

**Reducing indoor air pollution
in
rural households in Kenya:**

working with communities to find solutions

**The ITDG Smoke and Health project
1998-2001**

Dedicated to the memory of Peres Atieno Olumbo a member of the project team who died tragically young following a long illness

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Funded by:

GlaxoSmithKline; Veta Bailey Charitable Trust; Ajahma Charitable Trust; Emerging Markets Charity

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Executive summary

Around 80% of people in rural sub-Saharan Africa depend on biomass (wood, dung, crop residues) for domestic energy. There is mounting evidence that the resulting indoor air pollution (IAP) increases common, serious health problems, including childhood pneumonia and chronic lung disease. Previous attempts to reduce this have often failed due to lack of community involvement in developing appropriate, sustainable solutions.

The ITDG Smoke Project was launched on May 6, 1998. The aim of the project was to contribute to the reduction of exposure to indoor air pollution in the light of these negative health effects. Working with 50 households in rural Kenyan communities, participatory technology development through participatory research methodologies enabled the project to alleviate this pollution in people's kitchens. Evaluation of changes in pollution levels and community views about the process and interventions was carried out.

Two study areas were chosen; Kajiado where ITDG is involved in the Maasai Housing Project and two communities in West Kenya where ITDG is engaged in the Stoves and Household Energy project. These two areas are totally different climatically and geographically as well as culturally (lifestyles, cooking habits and house types). Baseline monitoring in the kitchens in these areas showed that smoke levels were unacceptably high: in Kajiado, the 24-hour average of respirable particulates was $5526\mu\text{g}/\text{m}^3$ and in West Kenya, the levels were $1713\mu\text{g}/\text{m}^3$. If one compares these values to the EPA standards for acceptable annual levels of respirable particulates of $50\mu\text{g}/\text{m}^3$, it can be seen that the daily rates (which are comparable, in these societies to the annual rates) are over one hundred times greater in Kajiado and twenty times greater in West Kenya than the accepted values.

By involving communities in areas where ITDG is well-known and respected, participation and co-operation from people in monitoring the smoke levels of their houses was assured.

Main objectives

The main objectives of the project were twofold: to improve the quality of life, through reduction in indoor air pollution, for households in these study areas; and to develop a participatory methodology for further research into appropriate ways to alleviate indoor air pollution. These objectives were to be achieved through:

- Carrying out a baseline assessment of pollution and exposure, fuel use and house structure
- Identifying participatory ways of alleviating indoor air pollution through development and installation of interventions. (*Interventions*, within the context of this project, were identified as any changes which took place as a result of project activities which could affect the levels of indoor air pollution to which the occupants of the kitchen, especially women and children, were exposed.)
- Evaluation of changes in pollution and exposure, community views of the process used, and the acceptability and affordability of the interventions
- Empowerment of communities by making them aware of the risks associated with household smoke and enabling mechanisms for its alleviation
- Development of a strategy in a national context for dissemination and sustainability within the market constraints of the communities
- Exchanging experience internationally to strengthen Kenyan work and to contribute to implementation of best practice in other countries
- Development of a replicable participatory methodology on appropriate methods for reducing indoor air pollution. This methodology will form the basis for future work in international studies on indoor air pollution and interventions.

Key methods adopted in project

The participatory methods described in this publication, combined with technical monitoring, allowed the project to identify interventions that are both *appropriate* and *effective* in reducing indoor air pollution. Some key aspects include:

- The involvement of households throughout the project
- Finding out those factors associated with smoke which the community members themselves found most problematic
- Knowledge sharing on the dangers of smoke so that people in the community are empowered to take action
- Local teams being open to ideas and suggestions from the community on ways to modify interventions to benefit the households
- Installation of interventions in collaboration with the household members
- Monitoring, to find out which interventions were really effective in removing smoke
- Monitoring both the kitchen and the cook so that the inter-relationship between the levels in the kitchen and the levels she inhales can be assessed
- After interventions had been installed, learning the preferred options from the community.

Participatory development

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
- That the key challenge is to tap the potential interaction between indigenous knowledge and that of outsiders.

Activities

- Research study completed in 50 households in West Kenya and Kajiado.
- Awareness created in all selected households.
- Interventions installed in 50 houses in both West Kenya and Kajiado.
- Reduction in indoor air pollution levels – respirable particulates (PM_{resp}) and carbon monoxide (CO)
- Benefits of appropriate interventions discussed with households.
- Eight artisans trained on fabrication and installation of technical intervention in two regions.
- Women trained on operations and maintenance of the interventions.
- Focus group discussions held with the communities that promoted participatory interactive communications on health related issues of their families.
- Dissemination of knowledge through various media: publications, video, conferences

Key impacts

Reducing smoke

The primary concern of the project was to reduce indoor air pollution. There were substantial reductions in the particulate matter and carbon monoxide levels in the sample households after the interventions were installed. Table 0.1 gives the overall results – the statistical significance of these results will be detailed later in this report.

Table 0.1 Overview of reductions in particulates and carbon monoxide resulting from installation of interventions			
Reduction in particulates (%) – (statistically significant results in bold)			
	Kajiado	West Kenya (4ft)	Combined
All interventions	36%	63%	43%
Smoke hoods	76%	70%	75%
Eaves spaces		60% (average)	
Windows		No observable change	
Stoves	Not adopted	54%	

Reduction in room carbon monoxide (%)			
	Kajiado	West Kenya (4ft)	Combined
All interventions	31%	53%	34%
Smoke hoods	77%	74%	78%
Eaves spaces		28% (average)	
Windows	No observable change		
Stoves	Not adopted	42%	
Reduction in carbon monoxide inhaled by cook (%)			
	Kajiado	West Kenya (4ft)	Combined
All interventions	6%	32%	16%
Smoke hoods	28%	59%	35%
Eaves spaces	Not adopted widely	56% (average)	
Windows	No observable change		
Stoves	Not adopted	5%	

Poverty impacts

The project has seen the project households accrue socio-economic, health, and cost benefits as a result of project activities and interventions. Whilst maintaining cultural requirements of housing design, the project has made improvements in ventilation, natural lighting, maintenance and general comfort in these households.

- Substantial reductions in indoor air pollution will have a positive impact on the health of the community
- Provision of more time to engage in economic activities through using stoves, rather than three-stone fires
- Increased income through manufacture of smoke hoods, stoves, windows & frames for eaves spaces
- Savings realised through reduction in use of kerosene lamps and burning fuel more efficiently in stoves
- The community noted a reduction in time and money spent in hospitals with burns, coughs, eye, and chest pains
- Improved status of project women within community
- Women have gained confidence through the participatory activities
- Project team empowered with skills in data handling and analysis
- Reduction in fuel consumption through stove use with consequent reduction in pressures on biomass sources

Negative Impacts

- Houses are now cooler and experience more draughts due to openings in the houses – this is a negative impact during cold and wet weather
- Some cultural concerns about lack of privacy and security
- In West Kenya, where there was a cost-sharing element, this proved difficult for some households
- Difficulties with wick lamps when it is windy and the window is open

Chapter 1 – The relationship between health and household energy

Introduction

It is currently estimated that around two-thirds of all households in the developing countries still rely primarily on unprocessed biomass fuels (wood, dung, crop residues) for their daily cooking and heating needs (World Resources Institute 1998); this includes around 80% of all people in rural sub-Saharan Africa.

In many of these households, fuel is burned indoors on open fires or poorly functioning stoves, often with no means of ventilation or smoke extraction. As a consequence, very large numbers of women and young children are exposed to high levels of air pollution, every day of the year. Indeed, it has recently been argued that the greatest global burden of air pollution exposure occurs not outdoors in the cities of the developed world, but indoors in poor rural communities (WHO 1997).

There is now consistent evidence that indoor air pollution (IAP) increases the risk of childhood acute respiratory infections, the most important cause of death of children under five years in least developed countries; and there is also association with birthweight, infant and perinatal mortality, pulmonary tuberculosis, some forms of cancer and cataract. Although the risks are poorly quantified, indoor air pollution may be responsible for nearly two million excess deaths in Least Developed Countries (LDCs), and around 4% of the global burden of disease (Bruce, Perez-Padilla, Albalak, 2000).

Table (1.1) shows typical values for particulate levels in the kitchen of a rural home, compared to current standards advised by the US Environmental Protection Agency (EPA).

Source of exposure	During use	24 hour average	Annual average
Biofuel (wood, dung, etc)	Typically from 1000 up to 20 000 or more	Typically 500 to 1000 or more	24 hour average levels are experienced every day
US- EPA standard		Only 1% of 24 hour periods to exceed 150	50

Health problems related to household energy

Each aspect of household energy use has particular health problems associated with it, which can usefully be considered under the following three headings:

Fuel Use

It is difficult to isolate any one cause of illness when extreme poverty, manifested in malnutrition, poor housing etc. affects much of peoples' lives. Nevertheless, there are several serious illnesses for which indoor air pollution from biomass is a major factor.

Smoke consists of many gases and particles which are known to have serious effects on health. The two major, well-identified constituents which are known to cause damage are: *particulates* and carbon monoxide.

Respirable particulates (PM_{resp}) are the small particles of smoke, less than 10 microns in size, which are inhaled and penetrate deep into the lungs. There is mounting evidence that particulates are a major risk factor for two serious illnesses:

- Acute respiratory infections (ARI) in infants
- Chronic obstructive lung disease (COLD) in adults - especially for the women doing the cooking

Carbon monoxide (CO) is responsible for poisoning (mainly from charcoal, and coal use); and lung cancer (from coal use).

There is mounting evidence that cooking with biomass substantially increases the risk of developing active tuberculosis (Mishra, Retherford, Smith 1997) and there is an increased risk of low birth weight. Eye problems are also frequently reported, but there is very little research evidence to date.

- Other direct effects include burns (open fires, kerosene), poisoning (e.g. from children drinking kerosene stored in soft drink bottles).
- There are also wider environmental health effects relating to the fuel efficiency of the fire/stove, and also to greenhouse gas production, which is a function of the completeness of combustion - this arises because a number of *products of incomplete combustion* (PICs) are quite potent greenhouse gases.

Fuel production

Production of biofuels can affect health in a variety of ways, especially through local environmental consequences:

- Land use (which also has economic implications, with indirect health effects)
- Erosion, and effects on water supply, etc.
- Energy, and natural resource use, for example associated with charcoal production

Fuel collection and supply

- The time taken to collect wood, especially as this becomes scarce, has an opportunity cost, mainly for women (but also children where they are involved) in terms of education, economic activity, child care, etc.
- Danger to women in current and past war zones, e.g. from land mines
- Physical effects of carrying large quantities of fuel wood, etc., again mainly involving women.

Despite considerable evidence for a link between smoke pollution from biomass fuels and a number of health problems, comparatively little research has been carried out to evaluate efforts in the household energy field to reduce this exposure. Given the high levels of exposure to smoke, and the very large numbers of women and children exposed in the world's poorest communities, substantial reductions in indoor air pollution from biofuels can be expected to have a tangible and important impact on public health. This project is seeking to identify appropriate ways to effect substantial reductions in indoor air pollution.

Chapter 2 – The ITDG smoke and health project

Project overview

The main objectives of the project were twofold: to improve the quality of life, through reduction in indoor air pollution, for households in these study areas; and to develop a participatory methodology for further research into appropriate ways to alleviate indoor air pollution. These objectives were to be achieved through:

- Carrying out a baseline assessment of pollution and exposure, fuel use and house structure
- Identifying participatory ways of alleviating indoor air pollution through development and installation of interventions. (*Interventions*, within the context of this project, were identified as any changes which took place as a result of the project which could affect the levels of indoor air pollution to which the occupants of the kitchen, especially women and children, were exposed.)
- Evaluation of changes in pollution and exposure, and community views of the process used, and the acceptability and affordability of the interventions.
- Empowerment of communities by making them aware of the risks associated with household smoke and enabling mechanisms for its alleviation
- Development of a strategy in a national context for dissemination and sustainability within the market constraints of the communities
- Exchanging experience internationally to strengthen Kenyan work and to contribute to implementation of best practice in other countries
- Development of a replicable participatory methodology on appropriate methods for reducing indoor air pollution. This methodology will form the basis for future work in international comparative studies on indoor air pollution and interventions.

Project locations

All the field work took place in Kenya (see Box 2.1) and was carried out in communities in two rural areas with whom ITDG has been working for several years:

- A Maasai community in the Kajiado region, located some 80km south of Nairobi
- West Kenya, in the Kisii and Luhya communities in Nyamira district (60 km SSE of Kisumu) and Mumias, 40km west of Kakamega.

Box 2.1: Facts about Kenya

Kenya remains one of the poorer East African countries, with a per capita GNP of US\$360million (ranking it 170th in the world) and an average annual growth rate of 0.1%. The rural population (comprising 68% of the total) is largely dependent on biomass fuels for energy. With 46.4% of the rural population living below the poverty line, 47% without access to improved water supplies, and infant mortality standing at 124 per 1000births (cf. 115 in 1980), the country displays both a high level of poverty and poor health, and a relatively slow pace of development. (World Development Report 2000/2001 - figures for 1998-99)

Although ITDG is well-recognised in these two regions, the households which were involved in the study had not benefited directly from earlier projects, so the homes were on the whole very traditional and suffered from high levels of indoor air pollution.

Table 2.1 summarises information on the incidence, intensity and severity of poverty for food, overall or hard-core poverty lines in the project areas. The incidence of poverty is measured by the numbers in the total population living below the poverty line. Because the communities with whom ITDG is working are among the poorest groups in these regions, the figures given in Table 2.1 are likely to be conservative. These figures are based on 1994 surveys.

Table 2.1: Incidence of poverty in the project areas						
Type of poverty	Food poverty		Overall poverty		Hard-core poverty	
Area	%	Actual numbers	%	Actual numbers	%	Actual numbers
Kajiado	30	80 369	22	60 926	14	39 257
Nyamira	55	227 046	52	261 698	34	171 757
Kakamega	49	514 297	51	537 141	32	327 307

Source: Ministry of Planning and National Development, *Poverty in Kenya – first report, June 1998*

Low incomes and wages characterize both Kajiado and West Kenya. However for the Maasai community (one of the poorer communities in Kajiado), food availability, especially a balanced diet, is lacking. The Maasai traditionally rely on livestock products as a source of food. On the other hand, poor nutritional status in the West Kenya region is attributed to low family incomes. The way this income is distributed across the family is such that women (who are the household managers) do not necessarily have access to it.

The Kajiado region

The area of Kajiado is 21,105 km² with a projected population in 1999 of 450 118 (growth rate of 5.54%) based on the 1989 census results (Kajiado District Development Plan, 1997-2001).

Economic Factors

- Employment levels were expected to be only half that of the total population in 1997. Employment is mainly in pastoral and livestock activities, and to a lesser extent in agricultural activities, waged employment, mining and quarrying.
- Child labour is common for males aged 12-15 years who have to look after livestock.
- Female-headed households cannot inherit property unless they have a boy child. This is a potential cultural barrier to development.

