Smoke, health and household energy

Volume 2

Researching pathways to scaling up sustainable and effective kitchen smoke alleviation

Smoke, health and household energy

Volume 2

Researching pathways to scaling up sustainable and effective kitchen smoke alleviation

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

2007

Smoke team:

Kenya: **Paul Chege, Hellen Owala, Vincent Okello**
Nepal: **Jun Hada, Min Bikram Malla, Rakesh Shrestha**
Sudan: **Rifaat Bashir, Ahmed Hood, Afkar Ahmed**
Europe: **Liz Bates, Nigel Bruce, Eva Rehfuess, Daniel Pope**

Specialist chapters:
Chapter 10 – Health Impacts: Nigel Bruce
Chapter 11 – Cost benefit analysis: Nigel Bruce, Min Bikram Malla, Eva Rehfuess

Acknowledgements

Practical Action is indebted to the UK Government Department for International Development (DFID), and the World Health Organization (WHO) who have supported this work[1]. Our thanks also go to several Trusts and individual donors who have made this work possible.

In all three countries, the communities have responded very positively to our request to monitor both the technologies and the quality of life indicators needed to ensure that the project was achieving its aims. Our thanks go to all those who have welcomed the project teams into their homes, and who have taken part in this research with enthusiasm and support.

This publication brings together a large amount of data. The authors have tried to ensure that everything present is accurate, but would welcome observations, corrections and additions.

Finally, as project manager, I would like to thank the project teams both overseas and in the UK for their help, guidance and encouragement as well as their tireless hard work in bringing this project to a successful conclusion.

Liz Bates 2007

Images:
Cover images:
Top LHS: Smoke hood, Nepal
Top RHS: LPG stove, Sudan
Bottom: Smoke hood, Kenya

All images in this book by: Nigel Bruce, Ahmed Hood, Rifaat Bashir, Vincent Okello, Min Bikram Malla, Liz Bates

[1] 'Researching pathways to scaling up sustainable and effective kitchen smoke alleviation – R8345'. This document is an output from a project funded by the UK Department for International Development (DFID) and the World Health Organisation (WHO) for the benefit of developing countries. The views expressed are not necessarily those of the DFID or WHO.

Contents

EXECUTIVE SUMMARY

Background

In May 2005, Practical Action published 'Smoke, health and household energy Volume 1, describing a participatory approach researched by the organisation into the design, installation, monitoring and assessment of smoke alleviation technologies or *interventions*. The thirty households in each of three communities involved in the original research project were from: Kenya, Nepal and Sudan.

- an urban community in Kisumu, Kenya
- a displaced community close to Kassala town in Sudan
- Gatlang, a high cold region in northern Nepal

However, achieving improved indoor air quality in thirty households in three countries does not even start to address the problem when millions are in need of new technologies. Indoor air pollution (IAP) is responsible for around 1.5 million deaths each year. This demands a more radical and long-lasting approach. Many millions of households need to get rid of the smoke from their homes if their lives and the health of their children is not to be seriously compromised. How can this be done?

Overview of activities

This second phase of research had, as its goal, Millennium Development Goal 4: Reduce Child Mortality, for which the study used proxy methods to determine the reductions in child mortality that could be expected for a given population from a known reduction in carbon monoxide (CO). The research focused around the impacts that could be achieved if ways could be found to enable a substantial percentage of the population to access interventions. The health of the women cooks is very closely associated with the well-being of their young children, and the research also focused on women's health, using similar proxy methods as well as questionnaires and monitoring. As many initiatives on improved household energy have foundered in the past through households not electing to use interventions in the longer term, the work sought to identify 'desirable product attributes' that would encourage purchase and long-term adoption of these interventions

Thus, to make substantial inroads on ill-health, the study needed to ensure that indoor air pollution was reduced, and at the same time, research approaches to achieve this for substantial numbers of people – identifying and overcoming the barriers that prevent people being able to alleviate the kitchen smoke in their homes. Provided that the pollution reduction levels could be maintained or improved, then if large numbers of people were enabled to adopt interventions, and continue to use them, the ill health associated with indoor air pollution would be ameliorated.

To achieve the large numbers required, the research looked at whether a semi-commercial approach could be implemented, identifying and overcoming the barriers to people being able to alleviate the kitchen smoke effectively in their own homes. An additional advantage of this approach is that people tend to value more those changes for which they themselves have paid. Based on the interventions selected by households in each country in the first project, activities focused on:

- Development of those interventions to improve their product attributes
- Awareness-raising on the problems of indoor air pollution
- Working with customers (beneficiaries) to identify desirable product attributes
- Micro-credit for those with insufficient up-front capital to purchase goods and for start-up raw materials for entrepreneurs.
- Training in manufacture, marketing and sales
- Support to sales through health and well-being promotional messages
- For entrepreneurs: Support with set-up; purchase of raw materials, wholesale goods, technology promotion, transport (in the early stages) and feedback from customers
- At policy level, raising the profile of indoor air pollution internationally

Monitoring

The numbers of households adopting interventions was disaggregated by savings group and by month in each country, to establish whether smoke-alleviation would be viable beyond the project end.

At the same time, recognising that the transition from small-scale project to a larger commercial approach often leads to reductions in impact (caused by lack of adoption, quality issues etc.) levels of smoke were monitored, and specific key impacts were investigated using questionnaires.

Finally, based on the numbers of households adopting interventions, and on the levels of smoke alleviated, a cost/benefit analysis looked at the effect of reducing indoor air pollution in terms of improved health, time-saving and income / savings. .

Critical success factors

All countries
The most critical factor throughout this study has been the transfer of ownership of the problem of smoke alleviation from the project itself to the community, and the creation of a framework that continues to allow people either to access the interventions they desire, or to make short-term changes with the aspiration to make further improvements in the future.

Another factor which proved key in each country was the creation of micro-credit systems to help overcome the barrier of the up-front cost of the more costly interventions. Very often, it was found that people regarded items as very costly, when their durability, and other positive impacts, meant that it was financially advantageous for the household to purchase them, provided ways were found to afford them. The smoke interventions were designed to address other issues, so, for example, fuel savings could be set against repayments, time savings could be monetised by some by additional employment or time spent growing food.

For those using LPG, it is important to involve the suppliers of the LP gas. If it is demonstrated that those on low incomes can still afford to buy LPG, this is a very big market. Suppliers should be persuaded to supply gas bottles at a low price as their market is in fuel, not in bottles. There is evidence in other programmes that if the bottles are given away, they get sold a local market, but with awareness-raising on the benefits of clean fuel provided by the project, only one LPG set is known to have been sold in this way (by the husband of a cook who was ill and away from home).

Kenya
The project team recognised that it was essential to start from the reality of life for most people, rather than from where the team might hope them to be. Those households adopting such interventions are reducing the levels of emissions by almost as much as those purchasing the more costly ones – albeit they are less convenient. This is a strong indicator that making people aware of the problem is very worthwhile even if they cannot afford the more costly interventions. People with very little money can reduce the pollutant levels in their homes.

Time-savings, convenience and modernity favoured bottled gas (LPG) among the more costly items – but just the ownership of an LPG stove did not necessarily mean that it was used all the time. Many households just used it for fast cooking – making tea in the morning etc whilst using polluting fuels to cook main meals. Fireless cookers (insulated boxes) were popular to reduce fuel costs.

Theatre and drama groups were very effective in Kenya, both in terms of awareness-raising, and because they raised the status of the community members.

Nepal
By the end of the first project, the smoke hood that had been designed, through collaboration between community and project staff, alleviated the smoke by an insufficient margin for the team to wish to disseminate it further. However, the community liked the hood and, because

they were fully engaged in the process, they were very willing to try out improved designs. The result was a hood that removed over 85% of the CO (compared to ~40% in the first project), and had more desirable attributes than the original design.

A sense of ownership of the revolving seed capital lead high levels of repayment of revolving finance – people discussed what would happen to 'their' seed capital if they did not make the repayments – so it was no longer 'NGO money' and therefore it had to be repaid. From low levels of repayment in the early stages, repayments are now very high. Default is usually only associated with those leaving the area – and if they return, it is expected that they will restart their repayments.

Engaging local government and other NGOs is vital if some form of direct subsidy is needed. The community have paid far more for the smoke hoods than they had originally indicated was feasible in the marketing survey, and no subsidy at all would have led to complete failure of the initiative, rather than the 500 hoods already installed or under installation. Smoke hoods have made a very major impact on levels of smoke. By engaging local government, the project has worked to get longer-term subsidies for smoke hoods. Lower-cost hoods and less transport costs in the lower regions are already designed and planned. These are unlikely to need subsidy, but the design is inappropriate for high cold regions.

Space heating takes up a lot of fuel, and leads to emissions of smoke over the longer periods when the fire is lit. Demonstrating how to insulate the dry-stone walls to reduce heat loss and to prevent cold air from blowing through the cracks has saved fuel and reduced emissions. The all-metal design of the hood allows the heat to radiate from the hood. Although this is more expensive, it does prevent households from lighting open fires in other parts of their house. This is important insofar as smoke going up through the chimney takes heat with it – and saving the heat through other means counterbalances the effect.

Smoke is a major issue in a country with a lot of high cold regions requiring space heating, and through the project, the Indoor Air Pollution and Health Forum was set up to provide an interface between those living in poverty and affected by indoor air pollution, and those with policy influence to effect change. Though Practical Action has handed over responsibility for smoke alleviation in this region to local government, local groups and entrepreneurs, it will continue to play an active role in smoke alleviation at a national level, incorporating other interventions that are more appropriate for other communities.

Sudan

Sudan produced very mixed findings, with revolving finance leading to nearly 1500 households with LPG stoves, and a continuing buoyant demand for finance to buy LPG appliances at the project close. This is largely because LPG is cheaper and promoted by government as it reduces deforestation. Women aspire to use LPG and like using it.

Over several years, Practical Action has promoted Women Development Organisations (WDAs), to empower displaced women through engaging in productive activities. These WDAs were chosen to run the business-side of the scaling up, including microfinance (as this was already part of their role). This allowed a rapid response during the early part of the project, but also caused problems due to lack of experience in dealing with the high demand.

Issues and problems

Kenya

The change process in Kenya may take a number of years for any given household, and this sort of study did not have the time to evaluate the impact of the work on many of the households who have started on the process of alleviating smoke, but had future plans for further improvements.

Repayments, though made, often take much longer than had been agreed – so for some households, the actual monitoring process only took place towards the very end of the project and not all the households could be monitored. There is an acceptance between those running the revolving finance, and those using it, that payments may not be made on time – it could take up to fifteen months. As a result, the revolving finance will not work as a business

opportunity for an entrepreneur wanting to use smoke-intervention sales as their main source of income. However, the revolving finance is running sustainably at a lower level which is acceptable to both supplier and customer and this suggests that a fully commercial approach, where several women use the small profits as part of their income, is a good model within such low-income societies. The 'spin-offs' of setting up revolving finance are all positive; the groups now run their own bank accounts and are planning to use the finance more flexibly in future for income-generating activities as well as smoke-alleviating options.

The other major issue in Kenya is that there are few interventions of intermediate cost to reduce very substantial amounts of smoke. Work is ongoing on the design of a rocket-type stove suitable for household use.

Smoke hoods have been adopted less than had been expected. They are seen as less modern than LPG, yet those who use them do so all the time, not just for quick meals, so they get rid of most of the smoke all the time. Smoke hood adoption has been disappointing.

Nepal
Running revolving finance through local committees has lead to very good levels of repayment. A less positive effect is that it is difficult to move the capital to support other villages as it is either 'theirs' to make other improvements, or 'NGO money' so does not need to be repaid….It is therefore important to try to get the balance right between the time that people have to wait for their turn to use this funding, and the need to make sure that it benefits as many households as possible.

Subsidy is an issue in Nepal – but without it none of the households living in poverty would have purchased smoke hoods. It is important not to dismiss subsidy out of hand. Where subsidies are needed, routes should be planned for terminating the subsidy, whilst supporting the ongoing subsidy whilst it is needed. A local entrepreneur now runs a business with four staff members, and he is aware of the need to cut back on subsidy or his business will run out of customers. He has worked closely with the team on the design of the smoke hood, and also on desirable attributes to make the item more attractive to customers.

Sudan
In the third round of monitoring, it was found that many households had reverted to charcoal. An additional survey found that this was mainly due to the difficulty in getting the bottles refilled because:

- the depot was at some distance from the households
- women would only start to save for the refills once the bottle ran out

This problem is likely to be resolved in the near future, as sales of LPG appliances within these low-income areas is still growing fast, and the gas supplier has promised to provide local depots and a mobile shop as the profits have been very worthwhile.

A second reason for the reversion to charcoal is that many displaced families are returning home at this present time. Charcoal prices are currently fairly low in Kassala – the convenience of buying charcoal by the day is thus a big factor in its favour.

The rapid growth in demand for LPG appliances meant that the WDAs had to take on much greater responsibilities more quickly than had been expected. Despite a lot of training from Practical Action, it was shown that many of those trained were not commercially focused, having engaged in WDA activities to help 'beneficiaries' through very small businesses, rather than to run relatively large operations. A new set up is planned, with recommendations that those running the WDAs are not necessarily those who run the micro-finance, will ensure that those running the microfinance are both well-qualified and well-trained. In the meantime, support is being continued through Practical Action until the team is more confident to run it autonomously.

Results

Smoke alleviation

This table looks at the levels of carbon monoxide, used as an indicator of pollution levels, before and after smoke interventions had been installed. For Sudan, because carbon monoxide is only used as a proxy, the maximum predicted levels for particulates are given, as a switch from wood and charcoal mixtures to almost exclusively charcoal reduced the levels of particulates (PM) – which are believed to be the main cause of the health problems. In both Kenya and Nepal, either the same fuel or LPG gas (with virtually no particulates) was used – so the CO data can be used directly to indicate percentage reductions.

	Kenya			**Nepal**			**Sudan**		
	Pre-	Post-	% change	Pre-	Post-	% change	Pre-	Post-	% change
Measured mean CO (ppm)	8.99	2.51	**72**	12.82	1.56	**88**	4.56	4.83	-6
Predicted mean PM ($\mu g/m^3$)							268	180	**33**

Adoption and continuing use of interventions

Kenya
Adoption rates for the more costly interventions are relatively slow. During the project period, around 350 households adopted interventions for which revolving finance was needed – this is around 2.5% of the total households. The natural adoption of other no-cost or low-cost technologies, such as fireless cookers, eaves spaces, and behavioural changes could not be monitored, but is believed to be high. The interventions purchased were still in use in all cases among those responding to the questionnaire in Kenya. Virtually all LPG users among those questioned used it exclusively for making tea –the only cooking done at breakfast time, although only ~25% used LPG exclusively for cooking their main meals.

Nepal
During the project period, around 450 smoke hoods were installed, or were just about to be installed. Continuing growth will depend largely on the priority given to alleviating smoke given by the District Development Committee, who will run the revolving fund and have committed to continue to support the initiative and to provide subsidy in the immediate future. As there are already larger subsidies on lighting and stoves, this is a positive development. There is currently a full order book for the entrepreneur and five assistants who are manufacturing the hoods in the area. All the smoke hoods installed are in constant use.

Sudan
Adoption levels in Sudan continue to be high, with a steady and ongoing installation rate of around 50 stoves per month. Problems associated with coordinating the revolving finance across all the WDAs has been addressed, and a new system and regulations, particularly the legal side regarding guarantees for repayment, has been put in place. Practical Action will remain in an advisory role during this period. In the third round, only one fifth of those monitored were using LPG as their fuel, although 50 of the 148 respondents said they used it either exclusively (31) or in conjunction with charcoal or wood (19) for cooking main meals. Setting up savings groups for fuel savings has already been started to address this issue, and local depots are promised to improve access.

Community satisfaction

Satisfaction ratings in all countries are close to 100% on all counts. Even in Sudan, where many households had reverted to charcoal, there was almost universal support for the use of LPG stoves. In Kenya, the major benefits were reported as time, fuel reduction, smoke reduction; in Nepal, the key benefits included smoke alleviation, fuel savings and health improvements: in Sudan, cooks cited time-savings, increased comfort and smoke reduction. Health was reported as improved in all three countries – though again, this was less

prominent for some questions in Sudan. In Kenya and Nepal, all households were using the interventions that they had bought or built. Households were also very willing to discuss problems, which reflected the good relationship set up between the researchers and the household members.

Transferability of findings

The **participatory approach** has been tested in three very diverse situations, and has proved highly effective in each country. Findings from Nepal, where the process initially created a less-than-ideal smoke hood, but led to an excellent technology for which people were willing to pay far more than they had at first indicated, suggest that it is necessary to keep faith with the process – it means that people make their own decisions so adoption is not a problem.

Awareness-raising can change people's priorities and create markets provided that the goods and appliances are available. Working with community groups to dissemination messages through theatre groups, drama, design of outputs can be a powerful tool to reach very large numbers of people.

Poverty is not a static condition, but it is where people sometimes find themselves, so working with those living in poverty to identify ways in which people can help themselves immediately and build up gradually will start an ongoing process of change.

Micro-credit, run by the communities themselves, has been highly effective, and has been shown to be useful even where it is not used for income generation. This is an important finding and runs contrary to conventional wisdom. This approach could be used for other household initiatives, such as water, sanitation, shelter provision etc. Discussions around its implementation, duration of loan, maximum loan etc. have given rise to good repayments and a sense of ownership of the system. Ideally, it should be used for a range of interventions across all services, as this would give those in community a greater say in its use.

Making **savings in costs and time** can be very valuable and should be part of the 'mix' wherever possible.

A **holistic approach** to the impacts is important if goods and services are to be promoted widely. Provided that interventions do not lose sight of their prime objective, other 'desirable product attributes' can encourage people to adopt such interventions.

The impact of **making changes in the kitchen** goes far beyond just alleviating smoke. Particularly in societies where the woman tends to have a lower status, many of the impacts reported are social, rather than environmental, benefits; women are aware of their improved health and that of their children; their homes are cleaner, their drudgery is reduced. This research indicates that improving the quality of life in the home can lead to increased wealth, better health, more time and improved status.

Overall conclusions and findings

Health

The approach taken has been to use the change (reduction) in IAP levels as the main indicator of expected impact on child health, by relating measured reductions in pollution to the best available and emerging evidence on the association between exposure levels and incidence of pneumonia. This indicated that if interventions were introduced into 25% of households such as those in the study, the number of cases of pneumonia could be reduced annually by between 150-300 in Kenya and Nepal, and around 100 in Sudan in populations ranging from around 63 000 in Kenya, 45 000 in Nepal, and 79 000 in Sudan. In Sudan this impact is indicated despite the numbers of households using charcoal the time of the study.

As well as pneumonia, substantial reductions in other health problems were reported in all three countries, particularly in Kenya and Nepal. In Kenya, there was strong evidence of a reduction in the prevalence of the general cough and wheeze symptoms, with many fewer indicating chronic problems.

There was a marked and statistically significant reduction in headaches in terms of frequency and strength of headaches. Although numbers are low, there is strong evidence that where interventions were in use, the risk of burns and scalds to children has been reduced. In all three countries there was a reduction noted in the number of visits to health providers and the cost of health provision. In Kenya and Nepal this was particularly marked.

Scaling up
In all three countries, scaling up through addressing both supply and demand sides has proved successful. Locally run revolving funds continue to provide ways for people to purchase smoke interventions. Entrepreneurs have been trained, and continue to work on interventions. All these operations are operating commercially, although in Nepal, subsidy is still being provided by the District Development Committee.

Impacts
The impacts of the work have been overwhelmingly positive. This is the case when specific questions were asked regarding health, time, income/savings, environment and prestige/quality of life, and also when people were asked to identify the impacts that the interventions had made.

The team are not aware of any major negative impacts, but problems (such as rain ingress in Nepal) have mainly been sorted, or are currently being addressed. Issues around savings in Sudan are being addressed.

Cost benefit analysis

Overall, these results show positive benefit to cost for all three countries, and a very high ratio for Kenya. Time saving is by far the most important component, but fuel cost savings are also substantial for Kenya and Sudan. The direct health benefits appear as a very small component, for reasons which are discussed in Chapter 11.

As health impacts were a small component, variations in estimates of exposure reduction, disease incidence rates, health costs and time lost due to illness would make little difference to the overall results. Even a substantial reduction in estimated time and fuel savings costs (up to 50 per cent) would still yield positive cost-benefit ratios for Kenya and Sudan. For Nepal, fuel cost savings were not relevant, and it was fuel collection time that was more critical.

This initial, household perspective CBA has shown positive benefit to cost ratios for households purchasing interventions that are achieving at least useful and often very substantial reductions in IAP. This should encourage efforts to assist prospective adopters with the financial arrangements needed for them to obtain these benefits.

Skills transfer
All three teams have developed very considerable expertise in monitoring and data processing. One of the Nepal team has provided expertise to the Cost Benefit Analysis (CBA), working with the University of Liverpool to provide this important policy output. Work is continuing on a Societal CBA as the project comes to an end.

Knowledge sharing
- Efforts were made to ensure that all the key team members attended conferences throughout the research so that other organisations could benefit from field knowledge as well as findings.
- The work has been reported through several papers focused on health, energy and development. It has fed into websites including those of WHO, HEDON and the Partnership for Clean Indoor Air.
- Two clean air networks have been set up – one in Nepal for the whole of South Asia, and another in West Kenya to help continue to disseminate the need for clean air beyond the end of the current work.
- Radio and TV programmes have been broadcast in all three countries and several programmes have been broadcast on the World Service.

Abbreviations & currency

ACORD	Agency for Co-operation and Research In Development (International)
ALRI	Acute Lower Respiratory Infection
ARI	Acute Respiratory Infection
CBA	Cost Benefit Analysis
CO	Carbon Monoxide
COPD	Chronic Obstructive Pulmonary Disease
CSD	Commission for Sustainable Development
DALY	Disability Adjusted Life Year
DDC	District Development Committee, Nepal
DFID	Department for International Development
FEV_1	Forced Expiratory Volume in the first second. The volume of air that can be forced out in one second after taking a deep breath
FVC	Forced Vital Capacity - the maximum volume of air that can be forcibly expired from the lungs
GBP	British Pound (£)
GTZ	Agency for Co-operation and Research In Development, Germany
HEDON	Household Energy Development Network (longstanding household energy network)
HH	Household
HHE	Household energy
IAP	Indoor air pollution
IAPHF	Indoor Air Pollution and Health Forum, Nepal
IQR	Inter-Quartile Range
IRR	Internal Rate of Return
KIAPNET	Kisumu Indoor Air Pollution Network
KSh	Kenya shilling (1000KSh ~£7.40)
LPG	Liquified Petroleum Gas
NPV	Net Present Value
NRs	Nepal Rupees (1000NRs ~£7.70)
OR	Odds Ratio
PCIA	Partnership for Clean Indoor Air
PEFR	Peak Expiratory Flow Rate - the fastest rate at which air is exhaled from the lungs
PM	Particulate matter (that gets deep into the lungs and causes respiratory illness)
RESPIRE	A major randomized intervention trial on Indoor Air Pollution in Guatemala
RF	Revolving fund
SD	Standard Deviation
SDD	Sudanese Dinar (1000SDD ~£2.52
UKP	British Pound (£)
UNDP	United Nations Development Programme
VDC	Village Development Committee, Nepal
WDA	Women Development Association, Sudan
WHO	World Health Organization
YLD	Years lived with disability
YLL	Years of life lost

Introduction

Nearly half the world cooks using solid fuels, ranging from coal, through wood to agricultural and manufacturing wastes such as crop residues, dung and sawdust. Much of this fuel is cooked on three stone fires or traditional stoves, leading to high levels of indoor air pollution, and consequent health impacts. Kitchen smoke is responsible for around 1.5 million deaths per annum globally. The majority of these deaths are young children below the age of five years. Poverty and lack of access prevents many households from accessing cleaner fuels and technologies.

In May 2005, Practical Action published 'Smoke, health and household energy Volume 1, which described a participatory approach researched by the organisation into the design, installation, monitoring and assessment of smoke alleviation technologies or *interventions*.

The communities involved in the original study were from Kenya, Nepal and Sudan.

- an urban community in Kisumu, Kenya – using wood, charcoal and agricultural residues as their main cooking fuels
- a community close to Kassala town in Sudan, where a large influx of displaced people has led to woodfuel shortages.
- Gatlang, a high cold region in northern Nepal, where communities need energy for space heating as well as cooking.

Woman cooking using a three stone fire

In the original project, the communities in each location selected thirty representative households. The various interventions chosen by the community were monitored for their effectiveness in alleviating smoke in these thirty homes.

Note: In this book, the word 'intervention' is defined as any change in technology, appliance, structural change, or behaviour brought about as a direct result of project activity to alleviate kitchen smoke.

However, achieving improved indoor air quality in thirty households in three countries does not even start to address the problem when millions are in need of new technologies. Indoor air pollution (IAP) is responsible for around 1.5 million deaths, and over 38 million disability-adjusted life years (DALYs[2]) each year. This demands a more radical and long-lasting approach. Many millions of households need to get rid of the smoke from their homes if their lives and the health of their children is not to be seriously compromised. How can this be done?

Project aim and objectives

The second phase research project, 'Researching pathways to scaling up sustainable and effective kitchen smoke alleviation' sought to identify those critical factors required to enable large numbers of people to access clean technologies, and thus reduce the high levels of smoke-related ill-health and death, particularly among children and their mothers.

The communities within this project are not completely without money; some of the women are small traders, and many of the men are in some form of employment. However,

[2] DALYs for a disease or health condition are calculated as the sum of the years of life lost due to premature mortality (YLL) in the population and the years lost due to disability (YLD) for incident cases of the health condition (WHO: http://www.who.int/healthinfo/boddaly/en/index.html)

commercialization approaches needed to be socially apt, such that resources could be unlocked through micro-credit and other financial mechanisms for both sale and purchase of effective and appropriate technologies.

The ultimate aim was for the 'beneficiary' to become the 'customer' and the role of the NGO to be superseded by the supplier or service provider. For this, the project sought to create:

- willing customers
- competent suppliers
- a pro-active interface between the two
- the 'right price' for the goods or services.

The project researched mechanisms for creating a sustainable infrastructure for long-term delivery of smoke-alleviating interventions through development of existing social and commercial structures to promote demand, facilitate purchase through credit, and support production.

The impacts of these activities were monitored in terms of pollution reduction, health of women and children, acceptability, durability, maintenance, cost, willingness to pay, market penetration and growth rate, policy awareness and action.

Around 150 of the early adopters were monitored in each country; these were households that had elected to buy interventions through one of the schemes instigated by the project. Although project households were therefore self-selecting, awareness-raising activities were conducted in locations experiencing greatest poverty, or those with serious challenges in accessing fuel, and monitoring took place in districts experiencing serious levels of poverty.

Whilst a participatory approach continued to be adopted in developing the technologies, a commercial focus was introduced to create a more sustainable infrastructure for delivery of interventions beyond the project end.

In terms of sustainability, much of this project was about converting project activities into commercial enterprises.

Research approach

As this project was a continuation of the earlier work, project staff were already supported by collaborators from other NGOs and local government. This provided a good starting point from which to scale up the work.

The study itself can be understood more clearly by considering the two complementary objectives driving the research:

- Creating a sustainable infrastructure by finding ways to overcome the barriers inhibiting both supply and demand for effective smoke-alleviating interventions. The project monitored growth in demand and levels of uptake of interventions throughout the project period.

- Providing evidence that the interventions adopted were alleviating smoke and improving the quality of life for the target communities. For this, questionnaires and some measurements on lung function were performed. Unless and until effective interventions had been identified, they could not be brought to scale.

Activities for both these elements ran in parallel throughout the project. However, for clarity, each element will be dealt with separately in the methodology. The results and discussions at the end of this publication will bring both aspects together.

Project dissemination

Knowledge that is shared can multiply the impact of a project many times over. Key target audiences were identified and dissemination approaches targeted to project, national and international level audiences.

Within the communities, initiatives ranged from street theatre, through films to house-to-house visits. Internationally, the project has presented its findings at workshops and conferences. Project staff have fed into publications, provided information for websites, advised other organisations on methodology and practice, and published articles in several journals. At policy level, Smoke Forums have been set up and a smoke campaign, linked to the project, raised awareness of the problems through highlighting the issue at major conferences and government lobbying. All these initiatives will be explored in greater detail throughout the book.

Structure of the book

Chapter 1 describes the communities and provides data from a baseline questionnaire to highlight issues that would influence the levels of pollution experienced by the households.

Chapter 2 looks at the research approach adopted during the work, leading to a description of the research methods in Chapter 3.

Chapter 4 discusses the technologies that were developed, along with the reasons for their selection, leading to the changes in levels of pollution that are detailed in Chapter 5.

Each of the next three chapters discusses the wider measured impacts particular to the project locations in terms of health, time, income etc – Chapter 6 looks at Kenya in detail, Chapter 7 discusses the research in Nepal and Chapter 8 discusses the findings in Sudan.

Chapter 9 looks at the research process, in terms of how it was enacted. It is not concerned with results, but rather whether the actions taken yielded useful results.

Two specialist chapters follow – Chapter 10 looks at the implications for health, and Chapter 11 provides a cost-benefit analysis of this approach to alleviating kitchen smoke.

Chapter 12 looks at how the research work has impacted on poverty, specifically addressing changes in human, social, physical capital. It goes on to assess the potential for indoor air pollution alleviation to impact on the Millennium Development Goals.

Finally, Chapter 13 looks broadly at the achievements of the research and how they could inform future action.

Chapter 1: The research communities

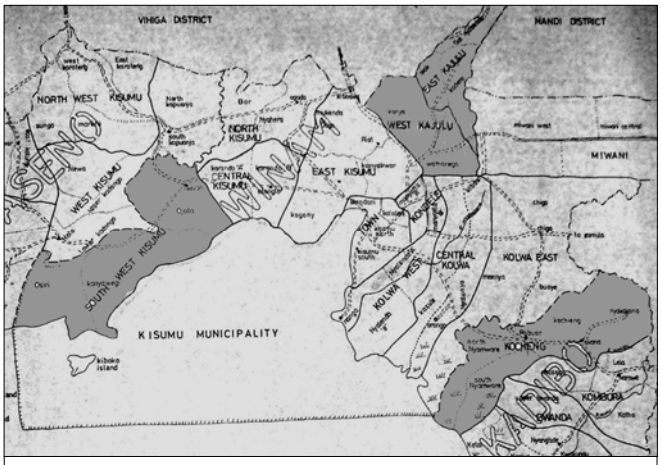
In each country, the work has radiated out from the location of the first project[3] from Kisumu in Kenya, Gatlang in Nepal, and Kassala in Sudan. These towns have become nodes from which the current initiative continues to expand geographically. It is intended that this will continue beyond the end of the project.

At the same time, the media (radio, TV, press) were targeted to spread the message to a much wider audience at national level. Campaigning and policy action have impacted at policy level both nationally and internationally.

Kenya – Nyanza province

Kisumu is the capital of Nyanza province, and is situated on the shores of Lake Victoria, in western Kenya. The map shows that scaling up has taken place throughout Nyanza and Western Kenya provinces (shaded areas).

