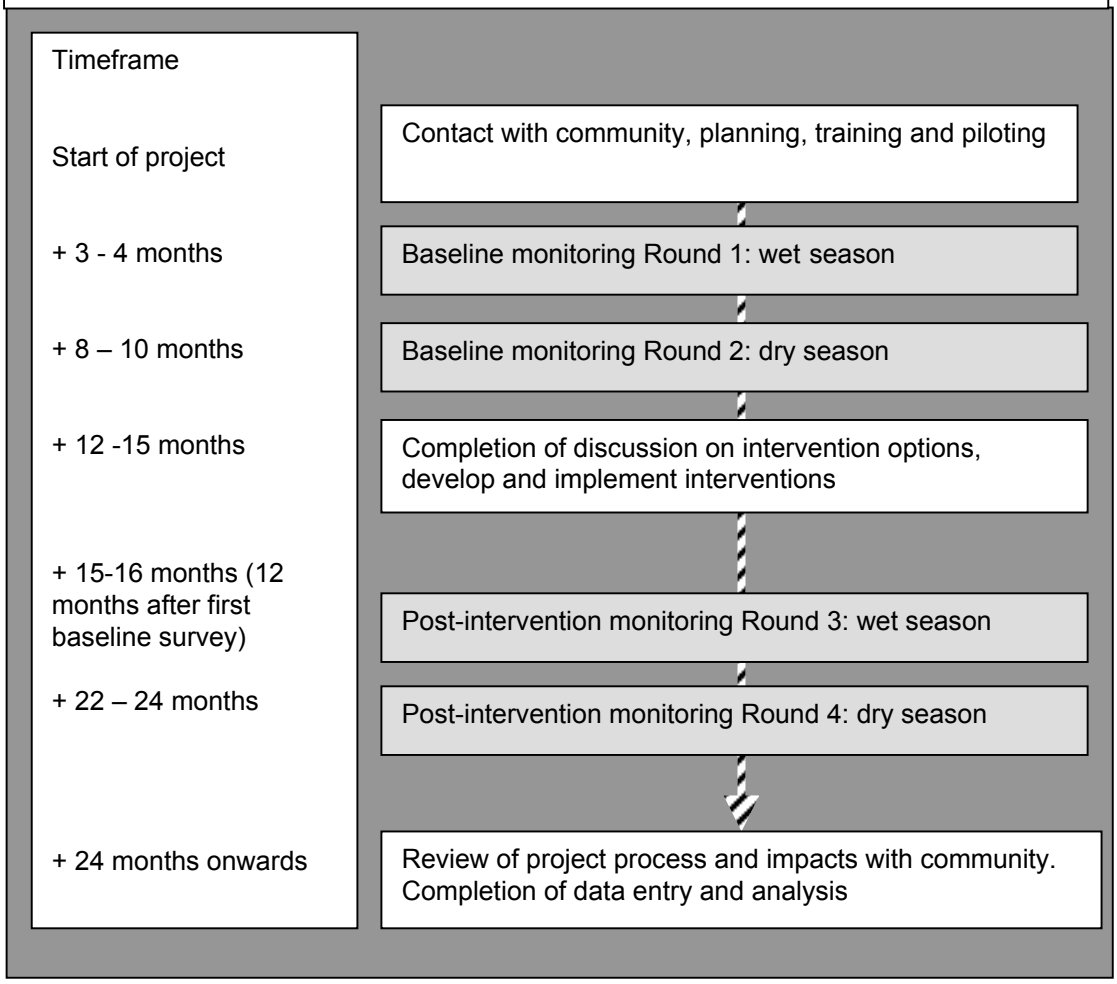
Exchange visit to Mumias , Kisumu
(photo: ITDG-EA)

Chapter 3: Monitoring smoke alleviation

Outline of field methodology

The overall design was a 'before-and-after' study (see Glossary), comparing the effects of installing smoke-alleviating interventions in the three project areas. The overall design is shown in Figure 3.1.
Impacts were measured both qualitatively and quantitatively.

Figure 3.1 Overall design of smoke alleviation study



Project team

The project team comprised an international multidisciplinary group:

- International Project manager: (engineering and development)
- Project consultant: (health and development)
- Country teams: (sociology & economics, development, engineering, data-handling, statistics) and project partners
- Statistical support was provided in the UK

Baseline assessment

In each country, baseline data was collected on the community, resources, skills and climate. Once households had been selected, data sheets on both the house and the household provided a more detailed examination of key factors involving energy use.

A range of factors that might influence pollution levels and exposure, known as *confounding variables,* were assessed during the course of the study, so their potential effect could be accounted for in the analysis. A total of 30 houses in each area were studied: twice prior to the interventions, and twice after, each survey period being several months apart and timed to include one dry and one wet season (in Nepal a cold season rather than a wet season was selected).

Smoke monitoring training in Sudan (photo: Nigel Bruce/ITDG)

Two components of smoke that are known to have an adverse effect on health were measured. These two key components are tiny particles of smoke, described as *particulates,* and carbon monoxide (CO), which is a dangerous gas in large concentrations over small periods of time, and is also believed to impact adversely on health at lower dosages. Although there are many other health-damaging components, it was not felt practical, or necessary, to include measurement of these.

Each team comprised a *field supervisor* and one or more *enumerators* working with the households. The supervisor was responsible for preparation of all the equipment. He / she would make independent checks on a proportion of the project households (10%). On return from the field, the supervisor checked all forms completed by the enumerators, and recorded information he/she was responsible for collecting.

An *enumerator* would visit the household, administer a questionnaire and measure the levels of pollutants over a twenty-four hour period. On return from the field, the supervisor would download data, filters were sent for weighing, datasheets checked and preparations for the next household completed.

Monitoring training

Smoke-alleviation and its measurement were new concepts to the teams in Nepal and Sudan. In Kenya, an earlier pilot project had provided the team with considerable expertise. Training and practice sessions were held in each country on:

- Basic understanding of the monitoring process
- Familiarization with the monitoring and pump calibration equipment
- Setting up the computer required for real-time CO measurement and downloading CO data
- Administering the monitoring questionnaire
- PM monitoring
- CO monitoring
- Feedback and development of methodology within country context

An outline of the training is given in Annex 5.

Field training: note woman wearing monitor around her neck – Sudan (photo: Nigel Bruce / ITDG)

After training, each team travelled to the project sites, where both the Field Supervisor and the support Field Supervisor piloted all procedures by completing a full monitoring cycle without support.

Training new field staff

Ideally the same staff should do all the monitoring during a project for consistency. However, staff leave and others must be trained to carry on the monitoring. During the project, new staff were trained through:

- Verbal introduction to the indoor air pollution work and briefing on monitoring
- Session with supervisor to understand the equipment and key areas to be observed during monitoring
- Direct observation in at least one household observing equipment set up and interaction with the woman during questionnaire administration
- Trial enumeration with supervisory support in at least 3 households
- Withdrawing close supervision in a staggered manner.

Monitoring questionnaire

Case study: Piloting test monitoring in Kenya

Test monitoring was conducted in households K01 and K28. During this period the team gained confidence on operating the equipment, down loading process and tested the monitoring questionnaire. Responses were satisfactory and data was acceptable. After consultation, the test monitoring results were used as part of actual monitoring results. At the end of the test monitoring, the sessions were evaluated and the evaluation was used for:

- Improvement of the logistical set up for movement and timing of the monitoring
- Improvising ways of securing and mounting of the different equipment in the household and on the woman

The monitoring questionnaire had four key functions in this project:

- To record systematic information on the implementation of pollution measurement in each household
- To provide information about the household members and their houses
- To determine the amount of cooking that took place on the day in which the house was monitored
- To give the households and enumerators an opportunity to make other comments about the process and any changes that that process may have created.

The complete monitoring questionnaires for superviser and enumerator are given in Annexes 6 & 7. Field handbooks to accompany the monitoring questionnaires are in Annexes 8 & 9.

Administering questionnaire in Gatlang, Nepal: (photo: ITDG)

Translation and back translation

Before going to the field, the exact meanings of what was written in English on the monitoring sheets were discussed, and the monitoring questionnaires were translated for field use, back-translated and duplicated.

In Nepal, where the project partners administering the questionnaire spoke only the local language and Nepali, the particulate monitors had instructions on the display in English, and had to be read by the supervisor who again checked them on return to the field office.

Ethical issues

No participant names were used on the data sheets. Instead a record of a two-letter identifier was used and the names recorded against this identifier that was held safely within the office.

The Field Manager obtained informed consent from all participants, ensuring that they understood what they were signing. As many of the participants were not able to read, a fingerprint was taken in lieu of signature. In line with recommended practice, ethical approval is being obtained from the University of Liverpool as the institution primarily responsible for data analysis Annex 10 .

Time / activity measurement

The time that each woman spent beside the fire was recorded in two ways:

- Time /activity charts
- Time / activity using the CO monitors

Results and further discussion appear in Chapter 7.

Time/activity charts

The monitoring questionnaire included a sheet which asked the woman to recall, at hourly intervals, the length of time she spent in the kitchen with the fire alight, and the time during which the youngest child was in the room. The skill of the enumerator was to identify key times – the fire being lit, bedtime, collecting water – and helping the woman to build up a picture of her day.

Time / activity using CO monitor

The number of minutes when the woman's CO levels were greater than zero for room carbon monoxide greater than three parts per million (ppm), and nine parts per million was recorded for each 24-hour monitoring. The concentrations of room CO>3ppm and room CO>9ppm were chosen because it was not known whether the CO>3ppm could reflect residual levels of CO emitted by the fire once cooking was completed, and thus be considerably longer than the time she actually spent cooking.

Comparing the two methods

Not all projects can afford to use real time monitoring, and it was felt useful to see the correlation between the two methods and whether the total CO to which the woman is exposed can be calculated using room data combined with the chart method.

Measuring levels of pollutant in a household

Measuring the levels of pollutants is perhaps the most arduous part of the whole work. A schedule of visits was agreed between the households and the project team. As the filters were changed after twelve hours, the equipment had to be set up in the house by around 6am. Prior to this, the supervisor would check the flow rate of the pump, check that all the equipment was in order, that the questionnaire recorded the correct house(s) for that day and that the filters etc. were correctly labeled.

After twelve hours, equipment was checked, any problems were addressed, and the filter for measuring particulates replaced so that it did not become completely blocked by pollutant.

At twenty-four hours, the final readings were recorded and the equipment switched off. The exposed filters, now loaded with smoke particles, within their labeled cassettes, were fastened with a clip to keep them safe and returned to sealed polythene bags.

Logistics

In each country the logistics of monitoring were very different. The Nepal community lived in housing which was closely concentrated within the village of Gatlang. However, because it was very remote, one team member lived in the village during the monitoring period, working with the local collaborator from SEARCH-Nepal (a national NGO). Having reached the village, each of the houses was easily accessible.

In Sudan, the community of Wau Nur is very accessible from the town of Kassala, and by working with the Women Development Organisation the team was able to reach the households easily.

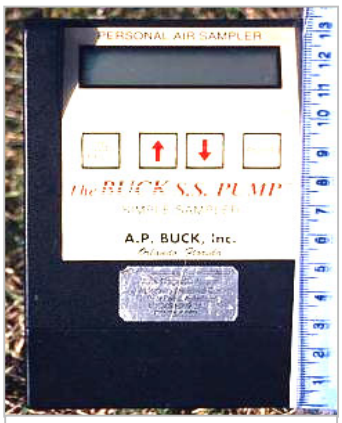
However, in Kenya, the houses were widely distributed around Kisumu and careful plans had to be made to keep travelling time and transport costs to a minimum. Annex 11 describes how this was done.

Pollutant measurement

Particulates

Air sampling filters were prepared using standard procedures, in the Department of Analytical Chemistry, University of Nairobi, Kenya and in the government metrology centres in Nepal and Sudan. Regular checks were made on calibration of the balance, with repeat weighing and laboratory blank filters used for quality control. Annex 12 describes the methodology used in Kenya and Sudan. This differed from the method used in Nepal where the Indian Standard for drying filters was used and heat was used to dry the filters. Consistency of methodology was maintained in each country throughout the project. A problem that arose in Sudan was that some the pre-intervention filters were not dried after they had been used in the household. A conservative adjustment was made, based on the minimum change of weight in each batch being deducted from each sample in that sealed batch.

Five point balance for weighing particulates



Buck personal air sampler (scale =cm)

Concentrations of respirable particulates were measured over 24 hours, using a Buck pump (personal air sampler) to draw 2.2 litres/minute of air through a cyclone. The cyclone is used to drive all the large (less health-damaging) particles away from a collecting glass-fibre filter, leaving the respirable particulates (PM_{resp}), collected on the filter for subsequent weighing. The cyclone was placed 1.3 metres above the kitchen floor, 1.3 metres horizontally from the hearth. The pumps were calibrated prior to each 24-hour monitoring session using a Buck bubble calibrator.

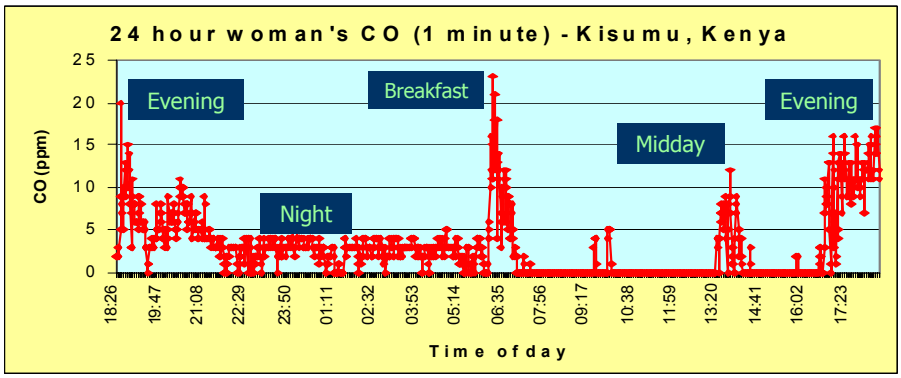
On arrival at the household to be monitored, the cyclone was placed 1.3 metres above the kitchen floor, and 1.3 metres horizontally from the hearth. Due to high levels of pollution, filter cassettes were changed after 12 hours.

The 'Buck' pumps used during the study have integral batteries which were used in an earlier project but these were found to discharge too often for this type of work. Using an external car battery to operate air samplers made the operation much simple. Charging time was completely cut out and back to back monitoring was possible.

Real-time CO monitoring

Carbon monoxide (CO) was measured in the kitchens using 'real time' electronic monitors (Industrial Scientific T82). These monitors measured the mean concentration of CO every minute at the same location as the cyclone collected the particulates. The data was downloaded onto computer. This provided a means of observing when the stove (or other nearby sources of pollution) was in use , on a minute-by-minute basis, and also observing the change in CO emission pattern caused by the interventions. Levels of carbon monoxide were measured at minute intervals for both woman and room. The CO monitors in the room and those worn by the woman measured levels of CO that rose when the fire was in use. By measuring the time when the CO was higher than 3ppm (a cut-off selected by the team), it was possible to identify fire events. Figure 3.2 illustrates the close relationship between room levels and woman levels – this was observed in the majority (but not all) of the households.

T82 monitor for CO measurement

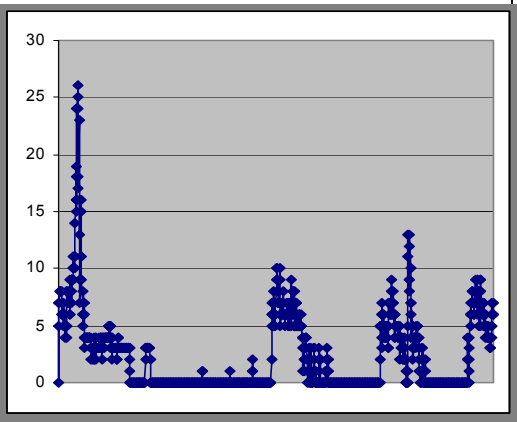


CO exposure for each woman (the cook) was measured at the same time as room sampling using the same model of T82 monitor fastened around her neck. The purpose of this was to measure CO as a health-damaging pollutant in its own right, as well as to use CO as a proxy for PM_{resp} exposure for the women, based on the method described by Naeher et al (Naeher, 2001) in studies using biomass. Monitoring the levels of pollutant using the lightweight silent CO monitor was preferable to using a PM_{resp} monitor, which is both heavier, makes a noise and only gives an integrated average over the sampling period. The woman was asked to keep the CO monitor close to her head when sleeping. Annex 13 gives further details of the all the monitoring equipment used.

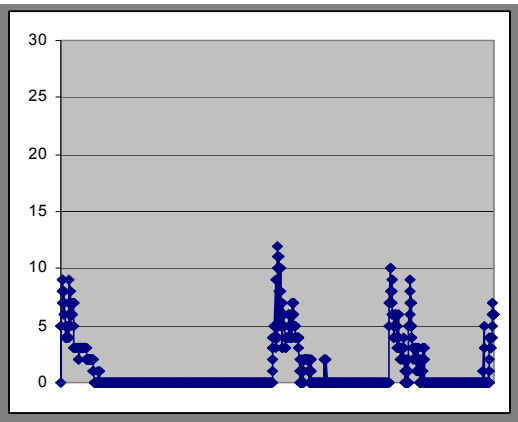
Between pre-intervention and post-intervention rounds, the CO monitors were sent to the UK where they were checked to ensure that the calibration had stayed constant over the monitoring period. Calibrating involved passing a fixed concentration of CO through the monitors and ensuring that the readings from the monitors had not changed over the period of monitoring. The concentration used, as defined by the manufacturers, was 100ppm. Three readings were taken for each monitor. It is worth noting that if monitoring is to be done in remote locations where electricity is unreliable, there must be access to a computer to download the data.

Figure 3.2: Typical carbon monoxide vs. time plots for 24hour data for households in Kenya, Nepal and Sudan

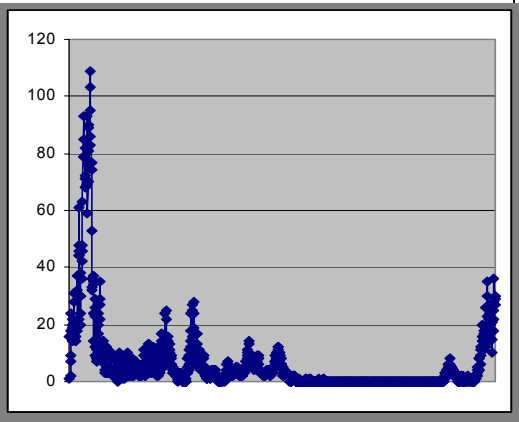
Kenya –room HH05 – round 3



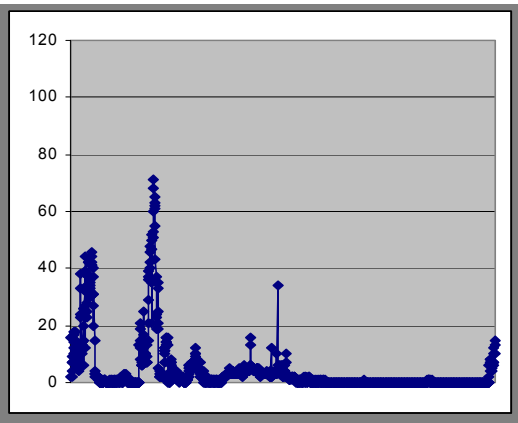
Kenya – woman HH05 – round 3



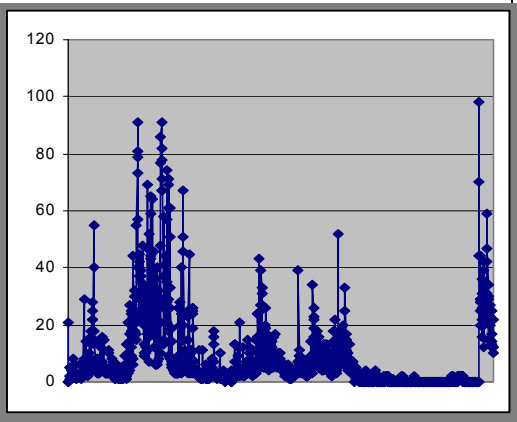
Nepal – room HH16 – round 2



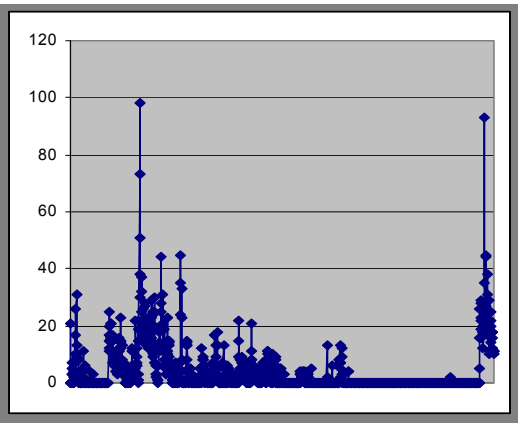
Nepal – woman HH16 – round 2



Sudan – room HH25 – round 1



Sudan – woman HH25 – round 1



Administering the questionnaire

With the equipment set up, the first part of the questionnaire was administered, relating to the woman, her family and her household. Once monitoring was completed, that part of the questionnaire relating to cooking events during the twenty-four hours of monitoring was completed. Part of this final monitoring sheet made provision for comment by both the woman being monitored and the enumerator. Time/activity was recorded at this point.

Downloading and storing data

Returning to the field office, data was downloaded and backed up onto computer and disc from the CO monitor, and the flow-rate from the particulate pump re-checked to ensure that it had not changed during the day. The filters were stored and sent in batches of six or ten to the laboratory for weighing. The supervisor checked the monitoring questionnaires for completeness, recorded the maximum and minimum temperatures for that day, and prepared the equipment for the next day. Details are given in the Supervisor Handbook.

Data entry

An Access database was designed to allow data entry staff in each country to transfer data from the monitoring questionnaires onto a spreadsheet. The input template looked similar to the datasheets themselves for ease of data entry. Although revisions were possible, the database ensured that the same sheet could not be entered twice without the staff member being aware of this duplication. Other limits were set to alert the staff member that the data being entered was not valid. Once entered, the data was checked independently. The usual method was for two people to be involved, one reading from the original data sheet whilst the other read from the screen.

The Access spreadsheets were sent to the UK, where the team noted any anomalies and went back to the country offices for clarification. Once complete, the data from the sheet was transferred to SPSS (a statistical data analysis package).

CO data for both the room and the woman was entered onto separate Excel spreadsheets, as the data was recorded on a minute-by-minute basis. Various household means and percentiles were calculated. A typical example is shown in Annex 14. Time / activity data from the monitoring sheets was transferred onto Excel files, and 24hr totals were calculated . An example from Nepal is shown in Annex 15. For both these spreadsheets, the ‘live’ versions of these files are very large; containing calculations on means, medians and time/activity calculations calculated directly from the source data.