Health and infant mortality

- The most common diseases in the district are malaria and respiratory diseases. Others are eye infections, worms, diarrhoea, skin diseases, generally due to scarcity of water and poor sanitation.
- Infant mortality is estimated at 90 per 1000 live births. The figure was drawn in 1997, only from those who sought help from medical facilities. The figure may have been higher because a large proportion of the population has no access to the medical facilities. Causes are malaria, measles, gastro-enteritis, acute respiratory infections, malnutrition, and polio.

ITDG's links with the community

The ITDG Maasai Housing Programme is community-based, working mainly with women's groups and individual women in a pastoral area in Kenya. Traditionally semi-nomadic, the Maasai have, over the years, adopted a more sedentary lifestyle. Whilst maintaining cultural requirements of housing design, the project has made improvements in ventilation, natural lighting, maintenance and general comfort.

In 1993, the Maasai Housing Project in Kajiado made a preliminary study of the exposure to carbon monoxide and respirable particulates in two Maasai households, which showed that the cooks were exposed to unacceptably high levels of both these (Young, 94). ITDG has thus been working in the region for a very long time, and this facilitated the in-house testing procedures, as the staff were trusted and made welcome.

Maasai houses

In Kajiado, problems with smoke alleviation interventions reflect both the extreme poverty and cultural barriers within the community; lack of finance; famine; dilapidated houses; cultural barriers (men do not like being looked at while they eat).

The Maasai households have lived for years in unventilated houses due to their pastoralist lifestyle. Now that the life has become more sedentary, the demand for durable housing is increasingly a burden for women. The height of the houses being monitored in Kajiado was mainly between 4.5 feet and 7 feet, with one or two falling outside this range. There are no windows but very small pigeonholes and hence poor lighting and ventilation and are usually so dark that tin lamps have to be lit during the day. Accidents happen, such as burns, snake and spider bites, loss of items, stepping on sharp objects, houses are infested with vermin and rodents, such as fleas, rats and bedbugs. The houses, including the roofs, are predominantly built of mud, which is plastered onto woven wooden stakes. Some roofs are made of ferro-cement.

Cooking practices

Food is usually cooked during the day so that the cook can walk outside during cooking periods to get away from the smoke in the house. Cooking is done on a three stone fire, and when people go to sleep, most of them do not put out the fire but cover it with ash so that the fire smoulders till morning when the fire is rekindled again.

West Kenya

In Western Kenya, the Smoke project worked in Nyamira and Mumias-Butere districts with the Kisii and Luhya communities. The two areas are different topographically since Kisii is a highland zone while Mumias is in the middle zone.

Mumias is a sugarcane growing area with very little land for subsistence farming and with relatively low rainfall patterns. Sugar cane is the major cash crop. It is grown commercially and sold to Mumias Sugar Company. Women have very little land for subsistence farming because the land is for sugar cane production and the income goes to the men. Some women opt to weed some two to three rows of sugar cane and in between the rows, they are allowed to grow beans.

Nyamira, on the other hand, is a highland region and subsequently has higher rainfall. There is a lot of subsistence farming (maize, beans, bananas, vegetables, tomatoes) in addition to the cultivation of tea, and coffee as cash crops.

Nyamira, covers an area of 861 sq. km while Kakamega district covers an area of 2963 sq. km (Nyamira District Development Plan, 1994-1996; Kakamega District Development Plan, 1994 – 1996).

Health and infant mortality

- In West Kenya, the prevalent diseases are clinical malaria, upper respiratory tract infection, skin diseases, diarrhoea, intestinal worms and HIV/AIDS.
- By 1996, the infant mortality rate stood at 85 per 1000 live births. According to the KEPI (Kenya Extended Programme for Immunisation) survey carried out in 1992, the immunisation coverage for children under one year within the district was 72%.

ITDG has worked in West Kenya on household energy projects based on the production of the *Upesi* stove for over a decade. Initially focused on stove production, the project subsequently moved to providing a sustainable route through marketing and commercialization (Abbott, V. 2000). The smoke project is part of the current Stoves and Household Energy Programme, which also includes marketing and promotion training for stockists, retailers and promoters of stoves (Owala, 2001), ceramic stove production, and the production and distribution of training manuals on household energy. The work on smoke alleviation has benefited from the long-term relationship which ITDG has with communities in this area.

Housing

All the houses are built of mud; roofs are generally of thatch, although some are made of iron sheet. Houses in the two areas are characterised, as described below.

General household characteristics for Mumias

- Houses have racks on top of the fireplace, which may hinder erection of smoke hoods.
- The main fuel is firewood and crop residues.
- Kitchens are separate from the main houses.
- Kitchens have narrow eaves spaces of about 2 to 3 inches.
- Kitchens have small circular windows, hence the kitchen is poorly ventilated.
- Some houses used three- stone fires, mainly in homes where the Upesi project had not worked before. Many of the houses having improved cook stoves in the area owe the technology to the activities of the Upesi project.

General household characteristics for Nyamira

- Kitchens separate from main house.
- No eaves spaces and, if present, they are blocked by the wood-rack (*Irongo*)
- Tiny windows and openings.
- In the period between the initial meeting with the women and the first pre-intervention monitoring, some people built upesi stoves in their kitchens

Chapter 3 – The participatory process

Community participation

Community participation has been a fundamental component of this project. This is built on ITDG experience over many years which shows that the people with whom the project works are best placed to express their own needs, and to identify potential solutions which suit their cultural, social and economic context. Indigenous knowledge has been highly valued throughout this work, and the community's (mostly women's) views and opinions have been listened to and addressed at all stages.

During the Smoke project, participation has helped the communities to understand some of the problems they face as a result of smoke in their houses and also to be actively involved in formulating solutions. This chapter describes the participative methods used throughout the project. Participation has been on three levels:

- Community mobilisation and house selection
- Participatory Technology Development (PTD)
- Community participation in research

Community mobilisation

House selection incorporated the participative process, where women's groups were informed of the intentions of the project by the field staff, and helped in identifying houses based on the project's criteria. This ensured the community members' support throughout the project in terms of their time, being inconvenienced by the project equipment, adoption of new technologies, and other aspects of the project.

Participatory Technology Development (PTD)

PTD is the key development tool used throughout the project. It can be described as the collection of operational approaches, methods and techniques emphasising a high degree of user's participation in technology development; identification, implementation and development. It has its foundation on the premise that users are the best placed to decide which technologies they want to adopt, therefore greater participation may result in adoption of more appropriate technologies (ITDG Kenya Annual Report 1997).

All the smoke-alleviating technologies, developed in consultation with the cooks and their families, and all project stakeholders, therefore incorporate PTD elements. The technologies chosen must be acceptable, appropriate, durable, affordable and accessible to the local community.

Common themes and principles in PTD practice include an understanding of the following:

- 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
- That the key challenge is to tap the potential interaction between indigenous knowledge and that of outsiders.

Focus group meetings

Focus group meetings were held:

- To ensure that people's opinions and wishes were heard
- To sensitise the community to the risks of smoke, and enhance the households' awareness of the pre- and post-intervention benefits of the project interventions.
- To involve both men and women in participatory interactive communications on health related issues concerning their families.

The methodology included; brainstorming, discussions, examining case studies, interviews

Exchange visits

Exchange visits form an important part of local dissemination. They involve individual members of a community allowing others to visit their kitchens, in order to show off the interventions which have been installed. This happens naturally to a large extent within the community, but structured visits can also help to disseminate new ideas, as described in field reports (Box 3.1). Because it proved impossible to arrange visits between Kajiado and West Kenya, photographs were exchanged, to show each community what was happening in the other.

Box 3.1: Exchange visits

Exchange visits proved an effective way of disseminating information between community members. Initial reluctance on the part of many of the cooks turned to enthusiasm once they had seen the interventions in place in other people's kitchens.

- At the start of the project, only two of the women in Kajiado and none of the West Kenya women wanted smoke hoods installed. Once two had been installed in Kajiado, other women watched as the installation took place and observed how the smoke disappeared through the chimney. As a result, thirteen of the households opted for smoke hoods.

Constraints on community involvement

Although the women in the project areas were keen to be involved in every aspect of the project, various constraints limited their activities. The project staff had to avoid certain days e.g. market days (Wednesdays and Saturdays) and most meetings were held in the afternoon since the women were mostly committed in the morning hours to routine jobs such as fetching water, watering their animals. Distance was a major constraint for some of the women who had to trek several miles to get to the meeting venues. In West Kenya, some husbands were less supportive, unless their wives were 'paid' with flour, sugar etc. for the time spent.

Stakeholder involvement

Both local government ministries and locally-based organisations have been supportive and proactive throughout the project. This is essential in order to build the infrastructure necessary to make the successful interventions sustainable.

Women's groups

In mobilising and training the community, women's groups played a key role. During the project, women's groups usually co-ordinated activities and the meetings that were held with their members. The key informants were the group leaders (chair ladies) who served as a major link between the project facilitators and the community members.

Local government ministries

The project team enlisted the active support of the Ministry of Health, Ministry of Public Works and Housing, community development workers.

The African Medical and Research Foundation

The local Environmental Health Department of AMREF are involved in ongoing discussions with ITDG – East Africa on various collaborative ventures and support through their environmental health, sanitation and house improvement programmes to further this work.

The Maasai Technical Training Institute (MTTI)

The Maasai Technical Training Institute (MTTI) was engaged in the design, fabrication and procurement of the smoke hoods, and in artisanal training

The Jua Kali sector

The Jua Kali (informal manufacturing) sector has offered techniques that are affordable, sustainable and easy to adopt. Artisans have constructed all the hardware – hoods, frames for eaves spaces, windows.

Chapter 4 – Project activities

Project structure

The project was devised as a 'before-and-after' study, for which the key outputs would be substantial reductions in indoor air pollution and improvements in the quality of life for the beneficiaries. The opinions of the beneficiaries were recorded on the changes brought about by the interventions, whilst the air quality was monitored for reductions in particulates and carbon monoxide.

The project involved a multidisciplinary team, including fund raisers, project managers, scientific advisors, statisticians, field staff, enumerators, data entry/counter-check clerks, various partners (NGOs, government ministries, and research institutions), community artisans, and other community groups, as well as the individual householders themselves.

Although structured as a 'stand alone' project, the methodologies were closely aligned with those of earlier studies looking at the relationship between indoor air pollution and ill-health. The project therefore benefited greatly from an adviser with direct experience in this related field.

Selection of households

The criteria for house selection were defined as follows:

- The most important criterion was willingness to participate in the project for its duration
- Preferably houses with children of 0 to 5 years. Mothers with children of this age tend to spend more time based in the kitchen and are therefore more vulnerable to smoke and the consequent respiratory problems
- A range of house types was chosen in West Kenya, from very traditional (often poor-quality) houses to houses which already had some improvements, such as *Upesi* stoves (see front cover) - this represented the living conditions experienced by the vast majority of people living in this region. The houses were identified and selected through the women's groups that ITDG had been working with since 1993 e.g. the Ichingo Women Group.
- In Kajiado, houses were selected that had not been improved by the Maasai Housing Project - again this represented the majority of homes. During house selection, the various women's groups were asked to identify houses that had not been improved under the Maasai Housing Project - the selection was done on ballot basis to avoid prejudices.

Training of enumerators

The field staff were trained as enumerators so that they could collect both numeric and descriptive data from each house. This involved training in: preparation of equipment, recording levels of smoke in each round, and recording household and house data.

Baseline survey

A baseline survey has two functions: to quantify the scale of the problem compared with international standards; to act as a baseline for any long-term changes brought about by interventions made during the project.

Data from the first two rounds of monitoring for particulates and carbon monoxide provided quantitative values for the levels of indoor air pollution in each of the households.

Questionnaires (see Annex 2) were used to identify key aspects of people's lives which might impact on indoor air pollution in their homes. These involved questions on households, housing, time budgets etc., a process which took about 20-45 minutes.

Focus-group discussions allowed the project team to discover the needs that the community identified as being most important to them. These discussions also allowed the team to find out the level of understanding within the community on the links between smoke and ill health.

Visits to all the households allowed the team to discuss any traditional beliefs that needed to be considered when selecting interventions.

Discussions with all the households to decide on the interventions they needed.

Selection of interventions

A participatory approach was adopted right from the start, with individual and group discussions with the project families, especially the women, to identify possible smoke-alleviation methods which they would find acceptable, affordable and which were felt could be effective. This approach involved:

- Discussions on methods of smoke reduction, including improved stoves, windows, room height, smoke hoods etc.
- Exploring any locally available knowledge among community members on interventions
- Discussions on lighting and ventilation principles
- Involving women in selecting the locations of the interventions in the houses (windows, smoke hood/hoods)
- Discussing with the community members about the operation and maintenance of the interventions
- Discussing the efficiency of various interventions and the importance of opening windows and the realised benefits.
- Developing prototypes of the interventions e.g. windows, smoke hoods with the community
- Discussions on wood selection and method of drying and storage before the rains

The role of ITDG staff was to highlight the need for smoke interventions and to provide ideas and stimulate discussion on what might be done. The community members, in their turn, generated ideas based on their knowledge of the reality of their lives, identified constraints and ensured that the final decisions were realistic and in accordance with their wishes.

The information from these meetings was shared with the whole ITDG smoke team resulting in three possible types of intervention being identified: ventilation by enlarging the size of windows or opening eaves spaces; adding smoke hoods over the cooking area; and thirdly the option of installing improved cook stoves.

Although women in Kajiado believed (probably correctly) that those who had raised their roof height felt that indoor air pollution had been alleviated, the project team felt that this intervention was too costly to be reproduced by large numbers of people, so it was not adopted by the project.

The final design and materials used for the interventions was determined by the women themselves and availability of materials. In this way, local skills are used, the interventions are well accepted, and this should promote higher potential for future replication of the interventions in the area.

Quantitative measurement of indoor air pollution

Levels of indoor air pollution must be measured quantitatively, through smoke monitoring, and qualitatively, through interview and group discussion. This ensures that any interventions promoted in future work are effective as well as acceptable. For quantitative measurements, the levels of smoke must be measured both within the kitchen itself, and also the smoke inhaled by the person most affected - the woman of the house who does the cooking - described as 'the cook'.

Two key components of smoke were measured; respirable particulates (PM_{resp}) - less than 10microns diameter, and carbon monoxide (CO). The respirable particulates were measured using an air sampler, and carbon monoxide was measured using stain tubes.

Both respirable particulates and carbon monoxide were measured for each household over 24hours. However, since the monitoring was being conducted through the night as well as by day, it was important that the equipment used to measure the dose inhaled by the cook was

as non-intrusive as possible. For this reason, the measured level of carbon monoxide she inhaled served as a proxy to assess the amount of particulates to which she had been exposed over this time. Statistical tests of association show a close correlation between CO and PM_{resp} in the kitchen, broadly in line with results reported by Naehler et al., hence it was felt appropriate to adopt this method for 24-hour monitoring as the CO/ PM_{resp} relationship (Naehler LP, Smith KR, Leaderer BP, Neufeld L, Mage D, 2001). The stain tube used to record CO is silent, much smaller, and much less intrusive than a PM_{resp} monitor would be.

For each household, two rounds of monitoring were done before, and two rounds after, interventions had been installed in the houses. The two rounds were to reflect the wet and dry seasons and their effect on the levels of indoor air pollution in the kitchen.