The Project covered 13 sub-locations within the Kadibo and Winam Divisions of Kisumu District targeting a total of 14 777 households within a population of 63 329 . Within these divisions, almost all use biomass fuels as their main source of fuel.



Project locations around Kisumu (shaded)

Poverty levels
The UNDP National Human Development Report for Kenya (2006) indicates that hotspots of poverty incidence are not concentrated in any one region but are dispersed within provinces (UNDP 2006).

The project works with communities in Nyamira, Central Kisii and Gucha Districts of Nyanza Province and Vihiga, Butere-Mumia and Kakamega Districts in Western Kenya. Many of these districts have been identified by the UNDP as having communities experiencing more than 70 percent poverty incidence. Nyanza Province ranks third in terms of contribution to Kenya's overall rural poor population. Most of its Divisions and Locations exhibit consistently high poverty rates, with some Divisions showing variations in incidence of poverty from around 60 per cent to 70 per cent (World Bank 2001).

Three quarters of those living in poverty live in rural areas while the majority of the urban poor households live in the slums and peri-urban settlements. Recent results suggest that Nyanza Province currently has the highest levels in Kenya, with 63 per cent of its population living in poverty.

In the urban areas, Kisumu town is accorded the highest poverty prevalence of 63 per cent, followed by Nairobi with 50 per cent. Nyanza Province has roughly a quarter of a million poor people living in urban areas. Winam Division has three Locations with over three-quarters of the population living in poverty. Within Winam Division, East Kisumu Location's depth of poverty reaches 41 per cent (in real terms, this means that each adult in East Kisumu would require an additional KShs 1086 per month to get out of poverty),

[3] Smoke, health and household energy – DFID-funded project working in Kenya, Nepal and Sudan 2001-2005

Child health in Kisumu district
Except for neonatal mortality, all childhood mortality indicators in Kenya are highest in Nyanza Province and lowest in Central Province. AIDS is a major issue Nyanza.

Political situation
First experienced in the advent of multiparty democratic elections in 1991, politically instigated ethnic violence remains a serious source of insecurity in Kenya. Attributed to political incitement, some politicians have used militia youth groups to carry out violent attacks on opposing regimes – creating further destabilisation within the region.

Households in Kisumu
The locations selected in Kisumu district for monitoring were representative of the thirteen sub-locations in which the scaling up was taking place through revolving finance. Because of the logistics involved in monitoring it was not possible to monitor in every location, so three areas were selected.

Improved house – note flue and enlarged window

Korando:
Korando represented a total of five sub-locations. It represents the middle ground, closer to town than some of the households, and the agriculture is dictated by the type of soil, some of which is black cotton soils, and some loam soils. The overlap between peri-urban and urban is very significant and the general lifestyle is affected by its proximity to Lake Victoria (3km), and at the same time it lies on the slope of the escarpment leading down to the lake.

Okok
This area is next to Kajulu hills and next to Nandi escarpment. The hills have been denuded of wood where they have agricultural production. Income levels are higher than the other two areas because they have food security occasioned by agricultural activity. People have to collect wood from quite a distance, as they collect from the foothills. Okok is similar in type to West Kajulu and Got Nyabondo.

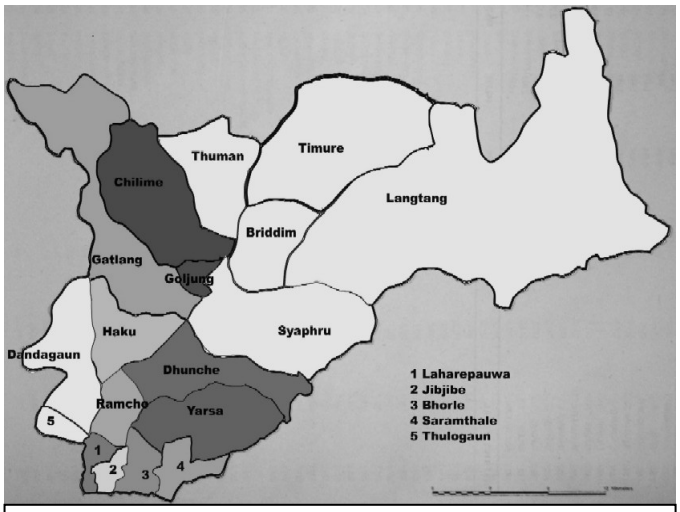
Nyamware
This is a flatter region with black cotton soil and there are chronic wood shortages. Burning of agricultural wastes is common, and people burn papyrus for fuel. Agricultural waste is seasonal, and there are major problems when it is not available. Poverty levels are the highest of these three groups, and the rainy seasons are very erratic – they can go for more than three years without a crop. This area represents Irrigation, South Nymware, Mehojo, and Kinda

Nepal - Rasuwa District

Rasuwa district comprises an area of 1544 square kilometres and is part of the Central Development Region of Nepal (UNDP1). It has a population of around 45 000, widely dispersed, mainly within small villages. The main town of the district is Dhunche, with a population of around two and a half thousand. Langtang, a mountain that draws tourists from afar, dominates the landscape. The trekking route to Langtang stops some miles short of Gatlang village and climbs up the neighbouring Langtang valley.

It is only within the last four years that efforts have been made to open up a route to the Chinese border via a non-metalled road which passes close to the original project site. Plans are now underway to create a highway linking Dhunche to Gatlang. This is likely to have a profound effect on the villages in the valley as it will make the area much more accessible to tourism.

It will provide a safe route through which vegetables can be exported to the local town. Currently, as the locally famous Rasuwa potatoes come into season, landslides regularly wash away the non-metalled road, preventing goods from reaching market. Landslides and mudslides on these roads have led to several fatalities during the rains.



Project areas in Rasuwa district (shaded)

Political situation

At the start of the project there was Maoist activity in the whole country. It was difficult to transport monitoring equipment as the security situation inhibited travel from the capital to the District and between villages. For example, on one occasion the project staff was jailed for a day by army because they were carrying batteries for running the monitoring equipment. Batteries were associated with bomb-making. On another occasion, a Maoist group demanded that the organisation register the activities with the Maoists – this was not done, which could have led to them preventing project activities.

However, neither the Maoists nor the army hindered the project because it was felt that the project was benefiting large numbers of people living in poverty.

This sort of occurrence was not specific to Practical Action. On occasions armed militia challenged project staff from many NGOs, and when the situation was particularly critical, work had to stop for several days.

In the recent past (2007), following the establishment of democracy, the situation has greatly improved. All parties of the coalition have recently

Typical house, Rasuwa – note the chimney flue

agreed at district level to support this initiative, including financial support. Practical Action is continuing to develop the understanding and collaboration with these groups.

Socio-economic data
A set of data, produced by the Nepal Government's Central Bureau of Statistics (2003), provides some indicators on Rasuwa district, based on 2001 data (Table 1.1).

Table 1.1: Socio-economic indicators, Rasuwa District, Nepal

	Whole country	Rasuwa district	per cent of national average
Access to drinking water	82 per cent	85.2	104
Access to toilet facility	46.8	31.9	68
Access to electricity	39.8	32.8	82
Solid fuel for cooking	76.9	91.3	119
Radio	53.1	40	75
Telephones per 1000 population	12.5	4.02	32
Acute Respiratory Infection per 1000 children <5	**229**	**652**	**285**
Diarrhea per 1000 children < 5 years	177	339	192
Ratio malnourished children under 3 years	15.8	18.3	116
Reported death per 1,000 population	4.81988	4.76	99
Primary school net enrolment ratio	81.1	93.3	115
Ratio of girls to boys in primary education	81.1	75.5	93
Student teacher ratio in secondary education	23.8	21.8	92
Literacy rate of population 15-24 years	70.1	45.2	64
Ratio of literate female to literate male 15-24 years	74.6	55.9	75
Share of women in wage employment in non-agriculture sector	17.4	11.4	66
Employment to population of working age ratio	64.2	85.5	133
Proportion of children 10-14 who are working	10.9	26.4	242
Yield of vegetables (Kg/Hectare)	10792	9000	83
Yield of fruits (Kg/Hectare)	9514	9013	95
Yield of cash crops (Kg/Hectare)	9465	9506	100
Yield of cereal crops (Kg/Hectare)	2199	1578	72
Yield of pulses (Kg/Hectare)	815	701	86

Central Bureau of Statistics 2003

Of particular note are the high levels of Acute Respiratory Infections (ARI) – an ailment that is closely linked to indoor air pollution. There are several high negative indicators, such as the number of children who are working, and the high levels of diarrheal infections among children. Malnourishment is slightly higher than the national average.

Sudan - Kassala and New Halfa, Sudan

Biomass energy (firewood, charcoal, and residues) composes more than 80 per cent of primary energy consumption in Sudan. Over many years, it has become evident that high dependence on biomass energy is a major factor, among others, contributing to forest cover depletion, environmental degradation and desertification. Combined with the successive drought cycles that have stricken the Sudano-Sahelian countries since the early 1970s, and from that time on, Sudan has suffered some lasting imprints and disastrous effects of the drought and the encroachment of the desert. The desert and semi-desert represent 51.5 per cent of the total area of 1.3 million square kilometres, and if the low rainfall Savannah zone is added, the figure jumps to more than 80.6 per cent. This indicates that the problem of desertification and desert encroachment is of a very serious magnitude in the Sudan.

The original project location was the displaced community of Wau Nur, situated on the outskirts of Kassala town. Even before the end of the first project, scaling up had started to take place due to the high levels of demand for LPG stoves once revolving finance had been made available.

For this study, low-income communities in Kassala town and the adjacent peri-urban settlements were targeted. A further district, New Halfa (population around 86K), was incorporated into the study. New Halfa (otherwise known as Halfa' al Jadidah) was chosen because of severe shortages of fuel being experienced in the area.

Kassala and New Halfa

Kassala

Kassala Town is the capital of the Kassala state, which borders both Eritrea and Ethiopia. Its location on the main Port Sudan to Khartoum highway makes Kassala town an important centre for trade. The local economy benefits from being close to neighbouring markets.

Local trade and industry in Kassala town is generally well developed, however it is frequently affected by border tensions that impact on the flow of goods between Kassala state and bordering countries.

Typical kitchen in Wau Nur, Kassala

Population
Since the 1960s, Kassala town has been a major point of entry for Eritrean and Ethiopian refugees fleeing conflict and war. Since the 1980s, the town has also been a haven for vast numbers of Sudanese people from rural areas in the Nuba mountain region, southern and western Sudan who have fled from a series of conflicts and drought, to relative safety of urban Kassala town. The numbers of displaced people have increased the population of Kassala state to around 1.2 million, 65 percent of whom live in rural areas. Of these, 350,000 are refugees or internally displaced Sudanese. Although a considerable number have managed to integrate into local communities in Kassala 760,000 displaced people are settled in displaced communities on the outskirts of town (IDMC 2006). The population is currently (2007) decreasing following the signature of a peace agreement.

Environmental concerns
With such a large influx of people, woodfuel has become very scarce. The main traditional fuel bought is charcoal, which is sold around the camps by men driving 4 x 4 cars, or on camels carrying wood from the far hills. Seasonal floods can also disrupt the town. In 2003 and July 2007, many houses in Kassala were washed away, and hundreds were damaged. On occasions, this leads to outbreaks of cholera.

New Halfa
In the early 1960s, the government set up a program to resettle Nubians displaced by Lake Nubia, formed by the construction of the Aswan High Dam in Egypt. To provide farmland for the Nubians, the government constructed the Khashm al Qirbah Dam and established New Halfa.

Located west of Kassala, this project was originally designed to irrigate about 164 000 hectares. The main commercial crops initially introduced included cotton, peanuts, wheat and sugar. The project enabled 200 000 hectares of land to be irrigated for the first time, but heavy silting and serious problems of drainage and salinity occurred. By the late 1970s the reservoir had lost more than 40 percent of its original storage capacity and was unable to meet the project water requirements.

To stabilise the ground, the low fast-growing shrub 'mesquite' was introduced. Unfortunately, it proved to be very thirsty and invasive, exacerbating the problem and leading to widespread desertification. Recently, the government has instigated a mesquite-clearing programme with the full support of the community. However, mesquite was used as fuel, and with its clearance, the occupants of New Halfa were left without an affordable option for cooking.

Children in New Halfa town

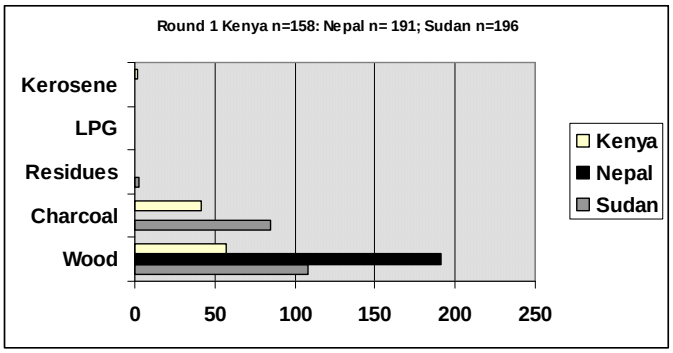
Political situation
At the start of the project, the political situation in Eastern Sudan was volatile. Warfare between Eritrea and Ethiopia over disputed border areas broke out in 2000, prompting a mass exodus of the Eritrean civilian population. Hundreds of thousands of Eritreans became internally displaced and around 12 000 fled across the border to the south and east of Kassala town. As the conflict zone spread, yet more refugees entered the Sudan. By mid-June 2000 when a ceasefire came into force, some 92 000 Eritreans had entered the Sudan.

In August 2006, the Government of Eritrea convened negotiations between the Eastern rebels, known as the Eastern Front (EF), and the Sudan Government. A peace deal (the Eastern Sudan Peace Agreement) was signed in the capital of Eritrea, Asmara, guaranteeing greater development for Eastern Sudan. As a result of this agreement, the situation is stable. There are moves to consolidate coordination between activities of UN humanitarian agencies and international NGOs operating in the region, shifting the emphasis from relief to development programs (UN 2007). This is in line with the approach adopted in the project – implementing training and capacity-building for local organisations and communities.

Baseline data on project households

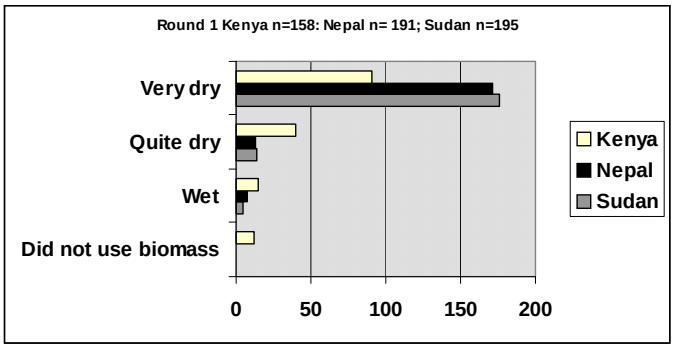
First round questionnaires were used to establish baseline information on all three communities with whom the project teams were working. The tables below show the similarities and differences in each country.

Figure 1.1:Fuels used for cooking



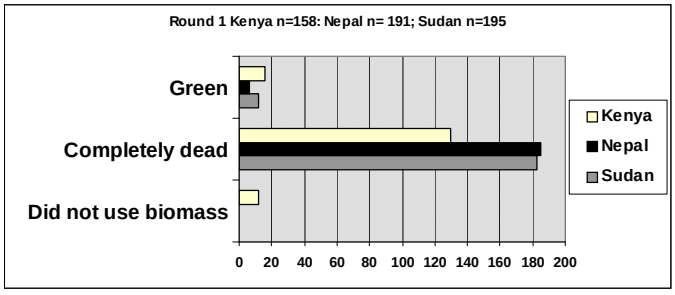
It can be seen that there is a heavy reliance on wood in all three countries. In Nepal every household uses it, whereas in Sudan and Kenya, wood is the dominant fuel, with charcoal a close second. Residues and kerosene are only occasionally used.

Figure 1.2: How dry was the fuel?



Using dead, very dry fuel is a low-cost way to reduce emissions. Most households used fuel that was dry and dead.

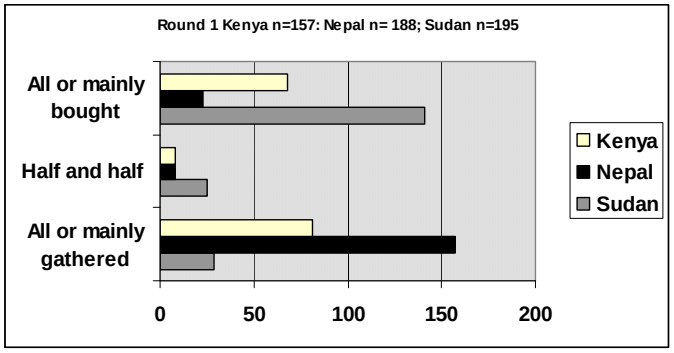
Figure 1.3: How dead was the fuel?



Fuel purchase

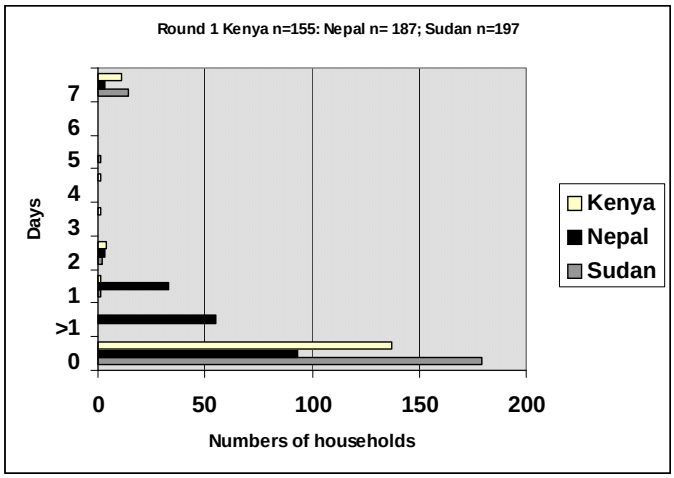
Fuel purchase is important in terms of revolving finance. If the intervention can both alleviate smoke and reduce the cost of fuel, it is more likely that people will be able to pay back the capital cost of the intervention.

Figure 1.4: How much fuel is bought?



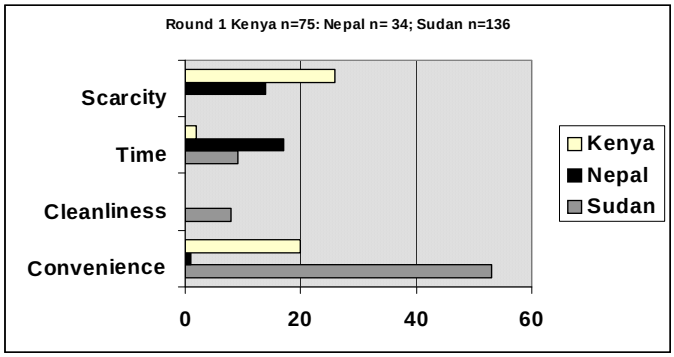
In Kenya, around equal proportions of people indicated that they bought and gathered fuel. Sudan's high dependence on purchased fuel is indicative of the role that charcoal plays, and desertification in the surrounding area. Fuel is both scarce and expensive.

Figure 1.5: Fuel for enterprise



The number of days each week on which households used energy for enterprise was recorded. Not many households expressed a need for fuel for enterprise. The higher levels in Nepal reflect the more open approach to brewing *Rakshi* – a homemade spirit that is drunk extensively in the area and is a source of income for the women who make it. In both Kenya and Sudan it is illegal to brew alcohol.

Figure 1.6: Reasons for buying fuel



Despite this scarcity in Sudan, the reasons given for purchasing fuel were convenience and cleanliness. To gather fuel would require several hours of walking, whereas fuel can be purchased within a few metres of people's homes

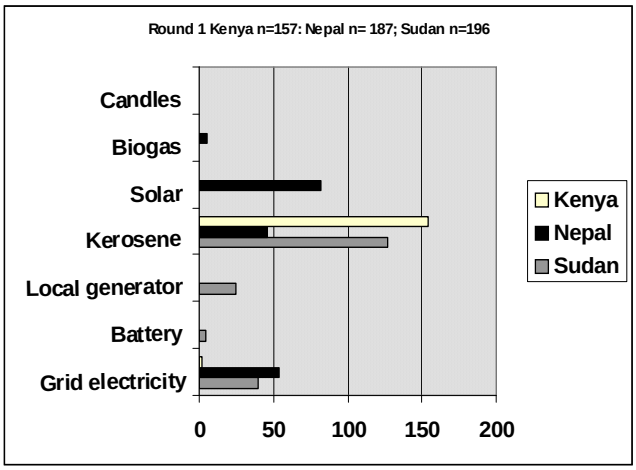
Lighting fuels

There is a wide diversity of lighting fuels. In each country mains electricity is available, but it is expensive and may not be installed in many of the households.

There is intermittent mains electricity in Rasuwa, Nepal, but there is also a good subsidy on solar home systems, which would otherwise be well beyond the income of most households. The project households had more solar than in most parts of Rasuwa due to a scheme there.With the subsidy, households opt for solar because it only has a maintenance cost and is reliable.

Despite grid electricity, kerosene is used almost exclusively in Kisumu and predominantly in Sudan, indicative of the very low income levels of the households in the study.

Figure 1.7: Fuels used for lighting



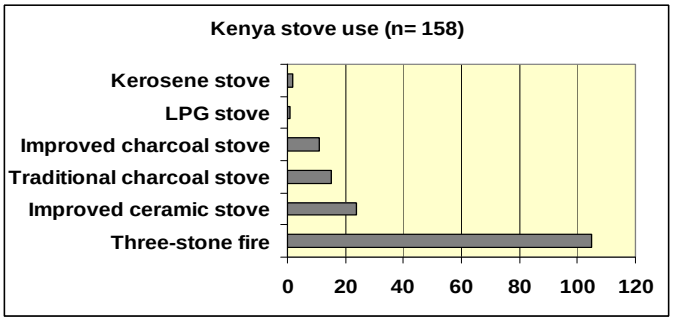
Stove use

Most households will use more than one fuel source and more than one stove or fireplace. Because of the complexity of stoves used, each country is reported separately. For this reason, also, the total number of stoves in these tables is greater than the number of households.

Stove use by country

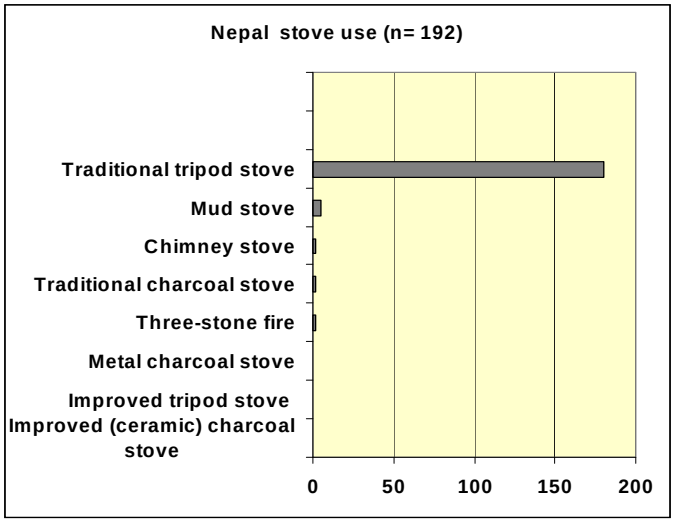
Most households in Kenya and Sudan use more than one stove each day, selecting the stove to cook either fast meals, such as making tea for breakfast, or slow cooking, such as cooking ugali – a kind of maize porridge which requires long slow cooking.

Figure 1.8: Stoves used in Kenya



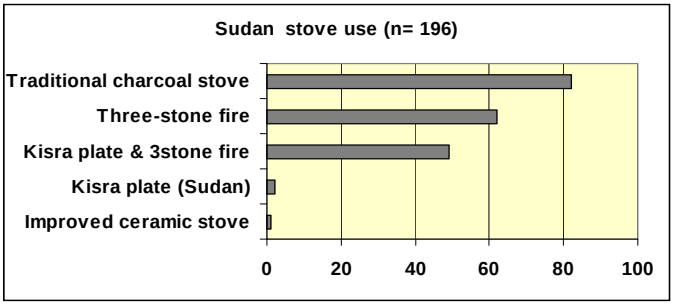
As illustrated, the majority of households cooked over a three-stone fire, with several households using more than one fuel. In general, charcoal and LPG has been used for 'fast' cooking, such as tea-making, whilst three-stone fires will be used each evening for cooking the main meal.

Figure 1.9 Stoves used in Nepal



Almost every household in Rasuwa district uses a traditional tripod stove. The tripod is made by local blacksmiths in the villages, which burns similarly to a three-stone fire, although the pot is held more stably. The tripod stove formed the basis for the improved stove implemented during the project.

Figure 1.10: Stove use in Sudan

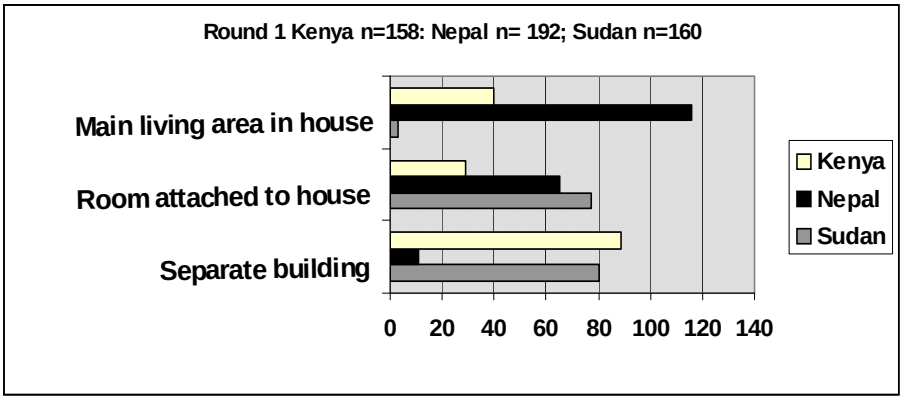


Kisra is a staple food in Sudan, although it is rapidly being superseded by bread. Cooking kisra needs a hot griddle plate set over a three-stone fire. This combination of three-stone fire for kisra and traditional charcoal stove for rapid cooking is still very prevalent in Sudan.

Kitchens

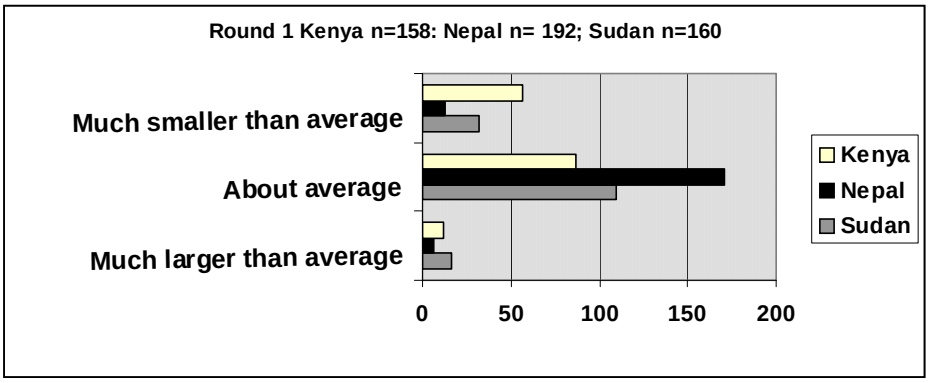
Kitchens can be the main room in the house, or can be a separate building. How they are used strongly influences the demands that are made on it.

Figure 1.11: Location of kitchen



In Rasuwa, Nepal, the fireplace is the central focus of the main room in the house. Families sit around the fire in cold weather, so it is important that families can see the fire and appreciate its warmth. In Kisumu, Kenya, the kitchen is often a separate building, and kitchens that are the main living area usually reflect greater levels of poverty. Children and others often sleep in the kitchen. The chart indicates that kitchens in Kassala, Sudan, are almost invariably away from the main living area, in a separate room or building.

Figure 1.12: Size of kitchen



The size of the kitchen was monitored to give some indication on whether the group buying interventions were typical, or only from the higher income bracket. Relatively few people with larger than average houses were part of the survey, whilst several were in the 'smaller house' bracket.

Chapter 2: Rationale behind the research approaches adopted

Overview

Two factors influence the numbers of people whose health can be improved by alleviating smoke:

- The number of people who can be reached with smoke-alleviating interventions through any given initiative.
- The reduction in the concentration of smoke to which they are exposed

To make substantial inroads on ill-health, the study needed to research approaches to achieve smoke reductions for substantial and growing numbers of people – identifying and overcoming the barriers that prevent people being able to alleviate the kitchen smoke in their homes. Provided that the pollution reduction levels could be maintained or improved, then if large numbers of people were enabled to adopt interventions both during the research and beyond, and that they continued to use such interventions, the ill health associated with indoor air pollution could be reduced.

Approaches to scaling up

For any change within a society to be sustainable, that change must become a part of the normal pattern of life for people, creating a sense of *ownership* of those changes that have developed. This chapter describes research focused towards this end.

Changing the 'beneficiary' to a 'customer' to whom the entrepreneur (not the NGO) supplies goods or services, for which the customer will pay, empowers the customer and requires that the supplier listens and responds to the demands of the customer. Although this reduces the dependency of the beneficiary, ways must be found to try to mitigate the cost of the intervention in terms of savings and/or time savings.

On the supply side, there must be a sufficient market for the entrepreneur to make a living, if the venture is to be sustainable and cleaner technologies will remain available for households to buy. Thus the project sought to ensure that there was a sufficient impetus to kick-start each small enterprise and turns it into an economically successful business venture.

The need to scale up was an integral part of the research and was addressed and monitored from project inception. The project sought to create an integrated package that would ultimately make support from NGO activities unnecessary, through creating a commercial framework which would enable access to smoke-alleviations to became part of the day-to-day norms of the society.

As many initiatives on improved household energy have foundered in the past through households not electing to use interventions in the longer term, the work sought to identify 'desirable product attributes' that would encourage purchase and long-term adoption of these interventions and monitored pollutant levels to check that smoke levels were actually being reduced.

The sustainable infrastructure activities of the project were split into two elements, each of which had to work if the plan was to succeed. Table2.1 outlines activities implemented to create a market.

The participatory approach empowers people to articulate their felt needs. Approaches were adopted to enable community members to make or purchase goods and services without direct financial support from the project, so that the initiative would not collapse with the end of the project. This transition to a more commercially focused activity, required a gradual handover of activities and responsibilities undertaken by the project to local enterprises and service providers.

Table 2.1: Creating a market for interventions

Customer	Entrepreneur
• Development of interventions in collaboration with community • Awareness-raising on the problems of indoor air pollution to empower community with knowledge • Working with the customer to identify desirable product attributes to meet their requirements • Micro-credit for those with insufficient up-front capital to purchase goods	• Training in manufacture, marketing and sales • Micro-credit for start-up raw materials • Support to sales through health and well-being promotional messages • Support with set-up; purchase of raw materials, wholesale goods, technology promotion • Support with transport until established • Feedback from customers

Moving from NGO activity to commercialisation

At the start of the project, community meetings, interviews with the key actors, focus group discussions ensured that changes fulfilled the aspirations of everyone involved. Suitable arenas were provided for community exchanges and dialogue with other key actors to enhance the natural flow of knowledge (community meetings, presentations etc.). The same approach was used to identify shortcomings in a project, and the views expressed formed an integral part of the scaling-up strategy.