Collating data for analysis

Data from these several sources was collated, for each household, into twelve SPSS spreadsheets, four per country. The data comprised:

- Each element from the monitoring questionnaires - number of children, number of meals, type of house etc.
- Particulate data; this had been collated at the laboratory which did the weighing on a separate data sheet
- Carbon monoxide data – mean, percentiles, time when fire is alight
- Time / activity data compiled into the time spent by both the woman and the child when the fire was smouldering and when it was burning brightly
- Max / min temperatures, recorded at the field office

Chapter 4: Smoke-alleviating interventions

What is an intervention?

Throughout this publication, the word 'intervention' describes any technology or activity brought about by the project with the intention of reducing smoke. Some of these interventions were common to all three countries whilst others were specific to that country, and that society. Teams collected information on social, cultural, technical, economic, health and institutional issues. Based on the collected information, the team proposed some intervention options. Decisions on the interventions were made after consultation with community and project partners. The process involved:

- Literature Review
- Field Investigation
- Socio-cultural study
- Study on house structures and temperature
- Study on availability of local resources and skill
- Study on energy consumption and availability of energy
- Discussion with the community on technological options
- Collect view of the relevant specialists
- Draft design development using local consultant
- Discussion with specialists
- Seek community consensus
- Design approved with specific emphasis on sustainability and maintenance
- Installation
- Collected response from users and specialists
- Modification and finalization of design

Identifying skills, materials, supply chains - Nepal

Annex 16 describes skills, materials and supply chain inventory for Nepal. Because sheet metal is not available in large quantities in Rasuwa district, it was necessary to ensure a viable supply chain for raw materials to ensure sustainability of supply, as shown in Table 4.1.

Table 4.1 - Supply chain for Rasuwa district, Nepal

Supply chain					Target market
Importers from India into Kathmandu	Wholesalers - for metal sheet in Kathmandu	Manufacturers / stockists / producers Dhunche town	Distributors: - fixed areas; premises for placing orders	Retail outlets: groups, hardware shops, garages, markets	Main target: High hills; rural households; biomass users; ~ 80% population
			Installers, promoter, assemblers		Secondary target: Restaurants / tea houses
Services	Tansport to Rasuwa district	Product designers	Credit	Installation	Market information on demand levels

Group meetings to raise awareness of options-Sudan

Using a participatory approach, the selection of appropriate technologies starts with the community. Group meetings can draw out successful technologies that have been used in the past, whilst raising awareness of the need to alleviate smoke and giving the community the opportunity to take ownership of the problem and its solution.

Through community meetings, the views and ideas of the community on possible means to reduce smoke in the kitchen were sought. The project staff presented a selection of

technologies including LPG stoves, improved biomass and kerosene. Discussions concluded with a list of technologies to be further explored by project staff. Table 4.2 illustrates the participatory group discussion with the households that outlined possible interventions to reduce or eliminate smoke, which summarizes the household's perceptions of smoke reduction interventions.

Table 4.2 Wau Nur household discussions on interventions

Method	Advantages	Disadvantages
LPG	No smoke	Explosion if the cylinder is left open Explosion if the gas is opened before lighting the match No LPG agent in Wau Nur, the nearest one is at Murabaat (neighbouring residential area)
Wick Stove (Kerosene)	No smoke if kerosene is used Available at the nearest shop Diesel oil could be used instead of kerosene	Soot deposit on pots, but only when Diesel oil is used instead of Kerosene Not for use outside the kitchen (air may blow off the fire causing fire hazard) Bad smell and smoke when Diesel oil is used instead of kerosene
Electrical Heater	No smoke	No electricity in the area
Charcoal	No smoke Available abundantly	
Chimney, Hood, More windows	Out withdrawal of smoke	
Kitchen design (hut or rakuba)	Some women said the hut design is much better than rakuba while others support the later design	

A staff meeting to discuss results of household's perception of smokes reduction led to:

- Community demonstrations of selected intervention techniques, in particular inviting the Civil Defence staff to talk about LPG culture –safety perceptions.
- A survey of the market and prices for LPG, kerosene, improved woodstoves – both appliances and fuel costs
- Investigation of possible agencies in Kassala and their co–operation with project
- A cost analysis of fuel based on survey consumption figures
- Calculation of costs of possible instalments and means of payment, to be paid by household for the selected intervention.
- Smoke reduction interventions procured, fabricated and installed
- The findings from these activities were presented to the community to inform their decisions.
- Costing interventions
- Community involvement in installing interventions and safety training

Interventions common to all three countries

These interventions are perhaps the most useful and most generally applicable.

Knowledge sharing

Of all the interventions, the key one is sharing the knowledge on the dangers of smoke and creating a sense of 'ownership' so that the community and the team together could alleviate the smoke problem. Women are empowered by being made aware of the problems that the smoke is creating for both themselves and their children, together with the recognition that there are things that can be done to alleviate the problem.

Fuel drying
For those who selected to continue to use biomass, the importance of drying fuel was identified as a cost-free (though not time-free) way of reducing the levels of pollutant. Damp fuel suppresses the heat within the fire as energy is used in driving off the water vapour emitted from the fuel. This is particularly true of 'green' wood, which has moisture right through it, rather than fuel that has been wetted by rain.

Reducing personal exposure
Smoke only causes ill-health when people are exposed to it. The need to move small children to sites away from the fire, where this is possible, was identified as a useful way of reducing child exposure. Similarly, women were urged to keep away from the dense smoke emitted from the stove.

Reducing the time spent cooking and near the fire
Although windows have not been shown to remove smoke, they allow air to circulate in the room and also improve the lighting, allowing women to cook and maintain the kitchen more efficiently. Stoves, likewise, though they may not reduce the levels of pollutant, reduce the amount of time taken to cook, and thus reduce the exposure of the woman to pollutant.

Interventions in Kenya

As described in Chapter 2, the Kenya team adopted a policy that everyone was ever told that there was something they could do - even if they had no resources. Apart from the behavioural changes described above, other low-cost options were included within the project. These options are listed below starting with the least-cost options.

Fireless cookers
These are also known as 'hay boxes' and comprise an insulated space into which pots containing already-boiled food are placed. The top is also insulated and the pot left to cook using its own contained heat. The insulation in Kenya comprised old clothes stuffed lightly into other pieces of fabric to form a cushion. These either lined the mud hole forming part of the fireplace, or lined a woven basket making the set-up more portable. Although people on very low incomes can make them at home, there are also plans to make attractive basket-type ones as a local small enterprise through the women's groups.

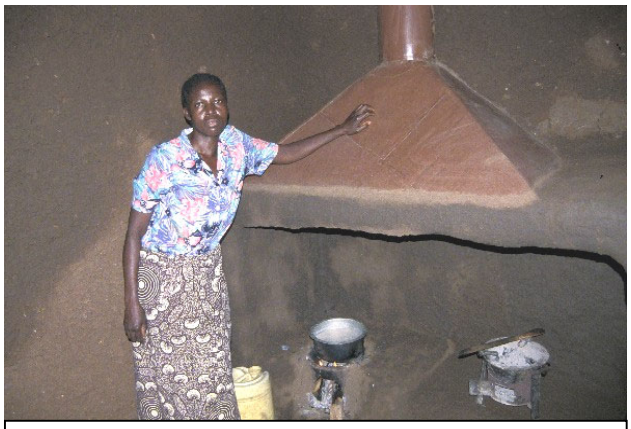
Haybox set adjacent to smoke hood with eaves space cut into wall behind (photo: ITDG)

Solar Cookers
Demonstrations of Solar CooKits were given as part of the project. Where appropriate, solar cookers can be a valuable addition to a household. The pre-requisites are that people are able to cook during the time when the sun is at its hottest, and that they have another means of cooking for night-time. Solar cookers can be used in conjunction with fireless cookers. Solar cookers are supplied through a project partner. These cookers are sold at public meetings, women's groups, markets etc.

Eaves spaces
Eaves spaces are long thin 'windows' at eaves level cut into the wall behind the fire that allow smoke to escape rather than curling round into the room. Eaves spaces remove substantial amounts of smoke, but are less appropriate if people are intending to sleep in the room as they allow mosquitoes to enter the room. In Kenya, the householders are able to construct the eaves spaces and windows, but in most instances, a local artisan has been employed to make and install the frame – creating more employment. The eaves spaces, windows and installation are from locally-sourced wood.

Upesi stoves
Upesi stoves were measured in a previous ITDG project to provide a small reduction in smoke levels. Other projects have shown them to have a more positive effect on smoke reduction. Upesi stoves reduce the amount of fuel that needs to be collected by around half, and reduce the time the woman spends cooking, thus creating less time when she is closest to the stove. Upesi stoves are widely available in Kisumu through the market stalls.

Smoke hoods
Smoke hoods were shown to be very successful in a previous ITDG project. However, these hoods were expensive and some efforts were made to reduce the cost by using recycled metal and making the walls of mud formed around a wooden frame. Although these lower cost hoods made them more affordable, they also proved to be less effective in removing smoke. A major problem was that the use of mud enabled people to make the openings much larger – more convenient, but not so good at creating the necessary draught to draw the smoke out of the room.



Enlarged opening on smoke hood to allow double upesi stove (photo: ITDG)

LPG stoves
Only two of the sample households opted for LPG. Although it is a clean, fast technology, all the fuel needed for it needs to be purchased, so although some households could meet the capital costs, the need to buy more costly fuel could prove a barrier. Recently, the taxes on LPG were removed in Kisumu, and this may encourage more people to buy them.

Table 4.3: Cost of interventions in Kenya

Description	***Price band*** **(Kenya Shilling – KS)***
Smoke hood with improve stove underneath	3000-6000
Improved stoves with improved ventilation (Windows and Eave spaces)	1200
Solar CooKits (low cost solar cookers popular in Kisumu area)	600
LPG gas stoves	3500
Fireless cookers (hayboxes)	450-700

** (1000 KS ~ £6.86)*

Interventions in Nepal

The community in Nepal needs fuel for both cooking and heating. When the weather is cold, doors and windows are closed and a fire set in the living area of the house is a focal point around which the family sits. Various criteria needed to be met:

- The fire needed to provide heating for cooking and heating
- It is important for people to 'see' the fire for their own feeling of comfort
- Most households brew beer weekly or monthly – unlike in Kenya or Sudan, this is culturally expected rather than done in secret.
- Fuel is adequate but scarce – the community wanted measures to reduce fuel consumption
- There is electricity (albeit erratic) but people do not have enough money to use it for cooking and it is mainly used for lighting (by a growing number of people)

As well as the 'free' interventions listed at the start of this chapter, three main interventions were selected:

Insulation
The walls of the households are made of gneiss – a hard rock with high thermal conductivity. A mix of local clay, straw and dung has been used to insulate the walls and reduced the heat losses. This intervention has proved popular as the households themselves can do it at no financial cost – but with a time cost.

Improved stoves
The local stove is a metal tripod, made by the village blacksmith. The pot sits rigidly on the tripod, and this system has been improved by; building a protecting base around the back and sides of the tripod. A wide area at the front has been left exposed for fuel feeding and to allow the occupants to see the fire. Currently, a bar set across the front of the stove, to allow air to pass beneath it, is being advocated. This should improve combustion.

Smoke hood
The concept of a smoke hood was well-received in the Gatlang community: it fulfilled the requirement that the fire could be 'seen'; from earlier ITDG studies it was known that smoke hoods can remove substantial quantities of smoke; although sheet metal is not used much in the community, there was a depot which bought in the right type of mild steel sheet in the nearest town of Dhunche. However, the community was also very clear that it wanted a hood shaped more like an inverted funnel, set high above the fire, so that the woman could sit beneath it. This was a compromise, but it was deemed more important to work with the community rather than imposing an externally-designed solution.

Smoke hood & improved stove, Gatlang. Hood now substantially redesigned (photo: ITDG)

LPG stove - Sudan (photo-ITDG)

Interventions in Sudan

In Sudan, despite a range of energy options being offered, the unanimous choice was for LPG stoves. Some households also purchased a *kisra* plate, for cooking the local sorghum-based staple pancake. The customer-based approach, evident from the start in Sudan, allowed a range of quality / price of stoves to be offered. These were commercial imports. Different sizes of bottle were included in the 'package'. The approximate price for a complete package of LPG stove, *kisra* plate and gas bottle retails at around £27.

Chapter 5: Methodology for data analysis

The data collected during this research fell into four main categories:

- Baseline data and data on other variables which might also have affected the levels of pollutant (*confounding variables*)
- Smoke data on all four rounds
- Impact monitoring on both smoke and other social and economic changes
- Monitoring the process to ensure that the households were satisfied with what had been achieved and to determine how things could have been done better.

Baseline data on project households

To understand the societies with whom the project was working, and to identify variables that could impact on energy use, the questionnaire looked at the topics/issues shown in Table 5.1.

Table 5.1: Topics covered by questionnaire

	Closed questions	Open-ended questions
Household	Age of the cook Ages of the three youngest children under five years Attendance at school Where children did their homework Literacy of mother Smoking	Household members involved in fuel collection *Sources of income** *Perceived benefits of smoke reduction** *Perceived quality-of-life improvements for the respondent** People sleeping in same room as main stove
Energy	Fuels for cooking, lighting, heating, boiling water, brewing, animal feed, and any other use (electricity for ironing was one common use in Kenya) The proportion of fuel used for selling was monitored Whether most fuel is bought or gathered Fuel costs collated by fuel type Frequency and time spent collecting fuel Dryness of fuel Type of stove; primary and secondary	*Threats to those involved in collection**
Shelter	Type of kitchen – separate / attached; enclosed / open Materials – walls, roofs Volume of openings – windows, eaves spaces, flues Volume of kitchen	
Health		*Woman;s perception of her own health** *Woman's perception of the health of her child**

**Data shown in italics was calculated or collated from raw data.*

Smoke data

Levels of particulates (PM_{resp}) carbon monoxide (CO) were measured in each round – a total of four times for each household. The relationships between particulates and carbon monoxide were analysed for the room, and the levels of exposure to carbon monoxide for the woman were measured.

Carbon monoxide

The CO monitor measured concentrations of the gas every minute, recorded in parts per million (ppm), producing a total of 1440 readings over 24 hours. Curves could be plotted for each household, both for the room and for the woman. In all three countries, it was noted that the shape of the curve for both room and woman tended to be very similar during the cooking periods.

Woman wearing CO-monitor in Sudan (photo: ITDG)

From these data, the following were calculated:

Room data

- Mean and median for raw 24-hr data
- Number of minutes per day when the room CO>3 and CO>9ppm
- Percentiles to indicate the physical processes involved in the CO reduction effected by the intervention

Woman's exposure

- Mean and median for 24-hr data
- Mean and median for woman during the time that CO>3 (i.e. the fire is alight)
- Number of minutes per day when woman value >0 during which room CO>9
- Percentiles for each round

Particulates

Room particulates

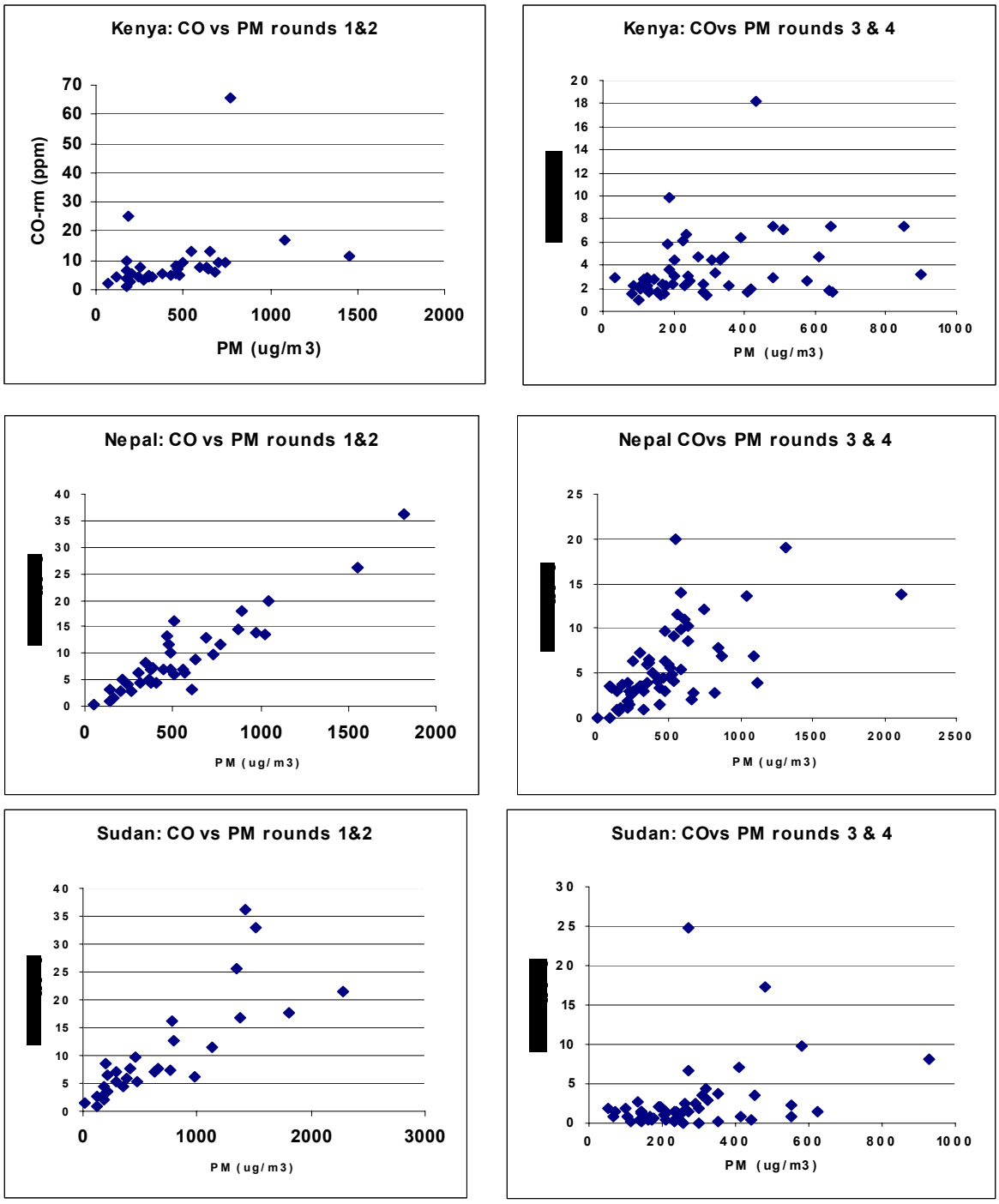
The total weight of small particles deposited on the room filter was recorded at the metrology laboratories in Nepal and Sudan and at the University of Nairobi in Kenya. The field team recorded the total volume of air drawn through the pump during 24 hours, displayed on the pump. The mean 24-hr concentration of particulates ($PM_{resp)}$ was calculated and recorded in microgrammes per cubic metre ($\mu g/m^3$) from these two sets of data.

Relationship between PM and CO

Although households which were highly polluted during one session of monitoring tended to be high in subsequent rounds, the range of values for PM and CO is wide even between households which are nominally the same, and use similar cooking practices. However, for biomass, the relationship between PM and CO in the pollutant mix has been shown to be reasonably consistent (Naeher et al, 2001) and this allows carbon monoxide to be used as a proxy to provide some measure of the levels of particulates to which the woman is subjected. It can be seen from Figure 5.1 that there is greater 'variance' (spread) at higher levels. Note also the continued pollution in Sudan, albeit at much reduced levels.

Because the intervention of choice in Sudan was one of fuel switching, it was deemed unlikely that the relationship between CO and particulates would be the same as when only one fuel (biomass) was being studied.

Figure 5.1: Relationship between respirable particulates and carbon monoxide before and after installation of interventions



Correlation matrices for CO and PM, all countries

This measure looks at the correlation between PM and CO to examine the relationship between the two pollutants. One issue of interest is what happens to the CO-PM relationship after the interventions in Sudan. We know that there is not a complete transition to LPG, and that some PM and CO exposure is coming from other biomass sources including other homes, traditional 'saunas' and lighting. These results suggest that the CO-PM relationship is somewhat weaker after the interventions (mainly based on PM_{resp} and room CO)

Correlation matrices
Data are: Spearman's rho (rank correlation) and p-value

Table 5.x Kenya correlation matrix

Measure	Pre-intervention (R1&2)		Post-intervention (R3&4)		All data	
	CO room	**CO woman**	**CO room**		**CO room**	**CO woman**
PM_{resp}	0.53 <0.0005	0.06 0.65	0.40 0.003	**PM_{resp}**	0.53 <0.0005	0.06 0.65
CO room		0.39 0.004		**CO room**		0.39 0.004

Table 5.x Correlation matrix - Nepal

Measure	Pre-intervention (R1&2)		Post-intervention (R3&4)		All data	
	CO room	**CO woman**	**CO room**		**CO room**	**CO woman**
PM_{resp}	0.76 <0.0005	0.20 0.141	0.65 <0.0005	**PM_{resp}**	0.76 <0.0005	0.20 0.141
CO room		0.424 0.001		**CO room**		0.424 0.001

Table %.x Correlation matrix - Sudan

Measure	Pre-intervention (R1&2)		Post-intervention (R3&4)		All data	
	CO room	**CO woman**	**CO room**		**CO room**	**CO woman**
PM_{resp}	0.88 <0.0005	0.50 <0.0005	0.41 0.002	**PM_{resp}**	0.88 <0.0005	0.50 <0.0005
CO room		0.44 0.001		**CO room**		0.44 0.001

Percentiles as a tool for examining impact of interventions on CO levels

Percentiles look at a set of data points and measure the value that is exceeded by any given percentage. Thus the 90th percentile for the CO readings taken over 24hours (1440 minutes) in a house is value at which 10% (144 values) are greater and 90% are less. This method calculated all the deciles (factors of 10) and the 98th and 99th percentile for each household. Once this had been done for all households, the arithmetic mean for each chosen percentile was calculated using the data from all thirty households. The same method was used to calculate the percentiles for the woman.

Calculating woman's exposure to particulates
Because of the weight and noise made by the particulate pump, it was considered socially unacceptable to request that the woman wore it around her neck. Further, the particulate monitor does not measure the real-time exposure of women to particulates (though equipment is currently under development to make this possible). One way that was researched to estimate the amount of particulates to which the woman was exposed compared the percentiles for both woman and room, plotted for pre- and post-intervention rounds; a good relationship between CO-room and CO-woman was produced. This data is shown in Chapter 7. Assuming that CO is a good proxy for particulates, one could approximate the fraction of room particulates to which the woman is exposed.

Confounding variables

Monitoring sheets
Monitoring sheets provided a way to identify changes that are not directly attributable to the project –*confounding variables.* Project impacts and confounding variables are not always completely unconnected. For example, if a woman is in the room for a shorter period, it may be because she can cook more quickly because of a stove being installed, or because she is now aware of the dangers…or it might be that she spends longer in the room because the intervention has made it a more pleasant place to stay. Additionally, there may be other explanations quite unconnected with the interventions.