Readings from the CO stain tubes were recorded by the field staff directly into the questionnaires. The particulates were collected on a filter paper which was dried and weighed using a six-point balance before and after monitoring to give the weight difference caused by the particulates. This procedure was organised by the project's scientific adviser at the University of Nairobi.

By comparing the levels of PM_{resp} and CO before and after particular interventions had been installed in a range of houses, it was possible to identify which interventions reduced indoor air pollution levels appreciably. A further step was to see the effect of the interventions on the indoor air pollution inhaled by the cook. The technical details involved in quantitative monitoring methods are detailed in Annex 1

Descriptive analysis and confounding variables

A series of questionnaires was devised (Annex 2), designed to be locally appropriate through discussions with members of the project team who were working in the field.

These questionnaires identified key aspects of people's lives which would be affected by their household energy use:

- A data collection sheet was used to record the levels of respirable particulates (PM_{resp}), levels of carbon monoxide in the room (CO) and personal carbon monoxide (PCO) for each household.
- A household questionnaire identified the size of the household, the way fuelwood was collected, the means of cooking, lighting, and other uses of energy.
- A house and kitchen questionnaire identified the type of house, the windows and other openings, the roof structure etc.
- Time/activity charts were used to determine when people were in the room whilst the fire was lit
- A basic health survey was done to identify the sort of problems which people were experiencing. Because of the low numbers in the study, this was not a baseline survey, but rather an overview of the health-related problems which the community identified.

Confounding variables are those aspects of people's lives (e.g. number of people to be cooked for), environmental factors (e.g. level of rainfall) which can influence the level of smoke pollution in the home and/or the level of personal exposure, and which are also associated with the interventions. The effects of these confounding factors need to be considered if the actual impact of the interventions is to be correctly assessed. Changes in the most important confounding factors over the course of the project (in particular changes from the pre to post interventions periods) have therefore been reported, and the potential for confounding discussed. There is limited opportunity for formal statistical analysis of confounding due to the relatively small numbers in the study, but this will be carried out separately.

Focus group meetings

Pre-intervention meetings

Focus group meetings were held both before and after the interventions were installed. Pre-intervention discussions focused on which interventions were needed, the perceived causes

of indoor air pollution, problems associated with indoor air pollution, and uses for smoke. The Smoke Project team gave a lead on some possible interventions that could be installed in the households such as enlarging the size of windows, eaves spaces, smoke hoods, installation of improved cook stoves. A sample of the outcome of these discussions is shown in Table 4.1.

Household number	Is smoke an issue?	Perceived causes	Problems	Smoke uses	Traditional beliefs	Possible changes?
HH 1	Yes	Lack of windows Door size Use of wet firewood Cooking for long hours Lack of other openings	Eye problems Cold	Chasing away insects Drying fuelwood Preserving cereals	None	Have windows Reposition the door Use bigger stoves
HH3	Yes	Position of the kitchen Size and position of window Lack of eave space Using wet fuelwood	Tearing of eyes and turning red Man avoids the kitchen Cold and flu	Was used for preserving cereals		
HH5	Yes	Size of openings Size of the kitchen	Colds and flu Coughs Tearing and red eyes	Insect repellent Drying fuel wood Preserving fuel	None	Build another kitchen Increase size of opening (window and eaves space)
HH6	Yes	Use of wet wood	Chest problem Breathing Cough	None	None	Build a new kitchen Is willing to work with the team on the changes required
HH8	Yes	Lack of eaves space Size of window Size of window	Tearing and red eyes Cough Flu	Dry fuelwood Preserving Cereals Insecticide	Smoke is a medicine for boils	Increase window size Increase eaves space Increase door size

Post-intervention West Kenya meetings

In the post-intervention period, they were used to understand the changes which had occurred in the communities over the duration of the project. Post-intervention discussions included training on how to use and maintain the interventions, such as the need to open windows for them to be effective. The focus groups involved the stakeholder communities, mostly the participating women, and sometimes their husbands. They provided a forum for highlighting the effects and benefits of these activities.

Time-activity studies

Detailed time activity studies were undertaken for individual women and for groups in each area, in both wet and dry seasons. These studies reflect how changes in indoor air pollution level affect people's behaviour in their homes. The household questionnaires and the time activity studies combine to provide an overall picture of lifestyle among the Maasai and West Kenya communities. A typical day in the life of one of the Kajiado families is recorded as a time/activity record in Annex 3.

Installing interventions

There were four main types of interventions selected by the community members in Kajiado and West Kenya

- Smoke hoods
- Eaves spaces
- Windows

- Improved stoves

Chapter 5 describes in detail the interventions that proved appropriate in each area.

Artisanal training

Kajiado

In Kajiado the Maasai Technical Training

Institute in conjunction with the Ministry of Health undertook the training of artisans. The cooks were involved in material selection, sizing, shaping, positioning and production processes. The groups were able to show the desired positions of windows, vents, and the position of smoke hoods. They were shown pictures of different types of chimneys and smoke hoods from which to choose and were supplied with hard manila paper to design a model of the desired hood. The artisans transferred the design to the plates and sheets to cut out the parts and qualified artisans supervised production of the product. Pre-testing of the product with the households was crucial since changes were effected according to performance.

West Kenya

An instructor from the Maasai Technical Training Institute trained two artisans and the Training Officer in the Kisumu YMCA. The training took eight days with all the five smoke hoods fabricated under his supervision. The hood designs were discussed in consultation with the households.

Follow-up activities

During this period, activities addressed sustainability at local level:

- Operations and maintenance of the interventions
- Proper use of the interventions
- Personal and domestic hygiene
- Monitoring performance and effectiveness of interventions

The Ministry of Health, Culture and Social Services facilitated some of the meetings and exchange visits on domestic and personal hygiene, income generating project ideas, housing sanitation and operations and maintenance of the interventions.

Data analysis

Monitoring data was analysed to provide;

- A descriptive analysis of the baseline level of pollution in the study households, as well as the social, household, health and other factors which relate to the collection/supply and use of household energy in the home
- A description of the different types of intervention selected, their appearance (with photographs and sketches), the numbers of households adopting each intervention
- The change in ambient pollution levels in homes achieved through these interventions
- An assessment of the personal exposure for the woman (PCO) and time/activity assessments of women and young children

The results of the monitoring have been analysed statistically. Differences between the pre-intervention and post-intervention results reflect the impact of the project in terms of smoke alleviation. Annex 4 gives further details on the statistical methods adopted during the project.

Financial arrangements

The financial arrangements were different in each area. Kajiado suffers from severe poverty which was exacerbated, during the project period, by a drought which caused loss of livestock. Food aid was being sent by the government to the project families, and under these circumstances, it was agreed that there would be no costs incurred by the project families.

Nevertheless, some provided assistance in installation of interventions, and some of the materials for building the interventions were purchased by the men in the community.

In West Kenya, there was a cost-sharing agreement from the start. Agreement was reached with the household owners of what each would contribute towards the cost of interventions.

Capacity building

Capacity building was addressed in several ways, and will form part of the ongoing smoke work:

Locally

- Involving other organisations throughout the project
- Training artisans
- Cost-sharing in West Kenya
- Dissemination through exchange visits, workshops, conferences, video

Internationally

- A new UK DfID-funded project 'Smoke, Health and Household Energy' started at the beginning of 2002. This project will build on the lessons learnt during this project to disseminate the methodologies in urban Kenya, Nepal and Sudan.
- Schemes to scale-up and commercialise the successful interventions within Kenya and the adjacent countries will form part of a further initiative through ITDG-East Africa and other key stakeholders.

Chapter 5 – Interventions

Table 5.1 outlines the selection made by each household. It can be seen that windows were popular in both areas, stoves and eaves spaces were favoured in West Kenya, whereas in Kajiado, smoke hoods were widely adopted.

	Window	Smoke hood	Upesi stove	Eaves spaces
West Kenya households	24	5	24	24
Kajiado households	24	12	0	2

**Some of these interventions were installed before project – see Chapter 6*

Smoke extraction through smoke hoods

A decision was made, in consultation with the community, to opt for smoke hoods rather than chimney stoves. This was based, in part, on two successful smoke hoods installed in Kajiado in the early 1990s and the failure of chimney stoves, several of which had been installed during a government scheme some years previously, and none of which had been used. In West Kenya there was little experience of either smoke hoods or chimneys. The figure opposite show the flue from the smoke hood and open window outside a house in Kajiado.

Ventilation - through windows and eaves spaces

As shown in Chapter 2, the homes in Kajiado and West Kenya are entirely different constructions. However, in both areas, the rooms were largely unventilated, so windows and eaves spaces were adopted as possible interventions.

The windows were all of a standard size (0.3m x 0.3m), and cost approximately £10.40 to install, whilst the frame around the eaves space cost £4.35 (Exchange rate: 1UK£ ~ 115Ksh). The eaves spaces were cut into the wall at roof height and above the stove and a wooden frame inserted. They were made 150mm wide, and of varying length (long enough to vent the smoke as it reached roof height), typically 4-5m. Mesh was attached across the frame for added security, and to keep out rodents. Box 5.1 describes the participatory nature of the window installation.

Box 5.1: Case Study of Window installation

Process in HH40 (JK's house)

The installation exercise began in household 40 (JK's house) on 5th December. The team arrived in this boma at about 11.30 a.m. and asked the woman to suggest the window positions. JK identified two locations which was a reflection of the husband's decision. The team however advised her that it would be better to have three windows instead of two to ensure through and cross ventilation. The size of the windows installed was 14 by 14 inches.

The exercise started at 12.00 noon and ended at 3.00 p.m. and it attracted women, men and children living in the same boma. The process created a lot of excitement as the house was opened up and some people sat inside to actually watch what was happening and they actively participated in passing their comments. After the first window was installed, JK (the owner of the house) really liked the idea of windows and decided she wanted four instead of three. However, the spectators were against the idea and said that this would infringe on her privacy since the house would be too open and the house would have less warmth which is characteristic of the Maasai houses. JK was actually lured to their idea and therefore the team only installed three windows in that house. JK later served the team with some tea (black tea since most of her cattle had died in the prolonged drought that the area had been experiencing).

After witnessing the process in household 40, the husband of N. (household 41) was more than eager to have windows installed in his house the following day. In household 39, four windows were installed on 7th December.

Improved combustion through improved stoves

West Kenya has a good tradition of improved stove use where it is well-suited to the typical kitchens in the region. The Upesi stove, promoted through the household energy programmes, has been shown to reduce fuel use by about 40% *(Habermehl, 1994; Abbott, 2000) compared with three-stone fires. A key element in its success has been the training of the producers, sellers and promoters of the stoves (most of whom are local women), in effective dissemination techniques (Owala, 2001). This often involves demonstrations, and advice on the installation of the stoves. Many of the households with these improved stoves have reported marked improvements in the household environment, saying that:

- the kitchens are cleaner;
- the children's safety from domestic fires/accidents have been improved; and
- there is considerable saving in the use of fuel wood.

Upesi stoves cost approximately £1.20 for a single stove, and £2.40 for a double – to buy, and a £0.40-0.80 – to install.

Interventions in Kajiado

The most popular intervention were windows, which everyone adopted, with about half the households opting for smoke hoods. None of the households adopted improved stoves and only two households requested eaves spaces. The eaves spaces were considered draughty, and also the house structure made it very difficult to cut eaves spaces at the top of the wall.

Interventions in West Kenya

As part of the participatory process with the household owners in the study, the West Kenya team selected a menu of activities to identify appropriate interventions:

- Visiting all the households to discuss the communities' perception of the indoor air pollution problems and the perceived causes of indoor air pollution. For most households, this discussion was held in the presence of the spouses.
- Exhibiting photographs of the interventions that had been completed in Kajiado evoked an enthusiastic response as described in field reports (Box 5.2)

- Revisiting the households to finalise decisions on the types of intervention and the method of installation.
- Reaching agreement with the household owners of what ITDG's contribution towards the interventions would be, and what would be met by the household.

Box 5.2: Technology transfer through photographs

Pictures of the Kajiado smoke hoods were shown to the households who were very excited to have the same in their houses. On brick smoke hoods, the Mumias community said it looked odd on the thatched roof and hence dropped the idea. Five smoke hoods were fixed in both Nyamira and Mumias with all the women very happy and excited. At one homestead, people danced with a lot of vigour to a traditional dance commonly known as "Mwana Abili Kayai" causing a stampede with a lot of ululation and thunder on the new technology.

The kitchen owners worked towards the improvements, identifying and negotiating with the artisans, and installing Upesi stoves in those houses where they had not previously been used.

Maintenance and use of interventions

- Discussions were held with households on the maintenance and use of each of these interventions – e.g. it was found that smoke hoods work better when there is a window directly opposite the fire, which improves combustion and when they are kept free from soot.
- It was found that during wet weather, families were closing all the windows – when cooking, the households are advised to keep some of the windows open to facilitate combustion and to minimise the pollutant concentration in the kitchen
- In West Kenya, the hood is made more durable by encasing the bottom of the hood in mud, and painting the hood to minimise rusting.

Chapter 6: Key findings affecting the communities in Kajiado and West Kenya

Descriptive analysis of households in Kajiado and West Kenya

Households

Table 6.1 looks at the number of occupants in each of the households in each area, before and after the interventions were installed. The large differences in children's ages reflect the fact that over a year had passed between pre- and post-intervention monitoring, age was not something which was considered important in the communities, and furthermore, the children often move between houses, especially in the Kajiado community. Adjusted meals reflect the smaller portions required by women and children, compared to those eaten by men (Stewart et al., 1987). It can be noted that there was no major change in the overall numbers of meals being cooked before and after the interventions were installed. Because of the famine in Kajiado, dried maize was included in the diet, which needed more cooking in the post-intervention period. Nevertheless, the questionnaires did not reflect any substantial change in the hard food / soft food ratio. (Hard foods included maize, beans etc. soft foods included tea, vegetables, milk, porridge)

The time spent cooking in Kajiado is considerably greater in the pre-intervention rounds. This reflects comments made by the women to the team that it is much easier to cook in kitchens where they can see what is happening clearly.

Characteristic	Level	Kajiado				West Kenya			
		Pre-intervention		Post-intervention		Pre-intervention		Post-intervention	
		n	%	n	%	n	%	n	%
Age of woman - years	<19	1	5	0	0	0	0	0	0
	20-29	8	42	13	54	5	20	3	13
	30-39	7	37	5	21	7	28	6	25
	40-49	1	5	4	17	9	36	8	33
	50-59	2	11	2	8	4	16	5	21
	60+	0	0	0	0	0	0	2	8
1st child's age (median)		8		5		7.9		4.38	
2nd child's age (median)		4.5		5		4.3		3.5	
3rd child's age (median)		2.5		2		3.5		2.75	
Time spent in kitchen		2.5		1.52		3.8		3.14	
Pre/post reduction (%)		39.2				17.3			
Type of food – % per meal	Soft	79		74		97		93	
	Hard	21		26		0		06	
	Both	0		0		0.03		0.01	
Adjusted servings/household/meal*		3.88		4.18		4.68		4.94	

* Child meals = 0.5 x adult meals: Female = 0.8 x male meals (equal nos. of male/female assumed)

Houses and kitchens

The data in Table 6.2 shows that wood is overwhelmingly the major fuel, with some use of biomass residues, especially in West Kenya. Kerosene is mainly used for lighting (using wick lamps) although a few households use it for secondary fuel for cooking. It would appear that fuel is not routinely dried. Whilst fuel is scarce, there was no significant change in its availability before and after the installation of interventions – scarcity was reported at around 20-25% in Kajiado, and 60-70% in West Kenya.