Knowledge sharing and awareness-raising

People's priorities are not static, but rather they change as their knowledge increases. Several studies, including those done by Practical Action, have indicated that the links between ill-health and indoor air pollution are not well understood by many low-income communities. The high levels of respiratory disease are seen as part of life, whilst the main problems that people associate with IAP concern eye discomfort, and sometimes headaches.

Once people are aware of the dangers of cooking smoke, their desire to alleviate it goes up their list of priorities. The community takes on ownership of both the problem and its solution, and alleviating smoke becomes a part of the normal pattern of life.

Awareness raising on the safe use of LPG in Sudan

Quantifying need

On a national scale, national demographic surveys and the World Health Report 2002 (WHO, 2002) showed that high levels of respiratory illnesses, associated with indoor air pollution, affected the three countries in the project.

However, large-scale studies, particularly those based on economic criteria (such as loss of earnings), or use of health care facilities (where there are very limited medical services), cannot always identify the needs of the most vulnerable. The project monitored the cook in each household - exclusively female. Thus, by its nature, the needs and opinions of women were expressed. The project sought the opinions of men during community meetings, as they often made the decisions on household expenditure.

The research plan was to have two market surveys in each country. Between these two surveys, promotional activities would raise awareness of the issues surrounding smoke. Levels of awareness and 'willingness to pay' were investigated as part of the survey. The findings from these surveys are given in Annex 2.

Identifying technologies and skills

The needs of a society are most keenly felt and best understood by that society. The strengths within a community group are also best understood by those belonging to it. Community discussions and monitoring identified both the needs of the customer, and the skill base and local materials available in each area early in the process, in order to build on the assets of the community. Chapter 4 details the interventions adopted in each country.

The quality and product life of each intervention is very important where people have little money. Desirability for reasons completely unrelated to indoor air pollution may persuade people to adopt and use interventions. The project sought to identify and promote appliances with 'desirable product attributes' - such as speed of cooking, fuel saving etc. through a very participatory approach – working with households to identify appropriate technologies, and working with them to develop and adapt them throughout the project cycle. If beneficiaries do not like any changes that have been made, there is little chance that they will continue to adopt and use them once the project has ended, and the benefits are non-sustainable.

Local entrepreur beside smoke hood he had recently built, Nepal

The cost of an intervention was equated against the willingness and ability to pay of the beneficiary. Almost invariably, women have less money than men. Thus it is useful to focus on the wider benefits of an intervention as well as the effects on the target beneficiaries, in order to arouse the interest of family members who can pay.A market survey to determine levels of awareness and potential demand was conducted before and after awareness-raising activities in Nepal and Kenya.

Finance

Most interventions require money, and making up-front capital available in the short-term, when it is needed, was one of the key approaches investigated. The project provided seed capital for revolving finance, using a different approach in each country.

Subsidies

Direct subsidies were avoided where possible, but hidden subsidies were applied. Training is perhaps the most powerful hidden subsidy. Workshops run free of charge on subjects such as small enterprise management, artisanal skills, quality control etc. were provided by the project

In Nepal, a direct subsidy was needed to cover the high transport costs to the remote villages. Ways to continue this subsidy beyond the lifetime of the project were addressed.

Monitoring growth and sustainability

Records of sales and their values were recorded in each country. Questionnaires were used to monitor the acceptability of the interventions and their usage levels. Monitoring was by month, with differences in methodology reflecting the differing intervention mixes and scale in each country, as described in Chapter 3. The pros and cons of these different approaches are brought together in Chapter 9, which examines the research approach. Two sets of questionnaires identified positive and negative impacts which could affect uptake.

Monitoring surveys
Three sets of surveys were completed in each country

- **Round 1:** A baseline pre-intervention survey was conducted on around 200 hundred households
- **Round 2:** A second (post-intervention) survey with a smaller group of households, and four to six community groups was held to ensure that no impacts important to the communities would be missed in the final quantitative questionnaire
- **Round 3:** The third (post-intervention) survey, made quantitative and qualitative measurements on the impact of the interventions

Monitoring smoke

The study used proxy methods to determine the reductions in child mortality that could be expected for a given population from a measured reduction in carbon monoxide (CO), as direct health measurements are not viable in a study of this size.

The health of mothers is very closely associated with the well-being of their young children, and the research focused on the health of the cook (usually the mother), using similar proxy methods as well as questionnaires and monitoring.

Dissemination

Different approaches were adopted to target various audiences; these will be described in detail throughout the publication:

- Within the project community, a wide range of media, theatre, promotional materials, exchange visits and group meetings were used to highlight the dangers of smoke.
- At district and national level, smoke forums raised awareness among policy makers.
- Practical Action set up a major campaign to highlight the dangers of indoor smoke.

Collaboration

Collaboration with other development professionals was important both in terms of their inputs into the project, such as support to training and dissemination, and also to ensure that knowledge coming out of the project would be retained within the project communities for the future. This chapter will look at building relationships, raising community awareness, monitoring, and setting up the infrastructure for commercialisation.

Chapter 3: Research activities

Collaboration

Collaboration in Kenya
Links with the Provincial Administration and the Ministry of Culture and Social Services were vital; the Medical Officer of Health for the district provided support, particularly through radio broadcasts on the dangers of smoke; the Ministry of Agriculture, stove manufacturers, and Solar Cookers International supported training activities (solar cooking was one of a range of options made available)

The most important collaboration was between the project team and the 'Community Resource Persons' from the community groups. These individuals will continue to be a vital resource for the promotion of indoor air pollution reduction. These groups, facilitated by the Community Resource Persons, have attended major functions throughout the area, disseminating information directly to several thousand people.

The people elected were already change agents in the community who were addressing many of the community needs. They now form the basis of the infrastructure for continued activities beyond the project end.

The group formed by bringing together the Community Resoures Persons has been instigated at a legal entity 'KIAPNET' – the Kisumu Indoor Air Pollution Network.

The role of the NGO to manage revolving finance and promote clean air has been transferred, during the project, to KIAPNET. KIAPNET has its own bank account, through which to administer the revolving finance for the community groups. It has its own chairperson, secretary and treasurer – none of whom belong to Practical Action. To the end of the project, Practical Action was a signatory to the funds, but responsibility now rests entirely with the group for continuation of the revolving funds.

Community Resource Persons - Kenya
The Community Resource Persons are women and men whom Practical Action have trained in awareness raising of smoke and health problems. They have become the change agents in the community as they continue to train other community members.

Community resource persons live in the community with their potential customers and understand their requirements.

They were elected by the community, using criteria that did not focus on particular skills but were felt by the community to be:
Trustworthy
Prepared to pass on the knowledge learnt through working with the Practical Action team
Willing to represent the needs and aspirations of the community

Since their election, team meetings have been held regularly with the Community Resource Persons to enable them to:

- handle the revolving funds within the community groups
- co-ordinate awareness-raising through local and district activities
- learn improved business skills

Although they were not paid for this role, an incentive scheme around their management fo the revolving finance was put in place, and until it started to yield dividends, they were paid 400 shillings (around £3UK) each time they attended a meeting. This was financed from a small mark-up on each item sold through the revolving finance. A profit-sharing initiative is now in place.

Dissemination to other organisations
Practical Action has been approached by other organisations to provide information and support in Indoor air pollution alleviation activities by other NGOs in the region.

Local policy-level meetings
Clusters were formed to address policy issues around indoor air pollution alleviation: technology development; awareness creation; health; micro-finance; provincial administration.

A two day meeting was held with the Ministry of Health at the Ministry of Public Works, health-focused NGOs, a representative from a children's home, and two representative from the Ministry of Health, Nairobi, from the Child Health Division and the Health Sector Reform Secretariat.

Collaboration in Nepal

At local level, all activities are implemented in close consultation and coordination with District Development Committee (DDC) Rasuwa . The Local Government Act 1991 has given power to the DDC to make district level decisions.

Meetings have been held with other stakeholders; District Hospital, Women Development Organizations, other NGOs, steel suppliers etc. to form a network at district level.

The field research has involved SEARCH NEPAL – a national NGO, through whom the revolving finance was set up. In researching the development of the smoke hood, the team worked with a local consultancy.

Indoor Air Pollution and Health Forum Nepal
This is an important regional forum set up by the project as a legal entity, with Dr. Mrigendra Raj Pandey, one of the foremost authorities on Indoor Air Pollution as Chairman. This Forum has raised the profile of Indoor Air Pollution in Nepal through engagement of policy makers, other NGOs (including Winrock, which has played a very active role), and the media, who have attended the meetings. This Forum will be discussed in more detail later in the publication.

Collaboration in Sudan

Practical Action Kassala involved many partners, particularly NGOs, the State Ministry of Health, the Faculty of Medicine (University of Kassala) and the private sector. Some partner NGOs, particularly ACORD (a large NGO), provided seed money for revolving funds in the Kadugli (Kassala) residential area and other areas. The project partners played a major role in the success of this scaling-up phase of the project. Training and awareness support was given by the State Ministry of Health, Forest National Conservation, Environment Conservation Society, and the Civil Defence.

Where new areas have been involved, such as New Halfa, Khamsa Arab & Elginaid, the Ministry of Health and the Civil Defence Force have worked with women in the local communities, providing knowledge on the dangers of indoor air pollution.

Representative from Nile Petroleum, Medical Officer of Health and Civil Defence representative attending Policy Forum

During the health monitoring part of the work, two staff members from the Ministry of Health wee assigned to the health impact monitoring team.

Private sector involvement
The private sector and particularly the Nile Petroleum Company were approached to cooperate with the project. An important message shared with them is that profit resides in LPG sales rather than cylinders. The company agreed to selling the cylinders on an instalment basis.

Awareness raising

Awareness raising - Kenya

Community meetings and exchanges
Stove promoters and staff from the Ministry of Agriculture collaborated in training on reducing indoor air pollution with community groups from eight sub-locations. These training sessions included information on the dangers of smoke, possible ways to alleviate it, and those attending were encouraged to identify ways in which they themselves could alleviate smoke, and were invited to share their ideas and decide what they would like to use to alleviate smoke. It was during these meetings, *Community Resource Persons* were identified. Exchange visits, where household members visited the homes of those using interventions, were arranged for some of the groups.

A set of community meetings was run specifically for the resource persons – two per community – and these meetings were held approximately two-monthly throughout the project duration. Initially the meetings were used to develop community action plans and set up theatre groups.

Eleven theatre groups, each comprising ten to twelve people shared their community action plans and ideas on ways for reducing indoor air pollution. They identified where and when they would perform their first five performances. Using community mapping, they looked at the whole area, and planned the key locations for promotion within their region. Community action plans included – cooking demonstrations, drama, dance and song, poems.

These groups, facilitated by the Community Resource Persons and Practical Action staff, have attended major functions throughout the area, disseminating information directly to several thousand people.

Since their election, team meetings have been held regularly with the Community Resource Persons to enable them to:

- handle the revolving funds within the community groups
- co-ordinate awareness-raising through local and district activities
- learn improved business skills

Dissemination to other organisations
Practical Action has been approached by other organisations to provide information and support in indoor air pollution alleviation activities by other NGOs in the region.

Local policy-level meetings
Clusters were formed to address policy issues around indoor air pollution alleviation: technology development; awareness creation; health; micro-finance; provincial administration.

A two day meeting was held with the Ministry of Health at the Ministry of Public Works, health-focused NGOs, a representative from a children's home, and two representative from the Ministry of Health, Nairobi, from the Child Health Division and the Health Sector Reform Secretariat.

Awareness raising in Nepal

Home to home visits
Home to home visits were carried out in expanded project areas (Dhaibung, Bhorle, Yarsa, Ramche, Laharepauwa, Jibjibe and Saramthali VDCs) and households were given a booklet raising awareness on indoor air pollution. The household members were made aware of the negative health impacts of indoor smoke and the availability of loans through revolving fund groups to purchase smoke alleviating products.

Exchange Visits:
Exchange visits for potential beneficiaries from neighbouring villages were set up, transporting them to sites where smoke hoods had been installed (Haku Besi, Sano Haku and Nesing villages) to make them aware of the technology and other related aspects.

Community meetings
Community meetings were held regularly to discuss all the main issues around interventions and their implementation.

Hoarding boards for awareness creation
Five hoarding boards were installed in five different places for creating awareness about the dangers of indoor smoke. The hoarding boards were found to be very effective in raising awareness.

Video shows
Village level video shows on the indoor smoke, health and household energy produced by Practical Action Nepal and NEFEF were organized in three villages. The video documentary was also broadcast on TV using a local cable network from the main town of Dhunche in Rasuwa

Community meeting to discuss revolving finance, Haku Besi

District Review and Planning workshops
These were held to raise awareness among district level stakeholders about the project initiative in Nepal, and to build coordination among the district level key players in overcoming the dangers of indoor air pollution. At the final workshop, organized jointly by District Development Committee, Rasuwa and Practical Action Nepal, thirty participants from different political parties, district level Government line agencies, I/NGOs, development programmes and village development committees attended. During the workshop the participants made their commitment to provide the necessary support to the Practical Action Nepal's initiative to make homes free from indoor air pollution.

Awareness raising -Sudan

Awareness raising concentrated on:

- increasing the understanding of the effects of smoke on women's and children's health.
- raising the socio-cultural and economic awareness of using LPG as an alternative cooking fuel, thereby reducing the health hazards associated with biomass.
- Safe use of LPG courses were led by the Civil Defence Force in each area where it was introduced.
- Orientation meetings were held for each new area as it became involved in project. In each area there were two lectures, one on the risks of indoor air pollution to women and children, and the other was about how to use LPG safely.

An agreement with local Radio and TV programs in Kassala provided

- Four dramas using both radio and TV.
- A special programme (Human and Environment) comprising two session were introduced on local TV.
- The project celebrated the Women's International Day by demonstrating the appliances available for provision of clean energy.

National and international dissemination

Kenya
It had been planned to have two routes to disseminate the smoke message via a local forum in Kisumu and a national forum in Nairobi. In the event, just one meeting was held in Nairobi, but the initiative was rather distant from the project work, and did not go forward as had been hoped. KIAPNET, in Kisumu, continues to disseminate messages on the dangers of smoke.

Nepal
Nepal has set up a very successful clean air forum. Starting with a legally registered national forum, the Nepal office was invited, during the South Asia Regional Workshop on Indoor Air Pollution, Health and Household Energy in 2006 to run the regional network for all of South Asia.

Sudan
Sudan produced several TV and radio programmes, reported in other parts of this publication, to raise the profile of smoke throughout the country.

International campaigning
The Campaigning part of Practical Action led a major campaign to raise awareness of the problems of smoke. This work was a direct outcome from the research, and support and information was fed into the campaign from all countries.

Monitoring growth, smoke reduction and impacts

Three rounds of questionnaires were conducted during the research:

Round 1 provided baseline information on up to 200 households per country and comprises a household energy survey and a health survey. The health survey included questions on the lung health of women, and was complemented by lung function measurement, using spirometry. The levels of carbon monoxide on the woman's breath were measured using a breath-CO monitor.
Round 2 was conducted with around six groups and 30 individuals in each country. Its role was to identify those impacts deemed important by the project communities so that they could be investigated in more depth later in the project. It was conducted soon after the interventions had been installed.
Round 3 looked across the whole group at changes in health status, through a questionnaire asking the same questions as in the first round. The household questionnaire sought to identify quality of life impacts, and the costs borne by the household in clean air provision. Lung function and breath CO was monitored again and the changes in all these health measures pre- and post-intervention were analysed using standard medical equipment. The full questionnaires can be found in Annex 1.

Measuring breath-CO in Kenya

Quantitative results were given where possible to identify successful interventions, and to give weight to arguments for policy influence. Interventions were evaluated within around 100-150 of the households that adopted them.

Monitoring smoke
Carbon monoxide was used as an indicator to see if substantial reductions had been achieved and to provide data to determine the reductions that could be expected in childhood respiratory illness. At the same time, the cook was invited to give her opinion on impacts affecting changes in smoke levels, time, income and expenditure, household environment, and any other impacts which were important to her.

As the links between carbon monoxide and particulates had been well characterised for these communities in the first project, only the room levels of carbon monoxide were monitored. It was not considered cost effective to engage in another complete study of particulate and personal monitoring since this relationship was already known. .

Monitoring impact

Health impacts
The main reason for removing smoke in these studies was to improve health for a large number of people, particularly the health of small children. However, it was recognised that the numbers of households involved did not allow for direct health measurements for infants. Instead, the levels of reduction in carbon monoxide were used as a proxy for reduction in the amount of ill-health in children.

Acute lower respiratory infections in children aged under 5 years
Documentation currently in print from the very major 'Guatemala study' (RESPIRE 2006) which proves the link between indoor air pollution and acute lower respiratory infection and which correlates reductions in indoor air pollution with reduced morbidity and mortality in infants has been used for this analysis.

Chronic obstructive pulmonary disease (COPD) in both women and men over 30 years
A detailed before and after questionnaire was used to record the reduction in symptoms associated with COPD for the cook. This was coupled with spirometry measurements before and after the installation of interventions in Nepal and Sudan, and to observe the symptoms in Kenya[4]. The questionnaires were used in all three countries as these provide good measures of the impact of reduced smoke on symptoms.

A second approach, similar to that used to predict changes in ALRI in small children was also adopted. This used the levels of reduction in CO as a proxy, and linked it to the best currently available data.

Other health impacts
Questions were asked about symptoms associated with stove use, including headaches in adults, and symptoms of respiratory illness in children. Questions were asked about burns to establish whether the interventions were helping to reduce the levels of burns in small children.

Measuring other impacts

People will only use interventions if it suits them, so the impacts in terms of time, kitchen environment, and income/savings were monitored. A short mid-project questionnaire targeted a small number of households, and between four and six community groups. The reason for this questionnaire was to ensure that other impacts which are important to the community, but of which the project was unaware, were captured in the Round 3 quantitative monitoring round.

Two changes were made to the third round monitoring. One was to include questions on eye health. Poor eyesight is not life threatening, but in societies where there is little welfare provision, improved sight can impact in terms of both quality of life and income generation. The second was to ask general questions about the main fuels used for cooking meals, making drinks and for other purposes.

Revolving finance

In each country, revolving finance was set up to provide a means for those with little spare capital to access interventions, particularly smoke hoods and LPG stoves. Since less than a dozen people bought these goods outright, the revolving finance records are a good indicator of the growth in demand. This section details the setting up of these funds as they have been the key to increased demand for these appliances.

[4] . This was an experimental approach that was most likely to show *changes* only with the extreme levels of exposure, such as in Nepal. Partly due to time constraints, this monitoring was not done for the final round in Kenya –lung function was measured in the first round. .

Revolving funds in Kenya

Revolving finance is being managed by the community groups, which were supported, until the end of the project, by the project team. Having formed a network KIAPNET, described earlier, Practical Action negotiated to get the group legal status; as a result it can hold a bank account through which it manages the fund.

Almost exclusively, those wishing to buy LPG sets, comprising bottle, burner and gas, use the fund. Smoke hoods have proved less popular, although they have several advantages over LPG in the context of Kisumu.

Seed funding from the project was used to buy both smoke hoods and LPG sets, dependent on demand. No money was therefore transferred to KIAPNET in the first instance. Both hoods and LPG sets cost around KSh4000 (£30UK) to the customer. This comprises:

- Wholesale cost of set: KSh3200
- Mark up to the network for running the network and fund KSh300
- Difference between this price and selling price – around KSh 500 to cover other costs, such as transport

Until June 2007, entrepreneurs had to sell at least 10 complete LPG sets or hoods to be eligible to claim any of the profit, but since this time they have taken responsibility for managing the whole operation and receive 10 per cent of any of the monies they collect.

As 10 per cent of KSh4000 is less than the difference between the price of the stove wholesale and retail, this is a useful incentive and they are aware that if they do not bring in the repayments, there will not be enough cash to service future demand.

As discussed in more detail later in Chapter 5, demand is low but steady, as the cost of the LPG set is perceived to be too high by most people. For the Community Resource Persons, this is not a full time income, but rather that the time they are spending is being rewarded appropriately. They can also make a profit by selling gas, although there is not a large profit margin from this activity.

Revolving funds in Nepal

The modality for the revolving funds was based on community discussions and knowledge of the methods used by Water Aid, and other agencies. Meetings were held to raise awareness about the problems related to smoke and to agree how they would be run. To purchase smoke hoods, households had to form an interested group of at least twenty households, and a membership fee of Rs 200 per household was collected.

The group themselves selected a management committee. The management committee is responsible for the management of the fund (disbursement of the loan, collect repayment, keep records etc.). Members of the fund wishing to install a smoke hood can take a loan from the Revolving Fund and payback the loan on an installment basis to the committee. The management committed would approach Practical Action for seed capital – the amount being dependent on membership.

Implementation was shared between the committee and Practical Action Nepal. A bank account was opened by the revolving fund committee in each village, facilitated through a letter from Practical Action. Each household had to provide an additional Rs800 up-front payment prior to them being eligible for a smoke hood. At this point, Practical Action would transfer the seed capital for the number of paid-up households in the group into the group's bank account. The District Development Committee, which is the development part of local government, will conduct this role in future.

Each committee reached agreement with the members on payment schedule and interest rate. Once the hood is installed, payment from households starts the same month (according to the agreement). Payments are made during the monthly group meetings. The committee

manages the record keeping system. There is a record for each household and a signature from both sides is required to show transfer of payment.

Files are kept on each individual's loan, and both the person repaying the loan and the committee member responsible for collecting the fund signs the book. Repayments are collected during revolving fund meetings. The monthly growth in purchase of smoke hoods has been collated for all the groups.

Practical Action has provided training for all those responsible for the administration of the loan. Before new funds become operational, additional training sessions have been run to which all those administering funds have been invited.

New structures were put in place at the end of the project to hand over management of the funds to the local District Development Committee, which has been engaged with the project team throughout the research project.

Subsidy
Subsidy is almost expected in Nepal for activities of this kind. Many initiatives give away appliances and goods, and it proved difficult even to maintain the subsidy at around 35 per cent. The second marketing survey indicated that the market would drop below 5 per cent if the intervention cost more than NRs3000. The subsidy brought the cost down to NRs3500, and covered the transport costs but little else as steel has to be transported up into the mountains. The hood is an expensive item for households to buy – and failure to provide some sort of subsidy in the first instance would almost certainly have led to the collapse of the project. As soon as the decision to provide a subsidy was made, ways were sought to continue it until such time as it could be phased out.

Subsidy is deposited into the group account when seed money is paid in, and is dependent on the number of households involved. The committee are responsible for paying the manufacturers for the smoke hoods in two instalments. The hood materials are selected by one of the manufacturers and one of the committee to ensure quality, and the committee pays the money to the supplier. Groups combine to purchase steel in order to reduce the cost of transportation and benefit from bulk purchase. Fourteen revolving fund groups are actively involved in providing loans to the members to purchase the hoods.

Revolving funds in Sudan

One of the basic actions taken by Practical Action was the organization of women from displaced communities into groups or Women Development Associations (WDAs). The WDAs received training in many aspects, particularly formation and management of revolving funds. The groups were linked with banks for managing the revolving finance.

Through the revolving funds, WDAs were able to provide their members with tools and equipment for conducting income-generating activities. Almost every WDA has a bank account and the two head offices in Kassala and Gedarif serve as collateral for the branches when a member or group of members are seeking access to credit. Each branch has its own revolving fund system managed by a committee headed by a president.

Revolving funds proved to be a vital element towards improving the livelihood of poor households. The smoke project benefited highly from the available social infrastructure and carried all its activities through the WDAs.

Delivering a batch of stoves to WDA headquarters

All WDAs are trained by Practical Action in the management and organization of revolving funds. Many members benefited from revolving fund services, particularly those running income-generating activities. A lot of women reported having the livelihood of their families greatly improved because of the revolving fund system. Otherwise they would never have access to credit.

The number of people wanting LPG at the outset was very large, and demand has not slowed down. Early management structures were not sufficient to monitor levels of repayment and management costs. A new structure was put in place mid-way through the project that is more transparent and gives greater control.

Management structure - branch level:

- At branch level each new customer has their name, the types of interventions ordered and the total cost recorded.
- A monthly schedule showing all the customers and their loans by month is updated monthly
- A signed receipt is issued to each customer
- A matching card is given to the customer with details of their repayments, marked up at the time of payment.

Management structure - Central WDA level:

- Records of each branch, the number of customers, the size of the loan and the number of appliances was recorded
- A loan agreement between the central WDA and the branch WDAs on the number of appliances delivered for sale, their cost, the downpayments expected and the total value of the loan.
- Once the goods had been delivered, a monthly record is kept of the total payments and downpayments expected each month for each branch
- A record showing all branches, the actual repayments, the planned repayments and the differences.
- All these are compiled into totals for each month of what had been paid against scheduled payments.
- Similar arrangements were made for the gas bottle repayments, as the loan for the cylinders had to be paid back to the gas company.

The results from these actions and the growth in purchase of LPG sets is discussed in Chapter 8.

Chapter 4 Technologies

This chapter provides a broad overview of each of the technologies promoted during the research to clarify the descriptions elsewhere. It does not include the range of no-cost behavioural changes, such as putting lids on pots and keeping children away from the fire.

Kenya technologies

In Kenya, the technologies promoted ranged from low-cost and no-cost technologies through to smoke hoods and LPG sets.

Fireless cookers – basket type

This fireless cooker is providing income generation and well as reducing the amount of time that people have to spend by the stove. The cushions forming an insulated basket into which hot food can be place. The insulation is made from discarded clothes, packed into attractive fabric cushions. An additional benefit is that people report eating more hot meals when they use fireless cookers. .

Fireless cookers – built-in type

In this case the fireless is built adjacent to the built-in Upesi stove so that food can be transferred directly from pot to insulated chamber. [The kettle is shown for scale].

Upesi stoves

Upesi stoves are well-known in Kisumu They are fuel efficient, provide a much cleaner safer working space, and cook quickly and efficiently. Because fuel has to be dry, levels of emissions will go down for those who have not dried fuel in the past. Upesi stoves can be built into a mud fireplace, or clad in metal and used outside in good weather.

Rocket stoves

This type of stove is becoming increasingly well-regarded as it gets rid of smoke through improved combustion. It can also be built at low cost. Research is ongoing into developing a new stove for the region built to ‘rocket stove’ principles to provide a more effective low-cost alternative.

Solar cookers

Although there has not been a lot of demand for solar cookers, they are one of the range of options that has been provided by the research through demonstrations and interaction with a solar cooking promotion NGO. This type of solar cooker retails at around $6US, so is a very low cost option

Smoke hoods and eaves spaces

Smoke hoods are built over upesi stoves in Kenya, allowing the smoke to pass out of the room through a flue. Unlike LPG stoves which are used for some meals, smoke hoods get rid of the smoke at every meal.

Eaves spaces have been shown to remove well over the half the smoke in a room if they are correctly positioned directly above the fire where the stove is against the wall.They comprise a space around 30cm deep the length of the smoke stain on the wall, just beneath the thatch, allowing the smoke to escape rather than curling into the room.

Used together they remove substantial quantities of smoke

LPG sets

Just one type of LPG set was introduced in Kenya to keep down capital cost. The set comprises a 4.6Kg gas bottle on top of which a burner is screwed directly.

The gas bottle is sold by Ken-Kobil, one of only two LPG companies to provide gas in small bottles.

Sudan technologies

LPG was the only intervention selected in Sudan, there was a choice of three stoves, one with two rings, one with three, and one was a better quality stove with automatic ignition. Some households opted to have a gas-powered kisra Sag - a hotplate for making Kisra - the staple food in some communities.

Left: Three ring stove with gas bottle stored safely beneath

Middle: Two ring stove

Right: Kisra Sag

Nepal technologies

Smoke hood

The smoke hood is the major technological change in Nepal.

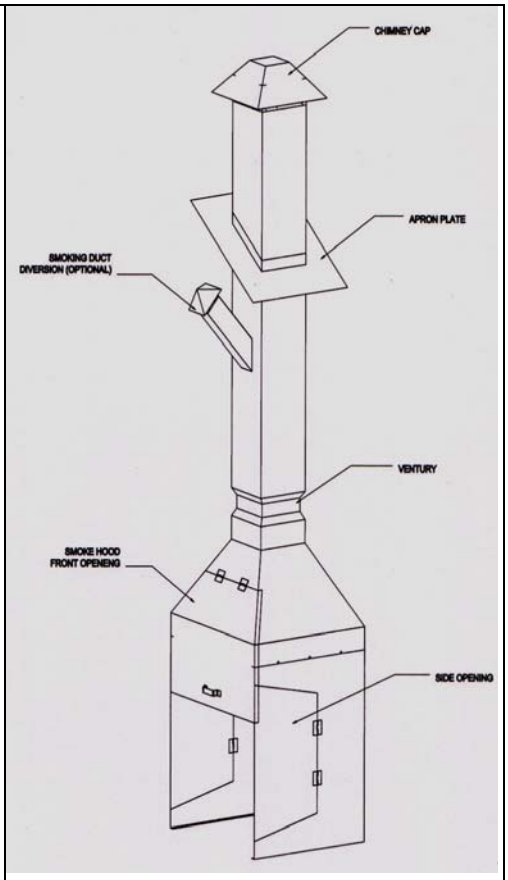
The side openings allow for the hood to be opened when it is fully burning during cold weather, so that other fires are not lit to keep warm.

The smoke duct at the top of the flue allows smoke to be routed into the roof space to protect roof timbers and get rid of pests in the grain stored up there.

The front opening allows tall pots to be put in place for cooking animal feed and brewing. However, it is recommended that once tall pots are place, the hood is used in the closed position.

The venturi closure is currently being developed to reduce blow-back from the wind (work in progress)

The apron plate extends to the top ridge to prevent ingress of water (innovation from original design).

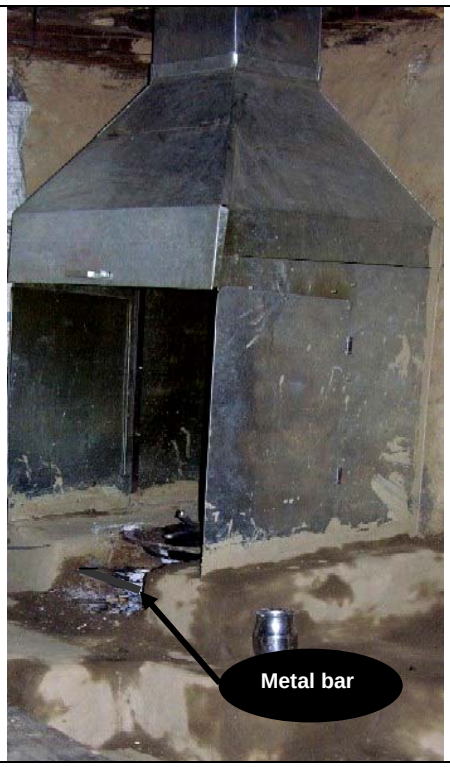


Other interventions

The smoke hood is the major intervention, built against the wall, and beneath it the traditional tripod stove has been surrounded by a mud base.