In the intervening period of several months between when the household is first monitored and the rounds of monitoring subsequent to the intervention, many circumstances may things will have changed. The same applies to day-to-day changes; more people requiring a meal, wood being used instead of agri-residues, weather changes. When the results from the datasheets are scrutinized, if major differences are observed, results can be compensated adjusted in the analysis to reflect these changes provided there are sufficient observations in each class. Otherwise the best way is to reflect the change when discussing the findings. Adjusting for confounding factors must always be recorded.

The key variables that may have contributed to confounding the observed effects of the interventions are as follows:

- Type of fuel - intervention in Sudan and confounding factor in Nepal and Kenya, although two opted for LPG –residues were used in one round and wood in the other
- Scarcity and dampness of fuel
- Cigarette smoking (active smoking by the cook, and others smoking in the kitchen)
- Kitchen materials, features and ventilation
- Openings in the kitchen (windows / eaves spaces) - an intervention in Kenya
- Smoke extraction – intervention in Nepal and Kenya
- Rainfall and temperature
- Number of people for whom a meal was cooked, standardised as'Adult male equivalent'.

Those confounders for which there was either an observed association with key outcomes or which changed between Rounds 1 - 2 and Rounds 3 – 4 (i.e. during the time that the intervention was installed) were adjusted for in regression analysis. This ensured that impact recorded was due to project activity and not extraneous circumstances.

LPG gas was an intervention in Sudan (photo ITDG)

Impact data

Project impacts not only bring about changes in levels of smoke, they can change the socio-economic status of women and households. Interventions may have impacts well beyond those anticipated when the project was implemented.

Monitoring sheets
As well as measuring potential confounders, monitoring sheets provided the most formal way of identifying changes in fuel use, time spent cooking, time spent gathering fuel. These were indicators of the ways in which the project had impacted on people's lives.

Individual and focus-group discussions

Community meeting Gatlang - participant stressing problems associated with lighting (photo ITDG-Nepal)

A further method was to look at the post-intervention comments made by the individual household members through questionnaires, impacts were monitored through focus-group discussions and individual interviews.

It was considered important to ensure that the needs and aspirations of the community were reflected in this assessment, rather than those imposed by the project. However, key areas of interest for the project were needed to structure the discussions. The key elements chosen were: improved environment; health and well-being; wealth-creation or savings; time; prestige.

Informally-documented impact

Through their close contact with households over the 2-3 years of the study, the field teams became very expert on the social aspects of smoke alleviation, and thus they were in a good position to be able to identify and record factors which might have a bearing on the quality of life of the communities with whom the project is working. These impacts were recorded informally, or through a section in the monitoring questionnaire for that purpose.

Reviewing project methodology

Questionnaires

The questionnaires provided space for three observations at the end of the interview:

- Ways in which the interviewee's day was different from how it would have been if monitoring had not been taking place?
- Other comments and observations from interviewee (non-obligatory)
- Other comments and observations from interviewer (e.g. reluctance of interviewee to answer a particular question)

Independent review

Each country identified a local person who was not connected with the project but who would be able to provide an objective review of the work that had been done within a context for which they had a good understanding. The outline terms of reference for this activity are shown in Table 6. The person doing the review was asked to identify shortcomings and potential for future action arising from this work. The review would cover two aspects of the work:

- Community
- Methodology

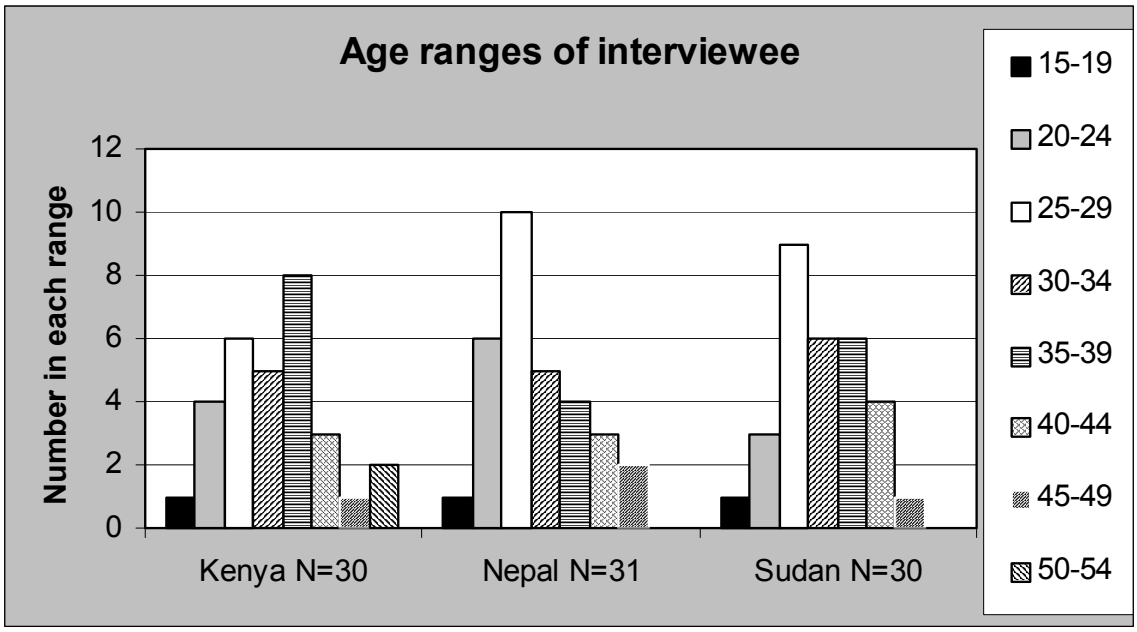
Table 6: Elements for external review – terms of reference

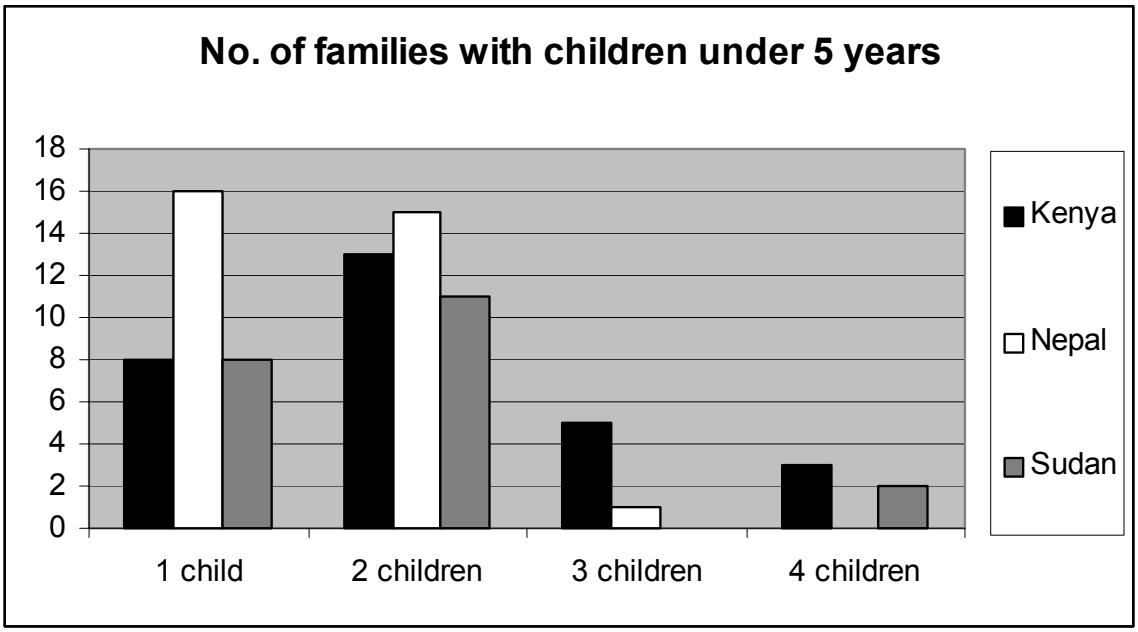
	Community	**Methodology**
Impacts direct and indirect of the project	√	√
Technologies adopted - efficiency	√	√
Technologies – cost effectiveness	√	
Social acceptability	√	
Project methodology / process	√	√
Potential for sustainability	√	√
Influencing – local level	√	
Influencing – policy level		√

Chapter 6: Household data

Baseline data from project households
Household information

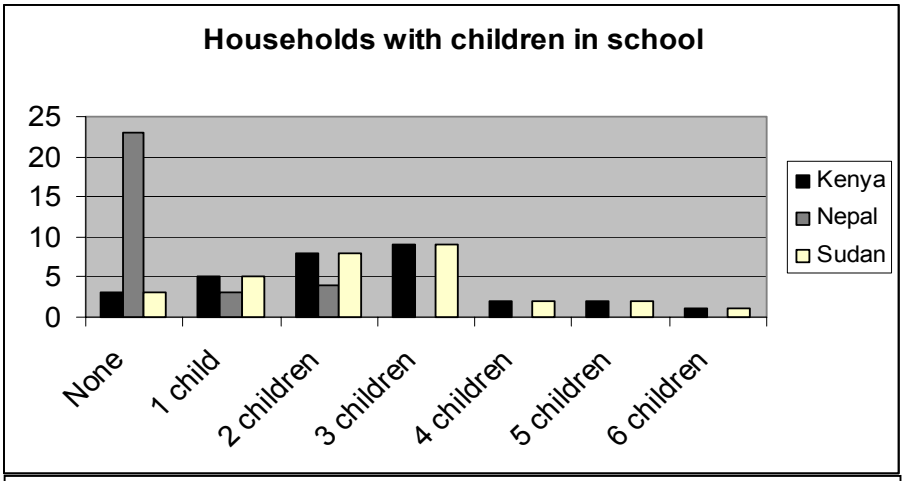
Age of the cook
The age profile in Kenya peaks in the 35-40 age group whereas in Nepal and Sudan, the highest number of interviewees is between 25-30. Most of the families in the study have one or two children aged less than five years.

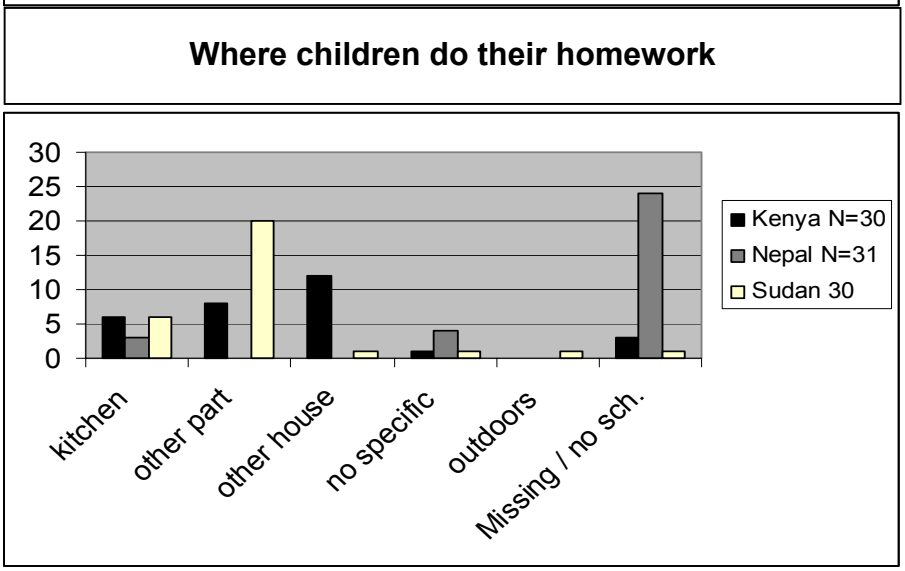


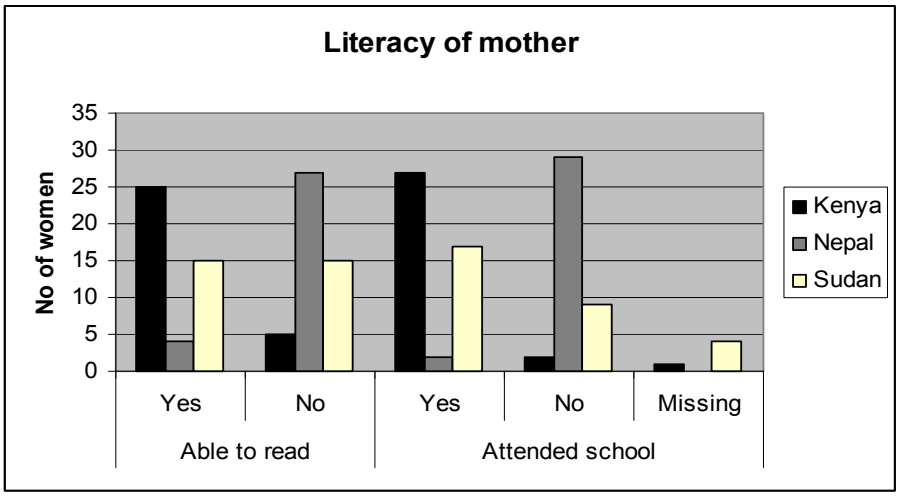


Education

The level of school attendance and homework is much lower in rural Gatlang than in both Kisumu and Kassala. Literacy figures show a similar pattern Most of the women in the study in Kenya can read and have attended some school. Very few women in Nepal could read – around half in Sudan.



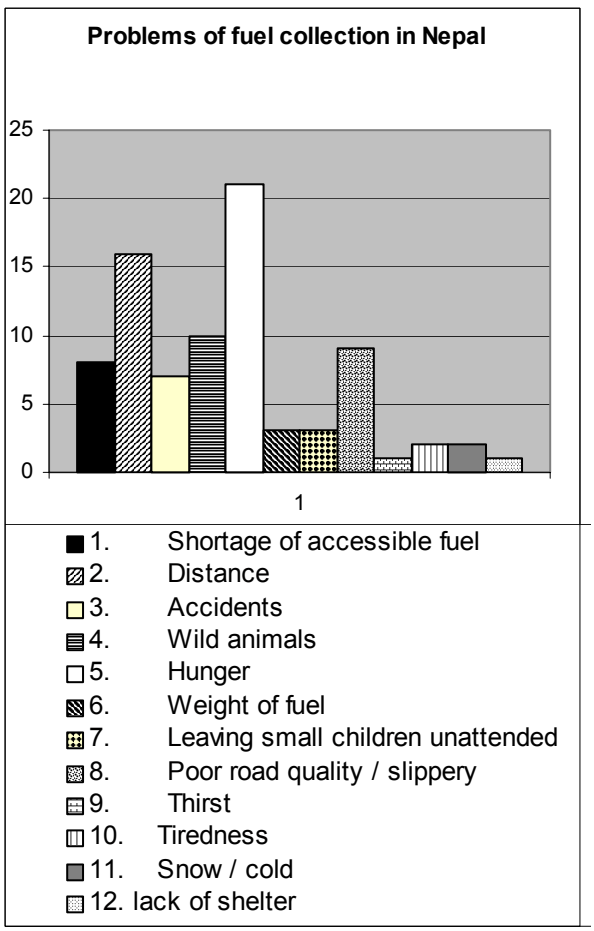


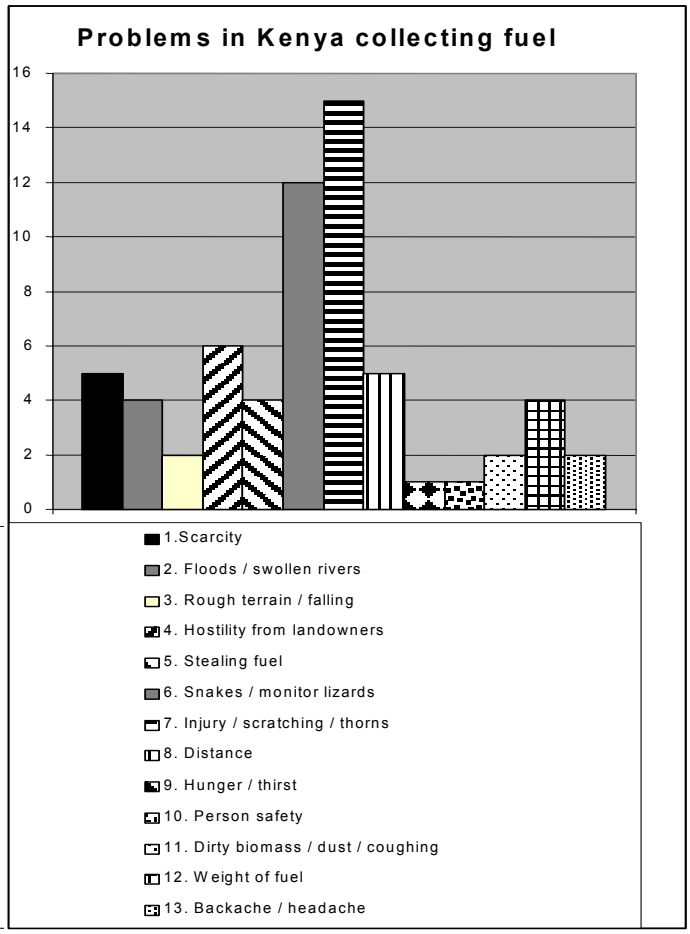


Fuel collection and use

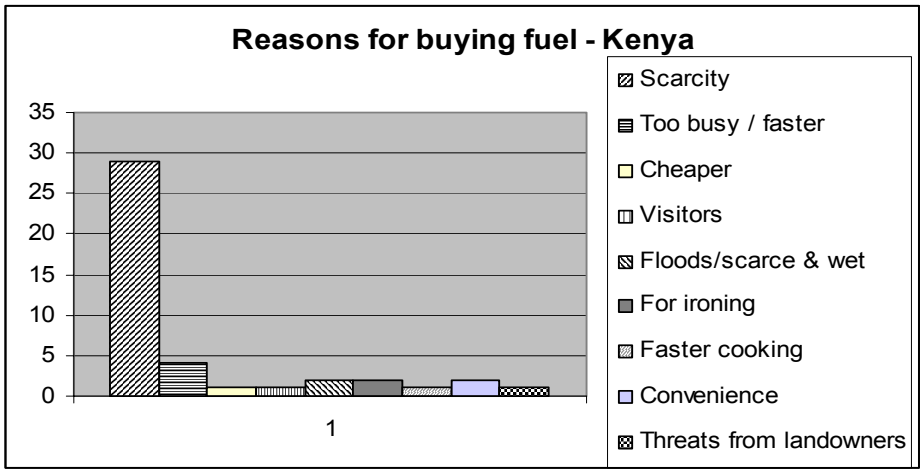
Nepal & Sudan
Virtually all fuel for cooking is gathered in Nepal, whilst in Sudan nearly all of it is bought due to scarcity of supply. Of the four households who collected some fuel, the reasons other than scarcity, which were cited, were snakes, scorpions and distance.

Problems in fuel collection



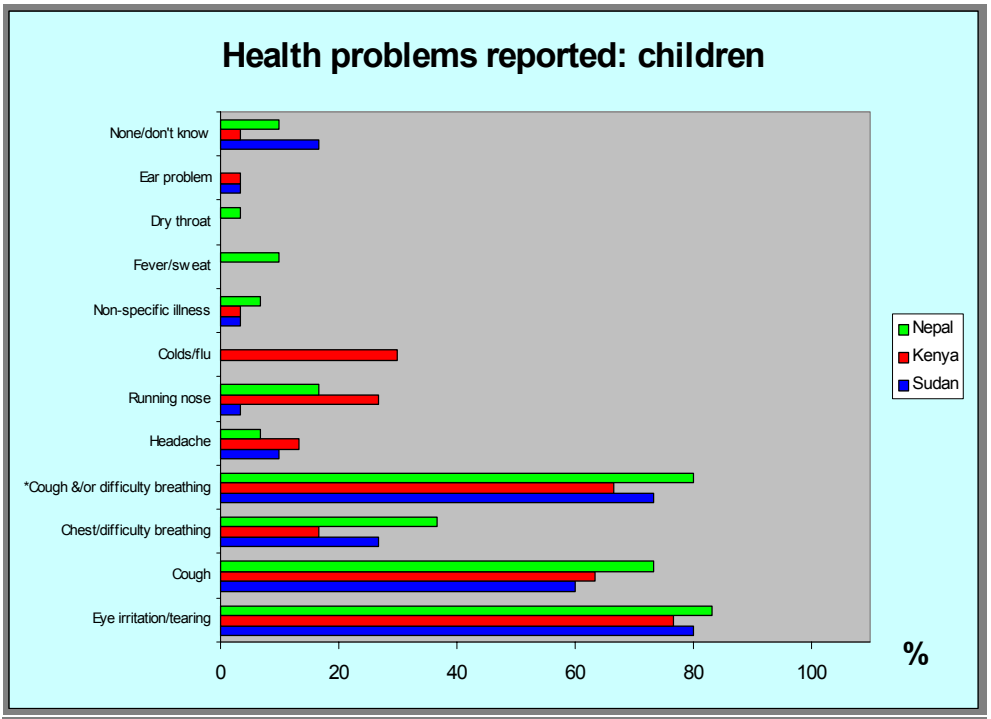


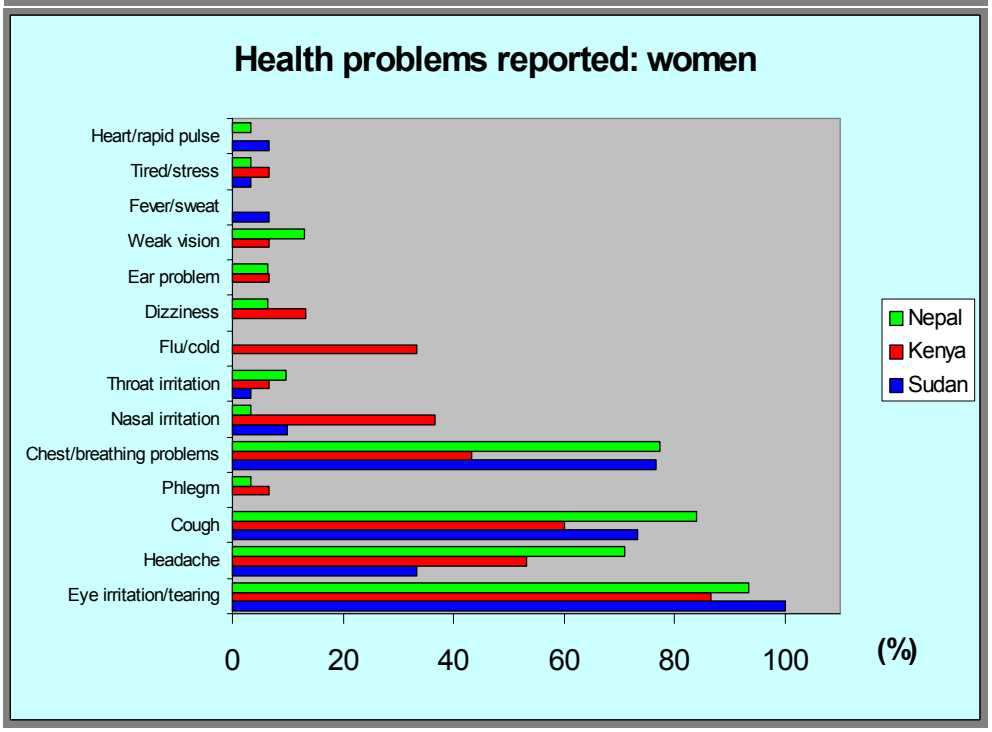
Reasons for buying fuel



Perceived health problems reported for effects of smoke

For children 'the cough and difficulty breathing' is a composite of other reported symptoms that fall under this more general term and is therefore in addition to other symptoms reported in the chart. The exact questions asked can be found in the monitoring questionnaire, Annex 7. The interviewer asked an open question first, to which the woman could make any response. Once this was done, a set of questions was asked on any aspect to which the woman had not made a comment.