Characteristic	Level	Kajiado				West Kenya			
		Pre-intervention (n=19)		Post-intervention (n=24)		Pre-intervention (n=25)		Post-intervention (n=24)	
		n	(%)	n	(%)	n	(%)	n	(%)
Main Fuel	Wood	19	100	23	96	25	100	24	100
	Residues & dung	0	0	1	4	0	0	0	0
Secondary fuel	Wood	0	0	0	0	0	0	0	0
	Residues & dung	2	10	3	12.5	13	52	9	38
	Charcoal	0	0	3	12.5	1	4	1	4
	Kerosene	0	0	0	0	1	4	2	8
Drying fuel	Usually	0	0	1	4	19	76	17	71
	Sometimes	4	21	4	17	6	24	6	25
	Never	15	79	19	79	0	0	1	4
Adequacy of fuel	Very adequate	11	58	10	42	4	16	3	12
	Just adequate	4	21	8	33	2	8	6	25
	Rather scarce	2	10.5	6	25	10	40	10	42
	Very scarce	2	10.5	0	0	9	36	5	21

Interventions

The results in Table 6.3 reflected the interventions that had been installed in the kitchens of the communities in Kajiado and West Kenya during the study—the vast majority of these changes were as a result of the project.

Characteristic	Level	Kajiado				West Kenya			
		Pre-intervention (n=19)		Post-intervention (n=24)		Pre-intervention (n=25)		Post-intervention (n=24)	
		n	(%)	n	(%)	n	(%)	n	(%)
Smoke extraction	None	19	100	11	46	25	100	19	80
	Hoods/chimneys	0	0	12	50	0	0	5	20
	Missing data	0	0	1	4	0	0	0	0
Eaves	None	19	100	22	92	9	36	0	0
	Medium	0	0	2	8	13	52	9	38
	Large	0	0	0	0	3	12	15	62
Stove	Improved	0	0	0	0	10	40	21	88
	Traditional	19	100	24	100	15	60	1	4
	Other or missing					0	0	2	8
Primary window	No window	0	0	0	0	7	28	0	0
	25mm-149mm	16	84	0	0	1	4	1	4
	150mm-600m	3	16	24	100	12	48	14	58
	>0.6m	0	0	0	0	7	28	9	38
Second window*	25mm-149mm	16	84	0	0	0	0	1	4
	150mm-0.6m	3	16	24	100	9	36	12	50
	>0.6m	0	0	0	0	1	4	11	46
	No window	0	0	0	0	15	60	0	0

*The increase in size is for the two largest windows. In Kajiado, several of the houses had three or four installed in total.

Women's health

This project was designed to look at the smoke-alleviating effects of installing interventions; it did not attempt to measure the health effects directly. Nevertheless, the pollution indicators recorded reflect the likely health impact of kitchen smoke on the cook and her children. Table 6.4 is a summary of the health problems reported by the cooks in the questionnaires, and is intended to give an overview of the smoke-related health problems experienced in each community. It is based on standard questions from the Medical Research Council for respiratory disease. Because of the limited numbers involved, it was statistically inappropriate to look at the before/after effects of interventions on health. Table 6.4 therefore gives a compiled number of reported ailments for each community, combining all pre- and post-intervention data.

Table 6.4 Health problems identified by the cooks					
		Kajiado		Kisumu	
		No. of records	% with problem	No. of records	% with problem
Cough	i)First thing in the morning	74	24.32	97	16.49
	ii)During day (or at night in wettest coldest season)	65	27.69	76	21.05
	If 'yes' to i) or ii), cough most days for up to 3 months a year	23	26.09	26	26.92
Phlegm	i)From chest in the morning during cold/wet season	73	20.55	102	20.59
	ii)During day (or at night in wettest coldest season)	70	21.43	87	21.84
	If 'yes' to i) or ii), phlegm most days for up to 3 months a year	17	5.88	44	13.64
Cough & phlegm	In last three years, cough and phlegm together lasting 3 weeks or more	73	13.70	98	18.37
Wheezing	Wheezing or whistling in chest in last 12 months	74	13.51	79	24.05
	Woken up last 12mths at night with shortness of breath	73	10.96	90	27.78
Chest illness	During past 3 years preventing usual activities for as much as a week	74	17.57	78	28.21
TB	Ever been told by a doctor that suffering from tuberculosis	74	0.00	98	4.08
Eyes	Red, watering eyes sometimes or much of time	47	55.32	67	17.91
	Sore, sometimes or much of time	47	27.66	66	13.64
	Swollen, sometimes or much of time	47	12.77	66	10.61
	Affected by light, sometimes or much of time	47	61.70	64	20.31
	Vision impaired, sometimes or much of time	47	29.79	67	38.81

Quantitative results on changes in indoor air pollution

Overall pollution levels

The pre-intervention levels of PM_{resp} in Kajiado were over $5000\mu g/m^3$ and in West Kenya were over $1700\mu g/m^3$. Kitchen CO levels were 74ppm in Kajiado and over 10ppm in West Kenya and personal CO (CO_{wm}) was about 7ppm and 4ppm in Kajiado and West Kenya respectively. It should be noted that the personal measures do not give any indicator of the peak levels either in the room or experienced by the woman.

Overall changes in 24-hour averages following the interventions in Kajiado showed a 36 % reduction in PM_{resp} , and in West Kenya there was an overall reduction of over 60%. Significant substantial reductions were observed in both Kajiado and West Kenya for particulates and room CO. There were reductions in personal PCO but these reached only a marginal level of significance ($p=0.06$ Wilcoxon).

For West Kenya, mean levels are consistently lower (30-45% reduction) for monitoring at 2.5ft compared to 4ft. The results in both pre- and post-intervention rounds show this characteristic. This emphasises the need for consistency in measurement, and the problems of comparing results with data from other projects.

		Kajiado (all 4ft)			West Kenya (see height)		
	<i>Height (ft)</i>	<i>N</i>	<i>Mean</i>	<i>(SE)</i>	<i>N</i>	<i>Mean</i>	<i>(SE)</i>
Pre-intervention mean	4	23	5526.7	534.2	23	1713.6	260.9
Post-intervention mean		23	3522.4	510.6	23	628.9	70.2
Difference (pre/post)		23	2004.3	850.6	23	1084.7	261.1
p-value: Wilcoxon			0.048			0.000	
p-value: T-test			0.028			0.000	
Pre-intervention mean	2.5				23	993.0	176.6
Post-intervention mean					23	421.9	51.6
Difference (pre/post) (95% CI)					23	571.1	186.4
p-value: Wilcoxon						0.003	
p-value: T-test						0.006	
		Kajiado and West Kenya combined – 4ft					
		<i>N</i>	<i>Mean</i>	<i>(SE)</i>			
Pre-intervention mean		46	3620.15	408.78			
Post-intervention mean		46	2075.63	333.84			
Difference (pre/post) (95% CI)		46	1544.52	445.24			
p-value: Wilcoxon			<0.001				
p-value: T-test			0.001				

Table 6.6: Changes in 24hr room carbon monoxide – all interventions							
		Kajiado (all 4ft)			West Kenya (see height)		
	<i>Height (ft)</i>	<i>N</i>	<i>Mean</i>	<i>(SE)</i>	<i>N</i>	<i>Mean</i>	<i>(SE)</i>
Pre-intervention mean	4	23	74.66	5.89	23	10.08	2.12
Post-intervention mean		23	51.37	8.10	23	4.69	0.45
Difference (pre/post) (95% CI)		23	23.28	8.92	23	5.39	2.21
p-value: Wilcoxon			0.010			0.018	
p-value: T-test			0.016			0.023	
Pre-intervention mean	2.5				23	6.67	1.26
Post-intervention mean					23	3.64	0.37
Difference (pre/post) (95% CI)					23	3.03	0.41
p-value: Wilcoxon						0.043	
p-value: T-test						0.085	
		Kajiado and West Kenya combined – 4ft					
		<i>N</i>	<i>Mean</i>	<i>(SD)</i>			
Pre-intervention mean		46	42.37	5.72			
Post-intervention mean		46	28.03	5.31			
Difference (pre/post) (95% CI)		46	14.34	4.74			
p-value: Wilcoxon			0.004				
p-value: T-test			0.001				

Table 6.7: Changes in 24 hour personal carbon monoxide – all interventions						
Time	Kajiado			West Kenya		
	<i>N</i>	<i>Mean</i>	<i>(SE)</i>	<i>N</i>	<i>Mean</i>	<i>(SE)</i>
Pre-intervention mean	23	6.98	0.75	24	4.16	0.97
Post-intervention mean	23	6.54	1.14	24	2.83	0.46
Difference (pre/post) (95% CI)	23	0.44	1.14	24	1.34	0.97
p-value: Wilcoxon		0.229			0.194	
p-value: T-test		0.704			0.183	
PCO	Kajiado and W. Kenya combined					
	<i>N</i>	<i>Mean</i>	<i>(SE)</i>			
Pre-intervention mean	47	5.54	0.64			
Post-intervention mean	47	4.65	0.66			
Difference (pre/post) (95% CI)	47	0.90	0.74			
p-value: Wilcoxon		0.060				
p-value: T-test		0.233				

Changes in pollution associated with specific interventions

Effect of hoods

Prior to the study, no smoke extraction hoods or chimneys had been installed in any of the study kitchens. During the project, twelve were installed in Kajiado, and five were installed in West Kenya.

A comparison of homes that received hoods with those that did not, showed substantial ly greater reductions in respirable particulates in both Kajiado and West Kenya respirable particulates as a result of this intervention; marked reductions were also seen for kitchen CO and PCO.

Table 6.8: Changes in 24hr respirable particulates: Effect of hoods					
Kajiado					
Time	Hoods (n=10)		Other interventions (n=13)		
	<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SD)</i>	
Pre-intervention	5991.2	1122.1	5169.4	4178.0	
Post intervention	1439.1	322.4	5124.9	541.7	
Difference (pre/post)	4552.1	1321.1	45.5	777.2	
p-value: Wilcoxon	0.007		0.81		
p-value: T-test	0.007		0.96		
Difference in pre- intervention values	509.5	1031.2			
p-value: Mann Whitney	0.6300				
p-value: T-test	0.90				
Difference in post intervention values	3764.5	652.5			
p-value: Mann Whitney	<0.001				
p-value: T-test	<0.001				
West Kenya (note only 5 with hoods)					
Time	Height (ft)	Hoods (n=5)		Other interventions (n=18)	
		<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
Pre-intervention	4ft	1167.6	434.9	1865.2	305.8
Post-intervention		345.9	87.7	707.5	77.3
Difference (pre/post)		821.7	449.9	1157.8	313.1
p-value: Wilcoxon		0.14		0.002	
p-value: T-test		0.14		0.001	
Difference in pre- intervention values		647.8	617.9		
p-value: Mann Whitney		0.21			
p-value: T-test		0.49			
Difference in post intervention values		458.5	244.4		
p-value: Mann Whitney		0.01			
p-value: T-test	0.25				
Pre-intervention	2.5ft	1158.1	392.1	947.2	202.4
Post intervention		208.5	30.7	481.2	58.2
Difference (pre/post)		950.0	396.4	466.0	210.2
p-value: Wilcoxon		0.08		0.74	
p-value: T-test		0.08		0.04	
Difference in pre- intervention values		192.9	419.1		
p-value: Mann Whitney		0.79			
p-value: T-test		0.65			
Difference in post intervention values		320.34	145.05		
p-value: Mann Whitney		0.002			
p-value: T-test	0.04				

Table 6.8: Changes in 24hr respirable particulates: Effect of hoods (contd) Kajiado and West Kenya combined				
Time	Hoods (n=15)		Other interventions (n=31)	
	<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
Pre-intervention	4383.3	962.8	3250.9	385.6
Post intervention	1074.7	253.5	2560.0	457.8
Difference (pre/post)	3308.6	994.0	690.9	379.0
p-value:Wilcoxon	0.001		0.03	
p-value: T-test	0.005		0.08	
Difference in pre- intervention values	836.6	876.7		
p-value:Mann Whitney	0.69			
p-value: T-test	0.35			
Difference in post intervention values	1516.3	503.7		
p-value: Mann Whitney	0.020			
p-value: T-test	0.004			

Table 6.9: Changes in 24hour kitchen carbon monoxide: effect of hoods					
Kajiado					
Time	Hoods (n=10)		Other interventions (n=13)		
	<i>Mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>	
Pre-intervention	67.81	10.16	79.92	6.90	
Post intervention	15.05	5.00	79.31	6.99	
Difference (pre/post)	52.76	11.57	0.61	9.09	
p-value: Wilcoxon	0.005		0.83		
p-value: T-test	0.001		0.95		
Difference in pre- intervention values	8.42	12.85			
p-value:Mann Whitney	0.24				
p-value: T-test	0.52				
Difference in post intervention values	65.21	8.72			
p-value: Mann Whitney	<0.001				
p-value: T-test	<0.001				
West Kenya – note only 5 with hoods					
Time	Height (ft)	Hoods (n=5)		Other interventions (n=18)	
		<i>Mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
Pre-intervention	4ft	7.79	3.17	10.72	2.58
Post-intervention		2.00	0.69	5.44	0.39
Difference (pre/post)		5.79	3.28	5.28	2.72
p-value: Wilcoxon		0.08		0.10	
p-value: T-test		0.15		0.07	
Difference in pre- intervention values		2.93	5.07		
p-value:Mann Whitney		0.41			
p-value: T-test		0.57			
Difference in post intervention values		3.79	1.05		
p-value: Mann Whitney		0.002			
p-value: T-test	0.002				
Pre-intervention	2.5ft	7.69	5.43	6.39	6.3
Post intervention		1.75	0.92	4.17	1.58
Difference (pre/post)		5.94	5.73	2.22	6.94
p-value: Wilcoxon		0.04		0.57	
p-value: T-test		0.08		0.19	
Difference in pre- intervention values		0.90	3.00		
p-value:Mann Whitney		0.41			
p-value: T-test		0.77			
Difference in post intervention values		2.48	0.73		
p-value: Mann Whitney		0.004			
p-value: T-test	0.003				
Kajiado and West Kenya combined					
Time	Hoods (n=15)		Other interventions (n=31)		
	<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>	
Pre-intervention	47.81	10.12	39.79	7.00	
Post intervention	10.70	3.67	36.4	7.25	
Difference (pre/post)	37.10	9.66	3.32	4.05	
p-value: Wilcoxon	0.001		0.26		
p-value: T-test	0.002		0.42		
Difference in pre- intervention values	6.15	12.16			
p-value:Mann Whitney	0.73				
p-value: T-test	0.61				
Difference in post intervention values	25.33	7.86			
p-value: Mann Whitney	0.007				
p-value: T-test	0.002				