Wall insulation
The walls were originally of dry stone and lacked insulation. Wind would blow through them bringing dust and dirt. During cold weather there were major heat losses. Now that the walls are plastered, less fuel is needed to heat the house and the intervention has been widely adopted

Tripod stove
Very little change has been made to the tripod stove, but a bar at the front allows primary air to reach the burning fuel, and the tripod has been surrounded by mud, onto which the smoke hood walls are attached.



Chapter 5: The effects of interventions on indoor air pollution

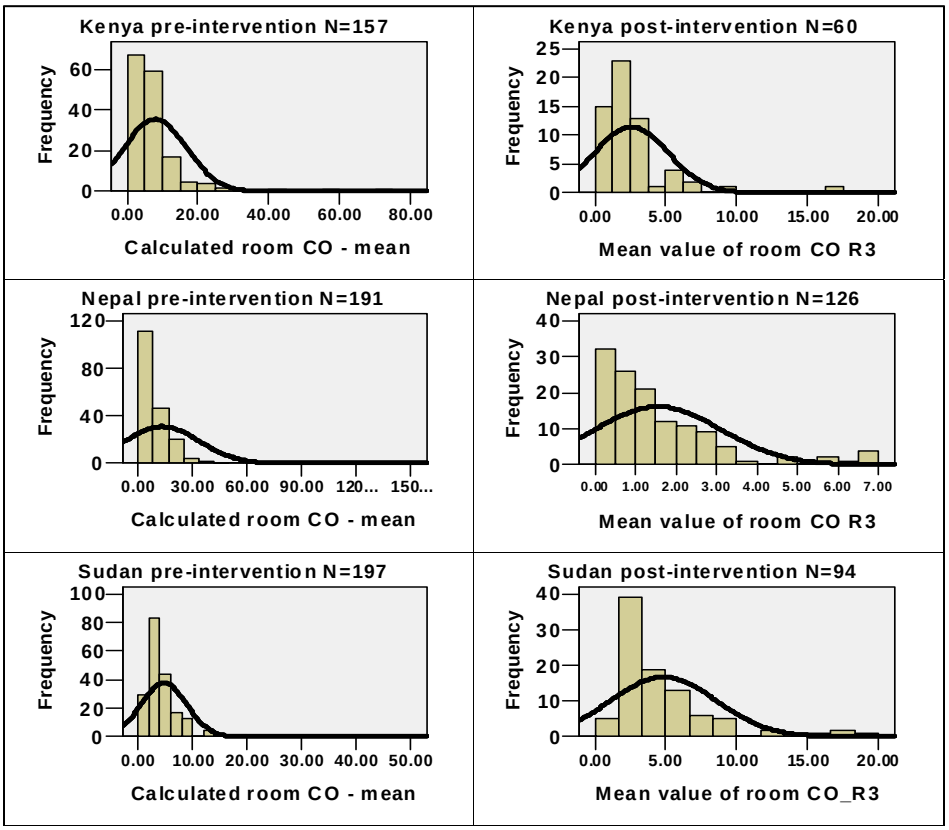
Introduction

Although this study is largely about reaching large numbers of households, the research is focused on contributing to Goal 4: Reduce child mortality. In the earlier study, a set of interventions was agreed through participative measures, to alleviate kitchen smoke. This second study looks at ways to make such interventions available to large numbers of people. However, it was necessary to ensure that the interventions remained effective, and that people were continuing to use them. It was shown that carbon monoxide (CO) is a good proxy for biomass fuels, or for very clean fuels, where residual sources of biomass show that mixed fuels are being used, or that there are other sources of pollution, such as auxiliary fires or polluting lamps, which are causing the pollution.

Distribution of pollutants

The distribution of CO was found to be skewed in all three countries, both pre- and post intervention. For reasons explained in other parts of this publication, not all households were tested for CO in the post-intervention round. All households have been shown for both rounds for CO distribution curves. Figure 5.1 illustrates the skewed nature of the distributions of CO. Comparative data for pre- and post-intervention levels of CO are given in the subsequent tables.

Figure 5.1: Skewed distribution of pre- and post-intervention distributions of room CO



For purposes of comparison and ease of interpretation, both means (and 95 per cent confidence intervals) and medians (and inter-quartile ranges) are reported in the following tables. Means have been compared with paired t-tests, and distributions with Wilcoxon paired signed rank sum tests. This section contains data for the main pollutants with data is matched for pre-intervention to post-intervention for all matched households.

Comparison of levels of CO: Pre- and Post-intervention

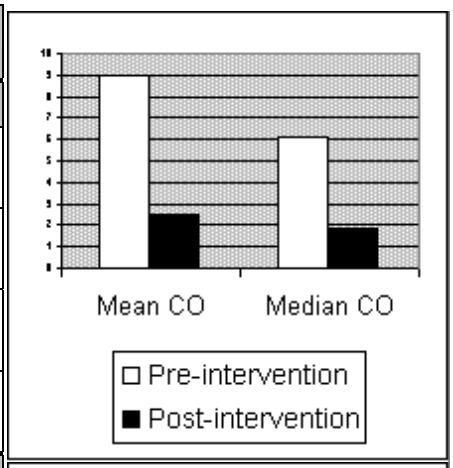
This table refers to the mean and median concentrations (in ppm) for carbon monoxide (CO) measured over 24 hours and recorded for a matched number of households for pre- and post-intervention rounds. The median value relates to the median value of all household means, *not* the mean of all household medians.

Reduction in 24 hour levels of CO

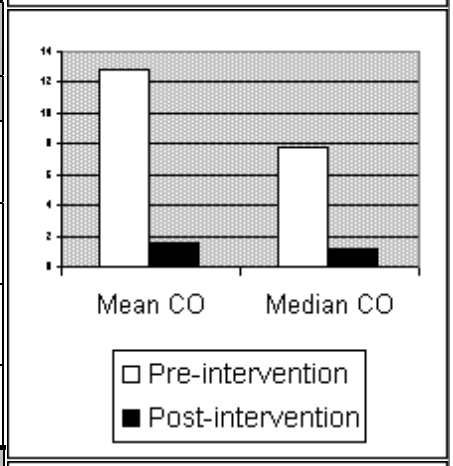
The Kenya change is around 70 per cent reduction for both mean and median. In Nepal it is around 85 per cent-90 per cent. This accounts for both cooking and background levels. In Sudan, the slightly raised value for both mean and median reflects the high level in use of charcoal – which produces a lot of CO but far less particulates.

Table 5.1: Pre- and post-intervention room means and medians

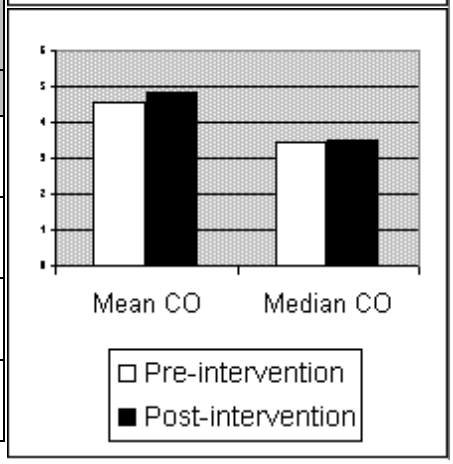
Kenya: Room CO (N=59)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
8.99	1.32-27.60	2.51	0.23-7.00	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
6.08	3.31-9.29	1.88	0.99-2.95	p<0.0005



Nepal: Room CO (N=124)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
12.82	3.68-30.16	1.56	0.13-5.87	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
7.78	5.53-12.87	1.11	0.49-2.06	p<0.0005



Sudan: Room CO (N=94)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
4.56	1.02-12.51	4.83	1.46-14.56	0.464
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
3.47	2.73-5.13	3.48	2.59-5.92	0.43



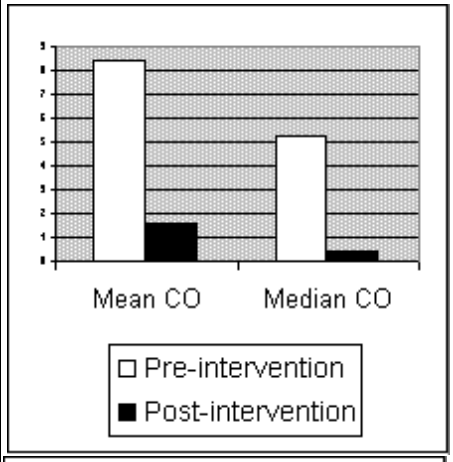
@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Paired Signed Rank Sum Test (non-parametric)

Room CO>3ppm

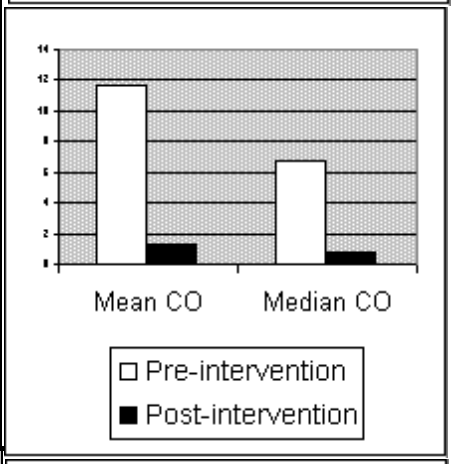
When cooking is not taking place, background levels can remain within the kitchen. A level of 3ppm is low, but has been noted during the studies. During the first study, there was some concern that this might be a machine effect. The effect of looking at CO > 3ppm makes little difference to the final outcome- tending to give a stronger percentage reductions of around 80 per cent-90 per cent in Kenya and over 90 per cent in Nepal. For this reason, raw data will be used in the analyses, as this is the more conservative data.

Table 5.2: Pre- and post-intervention room means and medians for CO>3ppm

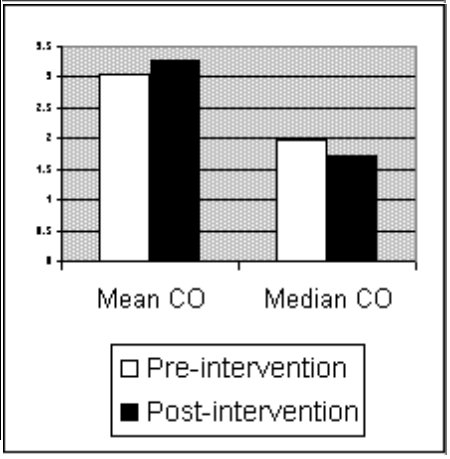
Kenya: Room CO>3ppm (N=59)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
8.38	0.95-26.76	1.56	0.00-6.76	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
5.28	2.57-9.17	0.41	0.08-2.03	p<0.0005



Nepal: Room CO>3ppm (N=124)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
11.72	1.69-29.13	1.25	0.01-5.65	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
6.68	3.93-12.34	0.76	0.17-1.75	p<0.0005



Sudan: Room CO>3ppm (N=94)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
3.06	0.33-11.37	3.26	0.03-14.56	0.632
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
1.99	0.73-3.71	1.71	0.52-4.68	0.81



@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Paired Signed Rank Sum Test (non-parametric)

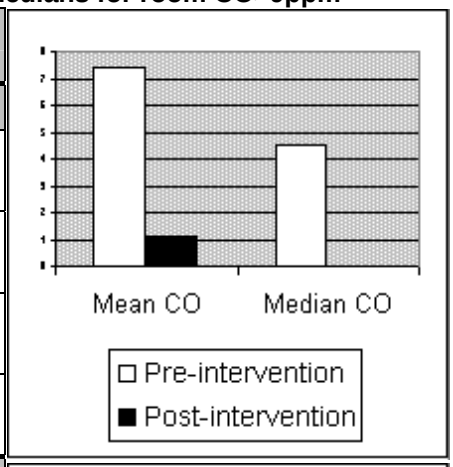
Room CO>9ppm

This measure looks at what is happening when cooking is taking place. It is very unusual to have CO>9ppm when the stove is not in use. The effect of looking at CO>9ppm must be viewed with care as the results are averaged over 24hours – thus the higher the number, the larger the CO_hrs that are being experienced in the room.

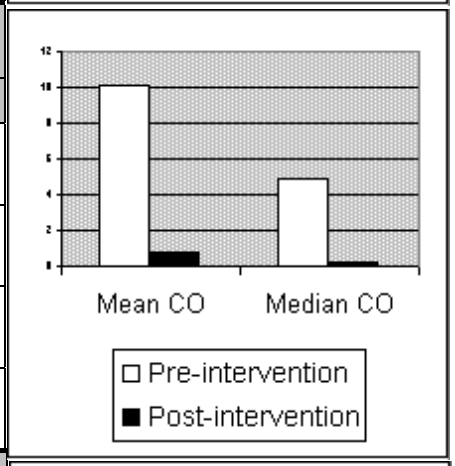
These values could be either a few very high values considerably greater than 9ppm or a lot of values just greater than 9ppm. The bar charts are indicative, however, of whether CO levels are reduced during cooking periods. It can be seen that for both Nepal and Kenya, reductions are very substantial. The Sudan results are again dominated by charcoal use.

Table 5.3: Pre- and post-intervention room means and medians for room CO>9ppm

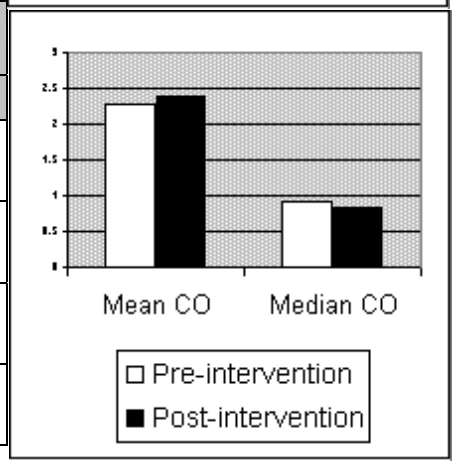
Kenya: Room CO>9ppm (N=59)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
7.44	0.27-26.14	1.11	0.00-5.40	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
4.55	1.65-8.20	0.02	0.00-1.36	p<0.0005



Nepal: Room CO>9ppm (N=124)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
10.1	0.19-28.59	0.77	0.00-4.57	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
4.9	2.25-10.61	0.17	0.02-0.99	p<0.0005



Sudan: Room CO>9ppm (N=94)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
2.29	0.00-9.90	2.39	0.00-11.72	0.789
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
0.91	0.26-2.53	0.83	0.10-3.25	0.86



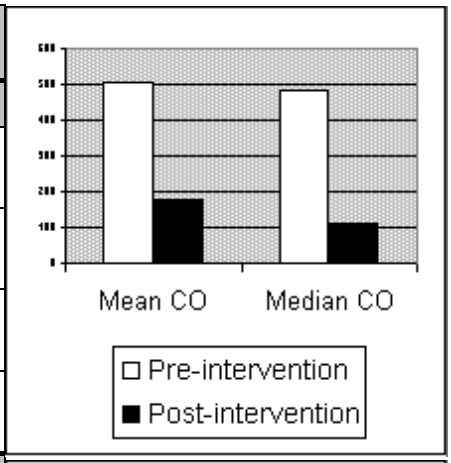
@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Paired Signed Rank Sum Test (non-parametric)

Time for which CO levels are elevated

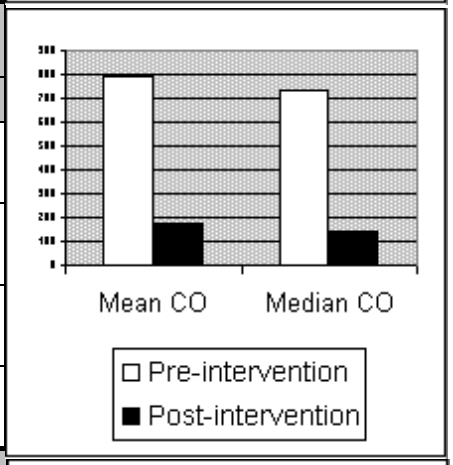
Number of minutes with room CO>3ppm
This measure suggests that in Kenya and Nepal, not only is the level of smoke being reduced, but also that once it is produced, it is dissipated much more quickly. The levels of residual CO exposure in Sudan remain of concern, particularly as households have a real desire to move to a cleaner fuel. It must be stressed, however, that this level of CO does not imply that particulate levels have not reduced.

Table 5.4: Number of minutes when room CO>3ppm

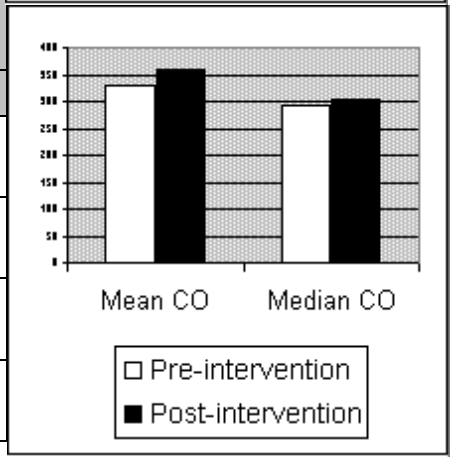
Kenya: Mins room CO>3ppm (N=59)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
508	18-909	178	0-672	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
483	351-642	111	24-261	p<0.0005



Nepal: Mins room CO>3ppm (N=124)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
789	347-1431	179	3-520	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
734	595-920	144	45-265	p<0.0005



Sudan: Mins room CO>3ppm (N=94)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
329	50-896	360	8-1158	0.356
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
291	140-426	302	120-510	0.49



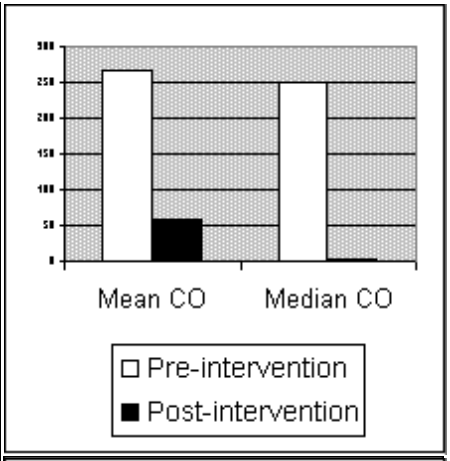
@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Paired Signed Rank Sum Test (non-parametric)

Number of minutes with room CO>9ppm

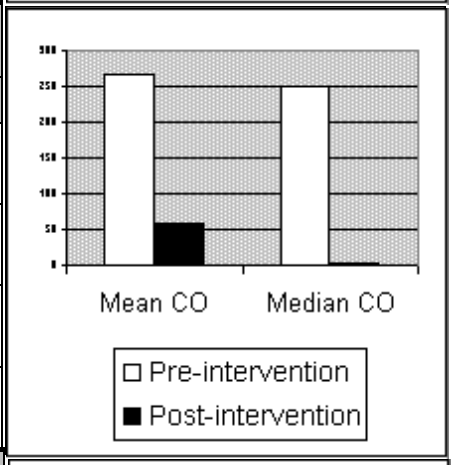
These graphs clearly illustrate that in Kenya and Nepal, CO produced during the cooking of meals is dissipated much more quickly by the measures that have been taken. Although the immediate effects of the interventions may be to remove CO more quickly than particulates, the magnitude of the change requires that a substantial proportion of the smoke has been removed. See discussion at the end of this chapter for the elevated levels in Sudan.

Table 5.5: Number of minutes when room CO>9ppm

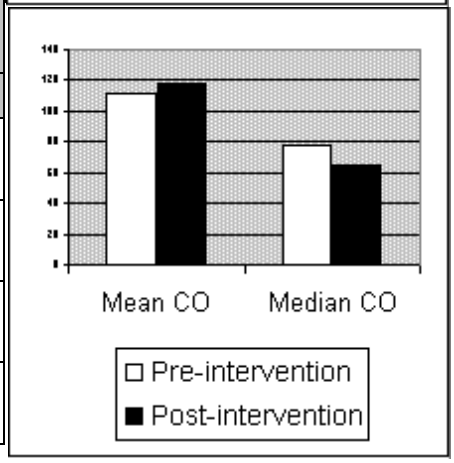
Kenya: Mins room CO>9 (N=59)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
267	27-591	59	0-273	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
249	135-390	3	0-99	p<0.0005



Nepal: Mins room CO>9 (N=124)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
367.23	21-815	56	0-302	p<0.0005
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
324	177-524	18	Mar-77	p<0.0005



Sudan: Mins room CO>9 (N=94)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
111	0-348	118	0-479	656
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
78	24-156	65	12-200	0.78



@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Paired Signed Rank Sum Test (non-parametric)

The effect of charcoal on room CO post-intervention - Sudan

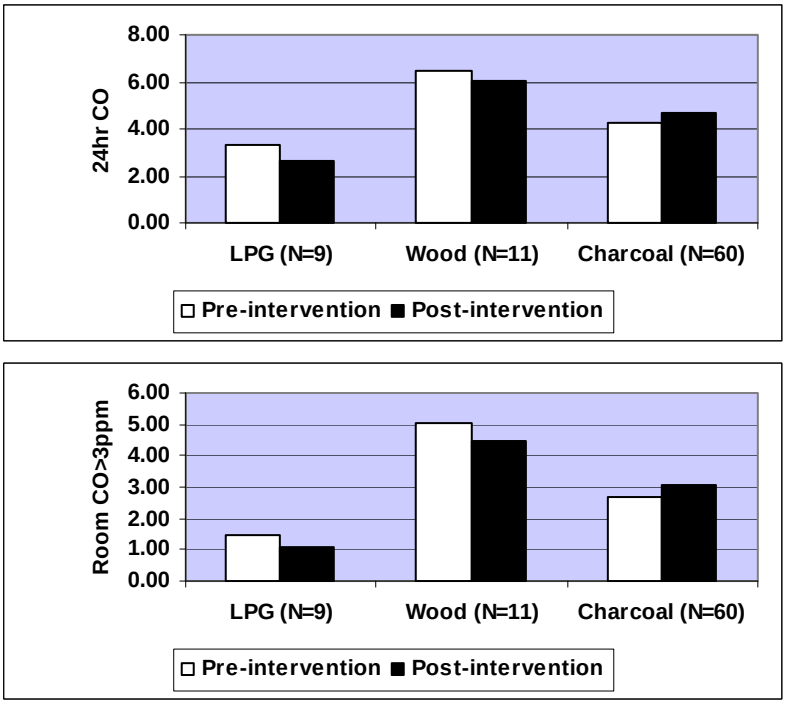
The interventions selected in each country suggested that either biomass fuels would be burnt, unchanged, or that people would move to LPG. In the event, for reasons that will be discussed in Chapter 8, the majority of study households in Sudan opted for charcoal for most of their cooking. As a result, the levels of CO are very high. They do not relate to the levels of particulates. If this outcome had been foreseen, direct measures on particulates could have been undertaken for a sample. Since the emissions from both wood and charcoal are well-characterised, an assessment of the levels of particulates can be made.

Because of the remaining high levels of pollutants, further analysis of the data was conducted for the post intervention round, looking specifically at the main fuel used for cooking during the monitoring period during the post-intervention phase. Matched pre- and post-intervention data used.

Because a much larger sample of people cooking using charcoal (N=60) will have had a strong influence on the overall means. Note that only one household used a single fuel during the day of monitoring. This meant that the reductions due to LPG use were much smaller than if it had been used for all cooking purposes.

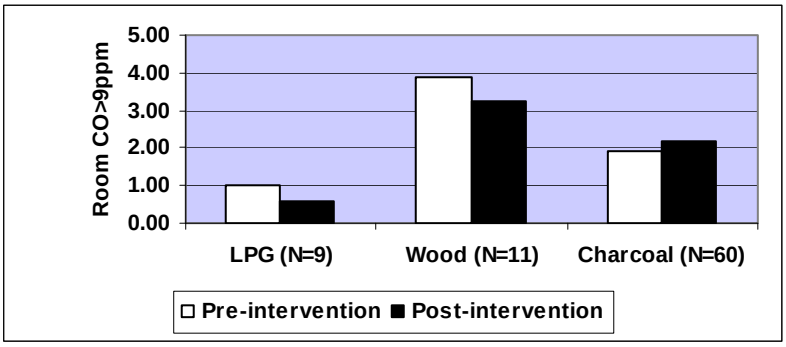
The effect of charcoal was evident whether one looked at the raw CO data, or where CO>3. In both these cases, the mean levels of CO rose from pre-intervention to post intervention when measured over 24 hours. For both LPG and wood as the main fuel, levels of CO decreased in Round 3.

Figure 5.2: Pre- and post-intervention room CO and room CO>3 by fuel



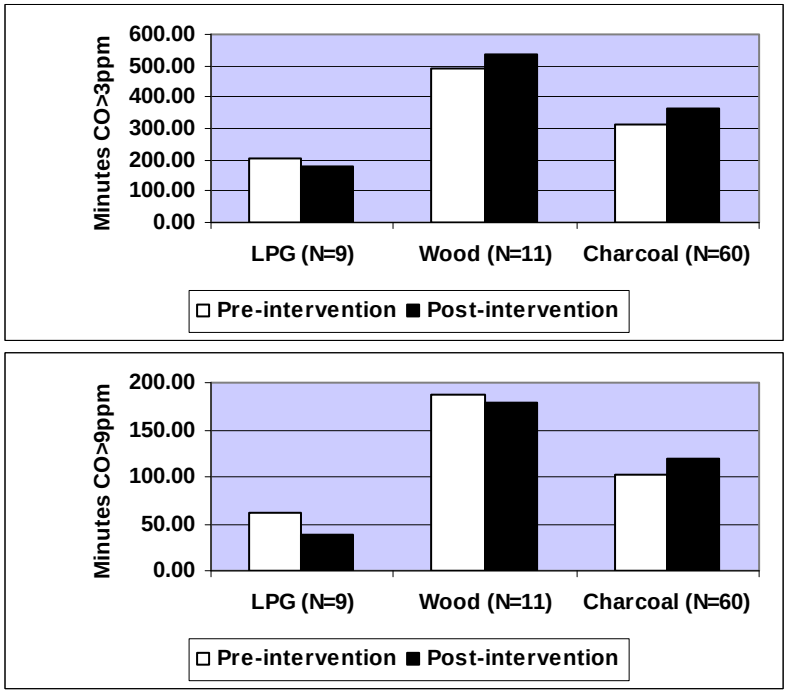
During cooking periods, 24-hr levels of CO (where room CO>9) were again seen to rise in the post-intervention monitoring, but only where charcoal is the main fuel.

Figure 5.3: Room CO>9 by post-intervention fuel type



The time during which levels of CO persisted were seen to increase post-intervention for both charcoal and for wood, whereas only for charcoal were high levels of CO (>9ppm) increased post-intervention.

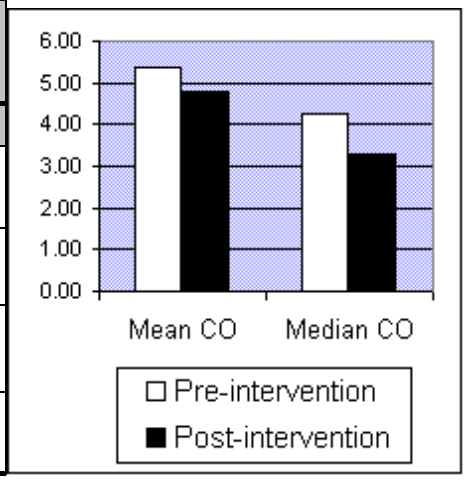
Figure 5.4: Minutes when CO>3 and CO>9 by post-intervention fuel type



Based on these findings, the data was analysed excluding all charcoal users in the third round, but matching the data for all the other households. Although biomass still forms a part of this group, the effect of removing charcoal burners shows a small but significant improvement. This indicates that the use of charcoal is the cause of the elevated CO levels.

Table 5.6: Reductions in CO for non-charcoal using households

Sudan - excluding charcoal (N=31)				
Pre-intervention		**Post-intervention**		**Sig.**
Mean	**95 per cent CI**	**Mean**	**95 per cent CI**	**p-value***
5.35	3.89-6.81	4.81	3.26-6.35	0.0004
Median	**IQR@**	**Median**	**IQR@**	**p-value+**
4.24	3.05-5.75	3.27	2.51-5.44	0.35

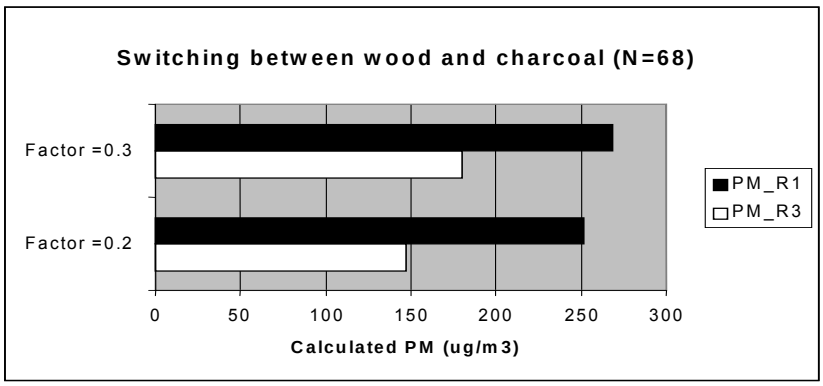


@Inter-quartile range
*Paired t-test (parametric)
+Wilcoxon Paired Signed Rank Sum Test (non-parametric)

The impact of charcoal on levels of particulates

Laboratory tests (Aprovecho Institute) indicate that charcoal emits approximately 20-30 per cent of the respirable particulates (PM) for the same amount of carbon monoxide emitted using fuelwood. It is the particulates, rather than the carbon monoxide, that are believed to cause respiratory disease. The emissions for those households switching from wood to charcoal, or vice versa, between Round 1 and Round 3 were measured for matched households. From this, the approximate levels of particulates were calculated, looking only at the primary fuel, and omitting those households for which either woodfuel or charcoal was not their primary fuel, omitting households using clean liquid fuels in Round 3 from this calculation. This conservative approach nevertheless shows a marked decrease in the amount of room particulates for both 20 per cent and 30 per cent wood/charcoal ratios.

Figure 5.5: Effect of switching between wood & charcoal



Health and other impacts impacts

In this chapter, numeric data on the reduction in levels of pollutant was recorded. Two specialist chapters (Chapter 10 and Chapter 11) discuss the potential health outcomes from these reductions, and provide a cost-benefit analysis based on levels of reduction and the number of households that reduce their kitchen smoke.

Impacts other than smoke alleviation and healths are important, not only in themselves, but because the attributes that are important to the household may be completely unrelated to health. If they, nevertheless, persuade a household to reduce their levels of indoor air pollution, they will produce the same result – less pollution and consequent improved health. These impacts are recorded by country in Chapters 6 – 8.