Sources of income

Note the very different employment patterns between countries and also between women and men. The prepared foodstuffs in Sudan are mainly carbohydrate-based foods, whilst in Kenya, the main foods for sale are fruit, vegetables and fish. In Nepal it is culturally acceptable to brew beer and it is not possible to identify the full extent of brewing in Kenya and Sudan. Women tend to take on the selling roles for foodstuffs and crafts in each country, whilst men tend to be more engaged in the stereotypical male roles of carpenter, mechanic etc. Both men and women are engaged in agriculture and livestock rearing.

Kenya: Sources of income

Woman	Beer brewing	Fruit & Veg selling	Fish selling	Charcoal selling	Selling water	Other selling	Dried fish	Farming	Other business
Number	1	10	4	2	1	7	1	6	7
Husband	Artisan / tinsmith	Carpenter	Builder	Repair man	Farmer	Casual labour	Formally employed (inc. teacher)	Other business	Retired / deceased
Number	2	2	2	3	2	2	5	4	5

Nepal: Sources of income

Woman	Agriculture	Alcohol selling	Weaving	Livestock	Micro-enterprise	Handicraft	Livestock
Number	31	6	3	0	1	1	2
Husband	Agriculture	Business	Carpentry	Service	Blacksmith	Livestock	
Number	28	6	2	5	1	11	

Sudan: Sources of income: **Sale of the following:**

Woman:	Brewing	Beer	Fruit / veg / nuts	Kisra*	Pasta	Sweets & jam	Zalabia*	Tasali*	Tamia*	Other business
Number	3	0	2	2	5	2		6	4	5

Husband	Shopkeeper / restaurant	Water vendor	Carpenter	Business	Mechanic	Guard	Soldier	Salary / teacher	Retired / deceased
Number	4	1	1	6	1	2	8	4	3

**Kisra* - Local pancake: *Tasali* - Local snack:

Zalabia - Doughnuts: *Tamia* - Chick pea based fried savoury:

Other variables

Other variables relating to fuel use, house structure, numbers of people for whom meals were cooked etc. were measured before and after the interventions were installed. Data on these variables are recorded for both pre- and post-intervention periods in Annex 17. This data was examined to see if there were any major confounding variables that needed to be adjusted for in the analysis.

Chapter 7: Smoke data

In this section, all the key data from the project is collated and observations made on the results. Table 7.0.1 indicates the rationale behind the choice of data collected.

Table 7.0.1: Definitions of variables used to describe and compare pollution and exposure	
Variable	**Interpretation and comment**
Particulate measures	
Room 24 Hour PM_{resp}	24 hour time-weighted average PM_{resp} concentration in $\mu g/m^3$ – the key measure
Room CO measures	
Average room 24 hour CO	Time weighted concentration (ppm) measured for room over 24 hours
Median for room 24 hour CO	Resistant measure of central tendency, although value is zero for some houses
Number of minutes room CO > 3ppm	This is the time period (minutes out of the 24 hours) that room CO exceeds 3ppm. This is when CO in the monitored kitchen is above background and the stove probably alight, an assumption that must be recognised.
Number of minutes room CO > 9ppm	As for minutes > 3, but cut-off is 9ppm. This has more relevance to established health guidelines as the WHO 8-hour average limit is 10ppm. The time period recorded here, however, is unlikely to be continuous.
Woman CO measures	
Average woman 24 hour CO	Time weighted concentration (ppm) measured for woman over 24 hours
Median for woman 24 hour CO	Resistant measure of central tendency, although value is zero for some women
24 hour CO for woman when room CO >3ppm	This is a concentration, expressed over a 24 hour averaging period, but only using data from the times when room CO is >3 (this is assumed to be when CO in the monitored kitchen is above background and the stove probably alight).
Number of minutes for which woman CO >9	Useful indicator of the total time over the 24 hours that the woman's CO exceeds 9ppm. Can be related to guideline, but note period of exposure not likely to be continuous as required by guideline.

Outline of tables presented

1. Comparative tables of main pollutants for three project countries
These tables look across all three countries, allowing a comparison to be made between them. For these tables, the data was matched Round 1 to Round 3 and Round 2 to Round 4. The data in these tables was not adjusted for confounders. A full set of data is provided in Annex 18.

2. Time / activity data
This section looks at the record of the time spent by the fire by the woman and for her child. A comparison of these records with the number of minutes for which the fire was alight allow observations on whether this is a valid way to calculate the exposure of the woman to pollutants.

3. Potential confounding data
Factors examined for change between pre-intervention and post-intervention rounds, are collated for this section. Since the data is very extensive, it is given in Annex 17. The key findings on each section are noted in the main text.

Association between confounders and 24hr-monitoring levels of pollution and exposure.
Where there is a confounding factor of particular note, further analysis is given in the main text. In this study these confounders were smoking and brewing.

4. Percentile data
Percentiles are used to look at:

- Which part of the spectrum of levels of CO was most affected by the interventions
- Whether it is feasible to predict the levels of carbon monoxide to which the woman is exposed from the room levels and thus infer her exposure to particulates.

5. Multivariate linear regression analyses
This analysis describes the impact of the interventions with adjustment made for those confounders that have changed between pre-intervention and post-intervention monitoring and that have been shown to have an effect on pollutant levels. This more complex analysis and discussion is presented and discussed in Annex 19.

Fuel cost
The change in fuel costs was included in this analysis.

Seasonal changes

Two rounds of monitoring reflected the two major seasons in each country – In Kenya and Sudan, this was the wet season and the dry season, whilst in Nepal, a decision was reached that it would be better to monitor the cold and the warm seasons (Table7.0.2)

Table 7.0.2 Seasonal variations in rounds

	Round 1	**Round 2**		**Round 3**	**Round 4**
Kenya	Wet	Dry		Wet	Dry
Nepal	Cold / dry	Warm / dry		Cold / dry	Warm / dry
Sudan	Wet	Dry		Wet	Dry

7.1 Comparative tables of main pollutants for three countries

This section contains *unadjusted* data for the main pollutants with data matched for Round 1 - 3 and Round 2 - 4 to reflect seasonal changes. The distribution of these pollutants across the thirty households was skewed, moderately so for PM, but much more for the carbon monoxide measures. For purposes of comparison and ease of interpretation, both means (and 95% confidence intervals) and medians (and inter-quartile ranges) are reported. Means have been compared with paired t-tests, and distributions with Wilcoxon paired signed rank sum test). [@]Inter-quartile range; *Paired t-test (parametric); [+]Wilcoxon Signed Ranks Test (non-parametric). The charts below illustrate the main findings, but greater detail and percentile tables are found in Annex 18.

Table 7.1.1 24 hour PM_{resp} data

This table refers to the mean and median weights (in $\mu g/m^3$) of particulates measured over 24 hours and recorded for thirty households for each of four rounds. It can be seen that very substantial reductions in particulates were recorded for Sudan, whilst in Kenya and Nepal, the reduction were more modest. The differences between Nepal rounds 2 and 4 were disappointing, and the reasons for this are discussed in Chapter 8.

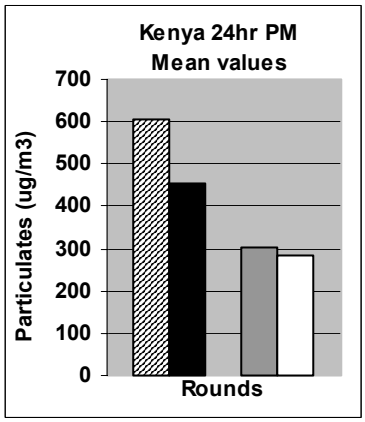
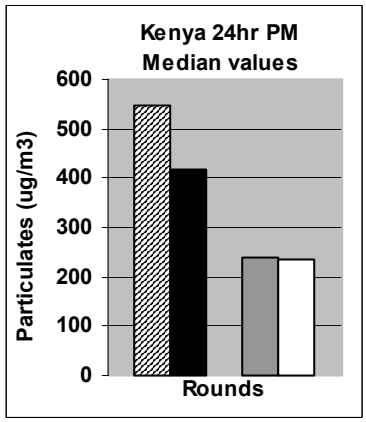
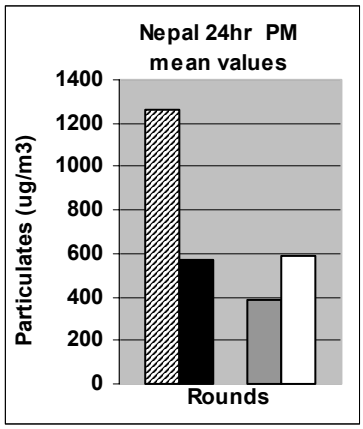
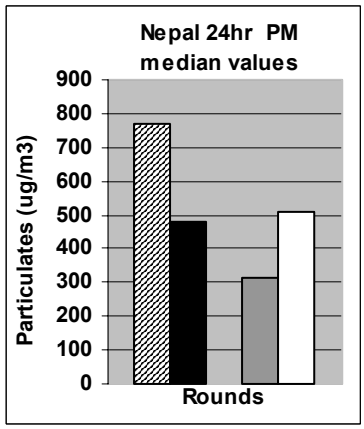
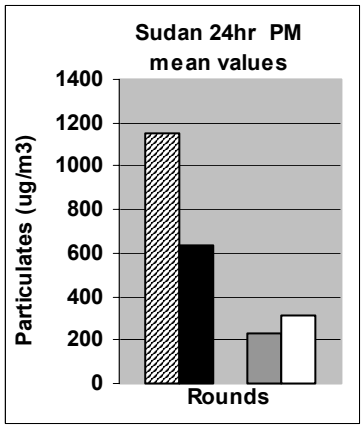
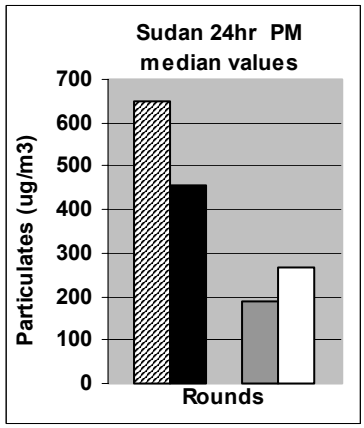
Reduction R1 to R3 50% p<0.0005 R2 to R4 38% p=0.009			**Reduction R1 to R3 56% p<0.0005 R2 to R4 44% p=0.009**
Reduction R1 to R3 69% p=0.046 **R2 to R4 -4%** p=0.832			**Reduction R1 to R3 59%** p<0.0005 **R2 to R4 -6%** p< 0.784
Reduction R1 to R3 80% p<0.0005 **R2 to R4 51%** p=0.002			**Reduction R1 to R3 71%** p<0.0005 **R2 to R4 42%** p=0.006

Table 7.1.2 24 hour mean and median CO for room

The CO-monitor recorded 1440 minute-interval readings to make up 24 hours. For each household the mean was calculated in parts per million (ppm). Table 2 shows the mean and median of all thirty household means. Around half the carbon monoxide has been removed in the Kenyan households whereas in Nepal, the reduction is much greater between the first and third round than between the second and fourth round. One possible reason for this is that a road is being put through close to the village and substantial quantities of beer were being brewed during the round 4 monitoring. This confounding variable was further investigated, and is reported later in this chapter. The reductions in Sudan are sizeable.

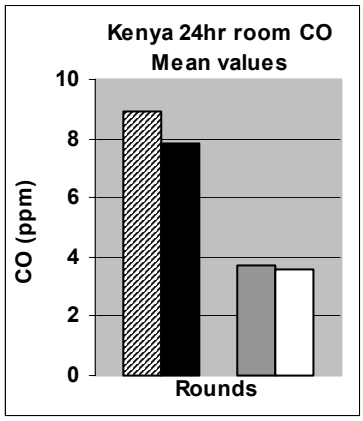
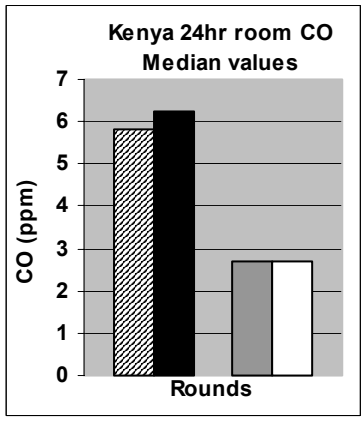
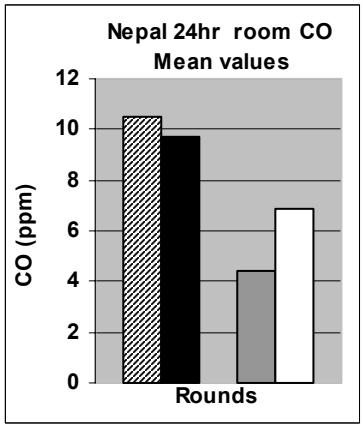
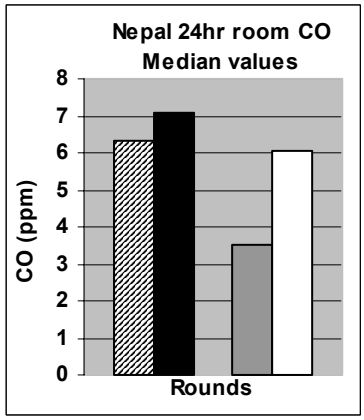
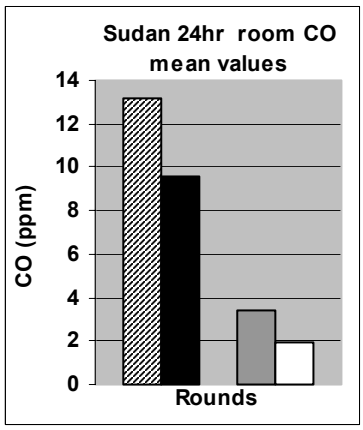
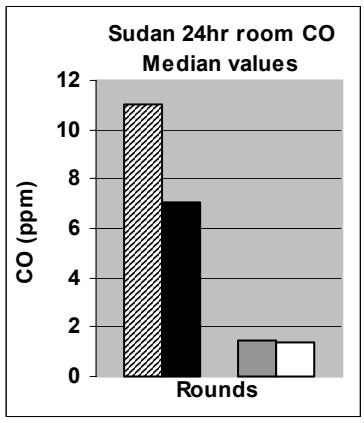
Reduction R1 to R3 58% p=0.038 **R2 to R4 55%** p=0.001			**Reduction R1 to R3 54%** p=0.001 **R2 to R4 57%** p<0.0005
Reduction R1 to R3 58% p=0.007 **R2 to R4 29%** p=0.068			**Reduction R1 to R3 44%** p<0.0005 **R2 to R4 14%** p=0.232
Reduction R1 to R3 74% p<0.0005 **R2 to R4 80%** p<0.0005			**Reduction R1 to R3 87%** p<0.0005 **R2 to R4 80%** p<0.0005

Table 7.1.4 Number of minutes CO > 3 - room

This project was interested in removing the kitchen smoke, but it only affects the woman when she is in the room. This measure was taken to get an indicator of the number of minutes during which the fire was emitting sufficient carbon monoxide to generate a reading of 3ppm or more on the CO monitor. In all cases, the time during which the room was polluted with carbon monoxide reduced after the intervention. Note particularly that Nepal showed a considerable reduction in this measure.

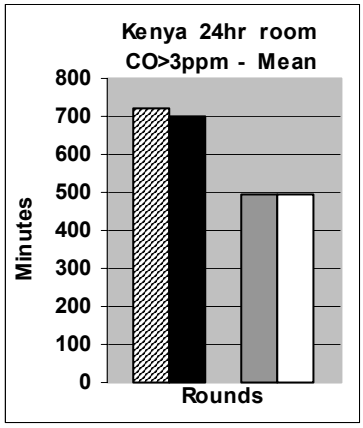
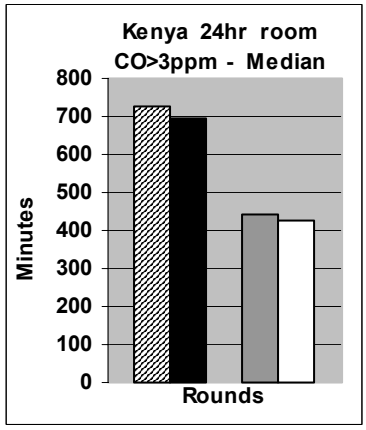
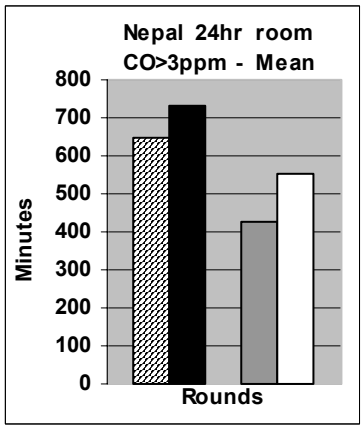
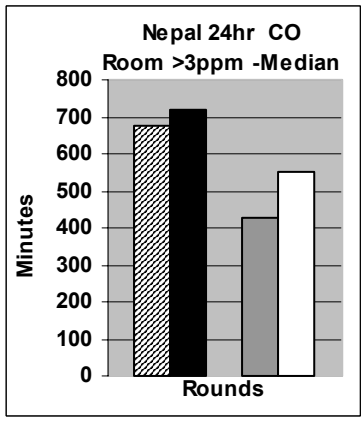
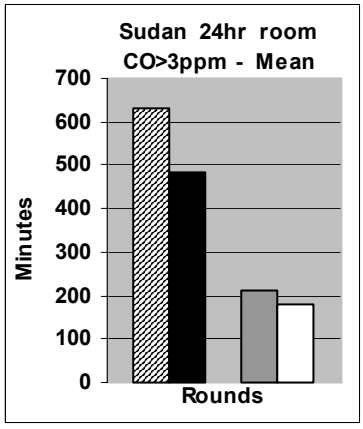
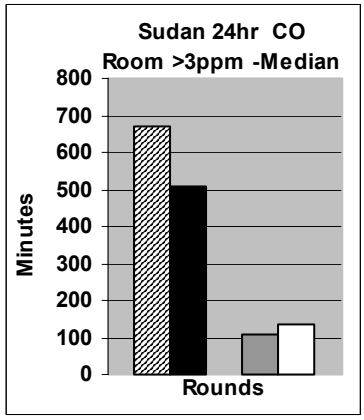
Reduction R1 to R3 31% p=0.003 **R2 to R4 29%** p=0.002			**Reduction R1 to R3 40%** p=0.005 **R2 to R4 39%** p=0.003
Reduction R1 to R3 34% p<0.0005 **R2 to R4 41%** p=0.022			**Reduction R1 to R3 37%** p<0.0005 **R2 to R4 23%** p=0.018
Reduction R1 to R3 66% p<0.0005 **R2 to R4 63%** p<0.0005			**Reduction R1 to R3 84%** p<0.0005 **R2 to R4 73%** p<0.0005

Table 7.1.6 24 hour mean and median CO – woman

The project sought to find ways to alleviate smoke in the room, but also to encourage women to consider their health and to address ways of reducing their exposure. Conversely, there is always the chance that women would find the rooms more pleasant for work when less smoke was polluting the room. This measure looked at how the intervention affected her personal exposure. It can be seen that in all cases but Nepal, the levels of exposure were reduced – some significantly. This is particularly notable in Sudan, but also in the median values for both Kenya and Nepal rounds 2 to 4.

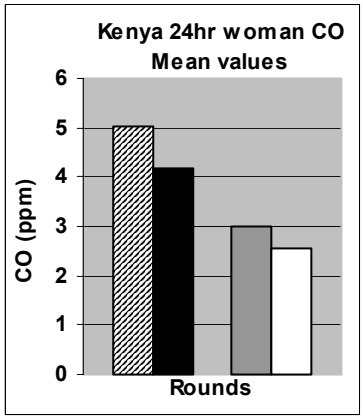
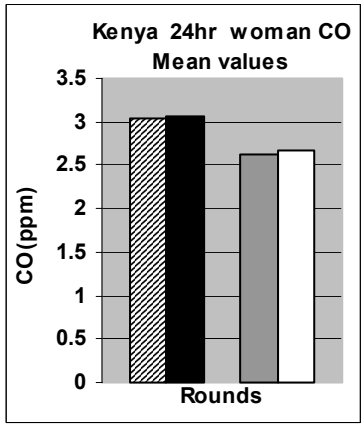
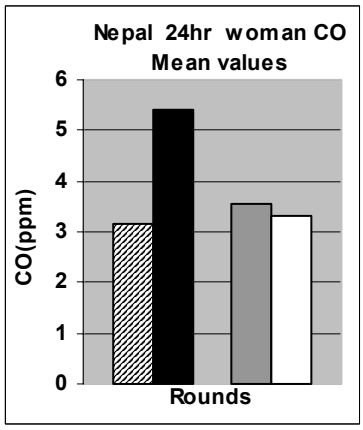
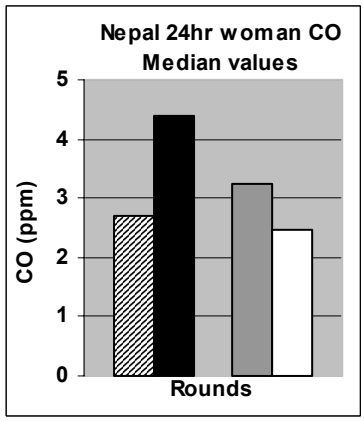
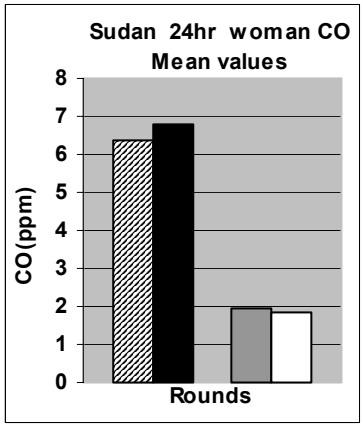
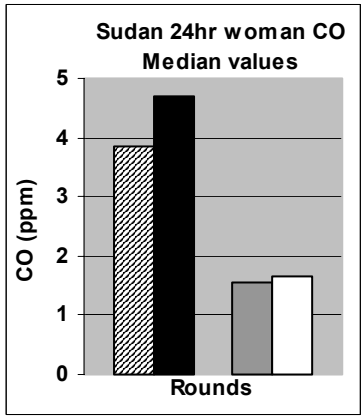
Reduction R1 to R3 41% p=0.191 **R2 to R4 39%** p=0.023			**Reduction R1 to R3 14%** p=0.163 **R2 to R4 13%** p=0.004
Reduction R1 to R3 -12% p=0.557 **R2 to R4 39%** p=0.072			**Reduction R1 to R3 -20%** p=0.581 **R2 to R4 44%** p=0.027
Reduction R1 to R3 70% p<0.0005 **R2 to R4 73%** p<0.0005			**Reduction R1 to R3 59%** p<0.0005 **R2 to R4 64%** p<0.0005

Table 7.1.7 24 hour mean and median CO – woman (with room CO > 3)

This measurement uses woman's CO readings only for those minutes when the kitchen CO is greater than 3 ppm, which is taken to be when the fire is alight. It is possible that the mean CO for the woman could be affected by completely different sources of pollution. Since the woman tends to be at, or near, the stove when cooking is taking place, this measure seeks to remove any exposure to carbon monoxide caused by the woman, for instance, standing behind a polluting bus, or visiting another person's house whilst they are burning biomass. All measures show a post-intervention reduction, although in the case of Nepal, not all the changes are significant.