Table 6.10: Changes in 24hour personal carbon monoxide: Effect of hoods				
Kajiado				
Time	Hoods (n=10)		Other interventions (n=13)	
	<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
Pre-intervention	6.92	0.73	7.04	1.22
Post intervention	4.93	1.73	7.79	1.47
Difference (pre/post)	1.99	1.39	-0.75	1.69
p-value: Wilcoxon	0.07			
p-value: T-test	0.19			
Difference in pre- intervention values	0.520	1.40		
p-value:Mann Whitney	0.22			
p-value: T-test	0.72			
Difference in post intervention values	3.10	2.16		
p-value: Mann Whitney	0.009			
p-value: T-test	0.17			
West Kenya – note only 5 with hoods				
Time	Hoods (n=5)		Other interventions (n=18)	
	<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
Pre-intervention	3.30	0.92	4.43	1.27
Post-intervention	1.33	0.27	3.11	0.56
Difference (pre/post)	1.97	0.96	1.32	1.28
p-value: Wilcoxon	0.043		0.65	
p-value: T-test	0.100		0.32	
Difference in pre- intervention values	1.46	2.47		
p-value:Mann Whitney	0.62			
p-value: T-test	0.56			
Difference in post intervention values	1.88	1.08		
p-value: Mann Whitney	0.003			
p-value: T-test	0.10			
Kajiado and West Kenya combined				
Time	Hoods (n=15)		Other interventions (n=31)	
	<i>Mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
Pre-intervention	5.71	0.72	5.52	0.92
Post intervention	3.73	1.22	5.07	0.80
Difference (pre/post)	1.98	0.95	0.45	1.02
p-value: Wilcoxon	0.01		0.91	
p-value: T-test	0.06		0.66	
Difference in pre- intervention values	0.20	1.32		
p-value:Mann Whitney	0.28			
p-value: T-test	0.88			
Difference in post intervention values	1.44	1.36		
p-value: Mann Whitney	0.018			
p-value: T-test	0.30			

Effect of eaves spaces

In Kajiado, eaves spaces were adopted by only two households, whereas in West Kenya, where the structure of the houses is more conducive to the enlargement of the eaves, every house decided to adopt this intervention to some extent. Eaves spaces provided substantial benefits in West Kenya, reducing respirable particulates by about 60% where the eaves spaces increased from 'small' to large', and to a lesser extent where moderate eaves spaces were enlarged. An interesting aspect of this intervention is that it was very successful in eliminating all the very high levels of particulates. This can be observed in the marked reduction in standard error, which is a measure of the scatter of the data. This is most evident at the 4ft level, where the smoke is nearer the eaves spaces and further away from the fire.

Table 6.11 Change in 24hour respirable particulates – effect of eaves spaces				
	Eaves spaces – 4ft		Eaves spaces – 2.5ft	
	<i>mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
<i>Small to large eaves (n=8)</i>				
Pre-intervention	2042.80	331.41	821.35	111.90
Post-intervention	766.70	105.70	464.65	96.66
Difference (pre/post)	1276.10	287.61	356.69	78.65
p-value: Wilcoxon	0.012		0.012	
p-value: T-test	0.003		0.003	
<i>Moderate to large eaves (n=3)</i>				
Pre-intervention	962.97	373.83	514.19	220.19
Post-intervention	469.87	115.55	407.50	128.67
Difference (pre/post)	493.11	258.42	106.69	330.18
p-value: Wilcoxon	0.11		0.59	
p-value: T-test	0.20		0.78	

Table 6.12: 24 hour kitchen carbon monoxide – effect of eaves spaces				
	Eaves spaces – 4ft		Eaves spaces – 2.5ft	
	<i>Mean</i>	<i>(SE)</i>	<i>mean</i>	<i>(SE)</i>
<i>Small to large eaves n=8</i>				
Pre-intervention	8.54	1.33	5.18	0.80
Post-intervention	5.65	0.50	4.32	0.52
Difference (pre/post)	2.89	1.44	0.86	1.00
p-value: Wilcoxon	0.092		0.482	
p-value: T-test	0.084		0.42	
<i>Moderate to large eaves (n=3)</i>				
Pre-intervention	4.93	1.59	3.19	0.14
Post-intervention	4.86	0.42	4.03	0.69
Difference (pre/post)	0.07	2.00	0.83	0.64
p-value: Wilcoxon	1.00		0.18	
p-value: T-test	0.975		0.321	

Table 6.13: 24 hour personal carbon monoxide – effect of eaves spaces		
	<i>Mean</i>	<i>(SE)</i>
<i>Small to large eaves n=8</i>		
Pre-intervention	4.08	1.07
Post-intervention	3.62	1.21
Difference (pre/post)	0.46	0.43
p-value: Wilcoxon	0.26	
p-value: T-test	0.32	
<i>Moderate to large eaves (n=3)</i>		
Pre-intervention	9.57	7.30
Post-intervention	2.36	0.27
Difference (pre/post)	7.21	7.54
p-value: Wilcoxon	1.00	
p-value: T-test	0.44	

Effect of stoves

In Kajiado, it was evident to the team that the cooks in this region wished to continue using the traditional three-stone fire, and there was no desire for change to a fuel-efficient stove. In West Kenya, although data from the houses receiving stoves during the project indicates a reduction in all variables, a similar difference is observed for those houses which have had stoves from the start of the project. This suggests that the effect is due to the eaves rather than the stoves, since all of these houses had some enlargement of eaves spaces. Further analysis of these inter-related effects is not being carried out due to the relatively small numbers. Only West Kenya houses without hoods were included in this analysis.

Table 6.14: 24 hour respirable particulates – effect of stoves				
Height = 4ft				
Time	Stoves installed during project N=8		Stoves throughout N=10	
	<i>Mean</i>	<i>(SD)</i>	<i>mean</i>	<i>(SD)</i>
Pre-intervention	1929	1347	1814	1327
Post-intervention	874	345	574	258
Difference (pre/post) and 95% CI	1055	1543	1239	1209
p-value: Wilcoxon	0.07		0.005	
p-value: T-test	0.09		0.01	
Difference in post intervention values	195.95	609.89		
p-value: Wilcoxon	0.46			
p-value: T-test	0.75			
Height = 2.5ft				
Time	Stoves installed during project N=7		Stoves throughout N=10	
	<i>Mean</i>	<i>(SD)</i>	<i>mean</i>	<i>(SD)</i>
Pre-intervention	971	759	979	990
Post-intervention	446	247	485	262
Difference (pre/post) and 95% CI	524	920	494	938.81
p-value: Wilcoxon	0.18		0.05	
p-value: T-test	0.18		0.13	
Difference in post intervention values	38.8	383.12		
p-value: Wilcoxon	0.43			
p-value: T-test	0.92			

Table 6.15: 24 hour kitchen carbon monoxide – effect of stoves				
Height = 4ft				
Time	Stoves installed during project N=8		Stoves throughout N=10	
	<i>Mean</i>	<i>(SD)</i>	<i>mean</i>	<i>(SD)</i>
Pre-intervention	10.63	10.22	10.79	12.05
Post-intervention	6.09	2.02	4.92	1.09
Difference (pre/post) and 95% CI	4.53	11.99	5.88	11.75
p-value: Wilcoxon	0.73		0.07	
p-value: T-test	0.67		0.15	
Difference in post intervention values	0.17	5.09		
p-value:Wilcoxon	0.93			
p-value: T-test	0.97			
Height = 2.5ft				
Time	Stoves installed during project N=7		Stoves throughout N=10	
	<i>Mean</i>	<i>(SD)</i>	<i>mean</i>	<i>(SD)</i>
Pre-intervention	6.67	5.82	6.62	7.08
Post-intervention	3.93	1.8	4.13	1.42
Difference (pre/post) and 95% CI	2.74	7.21	2.5	7.17
p-value: Wilcoxon	1.0		0.05	
p-value: T-test	0.55		0.13	
Difference in post intervention values	10.03	2.83		
p-value:Wilcoxon	1.00			
p-value: T-test	0.99			

Table 6.16: 24 hour personal carbon monoxide – effect of stoves				
Time	Stoves installed during project N=8		Stoves throughout N=10	
	<i>Mean</i>	<i>(SD)</i>	<i>mean</i>	<i>(SD)</i>
Pre-intervention	2.89	0.97	5.67	7.09
Post-intervention	2.72	1.24	3.42	3.06
Difference (pre/post) and 95% CI	0.17	1.65	2.25	7.14
p-value: Wilcoxon	0.62		0.75	
p-value: T-test	0.78		0.35	
Difference in post intervention values	3.25	2.13		
p-value:Wilcoxon	0.76			
p-value: T-test	0.19			

Effect of windows

In Kajiado, although the majority of the houses had windows, most of them were very small. In West Kenya, seven had no windows, but there was an external door. All houses had their windows enlarged, and where appropriate they were repositioned. A separate analysis showed that windows had no effect in West Kenya can be observed in Kajiado – (see Tables 6.8 and 6.9 pre- and post- results for no hoods). It would appear that the reduction of IAP in the houses without hoods is largely due to eaves spaces.

Social impacts of interventions

For an intervention to be successful, it must be acceptable to the cook if it is to lead to greater adoption rates in the region – the first stage in scaling up. The observations made by the community, both structured and unsolicited, were recorded by the staff in field notes from focus group discussions and individual interviews.

Poverty alleviation

The project has alleviated poverty in the project homes both directly and indirectly. This has been achieved through: -

- Changes in life patterns as kitchens can be used more effectively
- Increased income through training of artisans to make and sell interventions
- Use of stoves, and windows providing light have given household members more time to engage in other economic activities such as pottery, basket weaving, beadworking, collecting medicinal plants and leisure activities.
- Reduction in cost of kerosene for lighting
- Reported savings in time and money spent in hospitals with burns, coughs, eye, and chest pains.
- Reduced losses caused by attacks on domestic fowl by wild cats, due to grills/mesh on window.
- Reported reductions in common diseases and complaints
- Increased social capital; project women have reported more visitors in the kitchen and more willingness to welcome visitors in the kitchen.

Empowerment

- Women have gained confidence in decision making on house and kitchen improvement, intervention designs and installations. They have organised group meetings on their own to discuss the indoor air pollution reduction benefits.
- The beneficiaries have been empowered through involvement in design, development and production of desired interventions.
- An increased confidence of project participants through participatory training was noted by the project staff.
- The group members feel their status in the society has been raised as other community members keep sending requests to the respective representatives.
- Project participants at the community level have been empowered to disseminate project outputs through e.g. exchange visits, carrying out demonstrations and installing interventions (e.g. improved cook stoves) with their sub-contracted artisans who can install windows, chimneys and eaves paces for interested households.
- The Kenyan project team was empowered during the project by the transfer of statistical work to the Kenya office from initial management in the UK.

Gender impact

The project targets women and children but the whole family benefits. Both men and women were involved in the project at all levels.

- Women felt more confident through disseminating knowledge to their neighbours
- Husbands became supportive of their wives' initiatives when they realised how much the comfort of their kitchens' were improved
- Interpersonal relationships built up among the women as they worked on the project

In Kajiado, women provided unpaid labour; participated in project meetings/discussions; determined the position/location of the windows and chimneys/hoods and assisted in hood design. Culturally, among the Maasai community members, it is the women who are involved in house construction. However, when the men saw the improvements and the benefits derived by their families they started helping out in the construction of interventions e.g. buying water, windows, cutting trees/twigs, mixing mud, paid for cutting of poles for repairs during window installations. They can now stay in the kitchen, a place they previously used to avoid because of indoor air pollution, and entertain their friends and take beer in the greatly improved environment.

In Western Kenya, men paid for window construction and installation while others offered artisanal skills. Generally, the men in this region are involved in house construction while the

women are involved in house maintenance (smearing, installation of improved stoves, positioning and size of windows, eaves spaces).

Spouses now spend more time in the kitchen in West Kenya, sitting by the fireplace while women work, and eating food there, provided the children have left. Occasionally men will assist in the kitchen, which was not a characteristic phenomenon before the interventions were installed. The observations below describe the benefits highlighted by the community members themselves as a result of the smoke interventions. Box 6.1 is reported in the field notes in West Kenya.

Improved health

- Coughs, dizziness and chest pains relieved
- Reduced sweat and heat, so better sleep
- Less headache, malaise

- Reduction in aching eyes, tears and running nose
- Safer - smoke hood acts as a shield, preventing children and goats falling onto fire
- Snakes and rodents cannot hide in the house where there are windows
- Food free from soot contamination

Box 6.1: Reported health improvement

According to R, the husband used to suffer from asthma attacks therefore never used to go to the kitchen but after the interventions were put in place, he is now willing to assist her in some domestic jobs. Nowadays, he normally wakes up at 5.30 a.m., puts his bathing water on the fire then goes to bathe as he leaves the tea getting ready on the fire. The woman is now relieved from waking up early and doing all the household chores by herself

Improved environment and comfort

- Smoke removal
- Improved lighting and visibility through window installation
- Smell removal
- Fresh air circulation
- The hood prevents rain getting onto the fire when the roof leaks
- Men can drink beer in the cool of the house
- Introduction of new ideas: e.g. creation of more space, improved fireplace, introduction of cupboards

Increased opportunity – income generation

- Able to sew clothes and do beadwork in the house when weather unsuitable out of doors
- Reduction in time lost through ill health
- Improved children's grades at school, as they can work indoors

Reduced expenditure

- Reduced kerosene use due to reduced need for lighting (quoted by one householder in Kajiado; 4litres now purchased monthly instead of every two weeks by another)
- Cooking is possible using daylight through the windows
- Food stays longer without spoiling
- Can find lost items
-

Reduced drudgery

- Less soot on walls, ceilings, hair, sheets, children's books, clothes
- Easier to wash the children and do the housework
- Fire cooks faster, is easier to light, uses less fuel and can use any type of wood with smoke hood, so faster to collect.
- Can stay longer in the house (this allows tasks to be completed more quickly)
- Able to watch over calves through the windows

Negative impacts

As with any innovation, there were some negative impacts, which have been, or will be, addressed. These included:

Technical problems

- Some people felt that the kitchens are, at times, cold and draughty during inclement weather
- All the windows were made to a standard design, as this was the most cost-effective way of doing it. Some house owners would have preferred different sizes of window
- Cats could enter through the window – the cats were prevented from entering by having mesh on all windows and eaves spaces
- Leakage around the base of some of the chimneys during heavy rain – so flashing is required
- Wick lamps blow out if the windows are left open when it is very windy – so windows need to be closed, or hurricane lamps purchased

Social factors

- Some women were initially reluctant to communicate problems as they were enthusiastic to allow the project to progress unhindered
- Some people felt that thugs, sneak thieves, and peeping toms could see into their houses. Others feared it would infringe on their privacy. This was to some extent prevented by having shutters on the windows
- One cook observed that chimney hoods made it more difficult to lean over the pot to cook – however, during discussions, she agreed that she would probably get used to it.
- The smoke hood obviously takes up quite a lot of space. Women were consulted as to its position, in order to minimise this constraint
- It was assumed that there are more flies and mosquitoes when there is less smoke. However, in West Kenya the opposite was observed, as the increased air movement in the kitchens kept the mosquitoes away.