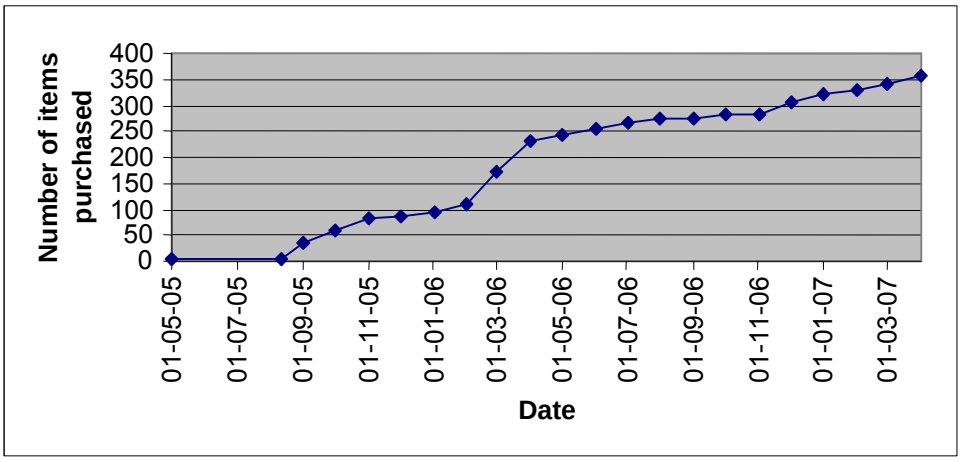
Chapter 6: Research findings and impacts: Kenya

Monitoring growth

For those interventions where revolving finance was needed, the growth in their uptake was measured through the take up of revolving finance and level of repayments. These interventions were either smoke hoods, or LPG stoves. Not many households adopted smoke hoods in comparison to LPG stoves. The implications of this will be discussed later in this chapter.

Figure 6.1 illustrates that the rate of growth is slow, but there is finance available for those who wish it to adopt the higher cost interventions. The women who run KIAPNET and who supply the technologies are part of the community, so the rate of adoption is managed to suit the households. Over 350 households have already availed themselves of the revolving finance schemes created by the project to buy either LPG sets or smoke hoods.

Figure 6.1: Numbers of items purchased by month using revolving finance



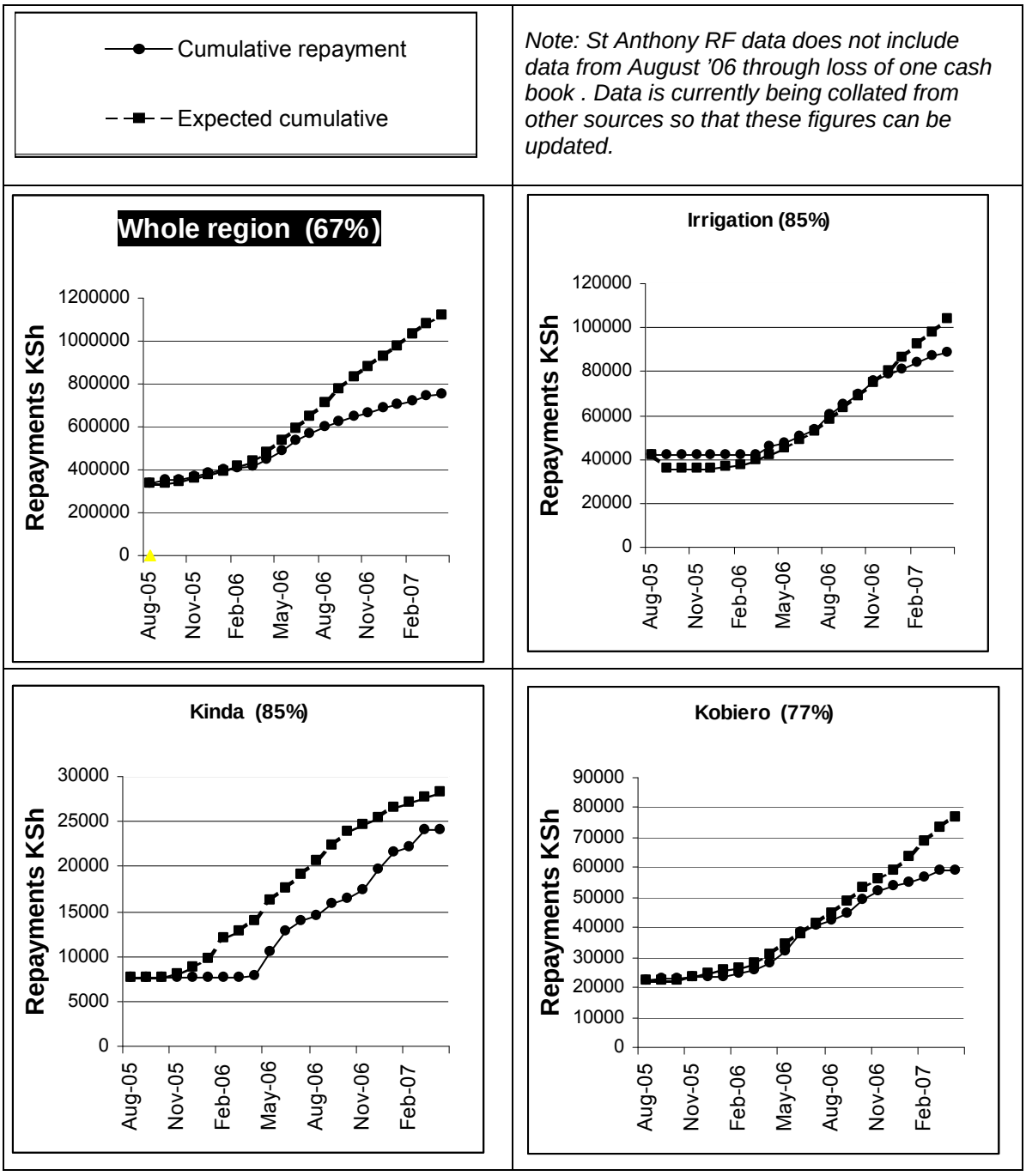
There are no households that are deliberately not repaying loans, but with levels of poverty so high, other needs, such as food, will be prioritized by households.

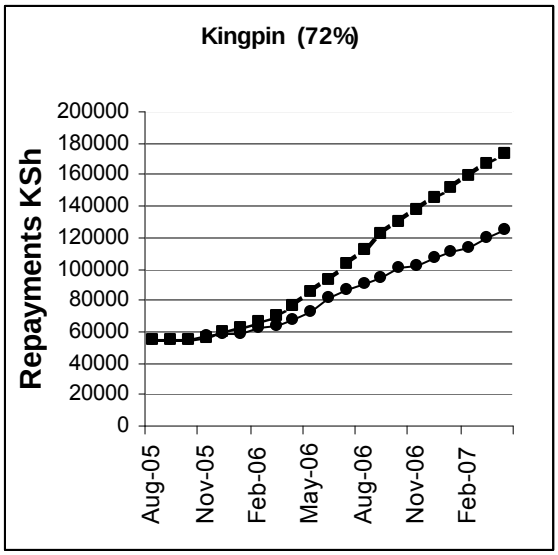
As one of the Community Resource Persons explained at a community meeting: 'If one goes and knocks on the door, then people will feel that they should pay their installment – whereas if no-one knocks, then they are likely to spend it on another more pressing need'.

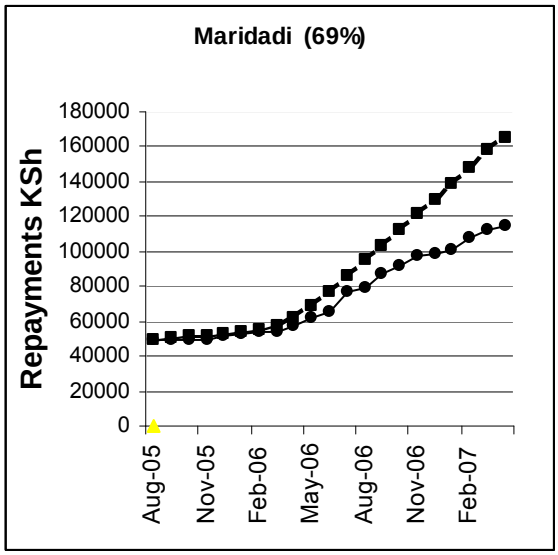
Figure 6.2 shows levels of repayment in each district. The model for repayment is based on a twelve-month payback period, which is longer than the six-to-ten month repayments envisaged by the community groups themselves. However, it appears that the target of full repayment is more likely to be met with a more realistic goal.

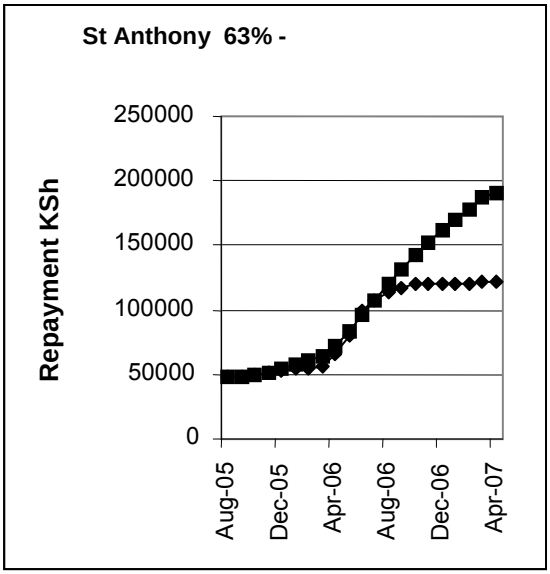
There are currently twelve revolving funds in action in and around Kisumu town which are run by community groups already in existence prior to the research project. Where there are two savings groups in a particular district (such as 'Irrigation' group in Figure 6.2), data have been merged. To join a fund, there is a downpayment, and records are kept of each subsequent payment. The Community Resource Person collects the repayments on a monthly or two-monthly basis – a receipt is given to the household using duplicate receipt books, and the money record is centralized for each fund. As the cost of smoke hoods and LPG sets is very similar, the rate of repayment directly matches the number of items purchased through revolving finance. It can be seen from Figure 6.2 that the growth has been steady in all but one district, Got Nyabondo, in which the initiative failed to take root and has subsequently been dropped by mutual agreement. The 'Whole Region' data includes the Got Nyabondo data, but since only a small number of people accessed the funds, it does not make a substantial difference to the overall percentage repayment.

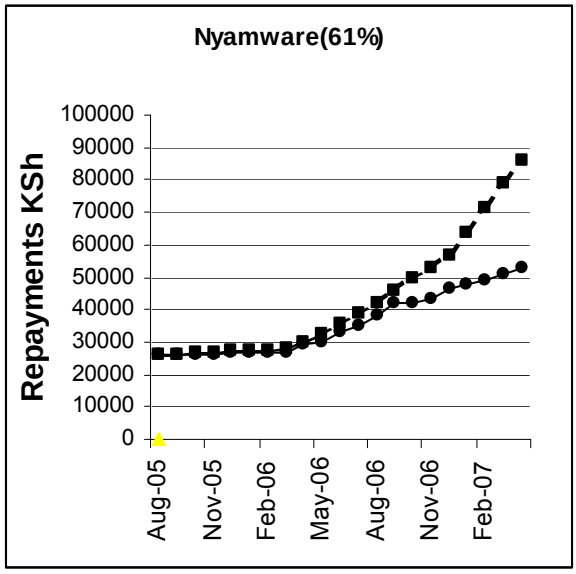
Figure 6.2 Actual cumulative repayment and planned cumulative repayment by revolving fund group

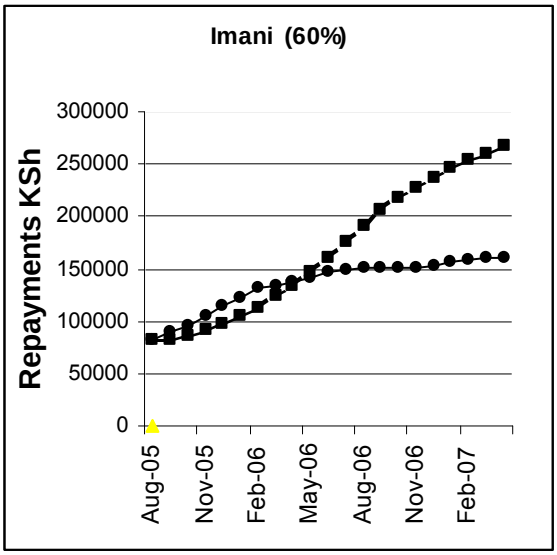


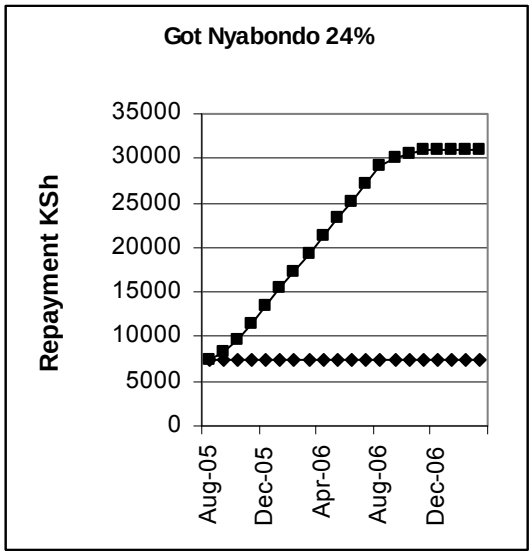

Kingpin (72%)
Repayments KSh
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07


Maridadi (69%)
Repayments KSh
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07


St Anthony 63% -
Repayment KSh
250000
200000
150000
100000
50000
0
Aug-05
Dec-05
Apr-06
Aug-06
Dec-06
Apr-07


Nyamware(61%)
Repayments KSh
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07


Imani (60%)
Repayments KSh
300000
250000
200000
150000
100000
50000
0
Aug-05
Nov-05
Feb-06
May-06
Aug-06
Nov-06
Feb-07


Got Nyabondo 24%
Repayment KSh
35000
30000
25000
20000
15000
10000
5000
0
Aug-05
Dec-05
Apr-06
Aug-06
Dec-06

Other interventions

Figure 6.3: Relative cost of interventions

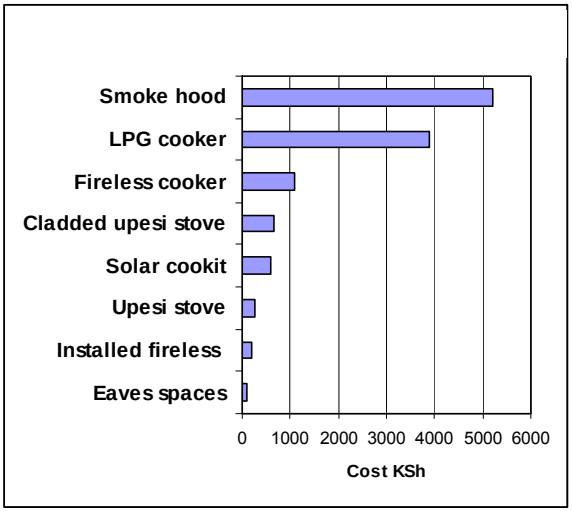


Figure 6.3 illustrates the difference in purchase price of low- and higher cost interventions. In Kisumu, lower-cost interventions play an important role. Not only do they remove much of the smoke, but they also serve as a stepping stone along which a household can travel before adopting the more expensive interventions(which tend to be more effective, and/or have other attributes such as ease of use).

It was not possible to monitor the adoption of these less costly options as many of them have been adopted naturally, with households building their own fireless cookers, or creating eaves spaces. Changes in use of energy for lighting were negligible.

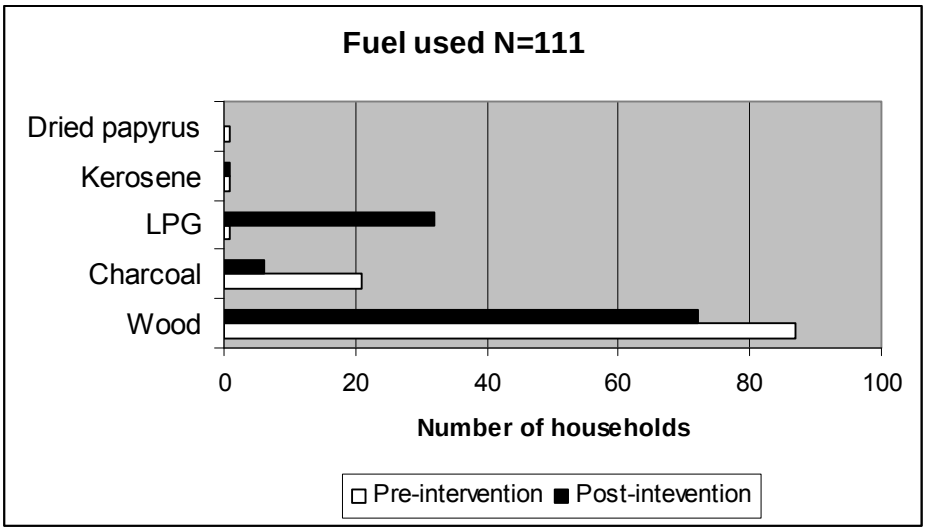
Chapter 5 provided numeric data on the reduction in levels of pollutant and on health impacts. In this section we look at other impacts recorded by the project household members on changes that have come about as a result of the research.

Impact on stoves and fuel

Changes in fuel patterns

There have been marked changes in the use of fuel among the project households – most noticeably the adoption of LPG by around 30 households. Households using LPG appear to come equally from those burning woodfuel and charcoal

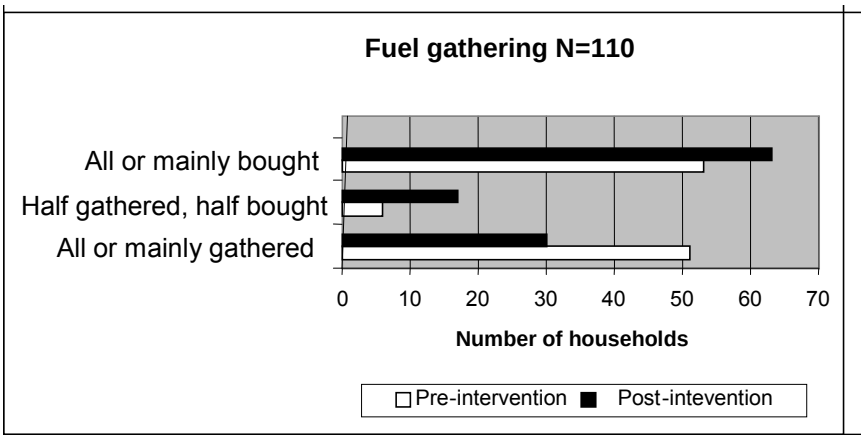
Figure 6.4: Changes in fuel use patterns pre and post-intervention



Fuelwood gathering

There is a reduction in the number of households gathering fuel, whilst more households are part-buying and part-gathering. Overall, the numbers gathering all their fuel has dropped substantially.

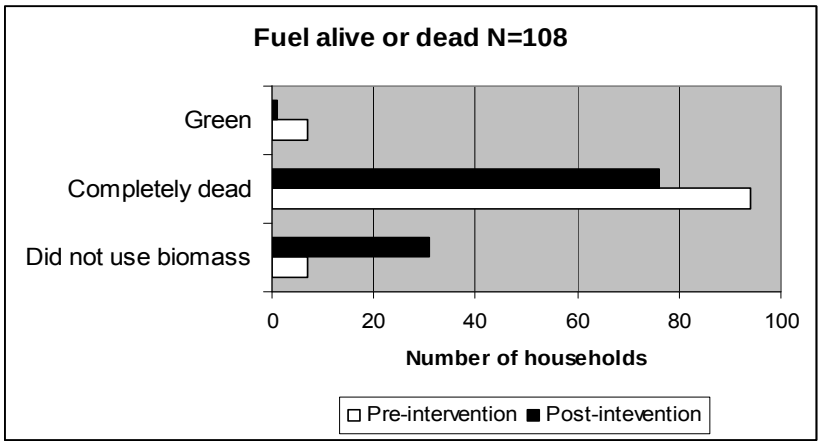
Figure 6.5: Number of households buying and purchasing fuel

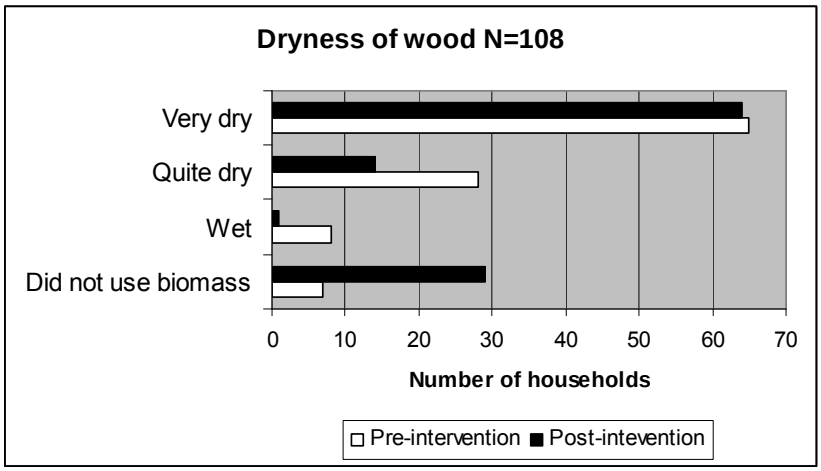


Fuel dead and dry

The use of green fuel can be even more damaging than wet fuel as the water in the live wood has to be be driven off, and this uses up a lot of energy. During this time the temperature of the fire stays low, and more smoke is created. Among the many who continue to use woodfuel, virtually all use wood that is both completely dead and completely dry. Upesi stoves only work well with very dry fuel, thus encouraging households to dry their fuel well; this reduces smoke.

Figure 6.6 Fitness for burning – households using dry/wet wood and live/dead wood

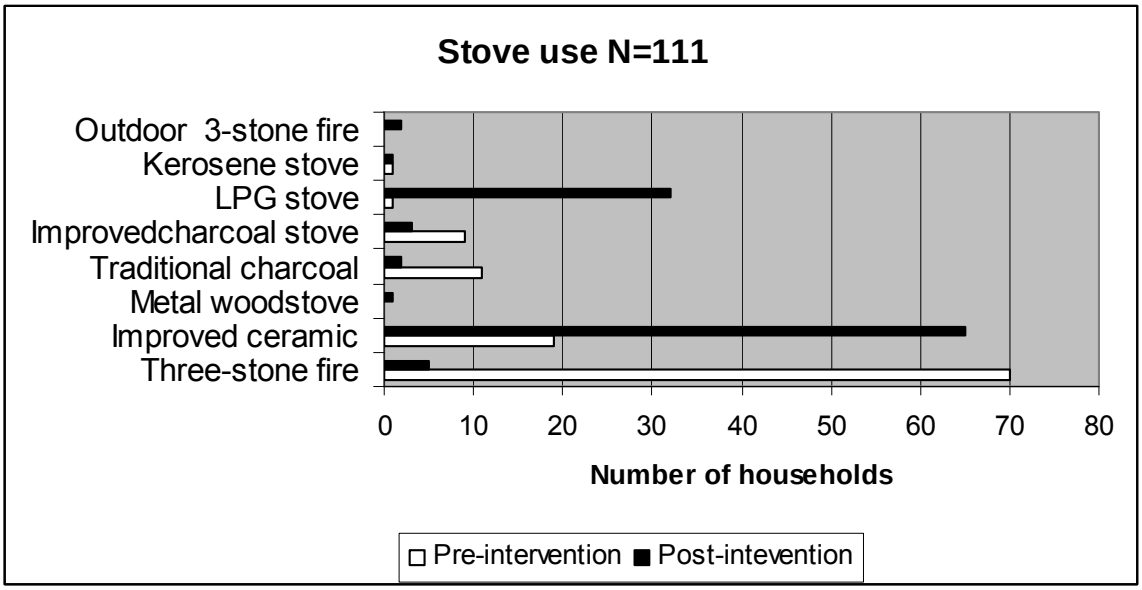




Main stove in use during the monitoring period

There is a big move away from the three-stone fire to cleaner and more efficient technologies. Over thirty households in this sample have shown that they can afford the fuel costs for LPG. This is partly due to the use of the fireless cooker into which hot food is placed to continue cooking without further energy inputs. Technologies, such as the improved ceramic (upesi) stoves, allow households to save on woodfuel and thus save costs.

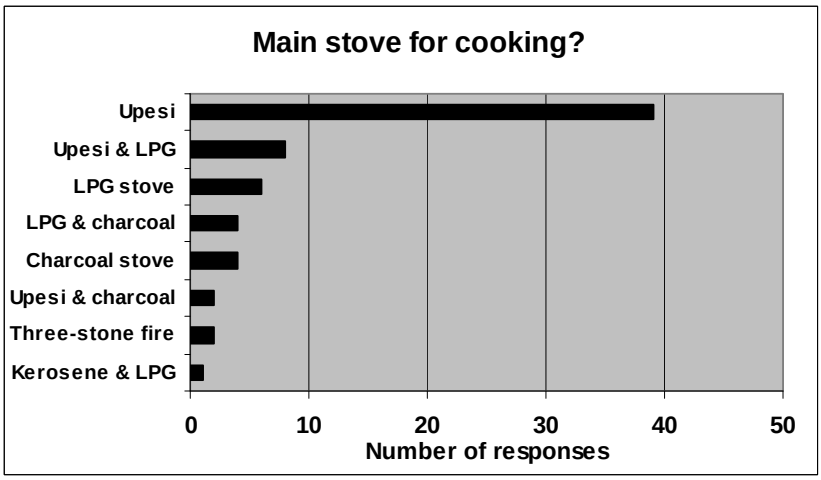
Figure 6.7:Changes in stove use



Main stove usually used for specific activities

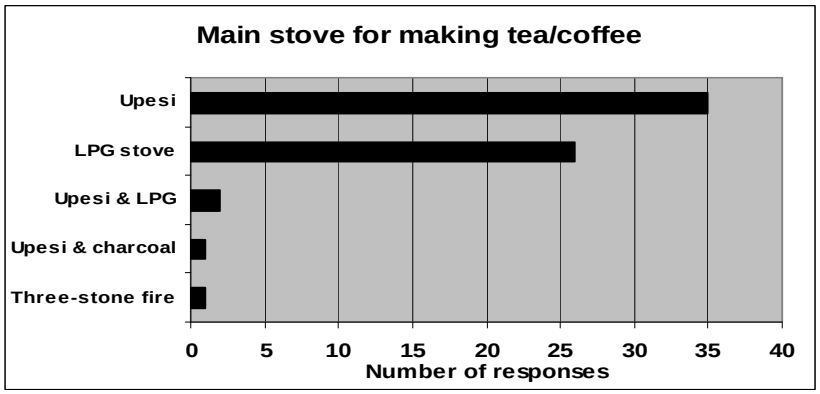
Households in Kenya often use more than one stove – selecting the appliance to match the task and their income. For this reason, questions were asked on which stove was used for three basic tasks: cooking meals (Figure 6.8), making tea/coffee (Figure 6.9), and for any other cooking tasks (Figure 6.10). Many of those who bought LPG stoves still use it only for part of their main cooking tasks.

Figure 6.8: Main stove used for cooking



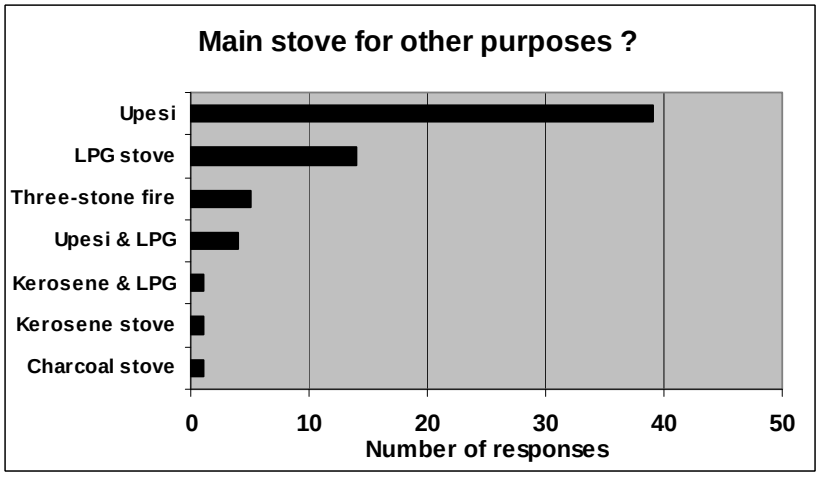
LPG is used in many more households for quick tasks such as tea and coffee making. Since most emissions happen early in the cooking cycle, this is an effective means of reducing emissions (Figure 6.9).

Figure 6.9: Main fuel used for making tea / coffee



What is noticeable is the almost complete absence of the three-stone fire - virtually only used for 'other tasks', and by a small number of households.

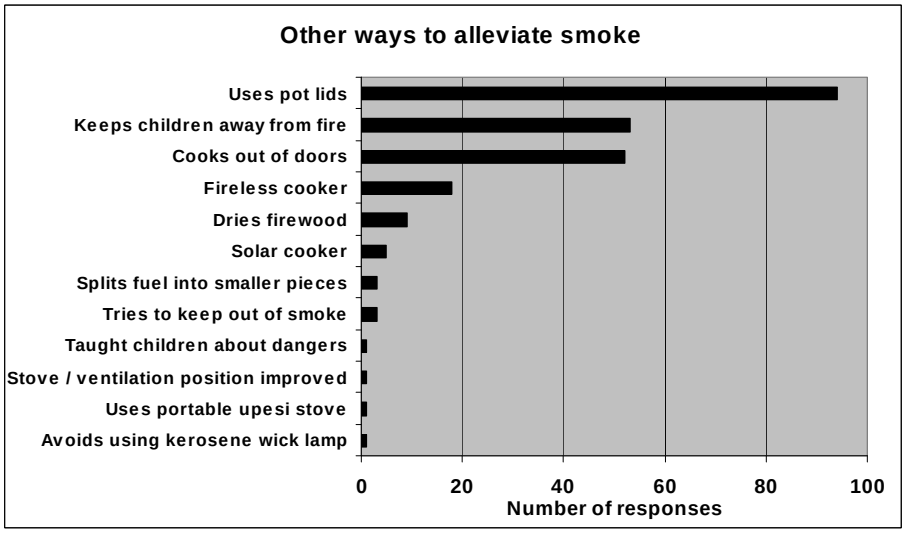
Figure 6.10: Main fuel used for other purposes such as water for washing etc.



Other ways of alleviating smoke

Because of the high levels of poverty, interventions that were no-cost or low-cost were popular. Pot lids are a particularly popular action.

Figure 6.11: Other reported methods for smoke alleviation



Project impacts

General Indicators

The indicators reflecting changes in gender equality are best seen in the open questions asked to the woman on the key benefits and problems which she herself identified. The questionnaire provided women with the opportunity to reflect what they regarded as the key impacts – both positive and negative. The questions were open questions, and they were compiled and standardised after the monitoring was complete.

These questions were the first in a set looking at the impacts of the work, so that the responses would not be influenced by later enquiries. These tables reflect very clearly the opinions of the cooks – *and what matters most to them*.