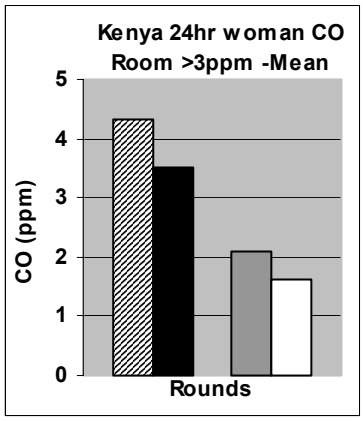
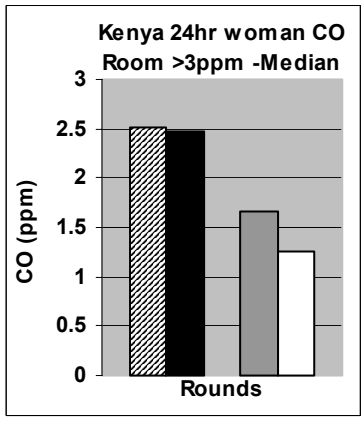
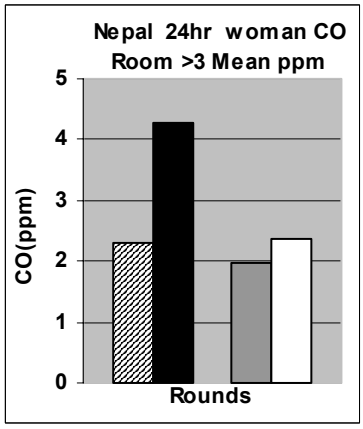
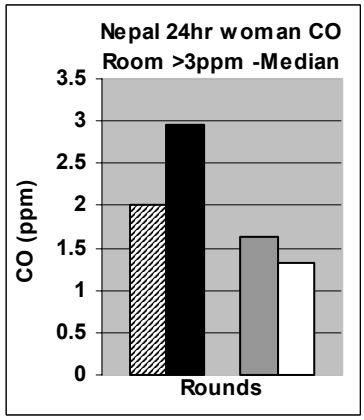
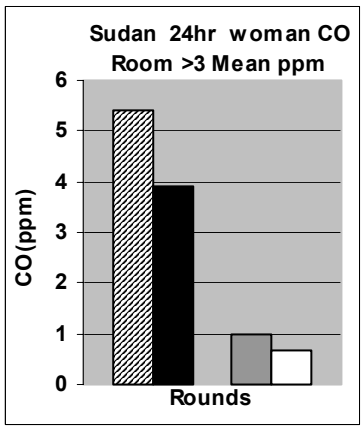
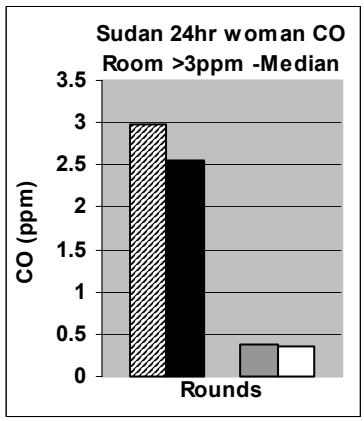
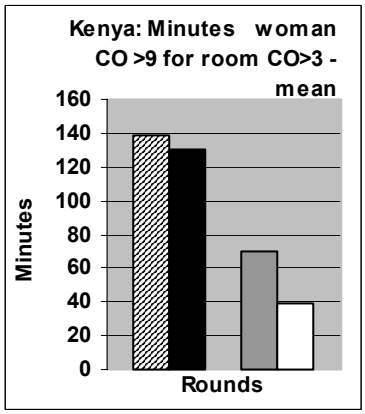
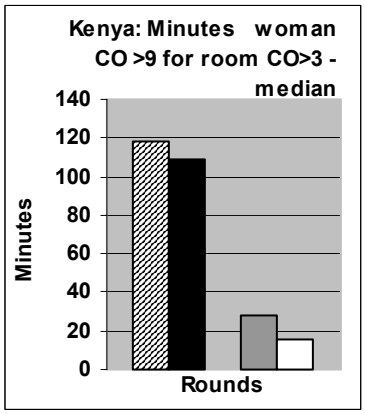
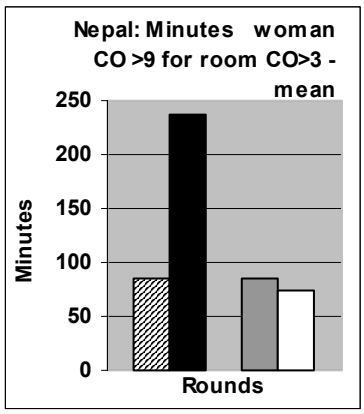
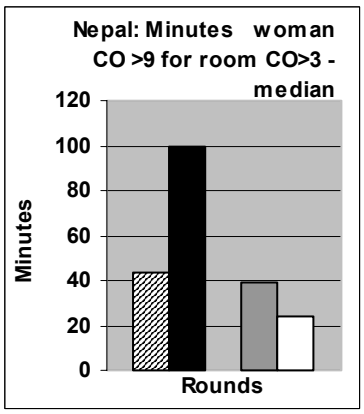
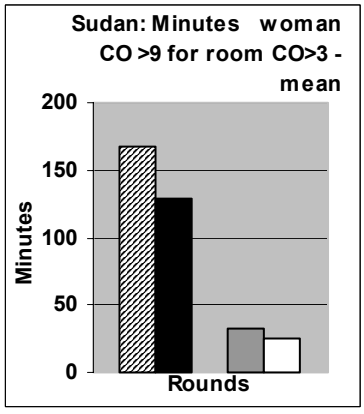
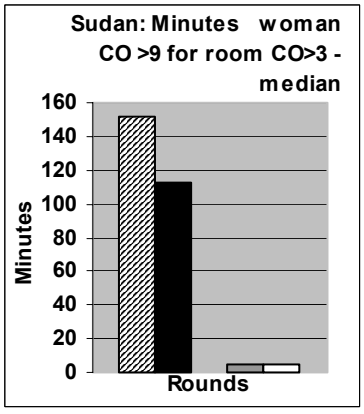
Reduction R1 to R3 52% p=0.162 **R2 to R4 54%** p=0.011			**Reduction R1 to R3 33%** p=0.041 **R2 to R4 49%** p=0.001
Reduction R1 to R3 13% p=0.571 **R2 to R4 45%** p=0.081			**Reduction R1 to R3 20%** p=0.475 **R2 to R4 55%** p=0.024
Reduction R1 to R3 82% p<0.0005 **R2 to R4 83%** p<0.0005			**Reduction R1 to R3 88%** p<0.0005 **R2 to R4 86%** p<0.0005

Table 7.1.9. Number of minutes CO>9 woman with room CO>3

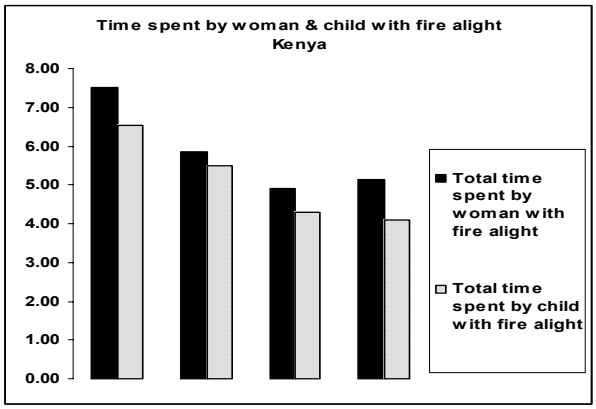
Reduction R1 to R3 50% p< 0.028 **R2 to R4 70%** p<0.0005			**Reduction R1 to R3 76%** p=0.021 **R2 to R4 85%** p<0.0005
Reduction R1 to R3 1% p=0.978 **R2 to R4 69%** p=0.014			**Reduction R1 to R3 11%** p=0.781 **R2 to R4 76%** p=0.012
Reduction R1 to R3 80% p<0.0005 **R2 to R4 80%** p<0.0005			**Reduction R1 to R3 97%** p<0.0005 **R2 to R4 96%** p<0.0005

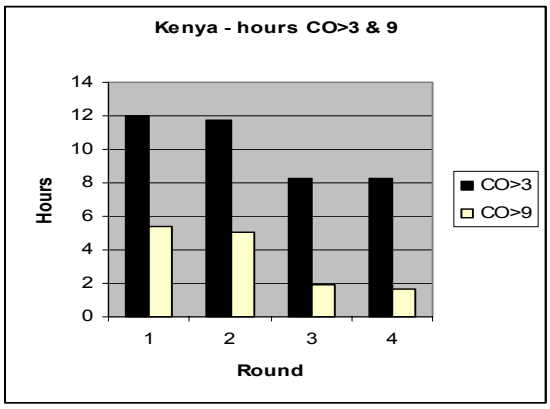
7.2 Time / activity data

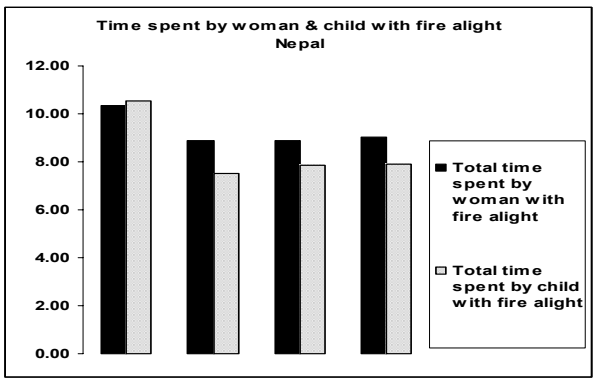
The time that each woman spent beside the fire was recorded in two ways. The first involved asking the woman to record when herself and her child were in the room with the fire alight. The second method recorded the number of hours at which the room monitor recorded levels above CO>3 and CO>9. The correlation between the time recorded by the woman, and the time at which the fire was burning was not as close as might be expected – even when observing individual house records. However, overall, the time spent by children in the kitchen seems to be greater in Nepal than in Kenya or Sudan. Women record spending less time in the kitchen after the intervention than before it. Observing Nepal, the increased number of hours by the fire might also explain the high levels of exposure relative the to room levels, as shown in the upper curve of the Table 7.4.2. for woman vs. room centiles.

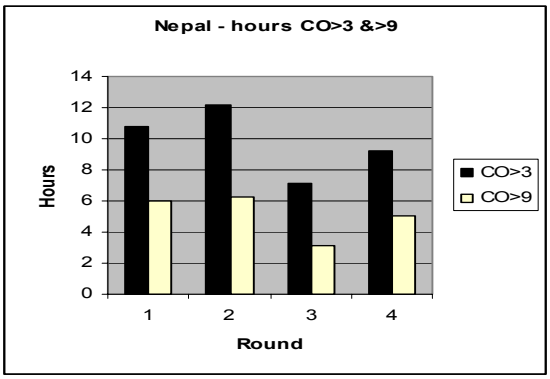
Table 7.2.1 Comparison of Time / activity and time recorded by T82 monitor

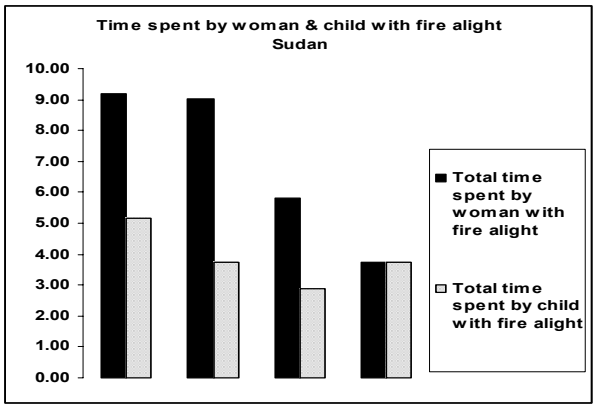
Time /activity chart	CO-monitor

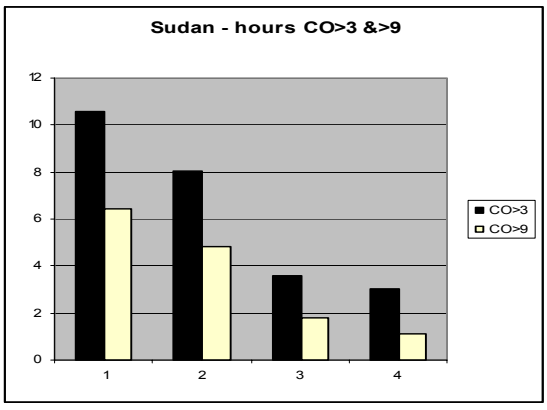






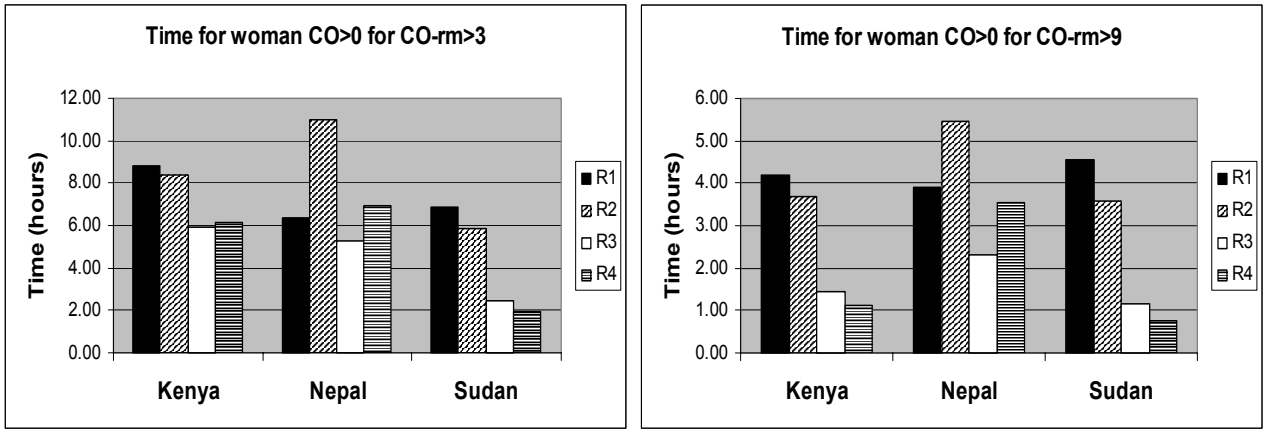






A further methodology examined the time when the woman's levels of CO were greater than zero for the room levels of CO>3 and CO>9. The value of note is the large amount of time spent by the woman when the fire was emitting CO in Nepal in Round 2. Also worth noting is that no brewing was done during the round 3 monitoring in Nepal. This correlates well with the high values of mean and median CO for the woman in Nepal in the comparative tables of main pollutants. The correlation between the time/activity charts and the CO>0 for woman when room CO>3 appears to be strong – particularly for Kenya and Nepal. Sudan, with a fuel change, is less easy to characterise, as much of the CO emitted will be from sources other than the main stove.

Chart 7.2.2 Time for woman CO>0 for room CO>3 and room CO>9



7.3 Association between potential confounders, pollution and exposure

Extensive data for the association between confounders and 24-hour levels of pollution and exposure is reported in Annex 17.

Type of Fuel Used (General) – Annex 17 Table 1
Data was measured across all four rounds for the fuel that the woman generally used. The fuel reported by the woman in this question is for that used on a day to day basis – it does not reflect the fuel used on the day of monitoring.

Kenya
In Kenya, low levels of fuelwood were used in round 4. Much of the fuel is 'twigs and scrub' and non-agri-residues (wood shavings) that are the cheapest option. Two households adopted LPG. Wood and other residues were important second cooking fuel in Round 4, while charcoal use is less. One solar cooker was in use.

The low levels of fuelwood used in round 4 reflected a lean time for those living in some of the villages. Agri-residues from the harvest are all used by this time and much of the fuel is low-grade residues (wood shavings) that are the cheapest option. The main fuel in this round was defined as 'twigs and scrub'. Two households use LPG. Wood and other residues were important second cooking fuel in Round 4, while charcoal use is less. One solar cooker was in use.

Nepal
Total dependence was reported on biomass for cooking, wood being the most important, and this does not change across all the rounds. Lighting is split between kerosene and grid electricity. The changes between R1 and R2 suggest four more homes started using

electricity and in R4, three homes reported solar PV. Fuel for preparing food to sell was not tabulated as only one household reported this.

Women gather Woodfuel from the surrounding area during harvest time (agri-residues) and by the men from the 'high hills' (dead wood). The large wood is stored under the house and allowed to dry. Gatlang has electricity but it is too expensive for most people, and is only used for lighting. People do not sell food currently, but a trekking route is opening up in the vicinity of Gatlang, and this may encourage electrification and improved kitchen quality.

Sudan
By round 4, there is an almost complete switch to LPG as the main cooking fuel, whilst the preferred second fuel has moved from wood to charcoal. For selling, results were somewhat difficult to interpret due to variable levels of reporting, particularly the low number in Round 3. Relatively little use of LPG for this purpose. Some biomass or charcoal will have been used for cooking at market. For lighting (main fuel) there is a reduction in use of kerosene and the increase in use of 'other' fuel, eleven households using car battery electrification and one the local electric grid

There is still some use of biomass, both within the home, and biomass or charcoal will have been used for cooking at market. It is anticipated that the trend for LPG will continue to increase as a depot has been built within the displaced community, thus facilitating access to refills.

Type of Fuel Used (for cooking each meal during monitoring 24 hrs) – Annex 17 Table 2

Kenya
Many households did not cook a fourth meal during the day, so the numbers recorded for this measure are low. A few households record that 'other cooking' was done. Those reporting using fuel for 'other uses' mainly report domestic uses, such as boiling water for bathing baby, rather than those related to enterprise. Over the four rounds, only six 'enterprise' uses were recorded on the day of monitoring; these were: Ghee making; Chappati; Fish; Green grams; Ugali; and Fried fish

Nepal
Wood is the dominant fuel across all four rounds. In the fourth round there appears to be less food cooking, although a few more households were involved in brewing. The Adult Male Equivalent (AME) (NRC, 1989) mean values assess the number of people for whom cooking was done. This is a factor that could be expected to change pollution levels.

Table 7 (Nepal): Meals cooked

	Round 1		Round 2		Round 3		Round 4	
	n	**Mean SD**	n	**Mean SD**	n	**Mean SD**	n	**Mean SD**
Meals cooked - AME Total mean (sd)	31	**13.3 5.33**	31	**16.3 7.14**	31	**12.5 4.78**	31	**11.0 4.64**

All the main fuel is gathered in Nepal. Fewer households reporting shortages would correlate well with both wall insulation and the use of an improved stove being installed, although the time spent collecting remained very similar. Alternatively, it may be due to climatic variations. Use of green fuel seems to show a seasonal change. The similar reporting of green fuel before interventions (R1 and 2) to afterwards (R3 and 4) might suggest that more emphasis on fuel drying would be beneficial. The continuing use of damp fuel suggests that this too requires addressing. However, if one observes the fuel being used on the day of monitoring, the number using damp fuel has gone down substantially, despite the weather in Round 4 being much wetter than in Round 2.

Sudan
The marked switch to LPG seen in the general fuel use question is confirmed in the 24-hour monitoring period, although there is some continued use of biomass. A very striking observation is that, whereas in Round 1 and 2 quite a few (between one-third and one-half) of homes reported using a second fuel (and this was mainly charcoal, wood, residues), after the intervention very few homes reported using a second fuel for these meals. There was very little change in the numbers (%) who reported other uses of the stove during the 24-hour monitoring period. Although homes reporting other uses of the stove had slightly higher levels of PM, room CO and woman CO, these were non-significant (t-test; Mann-Whitney)

The reduction in fuel gathering after the intervention reflects well on the use of LPG for cooking. The reasons for buying suggest that if woodfuel became less costly than LPG, there might be a reverse trend towards the more polluting fuel. The rapid natural growth of uptake of LPG stoves in Sudan needs to be exploited to ensure that the health and other benefits are promoted so that this knowledge is 'owned' by the community.

Gathering of fuel, scarcity and dampness– Annex 17 Table 3

Kenya
Scarcity was one of the reasons for fuel purchase, and this varied over the different rounds. During the period when round 4 took place, poverty was at its greatest. Fuel that was bought was cheap wood shavings. No one felt that that fuel was plentiful

Nepal
A reduction in those reporting scarcity was recorded over the rounds. Use of green fuel seems to show a seasonal change. Use of green fuel before interventions (R1 and 2) is similar to afterwards (R3 and 4). Dampness is inconsistent and does not relate to use of green fuel.

Sudan
It appears that less fuel is gathered after the intervention. The main 'reason for buying fuel' after the intervention (LPG) remains scarcity of supply. Unsurprisingly, there are few responses to adequacy of supply. Use of green fuel is consistent with some continued use of biomass after the intervention. Dryness is not an issue for those who switched completely to LPG and so the question is omitted –about one-third, while the seasonal patterns remain for the rest.

Features of kitchen and house – Annex 17 Table 5
Kenya
It can be seen that about 70% of homes have hood/flue based on extraction data. Shape codes allow the volume of the kitchen to be calculated.

As part of the 'package', households could opt for one or two windows, with shared costs for purchase and installation. It is interesting to note the large number of households benefiting from this change. Although windows are not believed to reduce smoke, they increase the light in the room and can reduce the need for polluting kerosene lamps, and reduce the time people spend working in the house.