Financial aspects

The cost of the intervention was a critical factor, as the households in the study are mainly on a very low-income. The project in Kajiado footed the whole cost, due to the extreme poverty in the area, although some materials and labour were supplied by the households. In West Kenya, a cost sharing element between the household owners and the project was feasible, with about half the cost provided by the household, and also because most of the husbands were willing to provide artisanal skills in installing the interventions. The cost sharing aspect was geared to ensuring sustainability of the smoke-alleviation methods, as described in (Box 6.2).

Box 6.2: Financial arrangements in West Kenya

Discussions were held and an agreement reached with the household owners of what ITDG's contribution towards the interventions will be and what theirs will be (cost sharing element). For example, if two windows are required, ITDG contributes one and they contribute another, if three windows are required, IT contributes two of them. The windows would have wire mesh so that they can open at night while they are cooking. For the eaves spaces, ITDG contributes the wire for preventing other animals from getting into their kitchens. In all cases, they each provide a person to build. In cases where an Upesi stove is needed, the household contributes in full. The cost-sharing schedule was acceptable to all households except for three, who said they were constrained with hunger, school fees and other financial problems and thus treated differently. Most of the houses would have eaves and windows except for specific cases such as HH09 where a hood was recommended.

Financial problems

Money to purchase the materials was scarce, and expenses incurred in installation of interventions caused by the cost-sharing element were a problem. In West Kenya, though the cost-sharing arrangement was important in terms of sustainability, it did mean that some people who would have preferred smoke hoods elected to have windows instead. This may have contributed to the smaller uptake of smoke hoods in this region, as they are more expensive.

Collaboration between project team and community

Throughout the project, there was a good rapport between the community and the project team. Excerpts from the field reports in Box 6.3 reflect the collaborative nature of the work.

Box 6.3: Collaborative activities between project team and community

...The women in Kajiado have been very hospitable throughout the study since they spare time for the project staff. Most of them always insist on sharing a meal with the project staff especially if monitoring coincides with their meal times e.g. breakfast at around 7.00 a.m.

...NP took up the responsibility of doing the repairs of the demolished parts. She together with her women colleagues shared the task of the repairs which would have cost her a few Kenya shillings. When the Kajiado team was taking internal measurements, NA was busy plastering and filling the gaps.

...The women thanked the team for everything including the incentives (sugar, tea and flour) during the hard times especially because of the drought experienced during the interventions, and promised to give the necessary assistance to make the project a success. The meetings were usually closed with a word of prayer by the women e.g. in one meeting, NO offered a word of prayer before the participants were released.

Dissemination at community level

- Some of the project families have already expressed a need for more interventions (windows and smoke hoods) in their main/living houses – this will provide employment for the artisans who have been trained by the project. The project women have requested training by the team on how to go about with dissemination of interventions where they will be acting as the key lead.
- Members of the women's groups who were not involved in the project have made representation that they had not been trained on indoor air pollution extraction techniques. They have suggested training local artisans (among the community members) to ensure sustainability.
- Neighbours of the women involved in the project feel that a bigger group needs to be targeted to meet the demands of the community – this will be addressed in future project work.
- The improvements have prompted several inquiries from neighbours of the household owners. One of the husbands, for example, has had many visitors inquiring about the chimney installed in his kitchen and the improved fire efficiency realised from the improved cook stoves.
- The Kenya office has used the national press to highlight the dangers of indoor air pollution, and to describe the project activities. It will now be seeking to inform the general public through this medium.
- Videos have been made in both regions, and these will be useful dissemination tools, allowing the women to discuss their own impressions of the changes which the interventions have made to their lives
- The project has shared experiences with Institute of Cultural Affairs of Tanzania (ICA - TZ), that was developing a proposal working with the Maasai community in Tanzania. The

Institute had been referred to ITDG by a donor, and it is anticipated that this may lead to future collaboration.

- The project has hosted an exchange visit by a team from Munduli district in Tanzania, GTZ - Kitui and Kisii districts.
- The smoke team will consult with the Maasai Integrated Development Partnership Project (MIDPP) on their Urban Livelihoods and Shelter (ULS) Programme.
- The project has worked with Cross-border Bio-diversity project in their planning sessions, and has influenced the project to involve ITDG in the energy component on conservation of energy at Namanga Hill, Kajiado district
- The project has liaised with the local office of AMREF
- The project has influenced the Ministry of Health (MoH), Ministry of Culture and Social Services (MOCSS), and Maendeleo ya Wanawake (an organisation set up to empower and improve the status of women) to participate and to campaign for indoor air pollution reduction.
- Local leaders have been involved in indoor air pollution reduction campaigns

Chapter 7: Key findings on project methodology

The project set out to identify ways in which indoor air pollution could be effectively be alleviated in people's homes. This chapter describes key aspects of the project methodology which were essential for its success, and highlights those areas which proved to be problematic for the benefit of others working in this field.

Household selection

There was no shortage of people wanting to take part in the project. Using the women's groups as the basis for identifying houses proved very satisfactory. A participatory approach, which gave the responsibility of selecting households to the communities involved, meant that everyone was satisfied that the correct houses were being monitored

Carrying out a baseline assessment

Pollution and exposure measurement

The protocols adopted by the project enabled the team to record the unacceptably high levels of PM_{resp}, CO and PCO experienced by the communities. A fundamental constraint is that no universal protocols exist for measuring these variables, so these figures must be regarded as indicative rather than absolute. It should be noted, though, that these values reflect an order (or two) of magnitude greater than commonly accepted norms, and this would be the case even if the monitoring equipment had been sited at any realistic position relative to the fire.

Fuel use and house structure

The protocols addressed the quantity and type of fuel used most often by the study household. In future studies, determining the type of fuel used on the day of testing would allow a more rigorous statistical analysis to be performed on fuel as a confounding variable. In this study, analysis of the pre- and post-intervention results reflects no major change across each community in the type of fuel being burnt.

The houses were characterised during the baseline survey by whether they were already improved a lot, a little, or not at all. This proved somewhat subjective and it might be useful to have a 'points' system to characterise the level of improvements. However, the teams provided excellent sketches, showing the positions of key components, such as doors, windows, stoves, both before and after the interventions were installed. key questions reflected the number of windows, eaves spaces, roofing etc. which might affect the smoke levels in each house.

The enumerators were asked to record the number of hours spent, and the number of times that people collected fuel. This was found to be a rather broad classification, and future studies would try to calculate the total fuel used more accurately.

Identifying participatory ways of alleviating indoor air pollution

This aspect of the project was vital to its success. Women's group discussions allowed the field team to identify possible acceptable and appropriate ways to alleviate smoke. The community were empowered to find their own solutions to their problems, which were realised through manufacture of the interventions in collaboration with the local technical college in Kajjado, and with local artisans in West Kenya– thus providing sustainable skills in the region. The value of committed and enthusiastic local field teams, working with communities who were keen to be involved throughout the process, cannot be over-emphasized.

Monitoring methods

The monitoring methodology is a compromise between obtaining sufficiently accurate results and not intruding too much on the lives of the women involved in the study. The latter aspect is vital, or the results will not reflect the usual day-to-day activities of the woman herself. The method used proved adequately sensitive to change, since the project was looking for

substantial reductions in indoor air pollution, in order to impact on the quality of life of the cooks and their families. The methodology provided a reasonable balance between accuracy and the low levels of disruption to household routine needed to make the results meaningful.

However, one constraint is the lack of 'real time' data – at the project design stage, this type of data is both expensive to procure, and more intrusive for the cook. However, without this data, it is difficult to know how and when the cook inhales the major part of her total daily dose and some real time data would strengthen any further research considerably for the following reason: If the major part of the smoke she inhales is that which is coming directly off the fire when it is being lit, then provision of windows through which the smoke can leave the room once it has spread away from the fire will be much less effective than a hood or eaves space which prevents the smoke getting into the room in the first place.

The time period for monitoring was selected as 24 hours, measured during one wet and one dry season. Since many of the women sleep in the same room as the fire, this was essential to capture her full exposure to indoor air pollution. A specific height and distance from the fire was selected, as the spatial distribution of concentrations would otherwise affect the 'before and after' nature of the study. Ideally, the results would be a lot more powerful if they could be compared to other studies being done using the same protocols. Currently no standard testing procedure has been agreed, though this may change in the foreseeable future.

Problems and constraints

Technical problems

The study has been carried out in two phases to assess the impact of the project: the pre-intervention and post intervention monitoring periods. In the pre-intervention period, three rounds of monitoring were needed in both areas to capture information that was inconclusive during the earlier rounds of monitoring.

Equipment

The equipment was chosen to be as discrete as possible, for the reasons described above. However, the power supply for the air sampler was working close to its limits, and replacement of the battery pack with a standard car battery and adapter (locked securely in a wooden box) proved more successful towards the end of the project. This battery also meant that the teams did not have to recharge the PM_{resp} sampler every night, so proved less stressful on the team.

In Kajiado, the high levels of indoor air pollution meant that some of the first round of monitoring was inconclusive. The solution was to change the filters and CO monitors after six hours during the day, and over twelve hours through the night. Nevertheless, the equipment became very dirty and contaminated very quickly, therefore required regular servicing.

Initial charging of the monitors in Kenya proved unsatisfactory due to climatic conditions. The pumps erroneously recorded that the built-in batteries were fully charged, with consequent failure in the field. This problem is now resolved by using the car battery.

Monitor height

The first round of sampling was conducted with the PM_{resp} and CO monitors set at 4ft height and 4ft distance from the fire. Following an external review which advised that monitoring at 2.5 feet would aid comparative studies with other indoor air pollution projects (4ft and 2.5ft are currently used by other practitioners), the suggestion to use 2.5ft was adopted for the second round of monitoring in West Kenya. The change only became evident to the rest of the team once the results from the monitoring came from the field. As it was not feasible to monitor every house again, a sample of kitchens was monitored at both 4ft and 2.5ft, and two height monitoring was used in the post-intervention rounds.

Recording data

It is important to know exactly what decisions are made by field staff on replacement of filters etc. when low values are recorded. If staff do not replace filters etc. every time, there is a risk that the mid-sampling value and the final value are added, rather than just the final value

taken. These records should form part of the monitoring sheet filled in during the monitoring process.

Installation

Despite the hoods being in two sections, there were problems in getting them into the kitchens in Kajiado, due to the geometry of the house. This could be a factor in scaling up this type of intervention, as it requires more than one person to transport and install the hood.

Installing both hoods and windows is both time-consuming and strenuous. A lot of dust and soot is disturbed, so protective clothing must be worn. Installing the interventions into new buildings would be considerably easier.

Field work

Training

Prior to field work, the team was given training in monitoring and field techniques. The importance of the team understanding why they were making specific measurements or asking particular questions cannot be overstated.

The arduous nature of the field work under field conditions are highlighted below:

Unseasonal weather

In some areas of Kajiado, such as Oloosuyian, people had been forced to migrate to other neighboring areas (Machakos, Nairobi, Thika, and Keroriti near Namanga). Meetings were therefore dictated by the household's availability. In addition, some interventions were delayed because some of the household owners had moved away with their livestock.

Torrential rains when there should have been dry weather in the first post-intervention round (see field report – Box 7.1) meant that the final monitoring in Kajiado had to be done when the weather was just turning towards the expected rains. However, the team ensured that all the testing was done at a time when there had not been sustained heavy rain, so the fuel could be expected to be reasonably dry.

Box 7.1 - General situation during the post intervention monitoring

When the post intervention monitoring was conducted from 13th November up to 14th December 2000, the area had been hard hit by drought in the previous months therefore livestock had died in large numbers which was evidenced by the gaping skeletons across the land. Due to this calamity, most of the pastoralists were forced to move to other areas in search for greener pastures in the neighbouring districts such as Machakos, Nairobi, Namanga region and some Northern parts of Tanzania. In addition, the food surplus in the area had declined so much that the community mainly relied on relief food (maize).

Rains began in mid November and the community members were hopeful that the weather would go back to normal and ultimately some household owners had started returning home by the end of November to early December.

Travelling to the field

In both Mumias and Nyamira, the distances covered were considerable; the roads were in bad condition, especially during the rainy season, and in instances when the pumps were troublesome, it meant visiting households late in the night. Scheduling to have start times and ending times corresponding with sunrise or sunset proved more convenient for both the households and the monitoring team.

Unreliable electricity supplies

Electricity power cuts, or no access to grid electricity at all, caused great difficulty in charging the batteries for the sampling pumps. This problem was alleviated towards the end of the project by using a car battery and adapter.

Social aspects

Local field staff

A key aspect of the success of the project was that field staff were already well known in the region; some of the field staff belonged to the communities with whom the project was working and were thus able to speak in the local language.

Determining the name and address of the cook

In Kajiado, women were known by different names, moved house within the area, and cared for different numbers of children. As the houses do not have any kind of recognised 'address' it was important to ensure that the cook was still living in the same house for each round of the study. This situation is likely to occur wherever the community is relatively mobile and where households are widely dispersed.

Determining the age of the cook and her children

Determining the age of the women and their children was difficult since it was not something which mattered to them, so they did not remember unless they produced their national identity cards or they related their dates of birth to certain historic events. In determining the age of the children, most women would relate better to the classes their children are in at school, and the monitoring team would estimate the age.

Health

In one house, a new baby had been born, and culturally this required both mother and baby to be confined, with all the windows closed and the fire alight throughout. In another house, a woman was ill during one round of monitoring. Field reports are given in Box 7.2. The situation was further exacerbated by heavy rains and cold weather, which persuaded her to keep the windows closed. As a result, the fire was on all day, and she was resting beside it. In both these instances, the levels were not representative of the day-to-day levels in that house.

Box 7.2: Monitoring in HH45

- The monitoring team went to HH45 on Thursday 16th November 2000 to inform her of the post intervention monitoring that was to start the following day. Unfortunately, S. and her husband were both ill and therefore they requested to be taken to Kajiado District Hospital. On being taken to hospital the physicians diagnosed S. and said she was suffering from Malaria while the husband was suffering from cancer of the leg. After the treatment, the couple was returned home to rest and the team was to go back once their condition was better.
- On the morning of 18th November the team went to start monitoring the house but this was not possible due to a heavy downpour making the road impassable especially because the Ol-Kejuado river transverses the road to this home. The team went back in the evening and was forced to leave the car next to the river since the car would be stuck in the mud. From there people had to trek for about 20 minutes to reach the home. The monitoring equipment was fixed at around 18.30 hours so that ample time would be left for the monitoring team members to get back to the car before dark. 12 hour readings were taken the following morning at 06.30 hours while the other readings were taken in the course of the day for a complete 24 hour cycle. The strange thing that was noted was the fact that 3 room tubes and 3 personal tubes were used throughout the study because the woman who was still sick was confined indoors and the fire was alight all through the 24 hour sampling period. Her bed was very close to the fire as compared to the distance between the fire and the other monitoring devices. She told the team that her house was very cold due to the heavy rains and therefore she tried to keep it warm by lighting the fire throughout the night and also keeping most of her windows shut.

Questionnaire design

The questionnaires were developed in consultation with staff in the regions. They have two roles: to provide an overview of the lifestyles of the people involved; to identify any changes that have taken place during the project. There are several key elements that need to be addressed in these questionnaires:

- How will the question be put to use at the end of the study?
- Does the question have the same meaning to field staff and community as it does to the staff who produce the questionnaires?
- Do we need to know, in general, about the lifestyle of the person, or do we wish to correlate data with the measurements of PM_{resp} and CO for the day that household was monitored? In the latter case, the questions must relate to the day on which the monitoring was done
- Care must be taken that every reasonable eventuality is addressed (e.g. there was some confusion about mealtimes for those people who only eat two meals a day).