Figure 6.12 – Major benefits of intervention

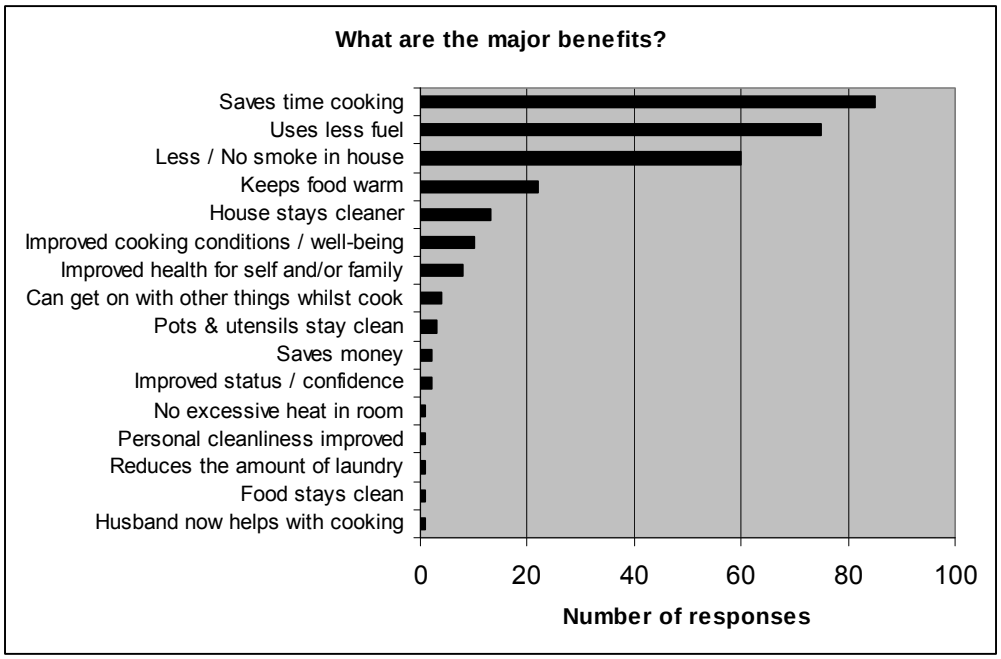
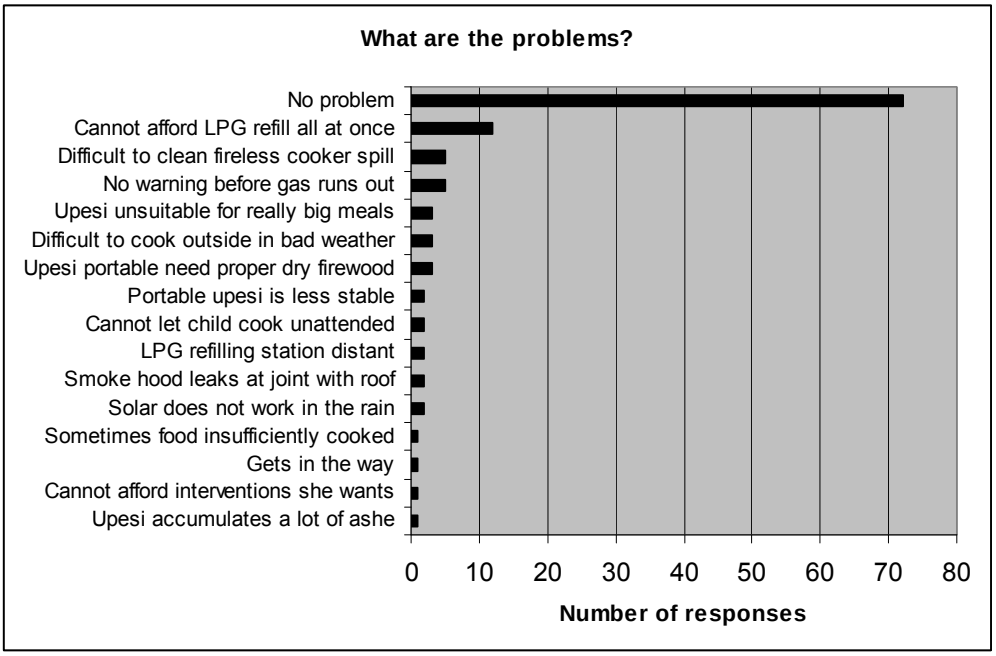


Figure 6.13 – Main problems with smoke intervention



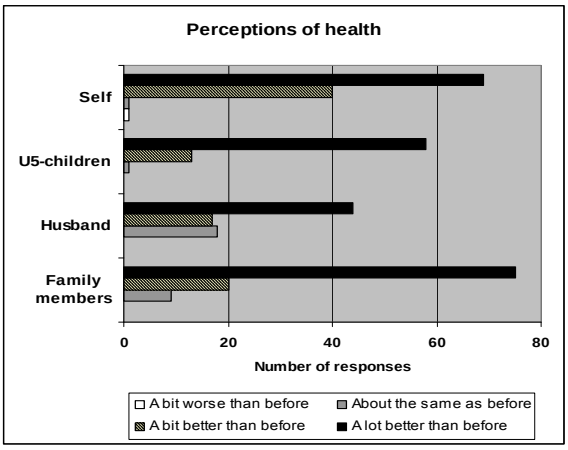
The Kenya responses show a reduction in time worked, money spent and improved working conditions. Using the fireless cooker has impacted on the flexibility of the cook's cooking practices. People feel that their houses, clothes, utensils, and food stay cleaner. Interestingly, health comes further down the list, although the changes in health are very positively reported when the question is asked directly. One person records her husband helping with the cooking as one of her three major positive impacts – this finding is not isolated, other women have mentioned that their husbands will make tea in the morning.

Cost of fuel is an issue, and usually a gendered one. Women in the societies around Kisumu tend to have far less money than their male counterparts. When people were buying interventions, the need to pay for fuel was highlighted, but LPG was generally the fuel of choice. This move towards LPG took place during the project period. What is interesting is that while the benefits on the whole describe changes to the quality of life for the cook, the problems – apart from the serious issue of fuel cost – refer to technical issues which can very likely be sorted out.

Multiple choice questions

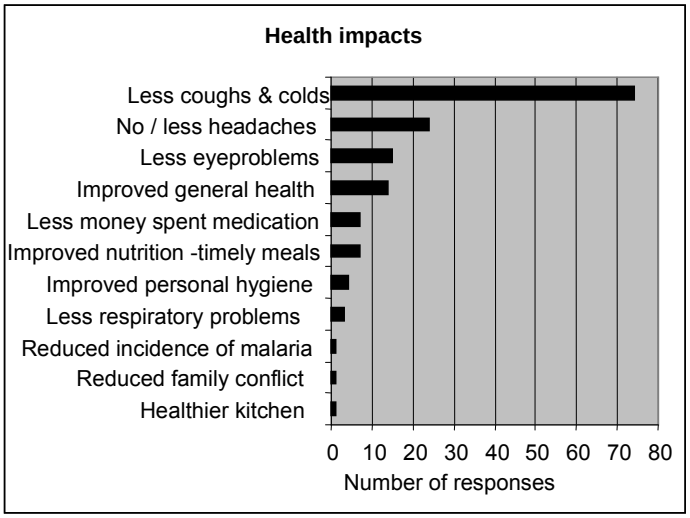
Questions were asked on individual aspects; health, time, savings and income in standardised format. A particular question about eye health was included as from the first round data, in which it had not been investigated, it was of obvious importance. The health questions were not the formal health structured questionnaire, but were more to identify what women felt as part of the overall pattern of impact. More formal monitored data is reported in Chapter 10.

Figure 6.14: Perceptions on health (N=106)



There is almost universal perception of improved health throughout the whole family. This is also reflected in the comments made in response to the open questions on health.

Figure 6.15: Ways in which health has changed



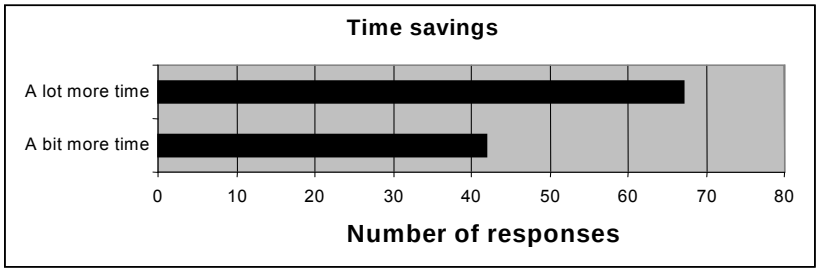
The woman was asked in what ways she felt that the family's health has changed. It is not the major ailments that are identified in Kenya, but rather the issues that affect day-to-day life – coughs, colds and headaches. Although they are not life-threatening diseases, they are part of the overall poverty burden. There is importance attached to having a hot meal ready. Where fuel is in short supply, any interventions that provide hot meals on a regular basis will impact positively on nutrition.

Eyes
Around one quarter of those interviewed experienced reduced eye discomfort and pain as a result of the smoke reduction.

Observations on time

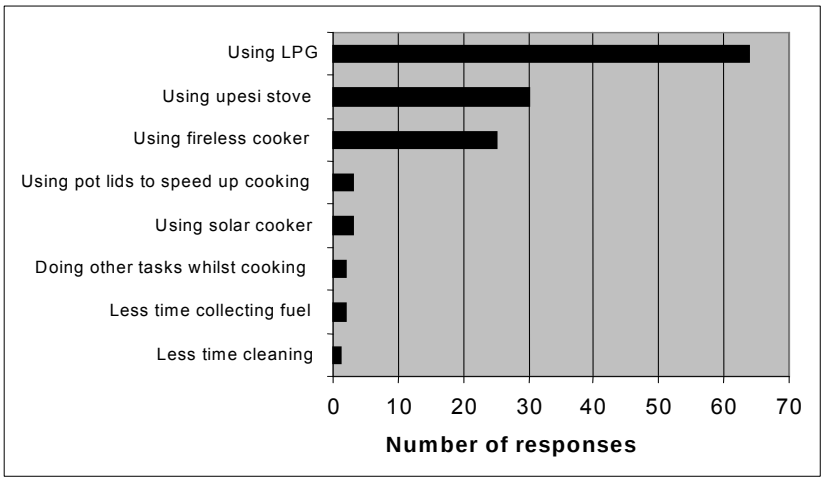
Time savings were based on questions related to weekly savings. The timesavings per week ranged from no change to seventy hours, with a mean value of 20 hours, and a median of 21.5 hours. The time saved ranged between zero and 70 hours per week.

Figure 6.16: Perceptions on time saving - Kenya (N=110)



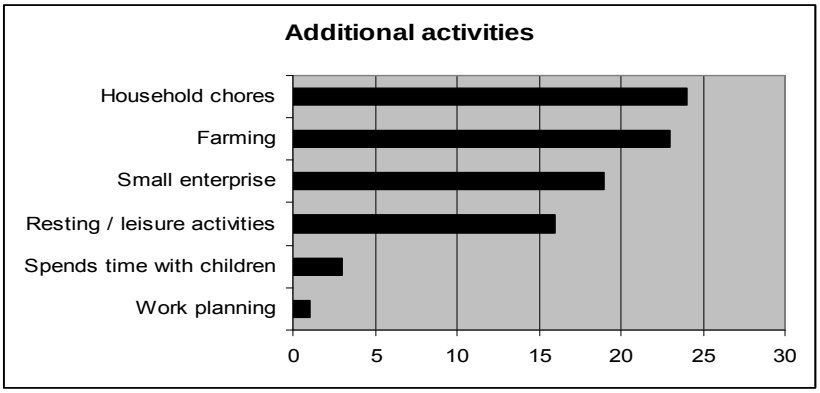
The interviewees were asked to identify what changes affected them most in terms of time. These were open questions that were standardised at a later date (Figure 6.17).

Figure 6.17: What has led to the greatest time savings - Kenya?



Use of LPG is highly rated, along with the Upesi stove, and fireless cooker. The latter works through freeing up time that would normally be spent guarding the stove.

Figure 6.18: What is done with the time saving - Kenya?



Time is used productively in Kenya, with over half of all responses indicating that time was spent on small enterprise or farming.

Savings and income

People were asked whether they felt that they were better or worse off as a result of the interventions. Over ninety respondents felt they were better off, with 12 saying they were much better off. Overall respondents felt that they were on average around KSh5400 (£40) per annum better off, ranging from £0 - £387.

Figure 6.19: Perceptions on income / savings - Kenya? (N=106)

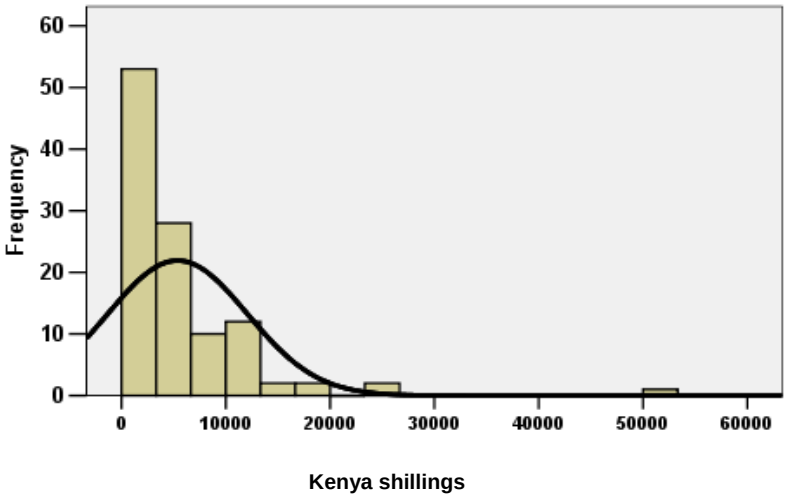
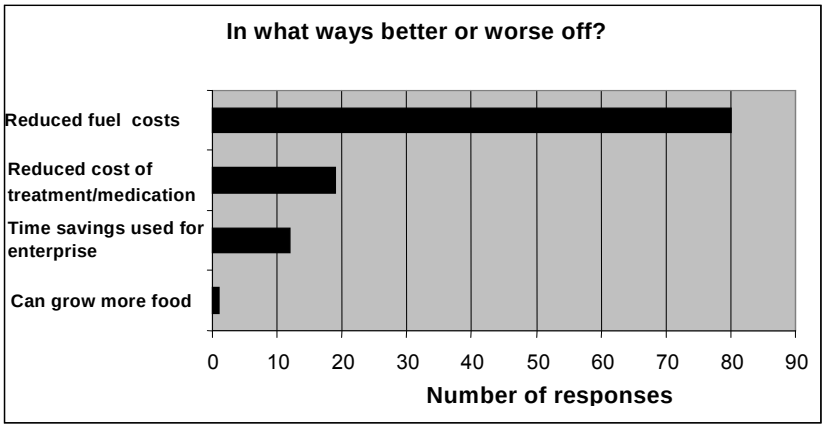


Figure 6.20: Ways in which savings and income are improved?

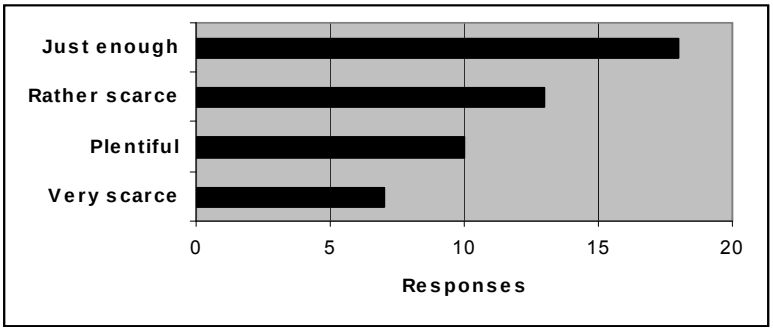


Responses were compiled to reflect the most positive impacts on people's savings. Well over half of the sample said that were spending less on fuel.

Environment

For those gathering fuel in Kenya, access to supplies is a problem for around 40 per cent. Although this is a small sample, households in the first research project also cited scarcity as a reason for purchasing fuel. The use of less fuel is the second highest benefit stated.

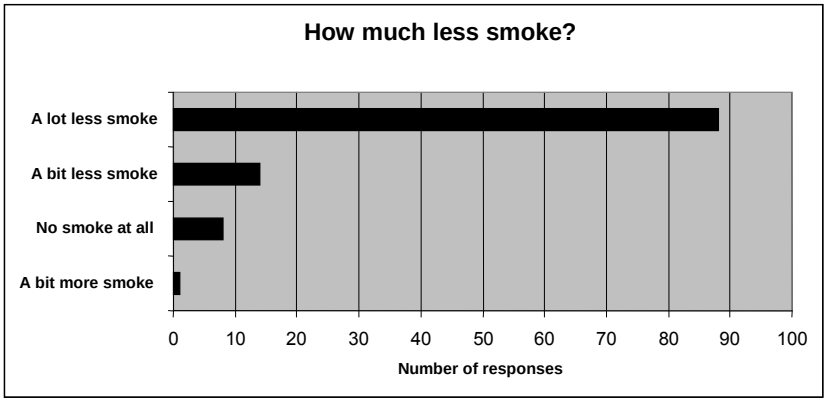
Figure 6.21: Is there enough fuel?



Family life

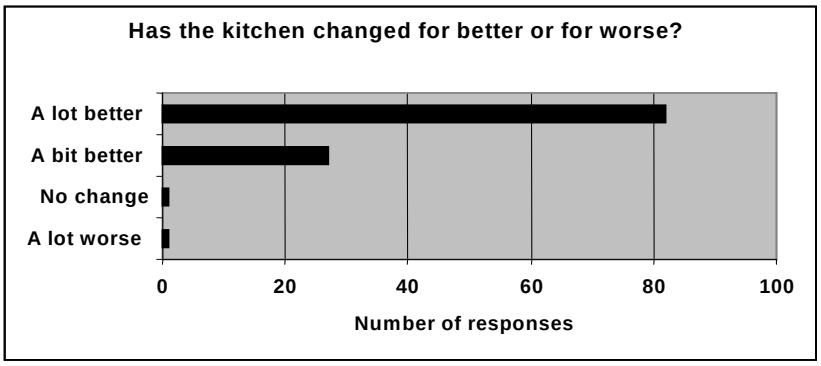
With cooking at the heart of the home, the project needed to find out if people felt that (as a result of the interventions): the smoke had diminished; whether the kitchen was a better / worse place; and whether changes in family life were on the whole better.

Figure 6.22: Impact on levels of smoke



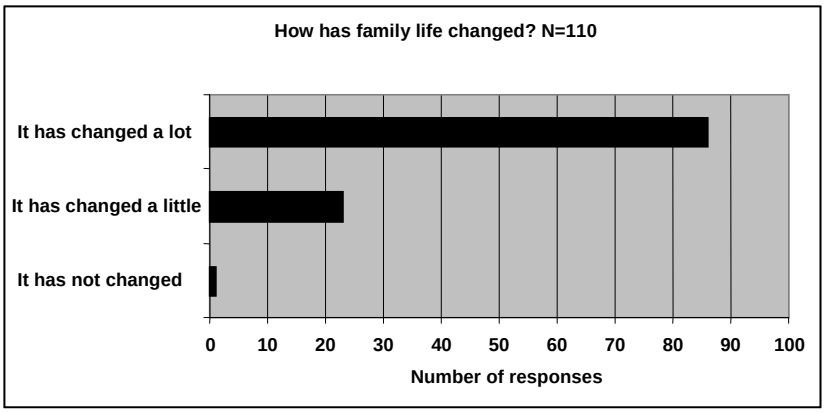
Agreement on the level of smoke being reduced was almost unanimous. Technologies may work brilliantly, but unless people like them, then they are likely to fall into disuse. On the whole, people feel that this change has been a positive one.

Figure 6.23: Does the cook feel that the kitchen is better of worse?



The kitchen may be better, but does this affect the way that people lead their lives. This evidence from Kenya strongly suggests that it can.

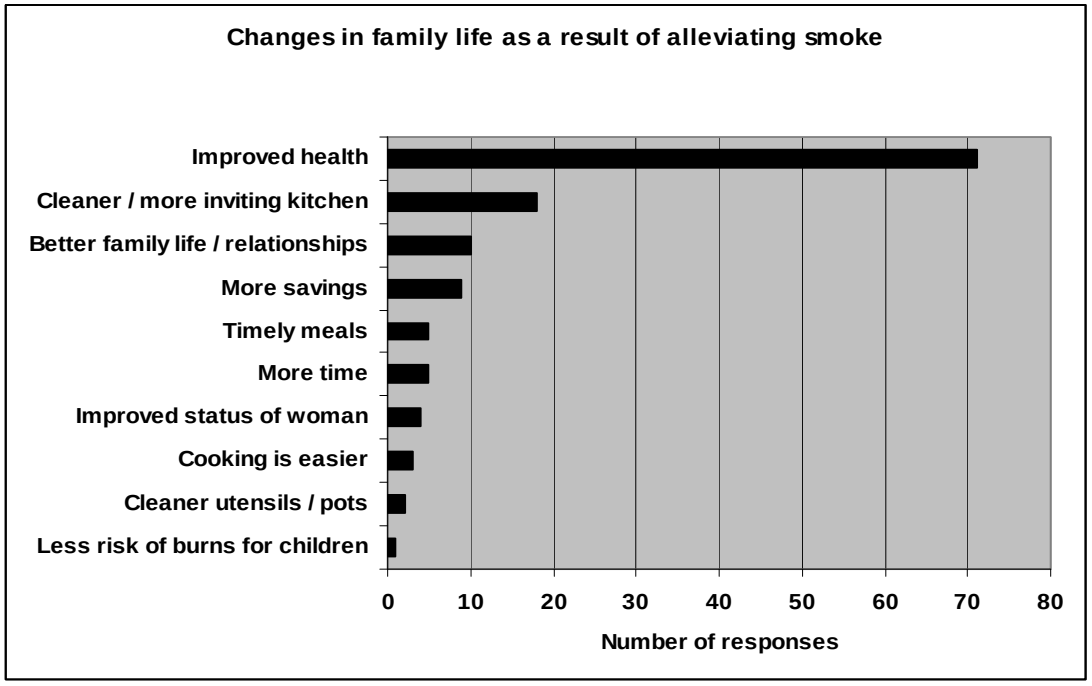
Figure 6.24: Can getting rid of smoke change family life?



To complete the picture, the cook was asked to describe changes both good and bad that had affected family life as a result of alleviating smoke in her kitchen.

Within these communities in Kenya, many women define themselves by their success as mothers and wives. To achieve the levels of reduction in smoke, most have made quite substantial changes, and the changes have not only removed the smoke but have also increased their prestige, both within their families and in their wider social circle. The changes recorded reflect what alleviating smoke has meant to them in their role of wives and mothers.

Figure 6.25: What changes have taken place in your household?



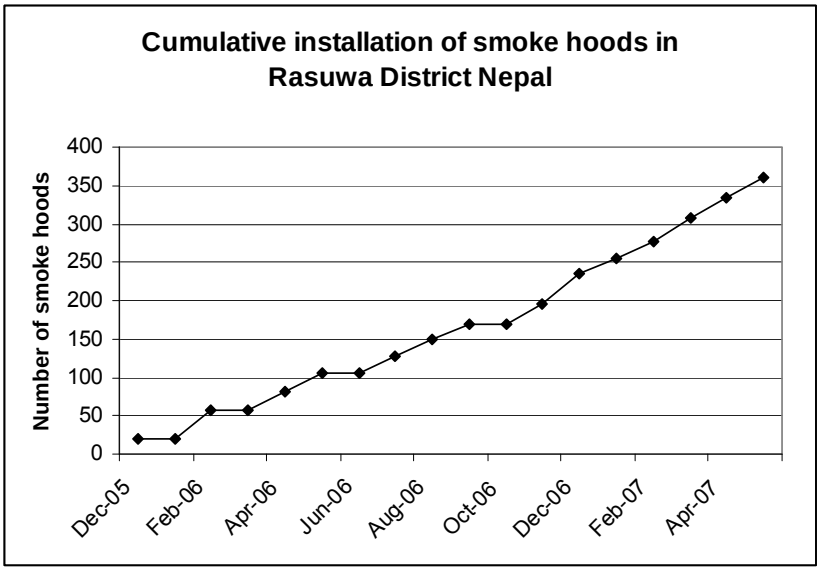
Although it is likely that people will give a positive response in an interview situation, people in this study paid for the interventions, and additional comments reflected gratitude to the project, improved health, a changed lifestyle, and a request for more opportunities to work with the team.

Chapter 7: Research findings and impacts: Nepal

Monitoring growth – Nepal

Three interventions were introduced in Nepal; smoke hoods, wall insulation and improvements to the traditional tripod stove. Out of these, only the smoke hood required financial investment by the household. Every smoke hood was bought using revolving finance. Table 6.1 shows the growth in smoke hood purchase during the project. A total of 360 smoke hoods were purchased and installed during the project period. Orders for the next few months have already been placed and a total of 450 hoods have been manufactured and are either installed or being installed.

Figure 7.1 : Total installations in Rasuwa district per month



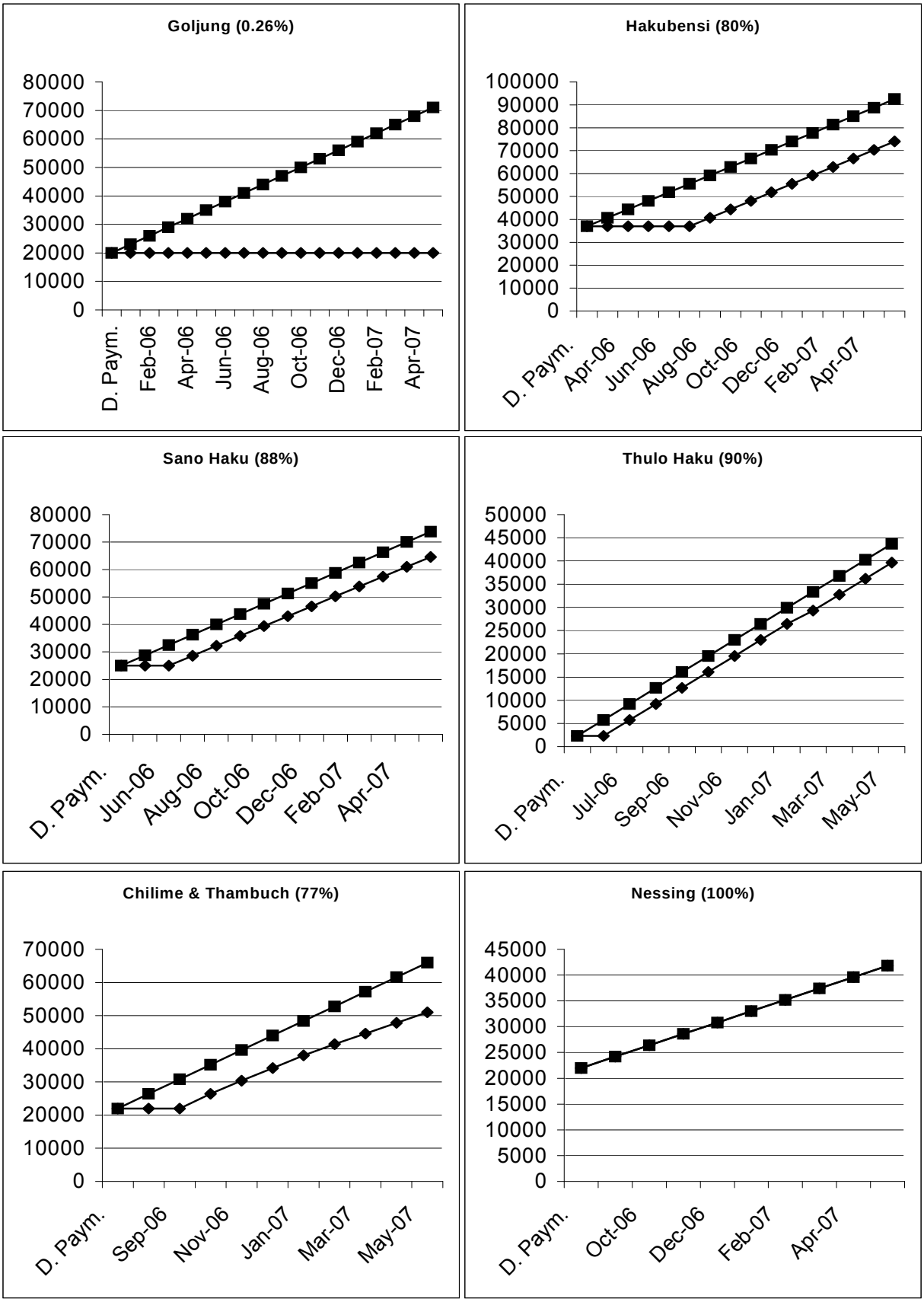
Repayments

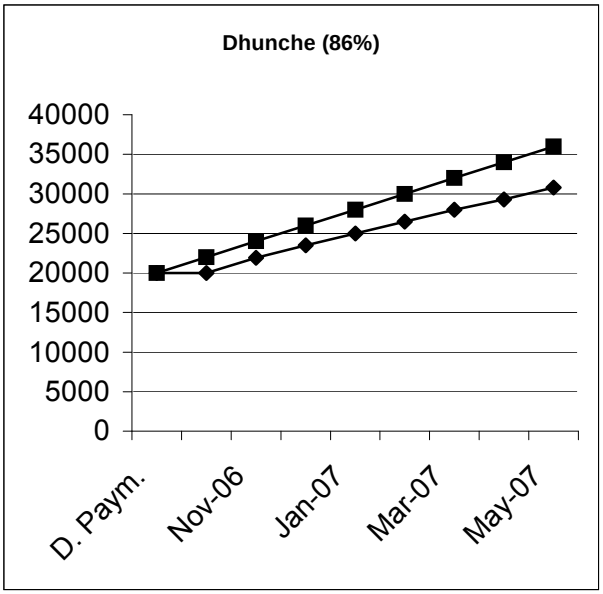
The first group of hoods bought with revolving finance was in the village of Goljung. This was very early in the study, no-one had experience of revolving finance, and the level of understanding of how revolving finance worked, and its monitoring, was not well understood. Although the downpayment was made, there was still a perception that it was 'charity money' and further repayments were not really necessary. For subsequent revolving finance, additional meetings were held, the need for this approach was discussed, and an improved structure for payments was set up.

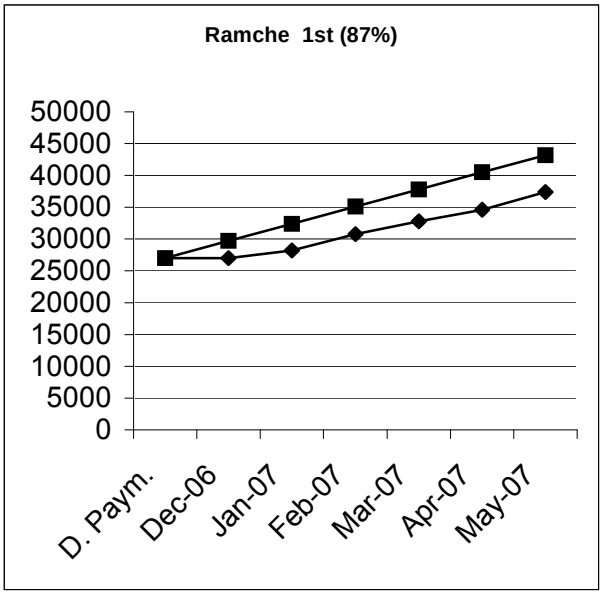
Overall, a total of 83 per cent collection rate of revolving finance has been achieved. Excluding Goljung, this rises to 89 per cent. The shape of the graphs indicates that repayments started late for the groups that were first formed. Full payment is thus likely to be achieved about five months late in the case of Haku Besi, and one or two months late for Sano Haku, Thulo Haku and Chilime. Additional revolving funds in Laharepouwa & Gombodanda, Yarsa and Gatlang were started after December 2006, but these are not shown in the graphs. They are showing similar levels of repayment.