Nepal
Changes recorded in kitchen type, windows and roof type are due to interpretation. Permanent ventilation inconsistencies in R1 and R2 are due to way dimensions interpreted.

There were no measurable changes in the house structure that would be reflected in these tables. One or two anomalies in the findings are believed to be due to the way the questions were interpreted.

Sudan
There is a gradual change across rounds in kitchen type (enclosed/semi-open) although permanent ventilation is unchanged. There was essentially no change in type of walls for kitchen. The change across rounds in kitchen type (enclosed/semi-open) is, in part, due to changes in structures, and / or because of using a more permanent structure to cook once LPG was installed. Responses to kitchen building seem to support the latter reason, as there has been a small increase in the number of households with the kitchen as part of the main living area.

Roof type changes are consistent with a move to more permanent building for a few households. The increase in the number of windows reported is due to the change in building used for the kitchen rather than them being installed as part of the intervention.

Season, Temperature, Rainfall, Number for whom food was cooked – Annex 17 Table 6

Kenya
General rainfall reflects season variation, but note that Round 4 is very dry, with 24 hour monitoring rainfall is consistent with general rainfall. This is consistent with the reduced amount of available agri-fuel. Mean, maximum and minimum temperatures are very consistent.

Nepal
Adult Male Equivalent (AME) of those for whom food was cooked shows some reduction across the rounds. There is a weak (marginally significant) +ve correlation (Spearman rho = 0.183; p=0.042) between PM_{resp} and AME [but this is not independent of the effect of the intervention]. Both general rainfall, and 24-hour rainfall show that Round 4 was wetter and this may account for the very high values recorded in this round.

Sudan
Post-intervention rounds were a little cooler and recent rainfall reflects season variation, although Round 1 (wet) was drier than Round 3 (wet). 24 hour monitoring rainfall is consistent with general rainfall. There is a reduction in AME across rounds.

Other cooking activities – Annex 17 Table 2

Kenya
The results reflected very few using the fire for 'other activities' and further investigation showed that most of these 'other activities' are boiling water.

Nepal
It can be seen in Table 7.3.1 that although there are substantial changes in the room levels, there is minimal impact on women's CO. This is likely to mean these are tasks that do not require the woman to be in the kitchen much of the time whilst brewing is taking place. This measure appears important in Nepal, so further analysis looking separately at pre-intervention and post-intervention rounds is shown in Table 7.3.2. It can be seen that in the pre-intervention phase, none of these results is significant, but are all in the expected direction. In the post-intervention phase, the differences seen for the room measurements are based on households doing 'other cooking' in Round 4 being compared with those not doing 'other cooking' in both Rounds 3 & 4 (as there were no households brewing in Round 3). This could be rather misleading, particularly due to the low numbers of households doing 'other cooking' overall. The very high levels associated with 'other cooking' shown in round 4, however, correlate well with the reports of high levels of brewing reported by the project team. These appear to have influenced the overall levels of the key indicators in the post-intervention rounds.

Sudan

As with Kenya, there was a small, but non-significant effect in the expected direction consistent with the two-season monitoring plan.

Table 7.3.1 (Nepal) –Other cooking activities							
	Other cooking		**Difference in means**	**95% CI**		**T-test**	**M-Whitney**
	Yes	**No**		**LL**	**UL**	**p-value**	**p-value**
PM_{resp}	1400.1	584.0	**816.2**	193.7	1438.6	0.011	0.002
Number	18	106					
Room CO	13.5	7.1	**6.4**	2.1	10.7	0.004	0.006
Number	18	105					
Woman CO	4.6	3.9	**0.65**	-1.06	2.36	0.453	0.508
Number	17	98					
Table 7.3.1 (Sudan) –Other cooking activities							
	Other cooking		**Difference in means**	**95% CI**		**T-test**	**M-Whitney**
	Yes	**No**		**LL**	**UL**	**p-value**	**p-value**
PM_{resp}	594.3	517.4	**76.9**	-167.7	321.6	0.534	0.225
Number	39	66					
Room CO	7.57	6.79	**0.78**	-2.73	4.28	0.662	0.243
Number	39	71					
Woman CO	4.49	4.05	**0.44**	-1.37	2.26	0.630	0.237
Number	38	71					

Table 7.3.2 –Other cooking activities Nepal				
Rounds 1 & 2				
	Other cooking?		**Diff. in medians**	**M-Whitney**
	Yes	**No**		**p-value**
PM_{resp}	654	504	150	0.605
Number of households	18	106		
Room CO	9.35	6.69	2.66	0.455
Number of households	18	106		
Woman CO	4.72	3.36	1.36	0.241
Number of households	17	98		
No. mins room CO >9	439	317	122	0.444
	18	106		
No of mins woman CO >0 with rm.CO >9	198	158	40	0.632
	17	98		
Rounds 3 & 4				
	Other cooking?		**Diff. in medians**	**M-Whitney**
	Yes	**No**		**p-value**
PM_{resp}	793	372	421	<0.0005
Number of households	18	106		
Room CO	10.85	3.83	7.02	0.003
Number of households	18	106		

Woman CO	2.4	2.89	-0.49	0.512
Number of households	17	98		
No. mins room CO >9	531.5	181	350.5	0.002
Number of households	18	106		
No of mins woman CO >9	47.5	55	-7.5	0.95
Number of households	17	98		

Smoking during 24-hour monitoring period and levels of pollution and exposure

Smoking status – Annex 17 Table 4

The question for the cook was asked as a general question – the question for 'others' was only for when they were in the kitchen. The question was not asked for the particular day when the monitoring took place.

Kenya

No smoking was reported by any of the cooks involved in this study, and the level of reporting of others in the kitchen was also very low. In Kenya, it is very unusual for women to smoke, and very few people were recorded as smoking in the kitchen.

Nepal

Only 7 women reported smoking (3 in R1 and 4 in R2) and none of them is the same woman). The amount smoked is not great, median 4 cigarettes/day (range 1-11). Table 7.3.3 shows the mean values for smokers and non-smokers for both cook and 'others' smoking. Smokers have higher levels, and these are significant for PM_{resp} and CO room. The majority reported that smoking in kitchen was occasional rather than regular. Results are not significant with the Mann-Whitney for 'other' smokers. There appears to be a reduction in smoking across the rounds.

Table 7.3.3 Nepal - Smoking in the kitchen

Cook smoking

		N	Mean	Std. Dev	Std. Error Mean	T-test	M-Whitney
PM_{resp}	yes	7	2658	4152	1569.62589	**<0.0005**	**0.031**
	no	113	593	752	70.78396		
24hr mean CO for room	yes	7	25.91	25.24	9.54026	**<0.0005**	**0.015**
	no	112	7.13	5.34	.50503		
24hr mean CO for woman	yes	7	6.46	5.21	1.97031	**0.045**	0.114
	no	105	3.88	3.12	.30456		
24hr mean CO for woman	yes	7	6.4626	**0.045**	0.114		
	no	105	3.8752				

Others smoking in kitchen

		N	Mean	Std. Deviation	Std. Error Mean	T-test	M-Whitney
PM_{resp} - weight difference / volume	No	54	504.2506	303.65775	41.32259	0.102	0.441
	Occasional /regular	56	921.5649	1833.08690	244.95654		
24hr mean	No	53	6.3806	4.69137	.64441	**0.043**	0.081

CO for room	Occasional /regular	56	9.9101	11.65963	1.55808		
24hr mean CO for woman	No	51	3.6175	3.18623	.44616	0.139	0.067
	Occasional /regular	52	4.6124	3.57141	.49526		

Although a substantial difference was recorded, given the amount of cigarettes reported (median 4 per day), one might be justified in questioning whether these higher levels are due to smoking. Care must be taken about very small numbers, confounding, and non-independence of observations. It would be welcome if the reduction of 'others smoking' between Rounds 1 & 2 and Rounds 3&4in Nepal is due to the improved understanding of the dangers of smoke, but no further investigation has been done in the field to ascertain this to date.

Sudan
Only two / three woman smoke, but at least half of homes report others smoking in the kitchen, albeit 'occasionally' for most.

7.4 Percentiles

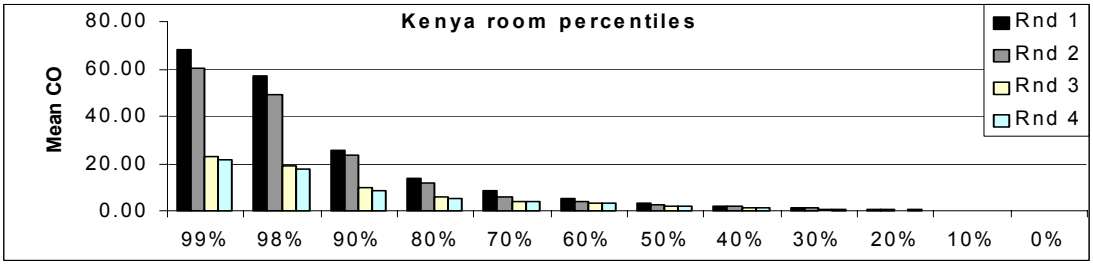
Characterizing the physical processes of smoke reduction

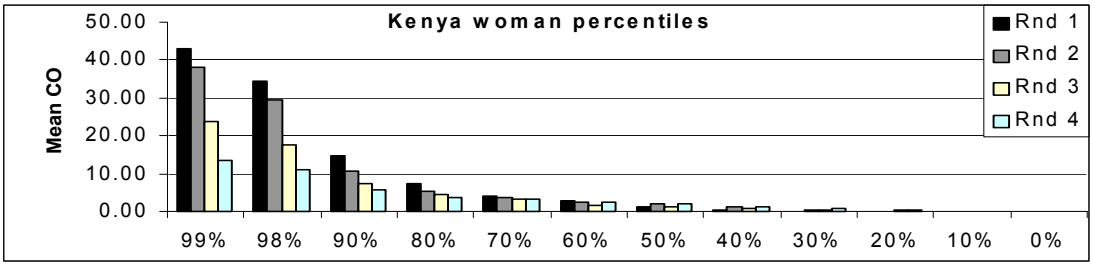
Because this sort of study produces a fairly wide scatter of results, it is useful to use percentiles to characterise emissions to observe the levels at which the intervention is having the greatest impact (Chart 7.4.1). Note: the 99th and 98th centiles are shown – these are not to scale – the remaining centiles are at 10% intervals. It can be seen that for both Kenya and Sudan, there are major reductions in the 99th and 98th centiles, showing that the very high levels of CO are being removed. This effect is much less marked in Nepal.

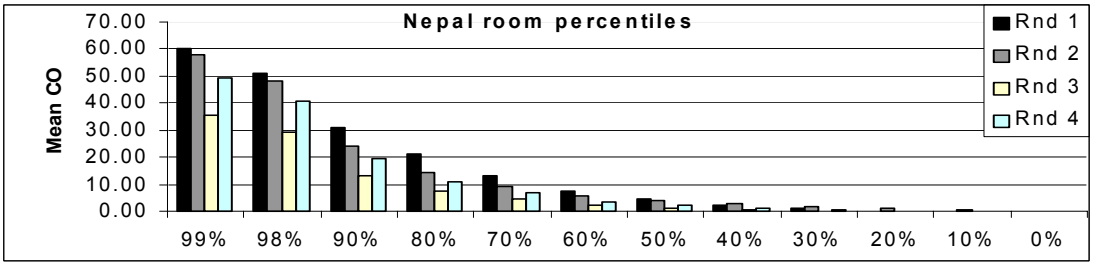
Analysis of the centiles demonstrates that in Kenya and Sudan the high levels of CO show a very marked reduction – for example, the 98th percentile, which represents the level exceeded by 2% of the day, around a half hour, is reduced by two thirds in Kenya, and three quarters in Sudan. Although Nepal achieved much less dramatic results there was 30%.

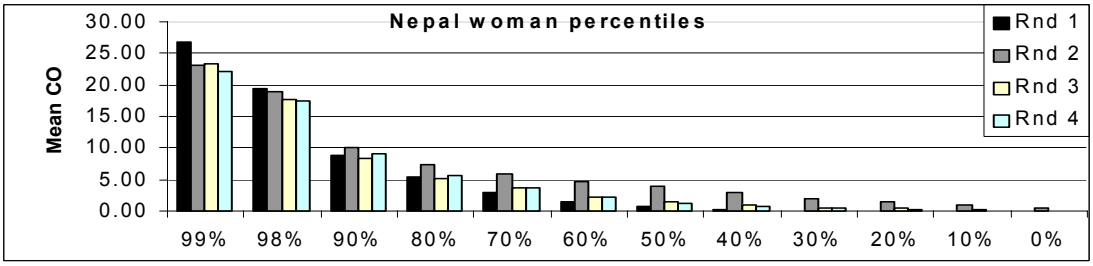
Using a similar rationale to Table 7.4.2, both household and woman's values of carbon monoxide were ranked and the percentiles for each were calculated. The near-linear relationship suggests that combining data for all houses, the distributions of room and woman CO are similar and approximately follow the relationship given – chart 7.4.2. This method enables all the data to be managed to describe the change in the ratio for woman / room CO before and after the interventions were installed. The two lines apparent in the Nepal and Sudan traces reflect the two rounds pre- and post-intervention. However, despite these differences, the general trends appear to be very similar for the pre-intervention rounds and for the post-intervention rounds

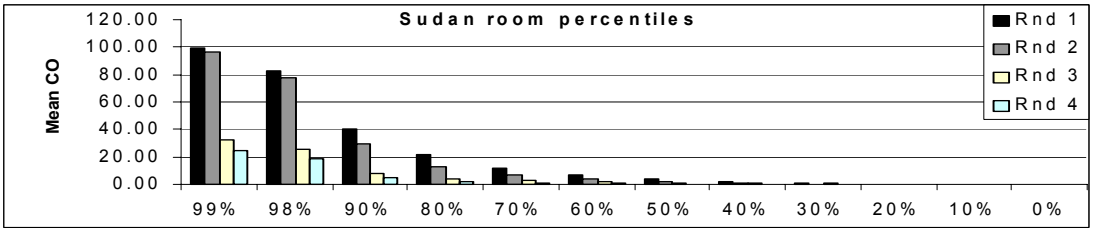
Chart 7.4.1: Percentiles by round for three countries – Kenya, Nepal, Sudan











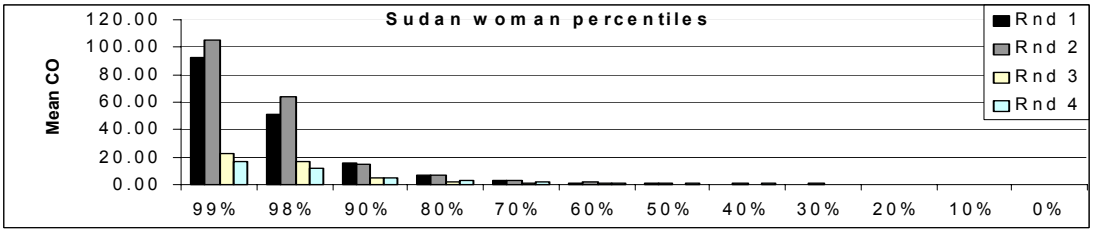
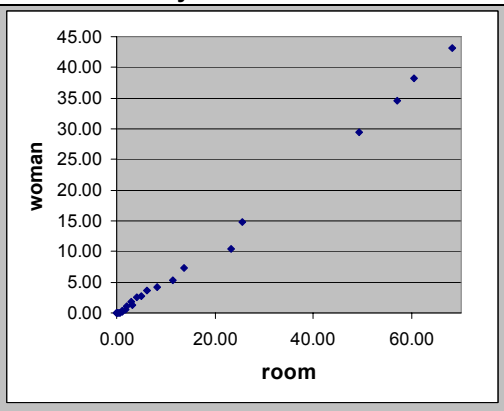
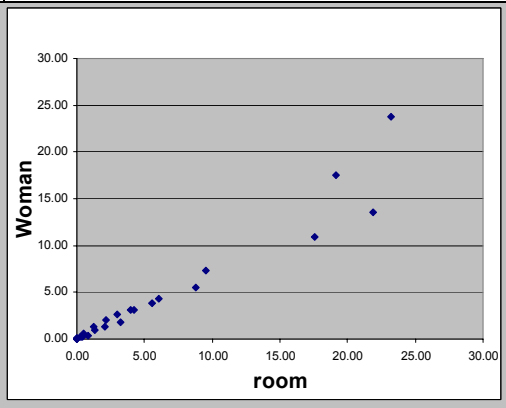
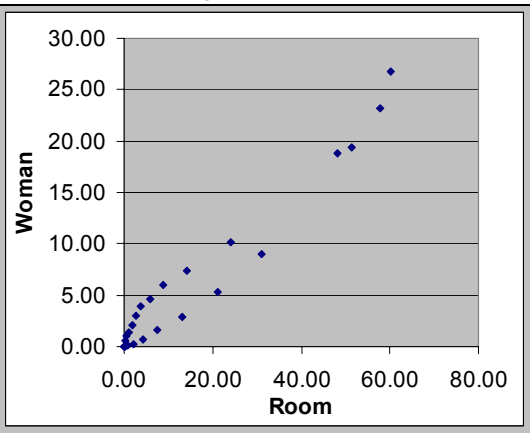
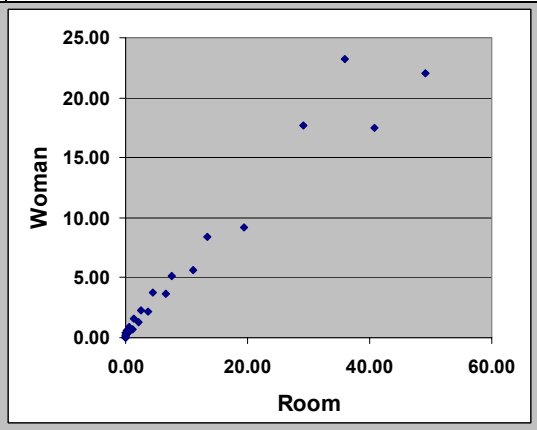
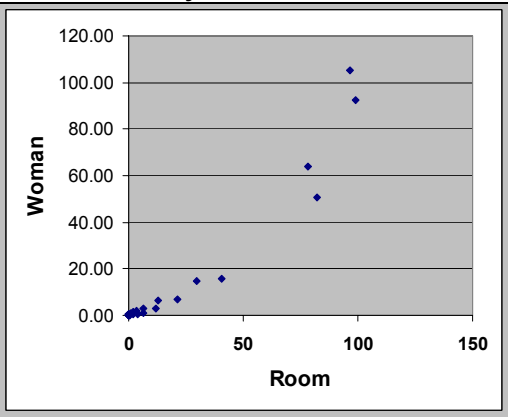
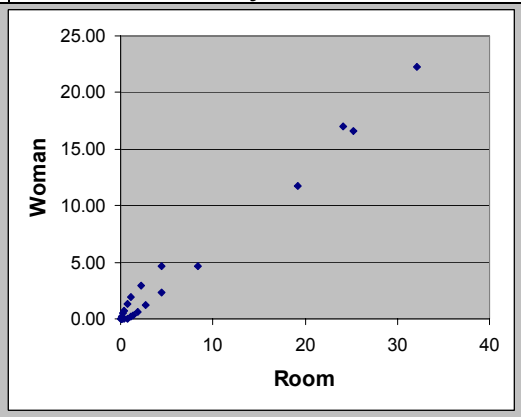


Chart 7.4.2: Percentiles characterising the relationship between CO-woman and CO-room

Kenya rounds 1 & 2	Kenya rounds 3 & 4
y ~ 0.6x	Y ~ 0.8x
	
Nepal rounds 1 & 2	**Nepal rounds 3 & 4**
y ~ 0.4x	y ~ 0.5x
	
Sudan round 1 & 2	**Sudan round 3 & 4**
y ~ 0.9x	y ~ 0.7x
	

Chapter 8: Discussion and conclusions

This chapter is arranged in six sections that discuss distinct aspects of the project. In each section the implications for future work is addressed.

- Impact on smoke
- Other impacts
- Interventions / Technologies
- Overall project design
- Project methodology
- National and international dissemination

Impact on smoke

Discussion on key outcomes in PM & CO here

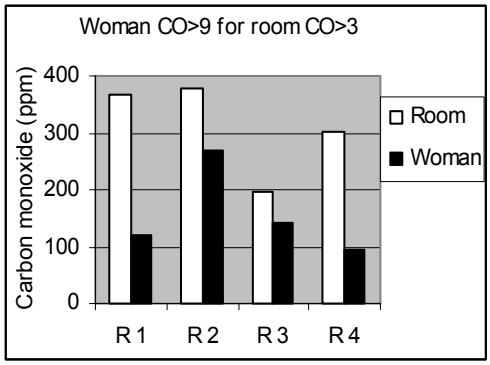
Kenya
In Kenya the levels of particulate were approximately halved when both mean and median are observed and around 55% reduction for room CO. The exposure for the woman is considerably less – nevertheless the levels to which she was exposed were reduced by a quarter.

The time for when CO>3 in the room (taken to indicate that the fire was alight) is reduced by about a third. For CO>9 the reductions were reduced by over 80%, indicating that the interventions are having a substantial effect on the higher levels of pollution.

Using the room CO>3 as an indicator of when the fire was alight, the reductions in woman's 24hr CO were greater when her levels associated with room CO were considered, indicating that some of the CO she inhaled was not due to the room CO but from sources outside the kitchen.

The total time for which the woman was exposed to levels of CO greater than 9 ppm was reduced by around 60% from around 2.5 hours to around 1 hour.

Nepal
Overall the results from Nepal are less consistent than in the other two project countries, but overall reductions in room and woman measures of exposure were achieved. Room PM went down by around a quarter and room CO by around one third. The woman's CO was reduced by just over 10%. There was however evidence of a larger reduction in the amount of time for CO>3 in the room – a reduction of around one third. This may indicate that the fire was alight for shorter periods of time. The time for when the room was highly polluted (CO>9) was reduced by around one third from six hours for both mean and median. One factor which was not measured, and which may be relevant, is the wind. It could be observed that when the wind was gusting it blew the smoke away from the hood.



For the women, the level of exposure to CO for the woman for when the fire was alight (CO>3) was reduced by around 30%. The findings for the time for which the woman was exposed above 9ppm are very inconsistent. Observing the room levels across these rounds, there is a reduction in room-CO between round 4 and round 2, and a reduction in the effect on the woman. This is consistent with the relatively low exposure of the woman, thought to be due to high CO room levels due to brewing in round 4.

Sudan

Of the three countries, Sudan showed by far the greatest and consistent reduction in terms of both room reductions and women's exposure. Room reductions of around 65% were recorded for the room and medians of around 55%. Room CO showed a larger reduction of around 80% for both measures. These translated in substantially greater reductions in woman's exposure, with a two-thirds reduction. This is consistent with reduced time spent cooking.