Loss of houses

Three women moved out of their original houses between pre- and post-intervention, which meant that the results could not be used. One house was lost in Shukaa location after the opted for a divorce, which culturally means demolition of a house to signify the disintegration of the unit. For reasons such as these, more houses should be monitored in the pre-intervention rounds than are required for analysis.

Education

People in Nkoile (Kajiado) are very receptive to new ideas, compared to the other regions. This is attributed to the proximity to Namaga and Kajiado town, resulting in a higher level of education.

Identification, installation and development of appropriate interventions

The field teams formed the link between the communities and the whole of the project team. Belonging to, or having worked with, the communities in the area meant that the team themselves had ideas which could catalyse the initial discussions on what would be appropriate. These ideas were distilled into three key interventions. This was vital, as a random collection of interventions, all being installed, would have prevented any kind of analysis on the impact of the interventions. This approach enabled both the communities themselves, and the wider development community, to benefit from the research.

Sometimes extra 'interventions' were made during the study. For one or two of the households, it was found that a wood-rack '*Irongo*' was blocking the smoke from leaving through the eaves spaces. In these cases, the rack was repositioned. These extra interventions need to be documented systematically.

Training and maintenance

Training and maintenance was mainly conducted through women's groups, and often involved other organisations, such as the representative from the Ministry of Health. Aspects of smoke alleviation were incorporated into other health messages. By using group discussion, everyone involved was able to share advice based on their own experience, thus increasing the knowledge-base of the whole community.

Linkages with other organisations

Linkages with other organisations are important as they raise the level of awareness among a far wider group than would otherwise be the case. They also pave the way for future work in-country and in other areas within that country. A further aspect is that the project brings together practitioners from several disciplines, health, finance, energy, technology, business, and their skills can provide a holistic solution in the longer term.

Chapter 8 – Discussion

The main objectives of the project were twofold: to improve the quality of life, through reduction in indoor air pollution, for households in these study areas; and to develop a participatory methodology for further research into appropriate ways to alleviate indoor air pollution. This analyses both the successes and any constraints to success which need to be addressed in future work.

Evaluation of changes in pollution and exposure

Effect of smoke hoods

Smoke hoods were undoubtedly the most successful intervention in terms of smoke alleviation – especially as windows were installed at the same time, which provided a good draught to optimise combustion. Smoke hoods are also good because they work in all weathers. As they are more tolerant than chimney stoves to variations in geometry, they can be made to suit the cook, and still be effective, and can be copied more readily at local level.

In West Kenya, where Upesi stoves and smoke hoods were used in combination, the stove minimises the sparks going up the chimney, increasing safety where the hood is built through thatch.

Effect of eaves spaces

Eaves spaces, though not quite so effective at removing smoke, are an extension of what is happening in several of the houses in West Kenya already – so they are very well accepted. Providing a frame formalises the need to have space behind the stove for smoke to escape. Building in an Upesi stove ensured that the eaves spaces were located at the optimum position. It was noted that some of the household members who slept in the room with the eaves spaces found that it got cold at night. Further work might enable the community to collaborate with the local artisans to provide shutters for the eaves spaces that could be closed at night to alleviate this problem.

Effect of windows

Those houses with windows as their only intervention did not show any marked improvement in smoke reduction, although they had several important social benefits. However, where extraction methods, such as hoods, are in use, it is important for there to be sufficient air coming into the kitchen to 'match' the hot air leaving, and it was observed by both the team and the householders themselves, that combustion improved when the windows were opened.

Effect of stoves

There was no statistically significant reduction in indoor air pollution through using stoves. This is an important negative result, but it is not the only study which reaches this conclusion (Ballard-Tremeer, G. & Jawurek, H.H. 1996).

It has been shown that stoves reduce the need for fuelwood, which might suggest that therefore there would be a reduced quantity of products of combustion. However, the products which are damaging to health are those which are overwhelmingly emitted during the 'heating up' stage of combustion – before the fire reaches a sufficient heat to convert the fuel into carbon dioxide, rather than particulates and carbon monoxide. A three stone fire has an advantage in this respect – there are no stove walls to be heated up during the early stages, so the fire can become hotter sooner. Thus for a fire of short duration, a three-stone fire can be a fairly efficient option.

This, however, is the only advantage of the three-stone fire as much of the heat is then dissipated and is not directed at the pot. Thus the 'benefits' of the three-stone fire are counteracted by the need to use more fuel for a longer time in order to get the food cooked. This is especially true where long slow cooking is required – once the stove gets hot, then it is a much more efficient means of cooking. The excellent combustion characteristics of the Upesi stove mean that for the types of meals cooked in West Kenya, this stove provides

overall advantages in terms of cooking time, and fuel efficiency and does not increase the level of emissions. It is also safer, cleaner, and increases the prestige of the cook.

It should be noted that recent studies showing reduced indoor air pollution using stoves (Ezzati, M. Kammen, D.M., 2001) involve the use of charcoal stoves rather than stoves burning the same fuel as the three-stone fires, and it may be that the improvement is caused by fuel change rather than stove use. In the communities in West Kenya, it is unlikely that a complete change to cleaner fuel would be acceptable as residues are available 'for free', whilst charcoal has to be purchased, even though, in some of the houses, charcoal was burnt in the main house for heating rather than cooking.

Community perspectives

Throughout the project, the field teams were made welcome by all the households taking part and were often invited to share a meal. The very high percentage of households staying with the project reflects the level of ownership felt by the communities for the project, and the skill and sensitivity of the field teams. There were minor problems which should be identified.

- Asking the times at which particular meals were taken made one family cook extra meals, just to provide the data required. Though this reflects the loyalty of the cook to the project, it is regrettable that she had to make the extra effort.
- Some of the husbands felt that their wives should have been paid for the time taken to attend meetings

Community views on acceptability and affordability of interventions

Acceptability

The overwhelming feedback from the community members is that the alleviation of indoor air pollution has far exceeded their expectations and a major reason for this is the participatory nature of the project. The marked decrease in smoke and increased well-being associated with this reduction were reflected in many of the formal and informal comments made to the project teams. Nevertheless, there are outstanding concerns which need to be addressed (improving privacy, ensuring that eaves spaces can be closed in very inclement weather etc.)

Affordability

Affordability remains a major constraint to indoor air pollution alleviation. There are positive signs that, in the case of some of those living in the nearby communities, the realisation of the benefits has made them re-evaluate the cost of the interventions. Of particular note is the interest taken by the men in the communities. They are the ones who, on the whole, are in control of household finances. Having been involved in installing the interventions, it is positive to note that they are discussing interventions in terms of the comfort value of a less smoky environment. Reports from the field suggest that people are now asking how and from where they can obtain hoods and windows. Entrepreneurs to promote, manufacture and supply these interventions will form part of future work within the project areas. Funding is actively being sought to provide this next phase in scaling up.

In Kajiado, the project families were not asked to contribute to the cost of the interventions. Smoke hoods, which cost the equivalent of the cost of two goats, are deemed expensive, especially if it is only the women who benefit from them. However, the men in the Maasai community are expressing interest in the increased comfort levels in the homes with smoke hoods, and if they decide that the hoods should be installed, it is likely that this intervention will be widely adopted, since they are the ones who control most of the family income. Reducing the cost of hoods by using cheaper, but effective, materials, or seeking a subsidy, comparable to that provided for vaccination on the grounds of health, could further increase the prospects for smoke hoods.

In West Kenya, cost-sharing meant that there was strong evidence that households were willing to part with money, reflecting their level of commitment to the need to remove smoke. However, the adverse effect was that some households chose the less-costly option of eaves spaces – still effective, but not so effective as the smoke hoods they might otherwise have installed.

Empowerment of communities

Making communities aware of the risks associated with household smoke

Empowerment through knowledge is among the most cost-effective ways of improving the quality of life for those with few capital resources (Tim Allen; Alan Thomas (eds.), 2000). The participatory approach has been very powerful in addressing this key aspect of poverty alleviation. Engaging with the cooks in every aspect of the project has made them keenly aware of the risks to which their families are exposed, and has empowered them with the means to do something about it.

Members of the field team have been requested by other members of the women's groups to be kept informed on what is being done in the project. Some of the women have described to the team their feelings of responsibility for passing on the knowledge to others in their community – this has increased their social capital within the community.

Empowerment through enabling mechanisms for alleviating smoke

Poverty leaves little time or resources for dealing with tasks outside the day-to-day activities needed for survival. In this project, women's voices were heard, their advice was taken and acted upon, and their ideas were scientifically tested. This approach, balancing local skills and knowledge with technical monitoring, has ensured that the interventions which will be further disseminated are both acceptable and effective. This has empowered the community to help provide the solutions to its own problems.

Development of a national strategy for dissemination and sustainability

These results, showing a very positive impact on the families with interventions, allow proven information on interventions which are both effective and well-accepted to be disseminated within communities with similar lifestyles in the regions. These initiatives are discussed further in Chapter 8.

Exchange of experience internationally

Internationally, the work has been disseminated through:

Conferences

- Gitonga, S.; 'Addressing the indoor air pollution and household health problem in Kenya' at *USAID/WHO Technical Consultation on Health Impacts of Indoor Air Pollution in Developing Countries, 3rd to 4th May 2000, Washington, USA, May 2000,*
- Gitonga, S.: 'Simple Interventions to Improve Children's Health by Reducing Levels of Indoor Air Pollution - Case of East Africa' at *Children's Environmental Health (CEHN) II: A Global Forum for Action* Washington, USA, September, 2001
- Bates, E. et al: 'Improving air quality in Rural Kitchens in Kenya' at *International Conference on Biomass-based Fuels and Cooking Systems (BFCS-2000)*, Pune, India, November 2000

Journal articles

- 'Safe as houses?' in *Small World, Issue 31, March 2001*
- 'Best choice for better households' *ITDG Eastern Africa Newsletter*, October 2000
- Bates, E: 'Smoke, Health and Household Energy – the link' in *DFID Energy*, November 2001
- Gitonga, S. 'Case study: Achieving Sustainable Reductions in Indoor Air Pollution and Improving Health through Participatory Community Technology Development in Rural Kenya' in *Energia News*, December 2001
- Bates, E. 'Smoke can seriously damage your health – especially if you live in the developing world' in *The Woman Engineer*, Spring 2001

Reports

- Doig, A. Indoor Smoke Pollution and Household Health; Reducing Smoke Exposure in Household Dependent upon Biomass Fuels: *ITDG Report* on First year May 1998 – April 1999
- Doig, A. Bruce, N., Bates, E. Indoor Air Pollution and Household Health: The Smoke Problem: *ITDG Interim Report* July 1999
- Doig, A., Bates, E., Bruce, N., Gitonga, S. Indoor Smoke Pollution and Household Health: Reducing Smoke Exposure in Household Dependent upon Biomass Fuels: *ITDG Report on Second Year* May 1999 to May 2000
- Kenya Smoke and Health Project 1998-2001, *ITDG Final Short Report*, December 2001

Networks

- Bates, E. 'Reducing smoke, improving lives' a case study from Kenya' in *Technology for sustainable livelihoods* website – case studies section at : www.livelihoodtechnology.org
- Proposed future international dissemination of best practice is described in the next chapter.

Development of a replicable participatory methodology for indoor air pollution alleviation

This methodology will form the basis for future ITDG work in international comparative studies – see next chapter. As a pilot project, this work enabled the team to test the methodology and protocols and identify shortcomings and improvements for future studies. Many of these findings have appeared throughout the text, but will be listed briefly below for convenience:

- This type of project should be participatory at all stages, and include key actors from the community including the household members, local authorities, artisans, health professionals etc. and an integrated project team.
- There is a pressing need for key technical aspects of the protocols to be standardised if findings are to be compared across projects. These aspects would include: the time over which the monitoring took place; the position of the monitors; the meaning of terms such as 'personal CO' ;types of fuel; cooking times; recording interventions; etc.
- Overall, the questionnaires reflecting household and house characteristics provided a good insight into those aspects of community life which have a direct bearing on energy use. However, it should be noted that these protocols were designed in consultation with teams who were working in the particular communities, so that the questions were locally appropriate and culturally sensitive.
- The 'before and after' nature of the project meant that certain changes took place which could not be avoided – weather, number of people in the household, availability of food and fuel etc. For more rigorous analysis of these confounding variables, it might be considered more effective to identify what the household uses by way of fuel and food on the day of monitoring, rather than seeking to identify what they identified as their staple requirements (e.g. dried maize distributed during famine will affect cooking time, but is not in the usual diet of the Maasai community). This, however, might make it more difficult to characterize the lifestyle of the community. Care must be taken not to overload the individual householder with questions – only those questions should be asked which can realistically be part of the overall analysis.

Chapter 9 – Future work

Local level

At the time of publication (January 2002), the project team in Kenya is actively seeking funding for follow-on work to scale up those interventions which have proved most successful. Scaling up activities which have been identified include:

- Working with other NGOs such as AMREF, and local government offices, to provide support for dissemination and further installation of smoke-reducing interventions
- Dissemination through extra women's groups, health centres, schools
- Forming committees on smoke-free environments
- Forming health committees on environmental health at village level
- Running capacity-building workshops for artisans manufacturing devices for reduction of indoor air pollution
- Introducing a child to child programme on indoor pollution campaigns
- Running workshops on indoor air pollution study findings, and community awareness

International level

The findings from this project will be disseminated through:

- International conferences, including;
 - Bruce, N. et al: ' Reducing indoor smoke pollution through participatory technology development in rural Kenya' to be presented at *Indoor Air 2002*, Monterey, USA, 2002
 - Doig, A.: ' Household Energy, indoor air pollution and health – experiences in Kenya' to be presented at the World Renewable Energy Congress, Cologne, Germany 2002
- Further dissemination through journals, including *Boiling Point* and through websites, including the HEDON website

One aspect of the project was enable ITDG to evaluate the success or otherwise of a participatory approach to smoke alleviation. The methodology has shown itself to be very effective, and a similar approach will be adopted in a new project, funded by the UK government Department for International Development. This project will involve communities in Nepal and Sudan, as well as looking at the urban context in Kenya. It is hoped that the three-country project, currently funded, will lead directly to a scaling-up phase and enable the lessons learnt to be applied on a sustainable and commercial footing. Funding is currently being sought towards this end.

Funding is also being sought for scaling up successful interventions within Maasai communities in Tanzania and Uganda.

Annex 1: The scientific process

Study methods

The overall study employed a 'before-and-after' comparison in the two study areas. One year of baseline monitoring followed by interventions over 6-9 months, then a further year of follow-up monitoring (total 2.5 years).

This design was judged most appropriate given the participatory nature of the development work, which would have made use of parallel control (non-intervention) areas very difficult to justify and maintain. Although this design left the study open to influences other than those implemented by the project, the methodology was deemed to be appropriate in communities where changes evolve slowly. The range of other factors that might influence pollution levels and exposure were measured during the course of the study, and changes over the course of the project assessed. In addition, the assessments of pollution and exposure were repeated twice per year both before and after the interventions, to allow characterisation of within-house variation across the wet and dry seasons of the year and more precise estimates of the true effects of the interventions to be obtained.