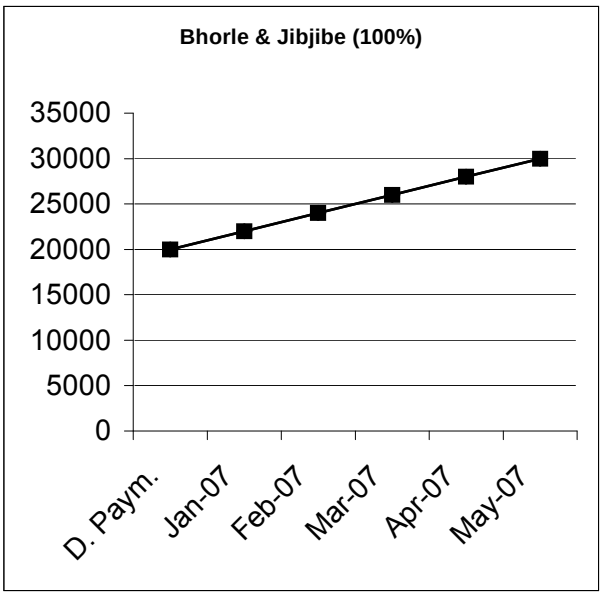
The situation at the end of the project is that the District Development Committee has taken on responsibility to train new revolving fund committees, and to support the level of subsidy whilst it is needed. Their role in ensuring high levels of repayment has proved vital.

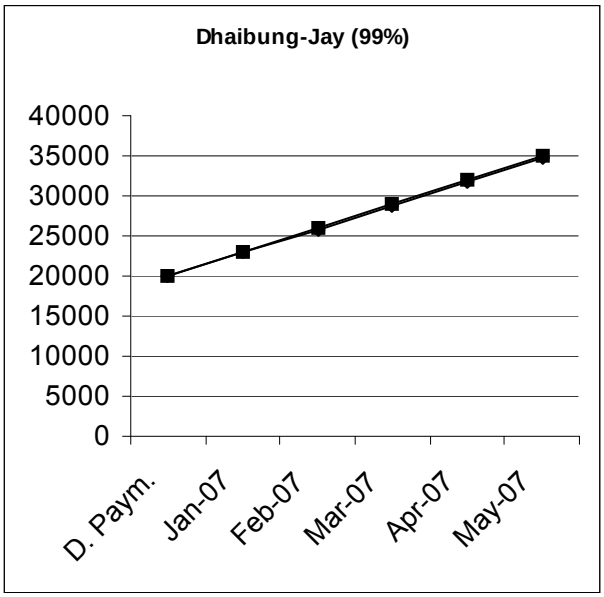
Figure 7.2: Actual repayments vs planned repayments for revolving fund groups in Rasuwa district, Nepal

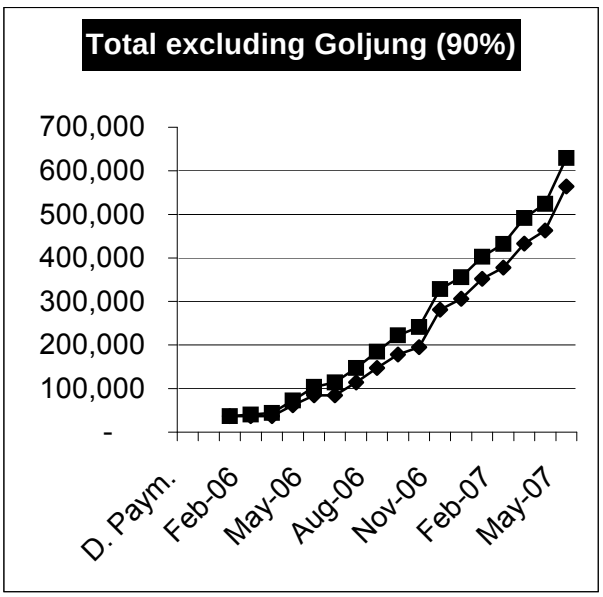


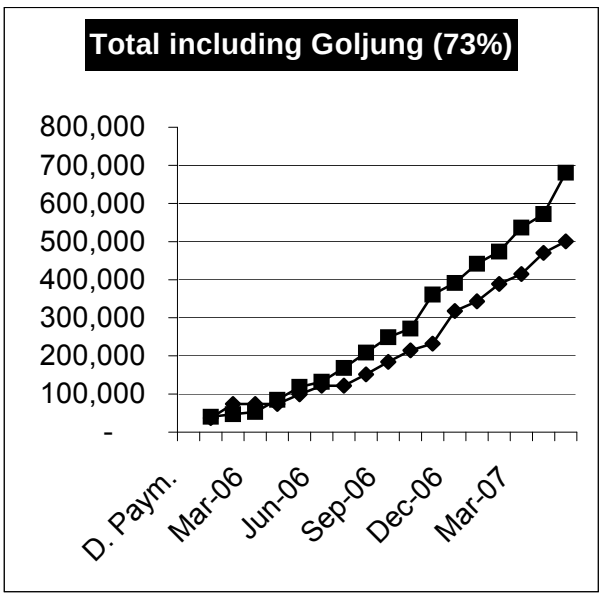

Dhunche (86%)
40000
35000
30000
25000
20000
15000
10000
5000
0
D. Paym.
Nov-06
Jan-07
Mar-07
May-07

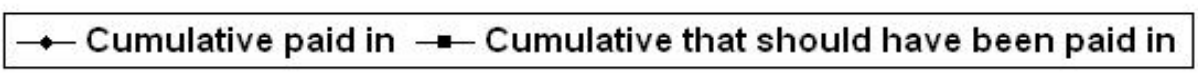

Ramche 1st (87%)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
D. Paym.
Dec-06
Jan-07
Feb-07
Mar-07
Apr-07
May-07


Bhorle & Jibjibe (100%)
35000
30000
25000
20000
15000
10000
5000
0
D. Paym.
Jan-07
Feb-07
Mar-07
Apr-07
May-07


Dhaibung-Jay (99%)
40000
35000
30000
25000
20000
15000
10000
5000
0
D. Paym.
Jan-07
Feb-07
Mar-07
Apr-07
May-07


Total excluding Goljung (90%)
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
D. Paym.
Feb-06
May-06
Aug-06
Nov-06
Feb-07
May-07


Total including Goljung (73%)
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
-
D. Paym.
Mar-06
Jun-06
Sep-06
Dec-06
Mar-07


Cumulative paid in
Cumulative that should have been paid in

Other interventions

Only the growth in smoke hood purchase was monitored through the project as, once designed, the other interventions described below grew naturally following demonstrations by the project team.

Improved stoves

The local stove of choice is a tripod stove comprising three steel legs with a circular ring on top on which to place the cooking pot. By enclosing the rear part of the tripod in a mud base, much more of the heat is transferred to the cooking pot (see Chapter 4). A further innovation, a bar set into the mud across the front of the stove provides a space for primary air and improves primary air reaching the pot. (Although it has been noted that cooks often allow this air space to block with ash.)

Ideally, the surrounding mud base should be made of an insulating material, and one of the better stoves had air spaces created inside the mud base when one of the artisans, by chance, used bent metal scraps from the hood manufacture to fill up the space behind the stove. This stove works very well and further improvements using an insulated surround could be achieved in the future.

Wall insulation

The households in the high hills in Rasuwa are all built of a dense stone – probably gneiss. They are dry stone walls with a wooden fascia at the front and wooden tiled roof. It was recognized that much of the heat from the stove was lost through the walls due to the high thermal conductivity of the dense stone, and wind blowing through the cracks between the stones. As part of the project, a few households had their walls insulated. The clay was sieved to get rid of stones, and a mixture of clay with all sorts of residues - straw, dung, ash – to provide air was added the mix.

Following these demonstrations, and the positive impact they had on comfort levels, virtually every household in the project areas has adopted wall insulation as a way of reducing the amount of fuel that they have to burn, and thus the amount of smoke produced. The insulated walls prevent dust and wind from blowing into the house, so the cleanliness and comfort levels have been greatly improved. Several hundred households have thus adopted this intervention.

Non-cost / low cost interventions

No-cost and low-cost interventions have been adopted by many. Project data shows that a substantial fraction of those involved in the initiative:

- Keep children away from the fire
- Use pot lids – a major saving in terms of fuel use
- Use dry fuel
- Cut the fuel into smaller pieces to make it burn more efficiently
- Some have even stopped brewing alcohol, or brew it away from the house

Impacts on fuel use

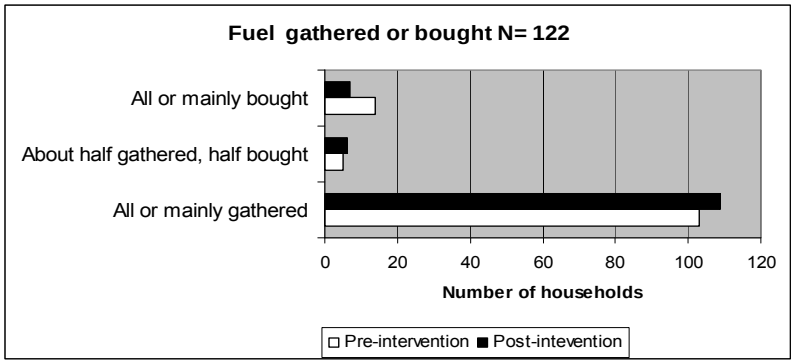
Primary fuel for cooking

In Rasuwa, most people live in the high hills, a long way from access to any other fuel beside wood. It is therefore unsurprising that there was negligible change in cooking fuel.

Secondary fuel use also showed little change, with two or three households using charcoal, LPG or kerosene as secondary fuel.

Fuel gathering

Figure 7.3: Number of households gathering and purchasing fuel



Very few households bought fuel, either pre- or post-intervention, and it was not possible to get a good overview of any change in the cost of fuel due to the low number of households buying it. The small numbers buying fuel are likely to be those living in or near Dhunche, the main town in the area. For the majority, travelling to the town to buy fuel would take more effort than gathering it. This is important insofar as savings in monetary terms through fuel efficiency cannot directly translate into money for repayment of the smoke hoods.

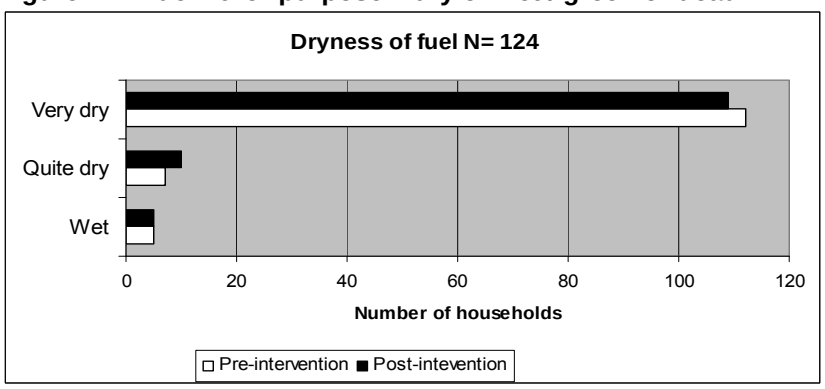
Using fuel that is completely dead

The number of people using fuel that was 'green' went up very slightly - but insignificantly. The marked reduction in indoor air pollution in the post-intervention round could not have been influenced by this potentially confounding factor.

Using fuel that is completely dry

The same is true of using fuel that is completely dry – with almost all using dry fuel in both the pre-intervention and post-intervention rounds.

Figure 7.4: Fuel fit for purpose – dry or wet / green or dead



Main stove in use during the monitoring period

By contrast to the consistent use of biomass, the switch from a very basic tripod stove with no smoke extraction in the room to an improved stove with hood was almost complete.

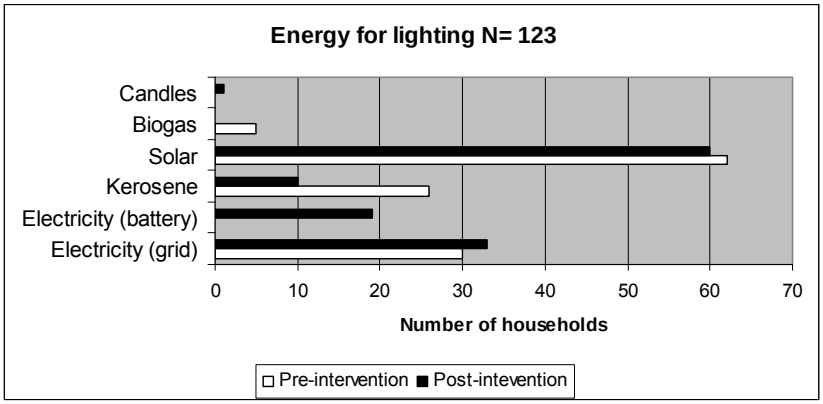
Table 7.1:

Main stove used N=126		
	Pre-intervention	**Post-intervention**
Traditional tripod stove (Nepal)	125	
Improved tripod stove (Nepal)	1	
Smoke hood with improved stove		126

Lighting

The majority of households in the area monitored use solar lighting as installing it is heavily subsidised by the government and has no associated running costs. This use of a free fuel in a high cost technology is a good parallel to smoke hoods when wood can be gathered. There is a marked reduction of people using kerosene wick lamps, and more people using battery power to produce clean lighting. However, it should be noted that monitoring was done in the first areas to have smoke hoods installed (Haku Besi etc.), and access to solar lighting is therefore atypical, and much higher in these villages.

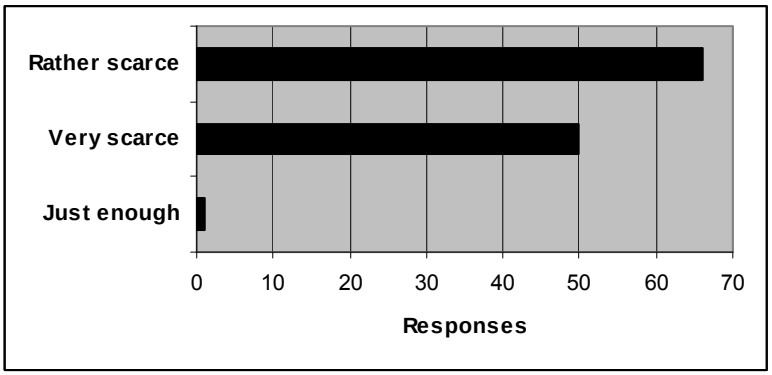
Figure 7.5: Change in lighting fuel during project period



Environmental sustainability

Fuel scarcity is a major issue in Nepal, so wood is used with great care. Insulating the walls and providing an intervention that still provided space heating led to reduced fuel consumption - the second key impact reported by those interviewed in Nepal.

Figure 7.6: Scarcity of fuel

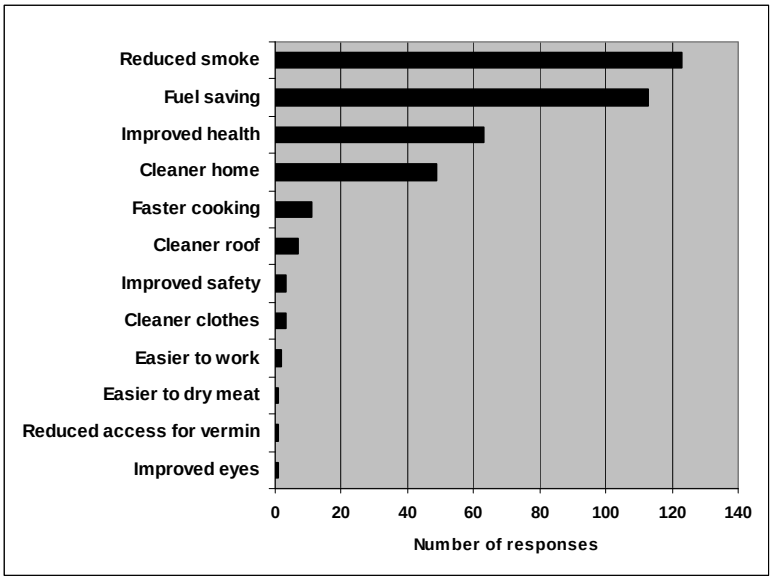


Project impacts

The women in Nepal showed a greater willingness to express both positive and negative observations. This is in itself a positive impact in development terms as people have taken ownership of the smoke hoods and other technologies and are willing to complain about any faults that they find as well as praising the positive effects. The open questions were asked prior to the multiple choice questions

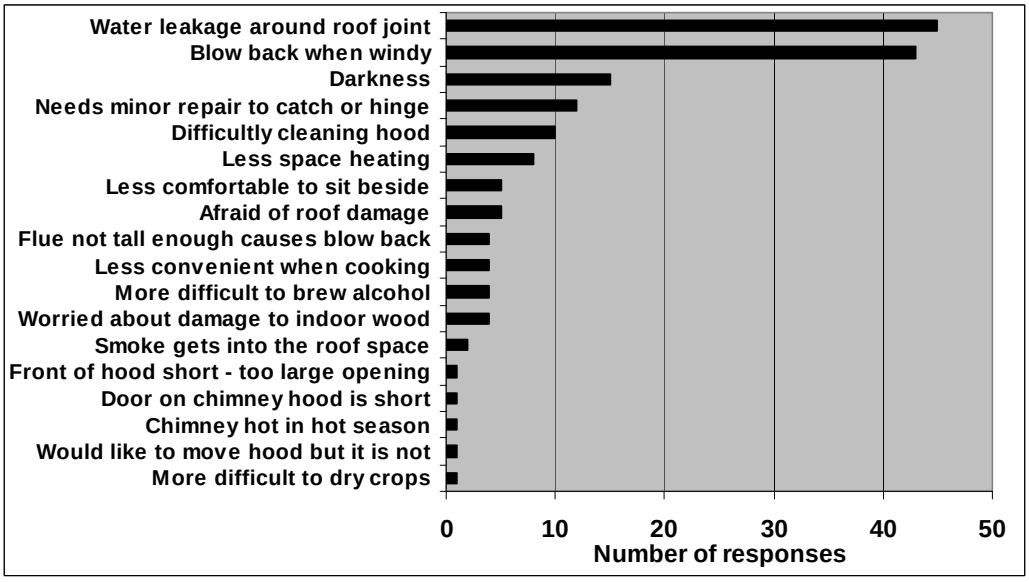
Prior to this initiative, smoke dominated the whole house in Rasuwa district,as the fire is the centrepiece of the main living room. It is thus not surprising that this was the major response as alleviating most of the smoke reduced the drudgery for the woman of keeping the room, clothes and children as clean as possible.

Figure 7.7: Key benefits reported by cooks



Whereas most of the benefits are gendered, the problems are mainly technical ones The main one, water leakage, has now been addressed, and the other key problem, blow back, is currently being researched.

Figure 7.8: Main problems reported by cooks

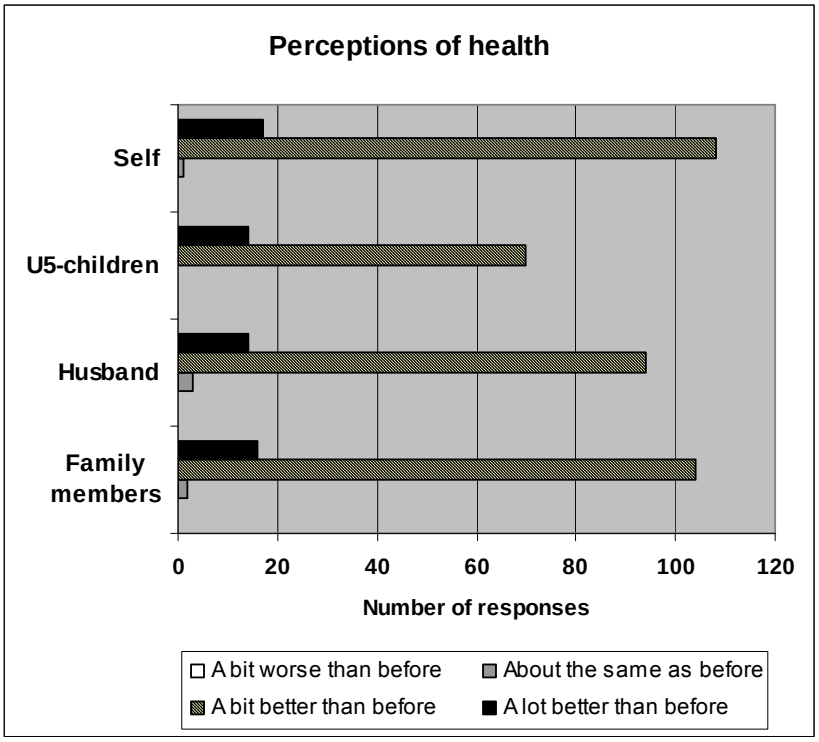


In this section we look at other impacts recorded by the project household members on changes that have come about as a result of the research.

In all the multiple choice questions there were at least five options - Much worse, a bit worse, the same, a bit better, much better. In contrast to the open questions, discussed in Chapter 9, where the interviewee showed a clear willingness to criticise certain aspects, there were no negative responses to any of these questions. This very positive willingness to criticize adds confidence to the level of positive replies to the multiple choice questions. The interviewees had paid for the interventions and were willing both to complain and to praise in equal measure

Health questions were asked informally as part of the overall impact survey– not as part of the more specialist health survey. Thus they were more like on neighbour talking to another, as opposed to a visit to the clinic.

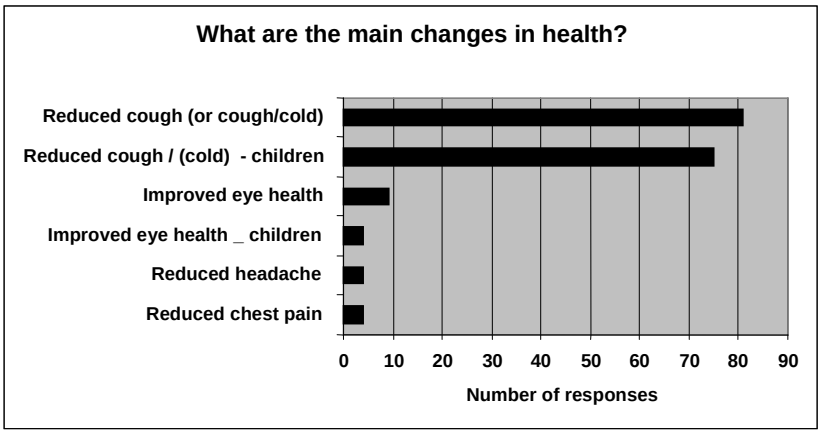
Figure 7.9: Cook's opinion on health of both herself and her family



The smoke hood was seen to have a positive effect on all family members. Most people felt that their health was 'a bit better'. This reinforces the open questions where very positive outcomes are reported.

The large numbers reporting a reduction in health problems (Figure 7.10) reported reinforce the responses about greatly reduced numbers of visits to health centres and the reduced cost of medical care. Although this high level of benefits should, in part, be attributed to people wanting to please the project team, it must be remembered that people were living in houses with tiny windows and a fire burning in the middle of the kitchen for both cooking and heating.

Figure 7.10: Ways in which health has improved



Most households reported reduced coughs (some said 'coughs and colds') for both adults and children. A reduction of eye discomfort was only reported by a few at this point, although it was due to the large number of women describing this problem to the project team that a secondary question was asked about eyes in the final round of questionnaires.

Eyes
All but eight of the 126 households reporting on eye health reported an improvement. Comments included reductions in redness, pain, tearing, infections, burning and disease. The eight households who did not import an improvement stated that there was not a problem prior to the hood being installed.

Observations on time

Table 7.2: Time differences

Do you have more or less time?	
About the same	2
A bit more time	123
A lot more time	1

Of the 126 respondents, just two said that they had about the same amount of time, and majority (123) said they had a bit more time. No-one reported having less time

Figure 7.13: Reported weekly time savings

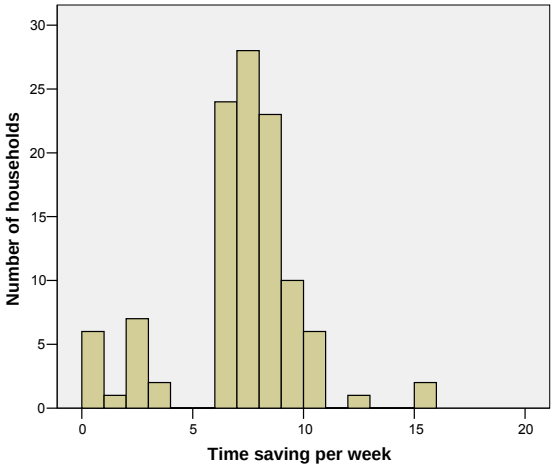
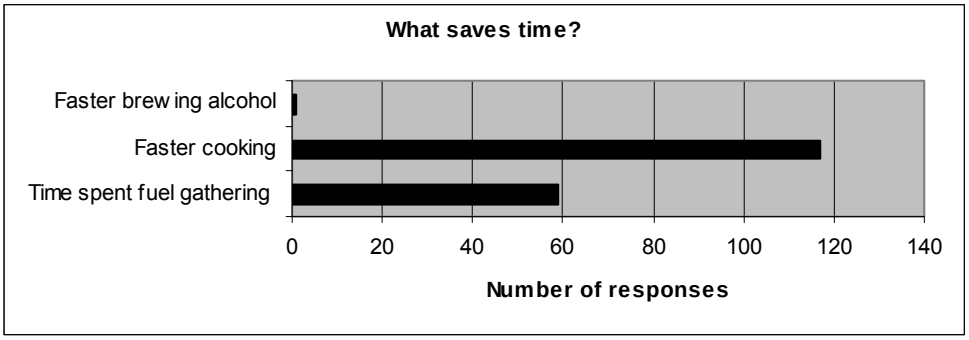


Figure 7.14: Reasons for time saving



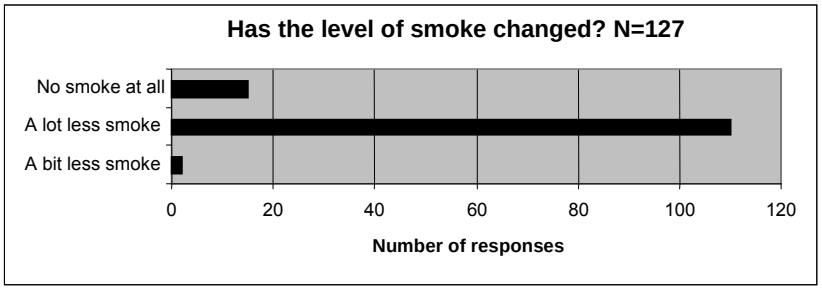
Asked to work out on a weekly basis how much time they considered they had saved, the mean value was nearly seven hours. This amounts to a mean of a little under 360 hours per year. Most of this time-saving comes from reduced cooking time – but a substantial part is the reduced time spent collecting fuel. There was no evidence to suggest that time spent by children gathering fuel had decreased.

Savings and income

The communities in Nepal do not use money for many of their basic needs. Virtually no fuel is bought for cooking or heating. Money saving was therefore confined to a reduction in medical costs, and everyone declared themselves 'better off'. Around 250 NRs was saved on average (£1.50) per annum. The team of Nepali interviewers explained afterwards that it was a difficult concept even to explain to those being interviewed – so this monetary saving is rather meaningless.

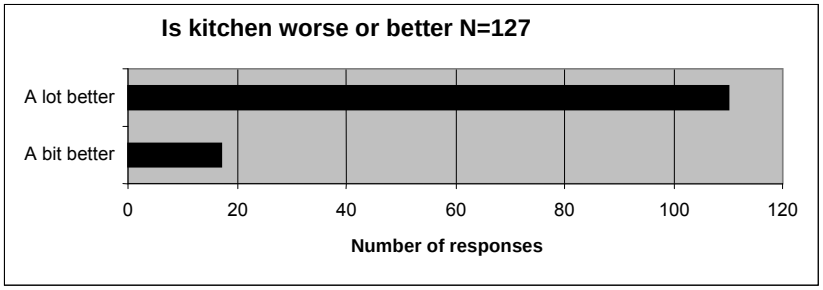
Family life

Figure 7.15: Smoke reduction



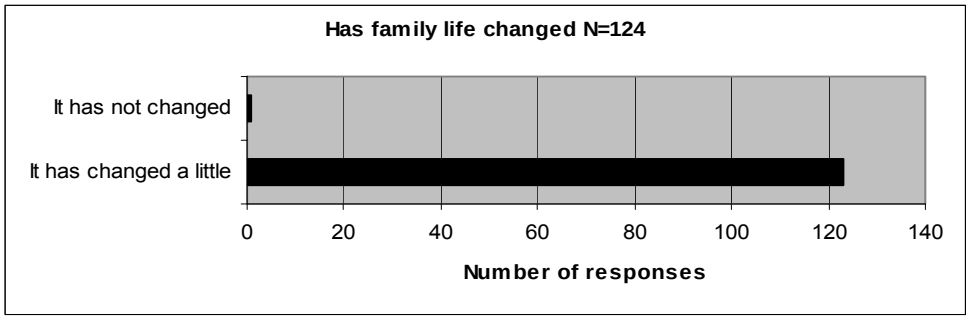
Almost every household agreed that there was a lot less smoke. This tallies with project data on the reductions in carbon monoxide which indicated greater than 85 per cent reduction.

Figure 7.16: Is the kitchen better or worse as a result of the interventions?



Soot was a major issue in the project households in Rasuwa and as the kitchen is also the main living area, reduction in the levels of soot have a major impact on the household.

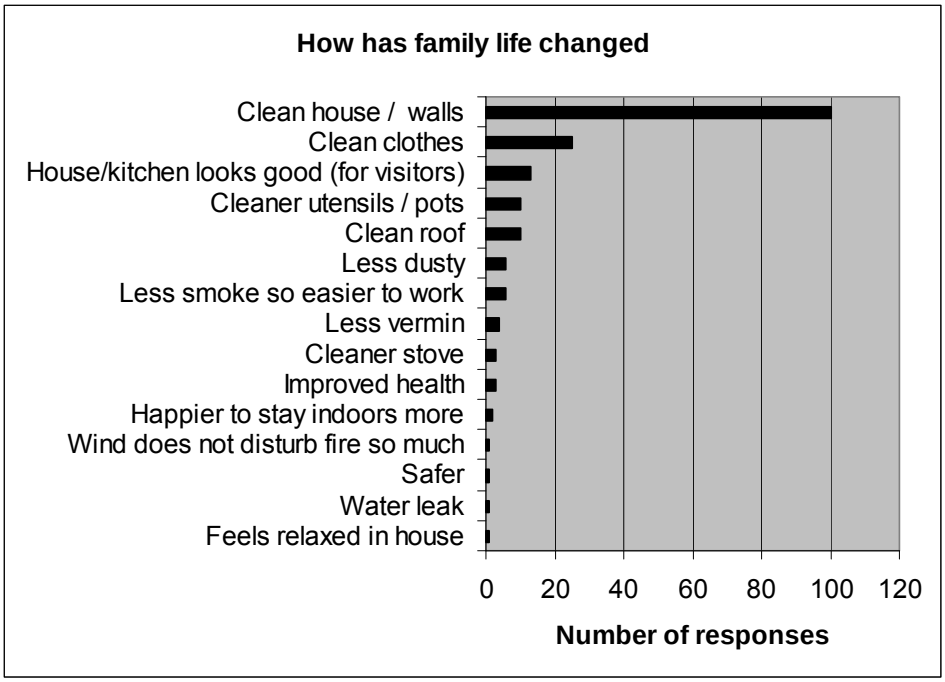
Figure 7.17: Has family life changed?