The time with the room CO>3 is reduced by around three-quarters, but it is difficult to refer this to 'time spent alight' because very little pollutant will be from the main cooking source (LPG). A similar reduction of around three-quarters of the time from a pre-intervention average of around 5-6 hours was seen for CO>9 for the room from a pre-intervention CO values . The average CO for the woman during the time when room CO>3 was reduced by over 80%. The number of minutes that the woman was exposed to CO>9 was reduced by around three quarters from around just over three hours.

Other impacts

Kenya

The critical part of this project was for women to realize that they could apply knowledge they received immediately, and to see the visible effects of the same, e.g., reduced irritations and fuelwood use and costs, right away, in their own kitchens, with locally available materials for such interventions as the haybox cookers - old clothes, sawdust, grass, dried banana fibres, etc. Taking control immediately of the kitchen smoke situation, with immediate effects

> **"** The improved stove does not use semi-dry wood and hence it produces less smoke compared to the other normal stoves. This smoke is then led out of the kitchen through the smoke hood out of the house. It is now comfortable and nice to stay in the kitchen even when meals are being prepared as compared to the situation before when there was too much smoke**"…….……Sentiments of an interviewee from Kajulu**

Health

Findings from an impact review (Annex 20) revealed that since the installation of interventions a marked change in the frequency and intensity of infections and illnesses is reported, which relate to indoor air pollution. Discussions during the interviews revealed that most of the positive impact was experienced by those households that had installed the stove and smoke hood. This they attributed to the nature and quantity of smoke that is emitted from the stove and how it is led through the smoke hood out of the kitchen into the sky to the safety of the household.

Income and savings

Broadly, interviews with the women revealed that there have been a lot of changes in use of income released from fuel savings within the households. The majority of the households with the interventions have experienced a new lease of life. Their standards of living have slightly improved. A number have engaged in other income-generating activities from the minimal savings they accrued from using the interventions.

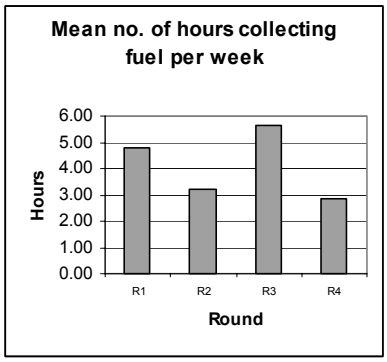
Income generation activities directly attributable to the project have begun, including manufacture of smoke hoods and fireless cookers. The revolving fund will in part be used for income generating activities that will allow members to buy smoke-alleviating interventions once they have generated some income.

Making attractive fireless cookers for sale (photo – ITDG-EA)

Time
Another finding was that the use of these interventions has led to saving more time in cooking and cleaning giving the womenfolk a window of opportunity to pursue other activities.

Time spent collecting fuel and cooking

From Tables 7.2.1 and Table 7.2.2. it can be seen that there is around a 30% reduction in the time spent cooking. This is evident from both the estimates using the time / activity data and/or implied from the CO data showing the time spent by the woman when CO>3.



Nos of HHs	R1	R2	R3	R4
All gathered	7	7	6	5
Mostly gathered	5	3	8	4
Mostly bought	13	10	8	9
All bought	4	7	5	8

There was little change in the buying or gathering patterns brought about by the interventions. This is similar to the situation in Nepal (where no cooking fuel is bought), and in line with other studies that indicate that people who benefit from fuel savings tend to use their savings to increase their access to energy (Bazile, D. 2001) Households who 'mostly bought' fuel were omitted from the calculation of hours spent gathering.

Cleanliness
Use of the smoke hood has led to cleaner and hygienically safer houses. It was observed that most houses with these interventions have experienced less soot and smoke in their houses.

Drudgery
The windows and eaves spaces have enhanced visibility through improved lighting. It was shared that it was now easier to undertake more household chores within the house, as there was more natural light even in the evening.

Comfort
Another added advantage as shared by the respondents was the improved circulation of fresh air with the houses and kitchens. It was explained that it was now more comfortable to cook and stay in the house even when cooking was in progress.

Status
There is a raised awareness and increased profile on indoor air pollution in the communities. The selection process raised the sensitivity of the household owners since they are representing their respective communities with a total population of 20,000 people.

The status of the kitchen, and thus the cook, benefited. Household owners saw the need to make certain improvements in the households as part of preparations for monitoring. For example, one woman had a new kitchen built for her by the husband; other households improved the build quality of the kitchen, levelling the floors, smearing the kitchen walls, improving the thatch.

Awareness
There is a raised awareness and increased profile on indoor air pollution in the communities. The selection process raised the sensitiveness of the household owners since they are representing their respective communities with a total population of 20,000 people.

Negative impacts
The external reviewer was specifically requested to determine any negative impacts that need to be addressed. It was shared that the eaves spaces act as inlets for mosquitoes, rain drops and cold air or wind in the night posing a great risk of getting infected by malaria and

pneumonia especially for the young children who commonly use the kitchen as their sleeping quarters. This indicates that some sort of shutters should be integral with the installation of the eaves spaces so that they can be closed at night once the fire dies down.

Another risk that was mentioned was that the smoke hood after long use collects soot that in some cases drops down into the food while cooking and may contaminate the food where the foodstuff being prepared does not necessitate covering the cooking vessel. This problem will be discussed within the ongoing project so that those adopting smoke hoods adopt more regular cleaning practices to alleviate this problem if they so wish.

Nepal

Records from the post-intervention monitoring sheets[2] report the following impacts from thirty-one households, each interviewed on two occasions:

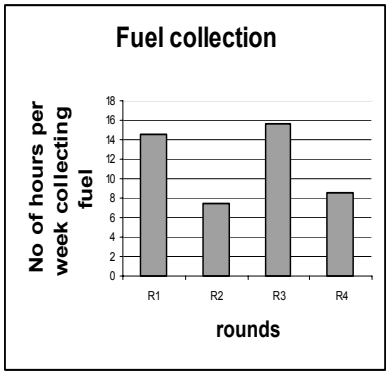
Table 8.1Collated data from post-intervention monitoring sheets

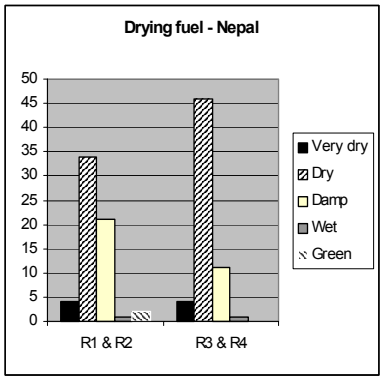
Health	Number reporting		Number reporting
Reduction in the following health conditions		*Reduction in the following eye conditions*	
Cough	20	Tears	13
Difficulty breathing	12	Eye pain	4
Chest pain	8	Eye visibility	2
Negative effects on health	13	Eye irritation	6
Diseases caused by smoke/ARI	18	Eye redness	2
Headache	1		
Well-being	Number reporting		
Easier to work in kitchen	20		
Feeling well	1		
Children cry less	6		
All-round benefits	6		
Feeling of cleanliness	2		

Other impacts recorded include more time being spent by household members in the room, and one instance of a child doing homework.

The villagers have started to demand that other development organizations support alleviation indoor smoke.

Fuel gathering





As is the case in Kenya, there appears to be little change in the amount of time people spend gathering fuel. The overall results are difficult to interpret. The team does not feel that it is 'just being told what they want to hear' and have learnt that whenever there are evening meetings, they are always held in the house of someone with a smoke hood, as it is more pleasant to meet where there is less smoke. The case study below reflects the consensus that what has been achieved has been very positive. However, ITDG recognizes that this design has not been

[2] Due to ill-health the external reviewer has not yet submitted the external review

cost-effective, and started to introduce the new design. A positive note is the slight increase in the number of people drying fuel before use – a 'no-cost' alleviation.

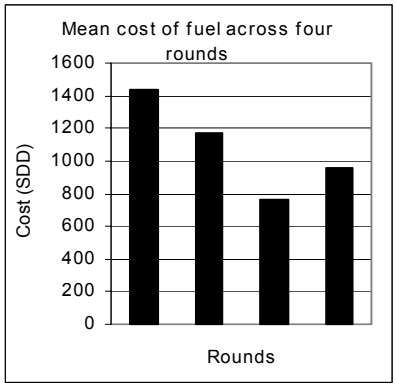
Negative impacts
The community is still very much in favour of the smoke hoods, despite the reservations of the project team.

Mrs. D., 37, is a resident of Gatlang Village Development Committee (VDC) of Rasuwa district. She has six children comprising of three sons and three daughters. She used to be suffered from eye irritation problem along with chest infection. Her children also frequently suffered from the same problem as well. She did not know the real cause of the problem. She used to blame it for witch and go with traditional healers for treatment. But when traditional healers also could not solve the problem, she used to visit health clinic as last resort where she had to spend significant amount of money on treatment of her children and herself.
When one of her friends Ms. L. told her that she saw the smoke graph at computer and it was so high during cooking period she also became convinced. She made frequent request to ITDG Nepal to carry out intervention promptly. Likewise, in the group she talked with friends on options to alleviate indoor smoke and agreed to provide input during technology development process to ITDG Nepal. She took part enthusiastically in research activities, participated actively during chimney hood installations, and with guidance of ITDG she herself did wall plastering and cook stove improvement. Some of her friends did not show much interest in wall insulation, as there was no such practice, she motivated them to do. Although it is short period to say something about change as intervention has been completed few months ago only, she has been feeling improvement in herself and children's health. Now she is very happy and gives advice to her neighbours to adopt the technology as well and get rid from the indoor smoke.

Nevertheless, having lived with the smoke hoods in their homes, the women in Gatlang have indicated that they feel that they take up too much room. This occurred before the results were made known, and it is a fortunate outcome as the new design is much smaller, allowing people to sit beside, but not under the hood.

Cost is going to be an issue and may reflect better whether people are willing to spend money on reducing smoke through this type of intervention.

Sudan
In Sudan, an external review described a very positive impact created by the project; 'Women interviewed had not the slightest doubt that abandonment of biomass fuels for LPG ushered a new brighter era into their communities for improvement in their lives.'
This may explain the high number of households (915 households – April 2005) who have already benefited from LPG technologies. These impacts are recorded directly from interviews with the women in Kassala during the review:



Health
- No more discomfort like headache, fever or smoke sickness etc.
- Children are healthier, no more coughs, sneezing etc.
- Greater family care because of time saved.
- Women are able to undertake additional social activities, such as dokhan souna (a traditional sauna), coffee gathering, and also other necessary activities such as medical check up and general relaxation.

Income and savings

Although some women could not envision payment of the LPG kit prices (SD 9200-17900) which are beyond the means of the their family income levels(SD 6000-10000) per month , they were more than happy to use the opportunity availed by the project in introducing the revolving credit fund. They were also equally felt happy to operate through their social institution, (WDA) which administered the loan

- Money saved as gas is cheaper than biomass
- Children can go to schools –even to private schools –as mothers can afford to pay the cost
- Women have the opportunity to run their own shops –El Radiya in Gedarif.

This reflection made by the woman is shown in their estimates of the amount of money they spend per week on fuel indicating a reduction of around one third.

One woman expressed it vividly as " I put away the SD 200-300 daily spent on biomass fuels only to find that I can not only afford payment of the instalments of SD 1000 ,but also have enough money for other purposes. Even those who were unable to pay for a fresh gas cylinder like M.I. temporarily returned to biomass until they had enough to pay for the gas , meaning that they are determined to stay on LPG."

Time

- Cooking time much less, by 1.5 hours per day.

Drudgery

- No more soot on pots, kitchen walls or clothes.
- No more ashes to clean after cooking
- No more drudgery of collecting or paying high prices of biomass fuel.

Comfort & leisure

- No more obnoxious odour of smoke from certain trees or from plastic used for firewood or charcoal ignition.

Status

- Plenty of time to take part in training programmes for new skills such as food processing, cloth dying etc
- Improved social status of women by being able to maintain cleaner homes, have better clothes, gold etc.
- Women able to take part in more frequent social interactions with neighbours and relatives

Social ties

- Reaffirmation of social bonds among women through the system of guarantors entirely based on personal trust for payment of the loans.

Security

- Women can cook even during floods (Kassala flood 2002)
- Gas cookers are multi purposes – regular food , biscuit , cakes etc.

Environment

- Contribution to environmental rehabilitation by no more cutting of the trees

Negative impacts

The review identified two areas that are currently being addressed.

- A few of the stoves have had technical problems. A mechanism for dealing with these under some sort of warranty will be part of the package in the scaling up programme
- There has been some default in payment in the Gedarif area (not intended to be part of the original project, but moved to that area because of the numbers wanting to be involved). More training will be given to those running the scheme in Gedarif before further funding for revolving funds in provided. The providers are aware of the situation.

Interventions and technologies

Kenya

Low-cost options
Fireless cookers, Upesi stoves, solar cookers and eaves spaces will be sold directly through the markets which are already in place. Fireless cookers and eaves spaces will provide new opportunities for small income-generating activities. Upesi stoves are sold everywhere in the region by a range of suppliers. However, by incorporating them into a 'package' of interventions, households will be able to make savings in fuel costs that can, in part, pay back the cost of the more costly interventions when people feel that they can afford the more expensive options.

Smoke hoods
The Kenya team recognised the need to reduce costs if people are going to be able to pay for them in the long term. The hood for this project was made with mud walls, and has a metal upper part. By using recycled metal and mud, a hood costs about 2600Ks. Each house with a hood also has eaves spaces and windows. To fit the wishes of the recipient households, the hoods were made taller and wider than the prototypes. They are thus not so efficient as those with smaller openings. Nevertheless a substantial amount of smoke leaves the kitchen through the hood – the remainder is taken out by the eaves spaces (especially on days with a blustery wind which makes the hoods less effective but the eaves spaces more so).

Based on these findings, the team engaged a local architect who has developed a newer design, incorporating the dimensions of the more efficient design, and some of its better features, but retaining the mud-based walls to reduce cost, as in the Tanzanian model. Recycled metal is being replaced by new metal sheet, as the quality of recycled roof sheet was too variable, as some smoke hoods are showing signs of wear less than two years from installation. Although this will increase the cost of the hood, revolving funds will make this intervention accessible to some households.

Nepal
Three technologies were introduced in Nepal.

Wall insulation
This has proved popular and other households not involved in the project are implementing this activity. Women appreciate the insulation because it makes the room feel more comfortable as wind cannot blow through the cracks. Women say that it stops dirt blowing in, and deters mice. One concern is that it will also slow down the egress of smoke, but it should also reduce the amount of fuel being used.

Improved stoves
The community is very keen to have improved stoves, specifically to reduce the amount of woodfuel that they need to gather. Some positive changes have been made to the traditional tripod and three stone fire that make it burn more efficiently without increasing smoke. There is a perception that less fuel is being used, and the stove, rather than the combination of stove and insulation is being cited as the reason for this reduction. It is apparent that the heat is better utilized with the revised stove and, once the new smoke hood replaces the current model, the improved stove will serve to direct the polluting gases up the flue.

Smoke hood
Testing of this 'funnel-type' flue during this project has shown that although it removes some smoke, the design is not cost-effective. Further, although the community likes the hood and is already aware of the benefits of using one, (all meetings are now held in houses that have smoke hoods), they are also now aware of the large amount of space which the hood takes up in the room. The most recent smoke hoods take up much less space.

This design is based on a smoke hood developed as part of an ITDG project in Tanzania and Uganda that has reduced smoke emissions very substantially in the Maasai community. Testing, using CO as a measure, will continue through the second part of the study to ensure that the hood behaves equally well in the Gatlang situation. Modifications from the Tanzania model include; spikes from the inside of the hood from which meat can be hung for drying; a small exit pipe into the roof space to allow the smoke to strengthen the wooden roof shingles, and smoke the cereals stored in sacks in the roof space.

New hood design training session (photo: ITDG – Nepal)

Around ten entrepreneurs in the district have been trained. These artisans currently make grills for security on windows and thus are already working with material suppliers. For the first few months, the project will subsidize the cost of transport, but this will gradually be removed. The retail outlets from which the craftsmen work are along a main route in the district. The Tanzania smoke hood design is given in Annex 21.

Sudan

Sudan has opted for a 'customer-based' approach, and women can buy a range of LPG stoves from basic two-ring burners to three-ring burners with auto-ignition and *kisra* plate. Currently these are imported products and if growth continues, it is expected that local entrepreneurs will recognize a profitable market and start local manufacture. Currently, the project is engaged in ensuring that there is a sufficient supply of quality, imported products to meet demand.

LPG is only appropriate where there are adequate supplies, and large areas of the country will have to continue to use biomass for the foreseeable future. Action for these communities is outside the scope of this study.

Strengthening the development of interventions

Development cannot be considered a on-off event that takes place over the project life. This project sought to engage the community in each aspect of the process so that they were able to change their lives in the way that best suited them. In retrospect, within this project, a longer period of development and demonstration might have ensured that the communities involved could have seen the technologies in action over a longer period – but other aspects would have had to be compromised. Because this study is ongoing, the project teams are in a position to develop the interventions in collaboration with the communities and limited monitoring will take place during the scaling-up phase to ensure that changes make positive impacts.

The balance between a technically successful intervention and a technology that is socially acceptable is initially wide in situations such as Nepal, but as people become aware of the benefits to themselves of reducing the smoke in their homes, they themselves will make the decision on the compromises that they feel are appropriate.

External factors

Kenya

The main 'external' factor in Kenya has been the very positive collaboration with other organizations, created through the efforts of the field team. The local chief has recognized the benefits of the removing smoke and has supported the team through engaging with the community through community meetings where he positively endorses the activities, along

with dance and drama groups set up by the project. Similarly, the Medical Officer of Health has supported the work through discussions on how this problem can be highlighted in clinics and health centers, and by giving her name and support to the radio programmes devised by the Kenya team (Annex 3).

Nepal
Nepal has also created strong links with collaborators at both field and national level. However, external problems have also had some impact on the project activities. Serious landslides during the wet season delayed the project by several weeks, as the risks in sending the teams into the region were too great. Initially monitoring was going to take place during the wet season, but having discussed the way fuel is stored away from the rain, and the increased need for space heating during the cold season, the team members felt it was better to change the schedule. All the project stakeholders were informed about the change. Some testing was conducted on smoke hoods in an 'energy village' nearer to Kathmandu where demonstrations of renewable technologies take place.

Political unrest has occasionally disrupted activities for a matter of days, and has seriously hampered communication with the UK on a number of occasions. Having a local partner and having engaged one of the village occupants to assist with monitoring has reduced the delays caused by these external problems. Of more concern is that the area within which the work is being done is relatively peaceful at the present time. Other NGOs have chosen to move into the area as a result, and they have adopted a 'distribution' approach, handing out stoves at no cost to the community. A dependency culture, already evident to some extent, is being further reinforced, leading to the community questioning why they should pay for the interventions being promoted by ITDG when others are giving products to them at no cost.

On a more positive note, the area is being developed as a trekking route, and this is making people more conscious of the need to make their houses more attractive and may lead to greater uptake of successful technologies.

Sudan
The most evident external factor leading to the high level of success in Sudan is undoubtedly the support of the government for LPG. This has created the right climate for change, with the majority of women in the country aspiring to own a gas cooker.

Cost of interventions

It is not always easy to convince people that cost saving can be as valuable as income generation for improving quality of life. Based on experience in Kenya, Table 8.2 illustrates possible interventions and shows the breakdown of costs and savings over a five-year period. Key to successful adoption is a credit system which is acceptable and which allows people enough capital to avail themselves of successful technologies. It can be seen that most of the interventions provide substantial savings over the life of a product.

Table 8.2 Cost vs savings for interventions in Kenya (Ksh)

Possible Intervention /fuel	Initial cost and fuel use for 1 year	Yr 1	Yr 2	Yr3	Yr 4	Yr 5	TOTAL 5 yr cost
3 stone fire[3]	0	14600	14600	14600	14600	14600	**73,000**
Charcoal[4]	450	18700	18250	18250	18250	18250	**91,700**
Paraffin stove[5]	350	22250	21900	21900	21900	21900	**109,850**

3 An average family uses and normal cooking uses Kshs 40 per day on firewood.

4 An average family uses Kshs 50 on charcoal per day

5 An Average family uses Kshs 60 on paraffin per day for cooking and 15 perday for two lighting points

Upesi stove and improved ventilation	1200	8400	7200	7200	7200	7200	**37200**
Fireless cooker/ Gas	3450	9690	6240	6240	6240	6240	**34650**
Smoke hood Upesi stove and Fireless[6] cooker	4450	8050	3600	3600	3600	3600	**22,450**
Smoke hood/Upesi stove	4000	11,200	7200	7200	7200	7200	**40000**
2 Solar lamp for lighting	5700	6180	480	480	480	480	**8100**
Paraffin for 2 point lighting	5475	5475	5475	5475	5475	5475	**27,375**

Kenya

Cost sharing

The price of smoke hoods will not be clearly known until they are available on the free market. It will also be affected by transport costs. The smoke hoods are being made in the 'tinsmith' area of Kisumu town, where there are appropriate tools to manufacture them. They will be transported in sections on public transport and assembled on site. They will be sold through retail outlets and will cost approximately 4000Ksh Stoves cost Ks 170 per stove – some households have opted for two. Eaves and windows together cost Ks1200.

The upper part of the hood costs up to Ks1000 to fabricate. For this project, and reflecting the research aspect of the intervention, families were asked to donate the scrap metal, whilst the installation cost was borne by the project. As well as these hoods, two windows were installed (with shutters) for which ITDG paid for one. ITDG also paid for the weld mesh for the eaves spaces to ensure that wild animals do not enter the house through these spaces.

Credit systems

An innovative approach to micro-finance for small-scale enterprise to fund the interventions has been widely recommended by the women within the communities with whom we are working. They point out that they cannot make money, nor can they save a lot of money, if they use the micro-finance to buy the smoke-alleviating technologies directly with the loan. As a research project, ITDG is testing an innovative mechanism with the poorer households who are seeking to access micro-credit through revolving funds to set up micro-enterprises within their community groups with an agreement that some of the cash created will go into savings for smoke alleviation technologies as described later in this report.

Nepal

To date, all the costs of the interventions have been incurred by the project, but the community is aware that this is because the smoke hood introduction was a very radical change and it was unlikely that people would be willing to pay for the initial prototypes. Since these have proved less successful than had been hoped (but are nevertheless well-liked by the community), this decision was probably correct. However, it is anticipated that there will be a considerable reluctance on the part of the community to purchase smoke hoods at commercial prices. Through incorporating desirable product attributes, it is hoped that gradually people will choose to adopt this intervention.

The smoke hood will currently retail at around £36 (4760N5Rs) but the cost is likely to go down if there is competition. Stove improvement work costs about one man day equivalent i.e. Rs.200 (UKP1.50). Wall insulation work needs about two man-days around NRs.400 (UKP 3.00).