Sample

A total of 50 houses (25 per area) were sampled. The criteria for sampling were that:

- the house structure should be typical
- the family were interested in the project objectives,
- they should be prepared to accept the questionnaires and monitoring over the 2.5 years of the study, and
- they should be keen to implement changes to the homes in consultation with ITDG staff
- the households should preferably include children aged under five years, as these are the households where women spend most time in the kitchen

Although it was recognised that this was not a random sample, the houses selected were considered to be typical for the communities involved.

Pollution assessment

Particulates

Particulates: 24 hour respirable particulates (approximate aerodynamic diameter 5 microns or less) were measured in houses using a Buck I.H. pump sampling at 2.2 litres/minute, a Higgins-Dewell type cyclone and 35 mm glass fibre filters (Whatmann) – this equipment conforms to BSEN-481 for inhalable thoracic response.

The pumps were calibrated using a Munro RM1069 rotometer prior to each sampling period. The cyclone was placed at 4 feet above the floor of the kitchen, and 4 feet horizontally from the hearth (in Maasai kitchens it is typically difficult to exceed this distance due to the small size of the room). Due to the very high levels of pollution, filter cassettes were changed after 12 hours to avoid clogging. The equipment was designed such that, if the sampling flow rate dropped by 5% or more, the Buck pump sampler suspended air sampling, and recorded the elapsed time and volume sampled before shutting down.

Carbon monoxide

Carbon monoxide (CO) was measured in the kitchens using Gastec 1D (1000 ppm/hr) diffusion tubes co-located with the cyclone. The purpose of this is twofold:

- The main purpose was to allow the use of CO personal exposure assessment (see below) as a proxy for PM_{resp} , as this avoids the use of cumbersome personal pumps which seems certain to interfere with normal daily activities. This method of exposure assessment is similar to that used in recent studies in Guatemala, and has shown promising results with correlation coefficients between room 24 hr integrated $PM_{2.5}$ and CO in excess of $r=0.9$ (Naeher, '96).
- The second reason for measuring CO was the potential for direct health effects of what appear to be very high levels in the kitchen.

Up to three tubes were used during the 24 hours, depending on the levels of pollution.

Personal exposure assessment

CO level

Twenty-four-hour integrated CO exposure for each cook was measured using a Gastec 1D 1000 ppm/hr diffusion tube. This was placed in a holder and clipped to clothing on the left upper chest. The woman was asked to place the tube/holder near her head when sleeping. Generally one and two tubes were used during the 24 hours depending on the levels of pollution (in one instance three tubes were used when the woman was ill and indoors all day).

Time-activity assessment

The index woman was asked to recall her activities, and those of the three youngest children who usually live in her house, for the same period as for air and personal sampling. To aid recall, the day was divided up into hour-long periods. The purpose of this assessment was::

- To provide an alternative source of information about exposure
- To allow interpretation of personal CO levels before and after the interventions, which are influenced by both ambient levels of pollution, and the time spent in polluted and environments. Both of these factors could be altered by the intervention: thus, reduced room pollution levels may not result in lower human exposures if the women and children 'compensate' by spending more time in the home.
- To provide information on the exposure of young children.

Data collection

Information on the household, house construction (windows, doors, ventilation), stove type, fuel used for various purposes, and cooking (foods cooked, numbers cooked for) during the air/personal sampling period, was collected in the two areas, using a standard questionnaire developed for the purpose. Symptoms of chronic obstructive lung disease (COLD) among the index women were also assessed, using a questionnaire developed by the Medical Research Council, with minor modifications to allow for local symptom terminology and seasonal patterns. In view of the relatively small sample size (n=50), and the nature of the sample (non-random), these questions were included only as an initial exploration of the extent of COLD in these populations. Symptoms of eye discomfort were also reported.

Laboratory methods (filters)

Filters for gravimetric analysis were prepared using standard procedures, in the Department of Analytical Chemistry, University of Nairobi. The filters were dried, and then weighed on a 6-place balance, prior to insertion into the cyclone cassettes, labelling and despatch to the field. On return from the field, the filters (still in cassettes) were dried, and then re-weighed. Regular checks were made on calibration of the balance, and laboratory blank filters used to check quality control.

Field supervision and quality assurance

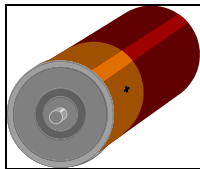

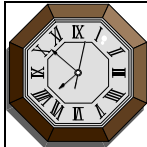
Each of the two field teams had a supervisor who was responsible for preparation of the questionnaires, CO tubes, filter cassettes and air sampling equipment (charging and calibration) for each house visit. The supervisor directly observed approximately 50% of household assessment (air sampling and questionnaires). Around 10% of questionnaires were repeated independently by the supervisor. On return from the field, the supervisor re-checked and recorded the stored pump data (time elapsed, volume sampled, flow rate). The room and personal CO diffusion tubes were sealed at the end of the sampling period, and re-read blind by the supervisor (for analysis the mean of the field worker and supervisor readings was used). A proportion of filters prepared in the laboratory were used as blanks, and returned from the field unused to act as controls.

Equipment and technical support

Equipment was supplied by Munro Group, Gilbert House, 406 Roding Lane South, Woodford Green, Essex IG8 8EY, UK. The representative of this company has given expert technical support and advice to the project team throughout the project.

Annex 2 – Sample pages from monitoring questionnaires

1. Sample page from protocol for preparing equipment

#	Step	Reminder!	Field
1.	Complete Fields 1-4 of data collection form.		1 - 4
2.	<p>Check flow rate of pump:</p> <ul style="list-style-type: none"> Place “practice” cassette in cyclone, and ensure that the cyclone lid is securely tightened to avoid leaks (but do not overtighten). Connect air flow meter, and ensure on flat stable surface Switch on pump, ensure pump fully charged (it will read about 107%) Scroll to <u>sampling mode</u>, and press enter to start sampling. Allow 1-2 minutes to stabilise, and check whether flow meter (top of red float is level with upper red line, 2.2 litres/minute: make sure your eye is at same level as the red line!!). Record flow rate from <u>flow meter</u>, before re-calibration <p>If the flow rate is 2.2 litres/min, go on to Step 4. If not, go to Step 3 to re-calibrate the pump.</p>	 <p>Is the pump battery fully charged?</p>	5
3.	<p>Re-calibrate pump:</p> <ul style="list-style-type: none"> Change to <u>configure mode</u>. Clear all settings. You may wish to switch the configure security code off at this stage. Ensure “practice” cassette in cyclone, and flow meter is attached. Change to <u>sampling mode</u>. Press enter to begin sampling, and adjust the flow using the UP and DOWN arrows until flow rate is exactly 2.2 litres/min. Use technique as described in Step 2. Wait until the display instructs you to press “enter”, then do so. Adjust the four digit display to read 2200 cc/min, and then press enter again. You will be asked whether to activate the keypad lock and configure security code at this stage: it is suggested you do this after you have cleared the elapsed time/volume sampled display (Step 4). 	<p>Don't forget to keep you eye at same level as red line when checking flow meter!!</p> 	
4.	<p>Clear time elapsed and total volume sampled:</p> <ul style="list-style-type: none"> Change to <u>configure mode</u>. When asked whether to clear all settings, enter no (otherwise you will erase the flow rate calibration!!) Clear elapsed time (and volume) only?, change to yes, and enter. 		

2. Sample page from data collection form (second page)

15.	<p>Position pump and cyclone:</p> <ul style="list-style-type: none"> • Connect cyclone to pump, and ensure cyclone lid securely tightened, and pipes well connected. • Identify site used in pre-intervention monitoring for cyclone (In kitchen, 4ft above floor level, at least 4-5 feet from fire, and away from smoke rising directly from fire). <p><i>Please use the same site as used in pre-intervention monitoring</i></p> <ul style="list-style-type: none"> • Fix pump and cyclone securely. Ensure cyclone is upright. 	Height of cyclone above floor level?	15
16.	<p>Switch on pump: Switch on (press on/hold button): pump in sampling mode. Record temperature</p>	Temperature = deg C	16
	<ul style="list-style-type: none"> • Record time of day (24 hour clock) 		17
	<ul style="list-style-type: none"> • Record atmospheric pressure from barometer 	Pressure =	
17.	<p>Begin sampling:</p> <ul style="list-style-type: none"> • Ensure that the elapsed time is zero (0:00). If not, you will need to go into configure mode and clear the time and volume - see Preparation protocol Step 4. • Start pump sampling (press enter). 		
	<ul style="list-style-type: none"> • Allow pump to stabilise, which may take 1-2 minutes. Check: is the flow rate between 2100 and 2300 cc/min ? Enter Yes or No 		18
	<p>If the flow rate is not between 2100 and 2300:</p> <ul style="list-style-type: none"> • <i>make sure the tubes are not kinked, and are connected securely.</i> • <i>make sure the cassette is in the right place, the cyclone lid is securely fastened, and the cyclone inlet tube is not blocked.</i> <p><u>If , after checking these, the flow rate is still not within the specified range, the sampling should be stopped and the pump re-calibrated.</u></p>		
18.	<p>Start the room CO diffusion tube (Type: Gastec 1D):</p> <ul style="list-style-type: none"> • Select plastic tube holder with the house number, and “room” already written on it. • Break end of tube • Insert tube in holder, and place next to cyclone • Dispose of broken glass end in bag. 	Write in the ID Number of the room tube here:	

3. Sample page of household questionnaire

Note to interviewer:

This questionnaire is set out in two parts. The **first** part should be administered before the air sampling period begins. The **second** part is to be administered on completion of the air sampling, and refers to the previous 24 hours - which is the period of air sampling.

PART A: QUESTIONS TO BE ASKED BEFORE STARTING THE AIR SAMPLING

#	Question	Data	Field
1	Household number		1
2	Date of interview		2
3	Time of day (24 hour clock)		3
4	Name of interviewer		4
5	Name of interviewee		5
6	Age: How old are you? [Please enter exact age if known, otherwise enter code number of the appropriate age group, (e.g. 4 for age group 30-34)]: 15-19 (1) 45-49 (7) 20-24 (2) 50-54 (8) 25-29 (3) 54-60 (9) 30-34 (4) 60-64 (10) 35-39 (5) 65+ (11) 40-45 (6)		6
7	Number of adults usually living in the house		7
	• Males		8
	• Females		
8	List details of ALL children usually living in the house, UP TO AGE FIVE YEARS, starting with the youngest.		
	Child 1 (youngest)	Sex: (Female=1, Male=2)	9
		Age: Years and months	10
	Child 2	Sex: (Female=1, Male=2)	11
		Age: Years and months	12
	Child 3 (oldest)	Sex: (Female=1, Male=2)	13
	Age: Years and months	14	
9.	What times of day do you usually cook meals? <i>(Please enter the actual time of day, spanning the time to cook, using the 24 hour clock)</i>		
	Breakfast		15
	Lunch (middle of day meal)		16
	Tea		17
	Dinner		18

4. Sample page of house and kitchen characteristics questionnaire

#	Item	Data	Field
1	Household number		1
2	Location/Area		2
3	House type: level of improvement 1- very traditional 2- traditional, minor improvements 3- substantial improvements		3
	If 2 or 3: briefly describe type of improvements: 		4
4	Kitchen type: 1- part of main house 2- separate building		5
5	Type of roof: Others: please specify 1- mud or cowdung 2- ferro-cement 3- Iron sheets 4- Thatch		6
6	Permanent ventilation in roof (this includes holes/vents deliberately inserted into roof, <u>other than</u> eave spaces) 1- None 2- Small (less than 3 inches in diameter) 3- Large (more than 3 inches in diameter) 4- Other (describe)		7
7	Eave spaces: 1- almost none, or none 2- moderate 3- large		8

Annex 3: Time-Activities Study of a typical Maasai household

Dry Season		
Hour	Activities	Fire?
12.00	At 12.00 m/n cover fire, put on githiri. 00.30 mother goes to sleep.	
01.00	Sleep	
02.00	Sleep	
03.00	Sleep	
04.00	Wake, light fire, make tea. Milk cows	
05.00	Prepare water cans Take tea	
06.00	Load donkeys	
07.00	Leave for water point	
08.00	Getting water	
09.00	Getting water	
10.00	Getting water, watering animals	
11.00	Watering animals	
12.00	Load donkeys and fill cans	
13.00	Return home	
14.00		
15.00		
16.00	Arrive back at home, rest. Light fire (4.30), prepare tea, wash dishes. Serve children tea	
17.00	Food on to cook, prepare vegetable	
18.00	Serve food for all family members. Collect wood	
19.00		
20.00		
21.00	Boys and girls help with milking. Boil milk and make tea.	
22.00	Prepare supper, then wash dishes.	
23.00	Eat supper, children to bed.	

Wet Season		
Hour	Activities	Fire?
12.00	Sleep	
01.00	Sleep	
02.00	Sleep	
03.00	Sleep	
04.00	Wake. Light fire, make tea. Take tea.	
05.00	Milk cows	
06.00		
07.00	Clean calf pen	
08.00	Release livestock, clean goat's kraal.	
09.00	Clean house, mend leaking roof	
10.00		
11.00	Light fire to help dry house. Clean calabashes.	
12.00	Separate goat kids from mothers. Prepare to go for fire wood. Feed children.	
13.00	Go to collect wood	
14.00	Collect wood, return 15.00	
15.00	Rest while making handcraft.	
16.00	Go for water nearby.	
17.00	Close livestock in the dock because of rains.	
18.00	Milk cows	
19.00	Separate calves from cows.	
20.00	Family in house and children go to bed.	
21.00	Prepare calabash for next morning.	
22.00	Mother goes to sleep.	
23.00	Sleep	

Annex 4: Statistical method

Sample size and power

The sample size requires to be large enough to demonstrate useful changes in pollution levels and exposure for the two area samples combined, and also for sub-groups as defined by the type of intervention and location.

Based on alpha level of 0.05, power of 80%, pre-intervention 24 hour mean PM_{resp} (respirable) level of $1500 \mu\text{g}/\text{m}^3$, standard deviation of $500 \mu\text{g}/\text{m}^3$, and reduction to be detected of 33% (to a mean level of $1000 \mu\text{g}/\text{m}^3$), this yields $n=16$ per group for an unpaired analysis, and $n=10$ for a paired analysis. Paired analysis is appropriate as the same houses were compared before and after the interventions.

The analysis

The main analysis consisted of the following steps:

- Descriptive analysis of house and household characteristics and how they have changed during the project
- Assessment of the mean pre- and post-intervention levels and differences in kitchen pollution and personal exposure overall (both areas combined), and by area.
- Assessment of the pre- and post-intervention difference in kitchen pollution and personal exposure by three broad types of intervention, with (a) both areas combined, and (b) areas analysed separately.
- Analysis of the association between room CO and PM_{resp}
- Analysis of changes in potential confounding factors associated with kitchen pollution and personal exposure levels, such as temperature, rainfall, meal servings etc.

Data handling

Data was entered in Microsoft Access, and all entries were rechecked by a second person. All data analysis was conducted using SPSS

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