6 A saving of 50% on the firewood is assumed for the fireless cooker.

Availability of credit
It is anticipated that credit will only be needed for the smoke hood, whilst a number of new small enterprises will be created in stove installation and wall insulation.

For smoke hoods, a revolving fund will be created in each Village Development Committee (VDC). Existing saving and credit groups will manage the fund. Loans will be repaid by the debtor on an installment basis in one-year period. Likewise, to promote supply side, training will be provided to the manufacturer and distributors. In addition, loan will be provided for six months to the manufacturer to buy raw materials.

There are savings and credit groups already in action for income-generating activities. Those groups will be made responsible to manage the revolving funds for intervention of hood installation. The groups will be provided seed money for the revolving fund and the groups will provide loan to the potential smoke hoods users for 12 months. Payment will be done on an installment basis on standard repayment schedule. The groups will decide the interest rate. The collected interest rate will be used for management (administrative expense) of the fund and other income generation activities.

Sudan
In Sudan, it was shown (through micro and macro economic household benefits analysis) that the average cost for the household energy using biofuels (wood and charcoal) could be reduced by around 54% by substitution by LPG. These biofuels composed about 73.7 % of the total cost of the household energy, the remainder being fuel for lighting.

Access to credit
- Suppliers

Seed capital from the project (around £15K) has been used by the Central WDAs in both Kassala and Gedarif to buy in stocks of LPG packages (Cylinder, Gas burners, Kisra Plates). These funds have already enabled around 800 households to buy gas appliances and the numbers continue to grow. Payment to the WDA for this service is providing employment for WDA members.

Gas companies in Sudan have been approached for further seed funding based on their profitability being through sales of gas – to date they have not availed of this commercial opportunity, but this avenue will be pursued as the impact of the project becomes more well-known. Growth can be achieved without further seed funding, but currently demand exceeds supply, so further revolving funds would accelerate growth.

- Customers

Women in the different residential areas are organised in groups as branches of the Central WDA. Each branch has its own revolving fund used to access LPG package through lease term installments. Levels of default are very low, as those not paying know that it will prevent neighbours from accessing credit.

Overall project design

There are a variety of ways in which indoor pollution can be monitored, and key to getting the right one is to decide on why it is to be used, and who will use the information. Currently, in partnership with the Partnership for Clean Indoor Air, the World Health Organization is developing a ‘Catalogue of Methods’ that will identify the most appropriate selection of methodology.

Careful consideration was given to the most appropriate community approach for the project, and a range of options considered. It was very important that the study design should build up the relationship between the community and the ITDG team working with them over the 2.5 to 3 years of the fieldwork and intervention development. Specifically, it was felt that having a group of ‘control’ houses, which would received no interventions over this period of

time would impact quite negatively on the team and affect their ability to work with the wider community both during the study and in the future.

This work is structured to demonstrate whether *substantial* reductions can be achieved through participatory methods in a way that makes them sustainable.

With hindsight, the questionnaire was perhaps a little too long. Analysis of the only confounders that showed that they were likely to affect the results did not make a really major difference to the findings – but it was necessary to do the research to find this out. We now know that projects should be advocating fuel drying, and that social aspects such as beer brewing and smoking should be accounted. It is surprising that the size of the room did not produce a more major effect – but this may be because the type of housing in these communities did not vary greatly, and any new project will need to decide whether such factors need to be collected in each round. There is a very good argument for collecting baseline data, if only so that the lifestyle of the community is to be well understood by those working with them.

In general, if there is not a very good reason for having a question asked, there is a very good reason in omitting it, as data entry and analysis is complicated by too much data. The caveat, with this, is that it is difficult to go back and ask a question later, if it is needed. Considerable time should therefore go into getting this balance right, and piloting and analysing the data early in the project. Further, it is most important that data that is to be compared with smoke levels should be data *for that day*. In this project, the question on smoking was put into the general section, and in retrospect should have been for the 24 hours. A better question for the cook would have been 'did you smoke in the kitchen when the monitoring was taking place'.

The 'open questions' were particularly revealing, and although more time-consuming to analyse, in their raw state, were particularly telling (Annex 22). They illustrate a picture of women fearful when collecting fuel and struggling against ill health, both for themselves and their small children. Health statistics from a health post in Gatlang reflect this situation. These tables are a valuable record of the felt needs of the community members.

Working with country teams who understood the communities, the country, the practices and spoke the local languages was vital. Households welcomed them as friends and extended this welcome to UK team members. No South-South exchange was built into this project, other than the launch meetings, and this was regrettable. A great deal would have been gained by such exchanges. However, all key team members presented internationally, and this was highly beneficial to Northern-based organisations.

Analysis was more complex and time-consuming than had been anticipated. Ways to streamline the process and make it more international are being developed for the second part of the study.

The participatory process

Participatory methods have produced a sense of 'ownership' of both the problem and the solutions. This has provided the groundwork for implementation for creating the necessary infrastructure for sustainable development. The positive aspects are overwhelming, with a high level of community engagement and decision-making. This sense of ownership is illustrated well by the infant in Sudan shown. Within the Gedarif community, married women take a 'sauna' each day, where they

Baby in cradle moved away from smoke – Sudan *(photo: ITDG)*

immerse themselves in special sweet-smelling wood-smoke. The family of this infant did not want to give up this practice, but they did not want their small child affected – so the infant is now hoisted in a cradle into the farthest corner of the room, adjacent to the eaves space.

In each country, the implications of participatory development have been somewhat different, and in some instances, it has not all been positive. For example, in Nepal the team found it difficult to compromise between 'good technology' which would have led to more effective smoke hoods, and the wishes of the community. Similarly, in Kenya, the smoke hood openings became larger than optimum for smoke removal. However, in the longer term, the trust and dialogue that has developed will allow problems that have been identified to be resolved. The new smoke hoods in both countries are being installed with agreement from the communities who are engaged in the process with the project teams.

Having identified these 'felt needs', engagement with other agencies on the ground has proved very successful, and this aspect should be created at the earliest opportunity. In this project, there has been tremendous success/acceptability experienced with partners in various forums - a unanimous agreement that smoke is an issue that needs to be tackled.

Natural growth

In all three countries, households outside the project have engaged in the process of smoke alleviation. In Sudan, this has been most apparent, with women joining the WDAs specifically so that they can avail themselves of the revolving funds. To date (April 2005) some 915 households have benefited. These households are 'within' the project, but scaling up activities had to start far in advance of the second project because of the natural demand.

In Kenya, too, there have been several households who have installed smoke hoods as a result of the promotional activities.

- **House belonging to retired Mennonite Bishop**

This gentleman had been impressed by the reduction in smoke brought about by the interventions and had requested the person whose house had interventions to help him install eaves, windows and a double chimney in a small store area of his house which could just fit the needs of the kitchen. This is notable because the woman herself built the wooden frame for the hood – usually only done by the men. The bishop was very positive about our work and its relevance to the community.

One of the women who was not a 'project household' was involved as a community mobiliser and she is very positive indeed about the benefits of the smoke hood. She has installed an upesi and a platform for her charcoal stove. During a project visit, the stove was in use and nearly all the smoke was going up the chimney. A strategically placed eaves space was taking the rest and the woman was very interested in the wider issues – many people had visited her and wanted to know how to get them. What were we going to do with what we had learnt. This interest in the wider picture was reflected in community meetings and is indicative of the level of collaboration and co-operation between the field team and the community.

Monitoring

Monitoring particulates

At the start of the project, the decision to use particulate monitors was influenced by the very high cost of 'real time' monitoring. However, using a car battery to deliver power, there were no pump failures in any round in any country. Problems in an earlier project appear to have arisen from inadequate power sourcing using an integral battery.

There are a number of standards that collect different particle sizes to measure the concentration of particles in the air that are inhaled deep into the lungs. The PM_{resp} adopted in this study does not have a sharp 'cut-off' of particle size, but rather is thought to reflect the respirable fractions inhaled by the lungs. No particles are larger than 10μm particle size;

around 50% have a particle size around 3.5μm and increasingly large percentages below this level. The equipment used in this study is widely used in occupational health, as it is robust and easy to use.

Using filters to monitor smoke directly requires a level of skill on the part of the supervisor and enumerators. The filters are delicate and need to be inserted into their cassettes with great care, but do not need to be taken out in the field. The cassettes are clipped shut during transit. Labelling is essential - otherwise a whole household monitoring can be lost.

New equipment is being developed which will allow real-time monitoring and should facilitate measuring particulates. Currently the correlation between these two methods is being researched. However, one important aspect that will be lost is the very graphic illustration of levels of pollution that can be achieved by showing women the completely blackened filters from their homes, once all weighing has been completed. This had a profound effect in the Sudan community.

CO Monitors

The T82 CO monitors are robust and easy to handle and read. They provide much more accurate results than are possible with stain tubes. The downloading aspect made it possible to look at the trends of CO patterns in the households, minutes after removing the equipment.

They also provide much more information on the distribution of CO levels throughout the day, and provide a good indicator or the exposure of the woman to CO. In many cases, the women were happy to wear this as they associated it with the mobile phones. However, it has been reported by other projects that for some societies, it is culturally sensitive to hang items round people's necks – especially when these are very strange and new. In Sudan, there was some small concern, but this did not prove insurmountable. In Kenya, despite considerable effort by the team, some women thought it could predict or cure the illnesses from which they were suffering.

Weighing particulates

Weighing is dependent on access to a five-point balance; this is most likely to be located in either a university or metrology centre – the quality of balance and the level of skill of the operators will dictate the quality of results. Weighing particulates has not yet been standardised, and a variety of methods have been advocated. In this study, the filters were dried before and after monitoring and a five-point balance was used for the weighing. There are two schools of thought about whether to use heat to dry the samples completely, or whether this would drive off volatile wood gases. Studies indicate that the quantities of volatiles driven around 100C are very low. (Czimczika, 2002). Whatever method is used, the same drying method must be used before and after exposing the filter in the field. Blanks and lab blanks (around 10%) should also be weighed.

Feedback on monitoring questionnaire

It is helpful to the community and useful for the project for those answering questions during the monitoring to have space to comment on the process and the questions. Similarly, the enumerators are the 'front line' working with individuals in the community, and giving them space to comment on each of the monitoring questionnaire has provided valuable insights into some of the anomalies which might otherwise be overlooked – e.g. a funeral on the day of the monitoring where the household wished for the team to continue the monitoring process

Constraints in the field

Adverse weather conditions

In Kenya, flooding prevented the car reaching the project site. It is good to have the equipment packed such that it can be easily carried. This is especially true where two houses are being monitored on the same day by the same team if errors in numbering filters etc. are to be avoided

Losing households
It is worth considering that some households will be 'lost' during a project and starting with more households than one needs, to provide statistically significant results. In our project, we started with 30 households in Kenya and Sudan and 31 in Nepal and lost six households in total across all three countries due to families leaving the area or bereavement.

Notes from field staff
This section highlights some 'useful tips' gleaned from field staff.

- Setting the sheets as in booklet format was easier to handle
- Some questions were bit sensitive e.g. smoking, beer brewing, education levels, and care must be taken in how these questions are approached
- Field 93 – 106 made the household owners give responses to what was not necessarily applicable to smoke related areas. It also gave a false sense of expectation.
- The project may give people a false sense of expectation - for example in cases where they had coughs and chest problems they expected medical attention
- Interviewees were not named on the sheets, but an 'identifier' was used; this should be on both monitoring sheets and supervisor sheets.
- Field 40 may need to be reviewed
- Downloading data, it may be useful to record on paper the file name rather than just recording that the download had been completed.
- A supervisor kit bag is useful where intensive monitoring is involved – some things to go in are: Spare monitoring questionnaire/data sheets; bubble calibrator; spare cassettes; distinct storage for used and non used cassettes

Ongoing and future work

Scaling up was envisaged from the start of this programme of work, and this was reflected in the methodology to develop sustainable infrastructure rather than measuring success by the number of appliances installed. Developing cost-effectiveness, supply chains, skills, revolving funding etc. have been key parts of the objectives. Part 2 of this publication will describe the activities and outcomes in detail. The ongoing project will monitor growth in infrastructure and sales as well as researching health and other key impacts. However, it is worth looking at some of the key aspects that are already under way.

Researching and developing markets
The size of the potential market has been researched in each country. This indicates that there is a market for all the interventions that have been developed. In Sudan, the size of the market growth is already leading to a waiting list to join the revolving funds. In a free market, this would suggest that the price of the technologies could be increased until supply matched demand. In this instance, however, the project is seeking to support those on the lowest incomes, and a more socially-motivated approach is required, albeit whilst still retaining commercial viability. This is particularly the case since those selling the appliances belong to the same community as those buying them.

National dissemination

Forums for smoke alleviation
As part of the scaling-up strategy, each country office has created a Smoke Forum, where field practitioners and those involved in policy can come together to share ideas. This has the positive effect of engaging policy-makers in the problem and allowing them to discuss what is really happening with those working at field level. It is hoped that this approach will be adopted widely through partnerships and other initiatives being driven by other organisations.

Media
Over the past few years, the smoke issue has risen on the political agenda. Using the media can reach far wider audiences than the immediate project area. Interviews on radio and articles sent to both the local and national press can keep the issue in the public gaze. This has taken place in both Sudan and Kenya where a very large proportion of the population has access to radio.

Micro-credit
The benefits of micro-credit have been shown to be highly effective in overcoming the constraints caused by the initial outlay needed for smoke-alleviation technologies. In Sudan, a very large number of people could benefit from LPG if micro-credit, (with supporting training for those running it) were available wherever LPG depots are accessible. This could have a very major impact on the levels of mortality in the country.

However, one of the constraints is that the gas company is state owned, and ITDG has, to date, failed to persuade the LPG companies that profit is to be made in the sale of gas, not in the sale of appliances. The main constraint to even more widespread adoption is the rate at which revolving funds can be set up. If the gas companies were to provide and manage loans, with similar payback periods and interest rates, they could substantially increase their gas sales.

Raising the profile internationally
Alongside the project work at field and national level, ITDG has worked with partners to raise the profile of the smoke problem through meetings in the US (in collaboration with the United Nations), Geneva (with WHO) and in the UK.

In this the project was supported directly by colleagues from the Universities of Liverpool and Nairobi and Kassala and by working closely with a colleague from the World Health Organization. International dissemination has included dissemination through workshops, networks, and conferences. Useful networks and organisations are given in the next section.

The topic of advocacy and international awareness will be dealt with in greater detail in the second volume.

Conclusions - strengthening the participatory process

There have been major benefits accrued from this project, and it is evident that the participatory process is a robust tool for community engagement and sustainability. Perhaps what is needed in the future, however, is to start this process even earlier in the project cycle. To quote from one of the field staff – 'It has been a strange experience to see households taking such drastic steps to alleviate smoke and yet still not able to assure food security - kitchens with technologically sound interventions but underutilized due to basic food insecurity'.

Case study: Child nutritional status – Kenya
Generally, nutrition in the project area is not very good; most homes rely on energy foods rather than balanced diet. Malnutrition is evident in young children of zero to five years especially protein. With free primary education, enrolment has risen for younger children. A school lunch programme subsidises meals to orphans and children with special needs only, but there is increased demand for this to cater for the whole school – over 1000 children. This lunch programme has a significant nutritional effect on the performance of the children in class, despite cooking going on in the households. A community activity of this sort would have major poverty impacts and also act as a platform for dissemination of energy technologies.

If participatory development is to be truly effective, it could be argued that the first approach is to ask the question 'What is it that is the greatest constraint to your well-being that we as an organization can support you to change?' Health, in the wider sense, is perhaps the most important indicator of a decent quality of life. Most people spend most of their lives in their homes – this is particularly true of women and children. In the current project, the focus of the

work was smoke alleviation, but this could be part of a wider context – creating 'healthy homes', building the work around the felt needs of the communities, such as energy (or infrastructure) for food security or income generating activity. Within some societies, this can be done on a household basis, whilst with others; the community can provide a stronger foundation for change, as in the case study above.

Perhaps the greatest positive impact of this project is that, by working with women on this serious problem, the project has both raised their awareness and supported them in their capacities to alleviate it. What is needed now is an international policy and economic environment conducive to large numbers of households being able to adopt these technologies.

Useful contacts

Networks and organisations

There are now several networks and organisations that are involved in indoor air pollution alleviation.

- **HEDON household energy network http://hedon.info** has been involved in household energy for many years. It has information and links to all the key activities and networks across the whole spectrum of household energy. Information and images of the methodology adopted by the project can be found in these pages.
- The **Partnership for Clean Indoor Air** came out of the Johannesburg Summit (WSSD, 2002) **http://www.pciaonline.org/** and is an umbrella under which the majority of those working in this field collaborate.
- At policy level, the **Sparknet** network **http://sparknet.info** looks at policy action in the fields of health, forestry and gender.
- **Aprovecho Research Center** is a non-profit organization that since 1976 has been disseminating and studying stoves and household energy, seeking to bring modern engineering design principles to NGOs building stoves around the world.
- **GVEP – the Global Village Energy Partnership http://www.gvep.org** GVEP is a voluntary Partnership that brings together developing and industrialized country governments, public and private organizations, multilateral institutions, consumers and others in an effort to ensure access to modern energy services by the poor.

International organizations

- The World Health Organization has a very comprehensive website on indoor air pollution **http://www.who.int/indoorair/en/**, particularly useful for graphically illustrated key statistics
- The UNDP **http://www.undp.org/energy/lpg.htm** is championing the use of LPG as a clean, safer cooking fuel through the LPG Challenge.
- Shell Foundation **http://www.shellfoundation.org/main/main.html** is a major player in this field, supporting and instigating major activities, including field studies, training, public awareness and international meetings.

Universities

- University of Liverpool – **www.liverpool.ac.uk/hehevaluation** Division of Public Health is a project partner. The university smoke programme, lead by Dr Nigel Bruce, is working on the health impacts of IAP, household energy, development and evaluation of interventions and policy to reduce IAP in poor countries.
- University of California – **http://ehs.sph.berkeley.edu/hem/page.asp?id=1** Department of Environmental Health Sciences. Professor Kirk Smith, who has championed the work on smoke alleviation for many years, has compiled a major collection of literature. There are also details of a particulate monitoring device that is being developed.
- The Universities of Nairobi and Kassala were engaged in sample weighing and analysis.

NGOs

There are now a substantial number of projects taking place at field level and rather than identify them individually, the networks above give detailed information on their activities.

Bibliography

Ballard-Tremeer, G. (1997), Emissions of Rural Wood-Burning Cooking Devices, PhD thesis, Witwatersrand, Johannesburg, S. Africa

Bates, E. et al. (2002) 'Participatory approaches for alleviating indoor air pollution in rural Kenyan kitchens' in *Boiling Point* Issue 48, 2002

Bazile, D. 'Improved stoves for preventing deforestation: myth or reality?' In *Boiling Point ,* Issue 46, Spring 2001

Bruce, N. G., et al. Reducing Indoor Air Pollution Through Participatory Development in Rural Kenya. *Indoor Air (2002)*, Monterey, 2002.V 590-95.

Czimczika, Claudia I. et al, 'Effects of charring on mass, organic carbon, and stable carbon isotope composition of wood' in Organic Geochemistry 33 (2002) 1207–1223, Elsevier Science Ltd 2002

Naeher LP, Smith KR, Leaderer BP, Neufeld L, Mage DT. (2001) 'Carbon monoxide as a tracer for assessing exposures to particulate matter in wood and gas cookstove households of highland Guatemala'.*Environ Sci Technol.* 2001 Feb 1;35(3):575-81. USA

NRC (1989) National Research Council. 1989. *Recommended Dietary Allowances.* 10th ed. Washington, DC: National Academy Press.

Warwick, H. & Doig, A. (2004) Smoke - the killer in the kitchen, ITDG, Publishing, UK

WHO (2002) World Health Report 2002 – Reducing risks, promoting healthy life ISBN 92 4 156207 2, World Health Organisation, Switzerland

WHO (2004) World Health Organization Website on IAP [online]: http://www.who.int/indoorair/en/ [accessed may 2005]

WSSD World Summit on Sustainable Development, 2002 Website: http://www.un.org/events/wssd/ [viewed May 2005]

Glossary

Adult male equivalent	The amount of food which is eaten by an 'adult male' compared to that eaten by a woman or child. This is used to compare the amount of food cooked – e.g. if a child is recorded, the 'meal' is multiplied by 0.5 to calculate the AME
AME	See 'adult male equivalent'
Before-and-after study	A study in which measurements are taken before-and-after an intervention is installed. This is in contrast to a parallel study where half the group do not get the intervention and are compared to the half that do.
Biomass	Wood, agricultural and other organic residues
Confounding variables	Variables which do not form part of the technical intervention and might affect the levels of pollutant and thus affect the findings
Exchange visits	Visits set up by a project that allows one community to visit another one that has already benefited from interventions so that they can exchange ideas.
Fireless cooker	An insulated basket or hole in the ground made to fit a cooking pot. The food is heated to boiling using a stove, and is then transferred to the insulated space where it is left to cook in its own heat. Most successful where there is a relatively large amount of food creating a large mass of heat.
IAP	See 'indoor air pollution'
Indoor Air pollution	Pollution caused by burning of fuel indoors - in this instance, from kitchen stoves and fires. It can also be due to kerosene lamps used for lighting.
Intervention	Any activities or technologies introduced by the project to alleviate smoke
Kisra	A type of pancake made from sorghum and staple in Kassala, Sudan
Particulates	Very small particles of smoke which get into the lungs
Peri-urban	In this study, peri-urban refers to communities which live on the outskirts of towns, using the biomass fuels which are most common in rural communities but living within the money-economy associated with urban lifestyle
Real time monitoring	Monitoring which shows what is happening at any particular time; in this instance a monitor that shows the levels of carbon monoxide each minute over the 24 hours of monitoring.
Shielded fire	A fire similar to a three-stone fire but built around with mud to direct more heat to the pot.
Smoke hood	A hood and flue set over a stove, but independent of the stove.
Ugali	A staple food made from maize with a consistency of thick porridge

Practical Action

Practical Action helps people to use technology in the fight against poverty. We work in partnership with communities to develop practical answers to their problems, based on local knowledge and skills and putting people's needs first.

Practical Action is a charity registered in the United Kingdom that works directly in four regions of the developing world – Latin America, East Africa, Southern Africa and South Asia, with particular concentration on Peru, Kenya, Sudan, Zimbabwe, Sri Lanka, Bangladesh and Nepal.

Practical Action has a unique approach to development – we don't start with technology, but with people. The tools may be simple or sophisticated – but to provide long-term, appropriate and practical answers, they must be firmly in the hands of local people: people who shape technology and control it for themselves.

Practical Action
The Schumacher Centre for Technology and Development
Bourton Hall, Bourton-on-Dunsmore
Rugby, Warwickshire CV23 9QZ
United Kingdom
Tel: +44 1926 634400
E-mail: practicalaction@practicalaction.org.uk

Website: **www.practicalaction.org**

PRACTICAL ACTION
Technology challenging poverty