How has family life changed?

Family life does not appear to have changed a great deal as a result of the interventions (Figure 7.17). The more welcoming environment is reflected in the observations on the house as a place where people live, rather than with any changes in family status (Figure 7.18).

Figure 7.18: Main impacts on family life



Chapter 8: Research findings and impacts: Sudan

Growth in interventions

Revolving finance started rapidly in Sudan. The repayment system included a management fee of 1.5 per cent per month of the capital cost to allow for some level of default, provide additional funds for growth, and paying incentives to those collecting the finance.

This table shows the pattern in sales that have taken place over the project. Each LPG set comprises several components, individual sales of specific items has not been recorded here. Instead, an average price per stove, based on the total numbers of LPG sets has been used.

Figure 8.1: Overall growth in sales

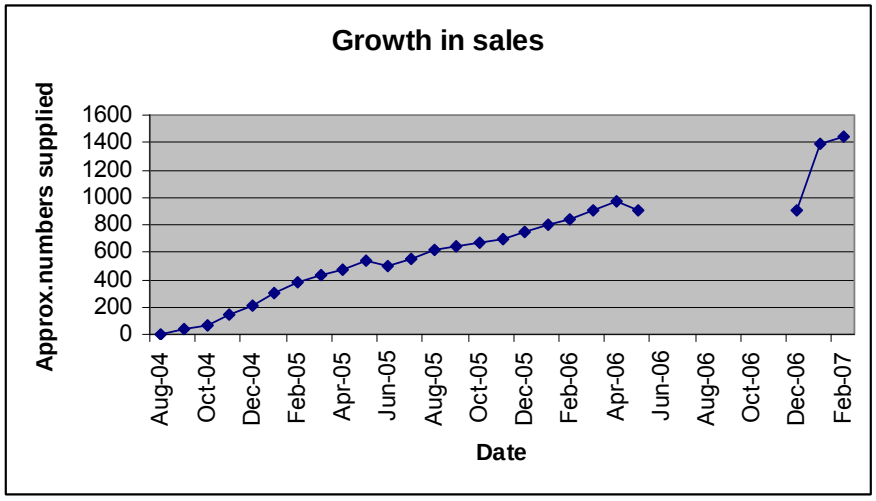


Table 8.1: Total beneficiaries by branch

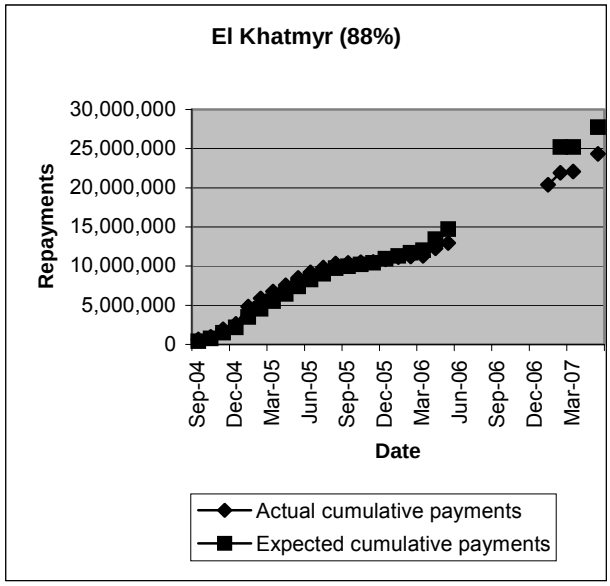
WDA Branches Name	beneficiaries
Elkhatmia	161
Elshabi	198
Eltraa	142
Shampop	82
Elshaheed	167
Elsgoon	147
Wau Nur	60
Kadgli	97
Elsaoage	49
Awad	39
Mokram	20
Kisra sellers	34
Beriai	42
distributed for all branch in batch 2	26
Elgenad	25
Khamsa Arap	41
WDAsHalfa	6
Elswra	79
Total	***1,415***

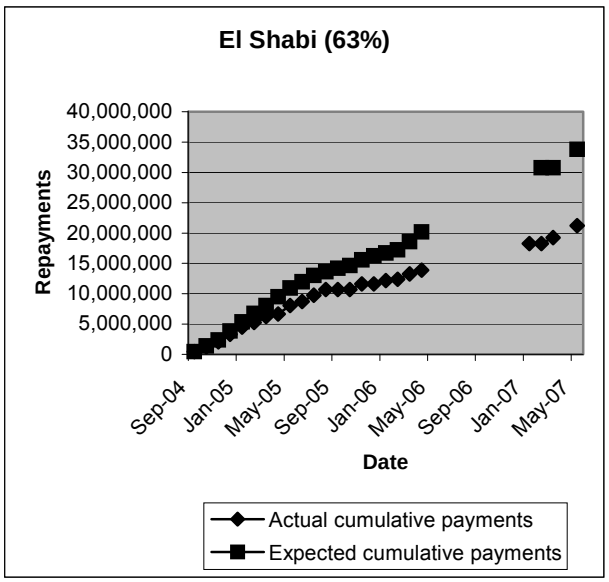
It can be seen that there is a steady growth in sales, running at around 15 per cent per annum. The problems around April '06 to December '06, and the action that was taken to correct problems is discussed in Chapter 9. Over 1400 LPG sets have been purchased through revolving finance, and there is a steady demand of around 50 stoves per month

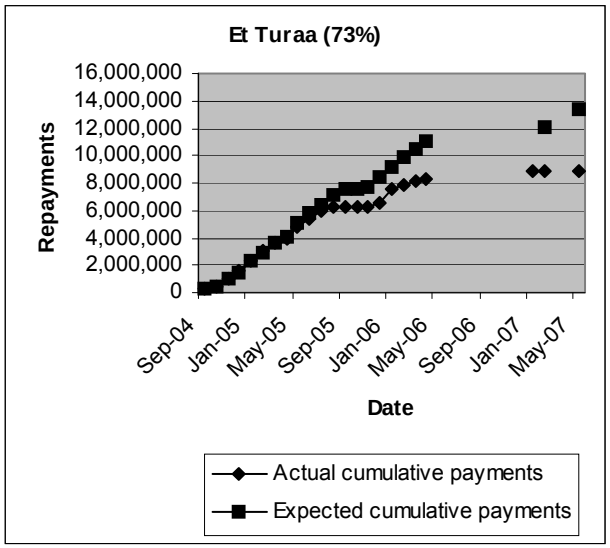
The plan in Sudan was to run the revolving finance as a business from the start, as getting rid of any type of subsidy would be more problematic once it had started.

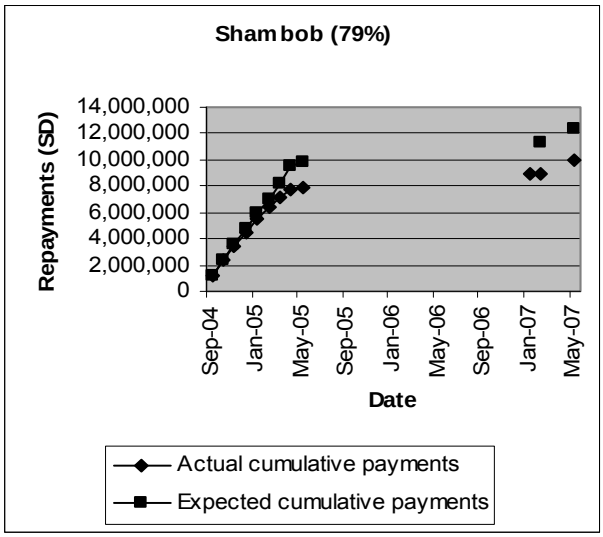
In Figure 8.2, the repayment figures show the planned repayment including this additional 1.5 per cent, per month which amounts to around 12 per cent overall for a repayment over eight months. Break-even, in terms of just recouping the appliance cost, would thus be around 12 per cent lower than planned repayment.

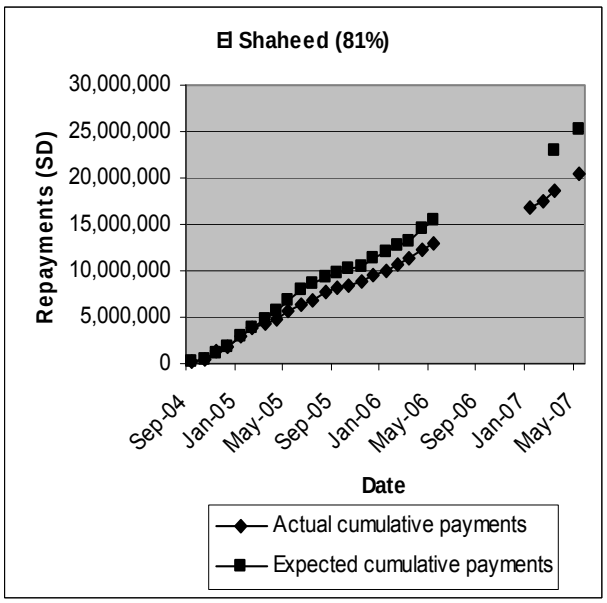
Figure 8.2: Repayments by WDA - Kassala region

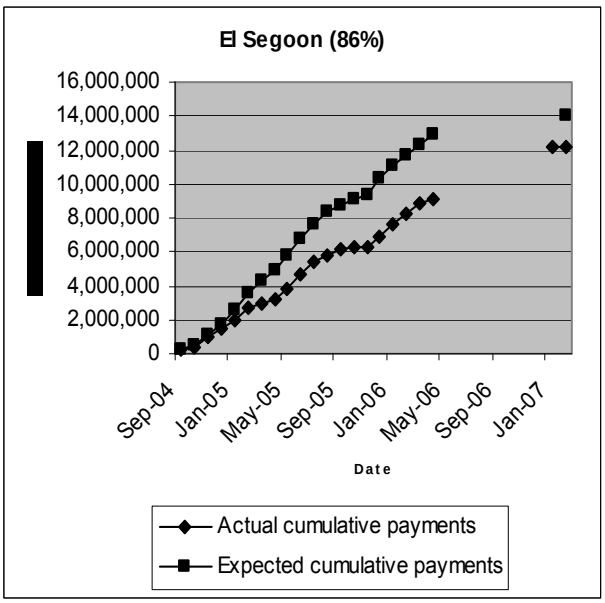


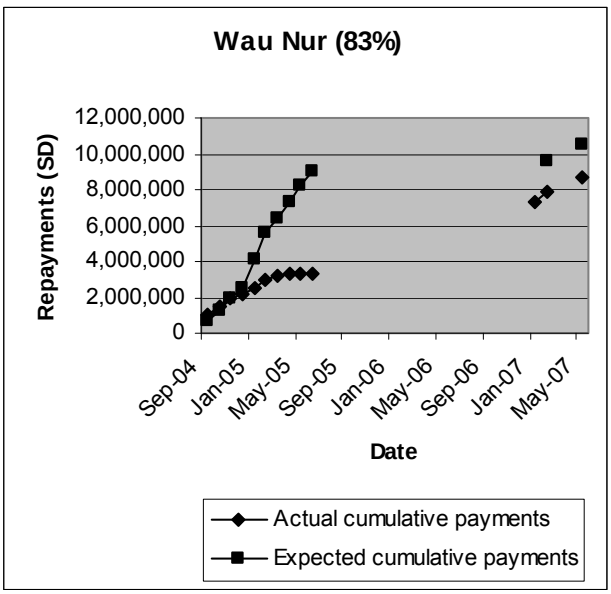


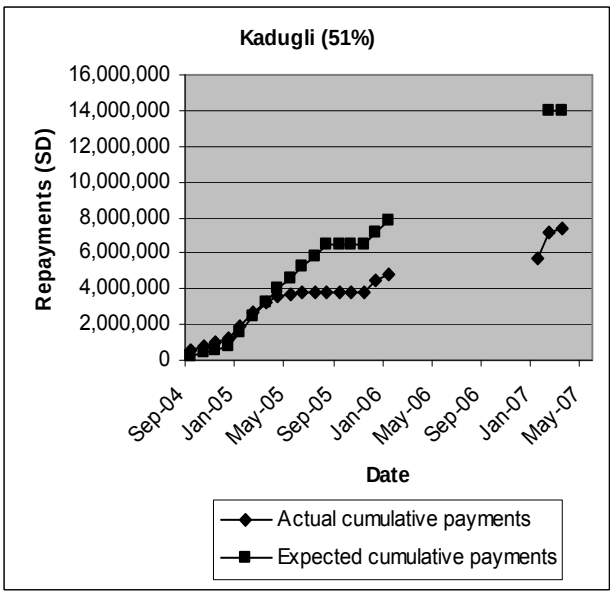


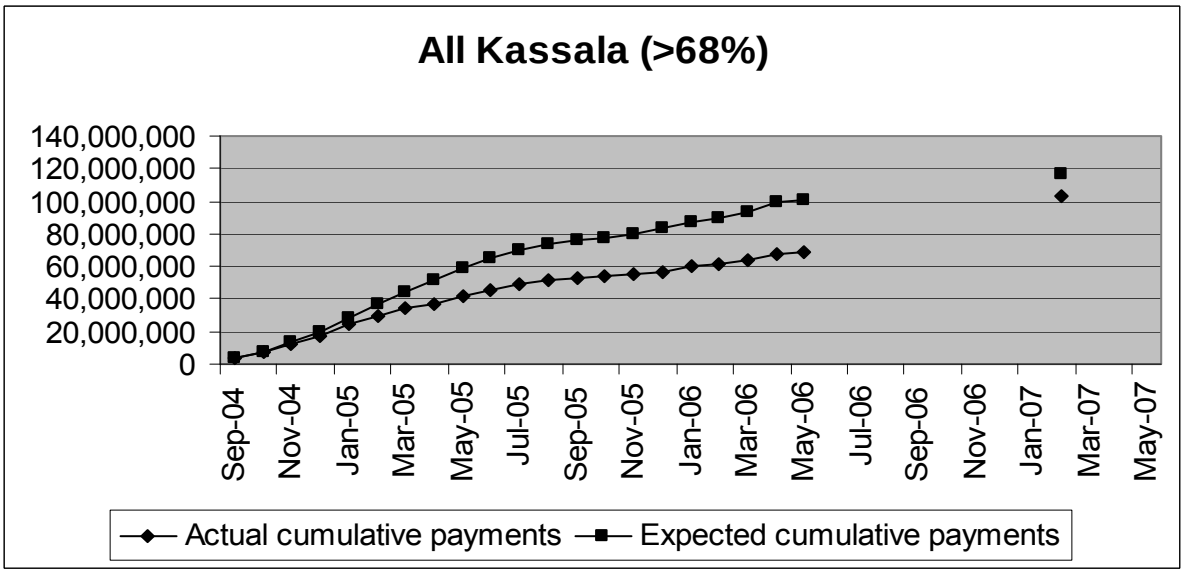












Around April-May 2006, the revolving finance was left with the WDAs unsupported, and various issues around the management and reporting of the funds became apparent. A new structure was put in place, and greater support was given to collect outstanding repayments. In some cases, funds had been collected, but had not been accounted. In other cases, households were visited and repayments were made. A new system of accounting was put in place, as described in Chapter 9.

At the close of the project, the outstanding payments are being collected, and the new system is working well[5]. Greater checks were put in place for those purchasing using credit, ensuring that both the cook and her husband were aware of the need to make the repayments, through signature of both husband and wife in these new loan agreements.

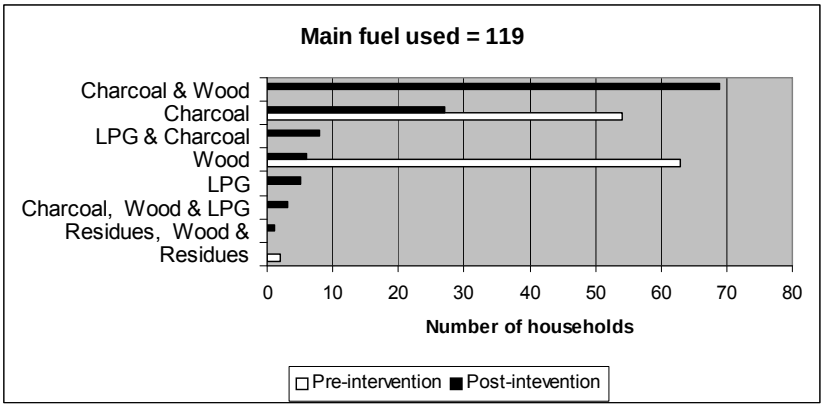
A new network, the Kassala State Women Development Network (KSWDN), will be supported in the short term by Practical Action staff. This network will represent all the WDAs in the Kassala region, rather than having one WDA being the dominant association in the region. The support being provided by Practical action is in line with other work being done by the organisation with the WDAs in training displaced women.

[5] The cumulative repayment reported is around 88 per cent as this book goes to print (September 2007)

Changes in fuel use patterns

The questionnaire asked about 'the main fuel you used for cooking in your kitchen whilst the monitoring was taking place' . A second question asked about secondary fuels. It can be seen that in the first round, just one fuel was in use as a primary fuel in each household. In the third round, a mixture of wood and charcoal is dominant, with a disappointing use of LPG. The reasons for this low level of use are discussed more fully later in this chapter Those using LPG either in part or for all their cooking needs had substantially lower levels of pollution in the their homes.

Figure 8.3: Changer is the use of fuel – main fuel used on day of monitoring

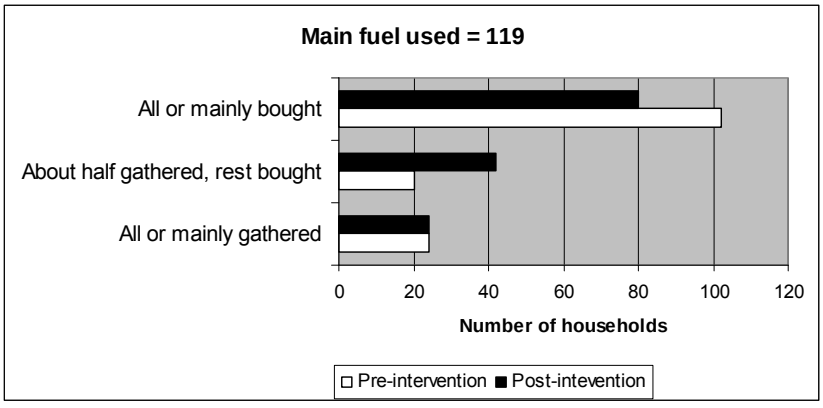


Coupled with data on the primary stove used during the monitoring period, it would appear that there has been a move from woodfuel via LPG to charcoal. Although this will have reduced the levels of particulates breathed by the woman, it leaves the levels of carbon monoxide at an unacceptably high level for good health. Many of the households still use woodfuel alongside the charcoal.

Buying and gathering fuel

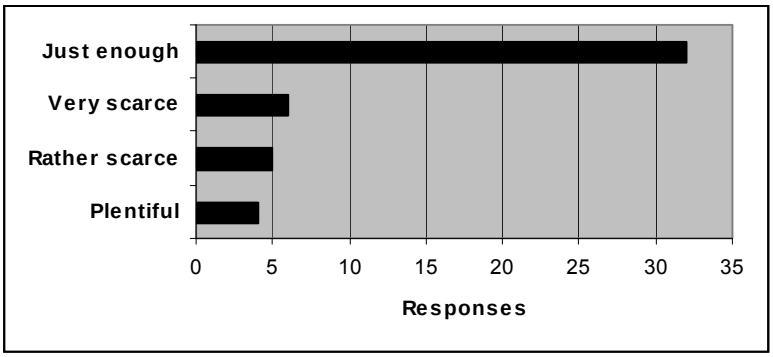
More people appeared to be gathering part of their fuel than at the start of the research. This may reflect an increase in the amount of fuel available for gathering as many displaced persons and refugees have returned home. The increased availability of LPG for the more affluent sectors may have taken some of the pressure off biomassfuel supplies in the short term.

Figure 8.4: Changes in the numbers of households buying or gathering fuel



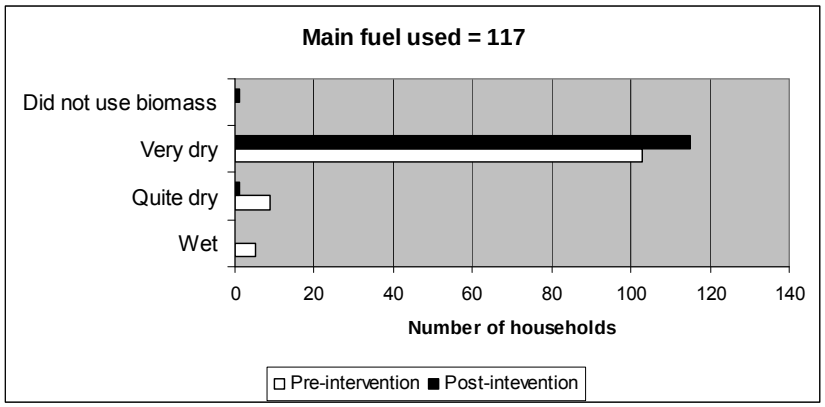
Environmental impact
The majority of those who gather fuel feel that there is just about enough. This again reflects an increased availability for those gathering fuel. However, very few gather all their fuel.

Figure 8.5: Scarcity of fuel supplies for gathering



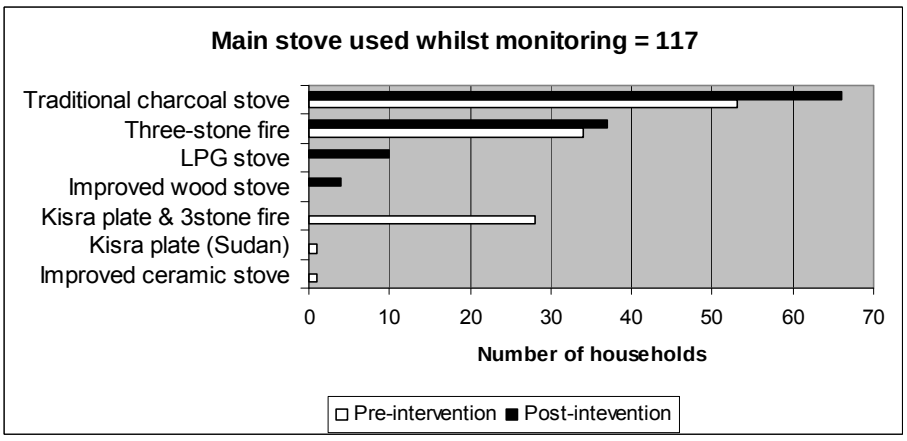
Fuel wet or dry
A small positive change in the numbers using dry fuel was reported with only one household reporting the use of fuel that was not completely dry. There was very little change in this indicator – although ten people reported using green wood in the first round, nobody was using it in the post-intervention round.

Figure 8.6: Fuel fit for purpose: dryness / wetness



Main stove in use during the monitoring period
Many of those using wood on a three stone fire or with a kisra plate have moved to using charcoal in this round.

Figure 8.7: Changes in stove use

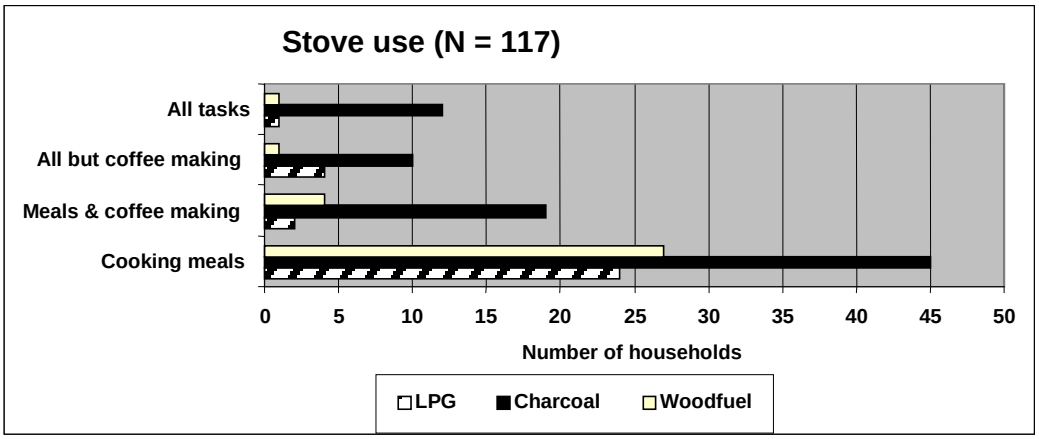


There has been a drift away from kisra to bread over the project period, and when sorghum is expensive those on low incomes will buy the cheaper bread alternative. Kisra can also be bought – so this reported non-use of the kisra plate may reflect a changing pattern of cooking linked to a change in eating habits for both economy and pollution reduction.

Which fuel for which task?

A set of three questions was added to the third round questionnaire in Sudan and Kenya, asking cooks what they usually used for : cooking meals; making tea/coffee; other tasks requiring a stove.

Figure 8.8: Stove usually used for particular tasks



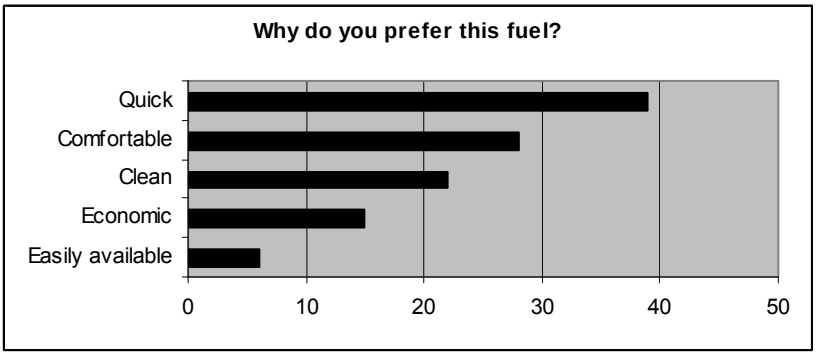
The table shows that charcoal is still the predominant fuel, and woodfuel is still used by many. LPG is cited as the main fuel by a larger proportion of households than were recorded using it on the days of monitoring. Charcoal dominates for all other uses.

Why are people not using LPG at this time?

To examine in greater detail why people had gone back to using charcoal , a sample of 42 households was revisited, and was asked to report the reasons for not using LPG.

Overwhelmingly LPG was the fuel of choice. One person prefered woodfuel because it could be gathered at no cost, and three preferred charcoal either because it could be bought next door or because it could be bought in very small amounts.

Figure 8.10: Reasons for preference



The reasons for the preference were exactly the same as the main survey – time saving, comfort and ease of use, cleanliness, and economy.

What would make things better?

Respondents felt that being able to pay a small amount each day to a local depot to save for the next refill would be very helpful. Instead of having to find SDD1700 (£4.30) every four to six weeks, they would pay in SDD100 each day as they do for charcoal. It is interesting to note that they would have saved up enough in 17 days whereas the bottle would last them for between four and six weeks.

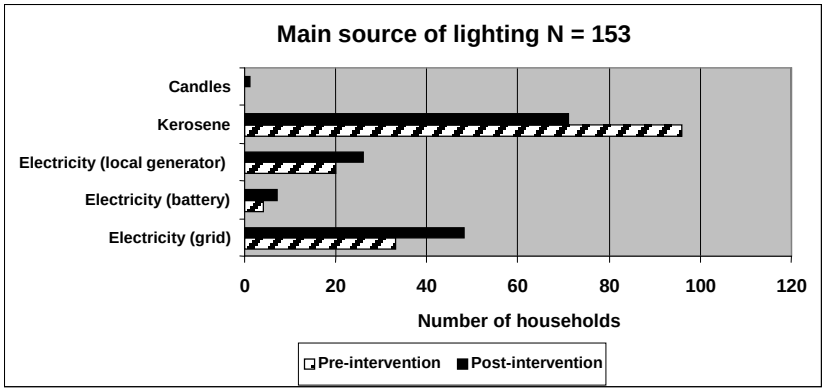
The issue of local depots is likely to be resolved in the near future as the supplier, Nile Petroleum, has already offered to create additional depots in these poorer areas. He has recognised that supporting those on a lower income to use LPG is commercially viable, and that those buying the gas can also find it cheaper once they have sorted out these initial problems.

The other suggestions on what would be helpful comprised:

- Further training on the use of LPG
- Getting credit to replace the cylinder / stove that had been taken away
- Getting a good safe kitchen with a lock to keep the children away

Lighting

Figure 8.12: Fuel used for lighting

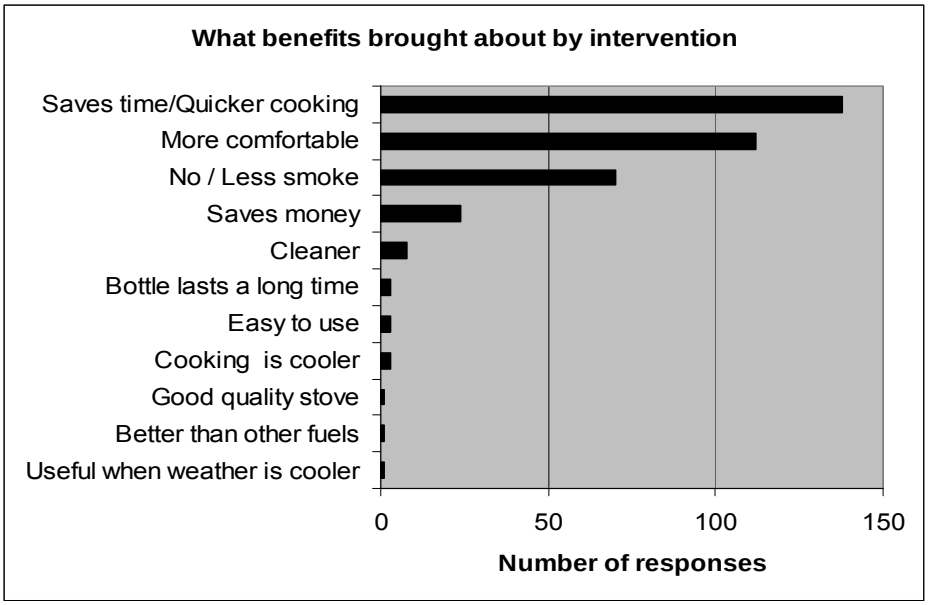


More electricity, from both grid and local generator, is now in use than during the first round of monitoring. However, there are still many households using kerosene to light their homes. These are usually highly polluting wick lamps.

Project impacts

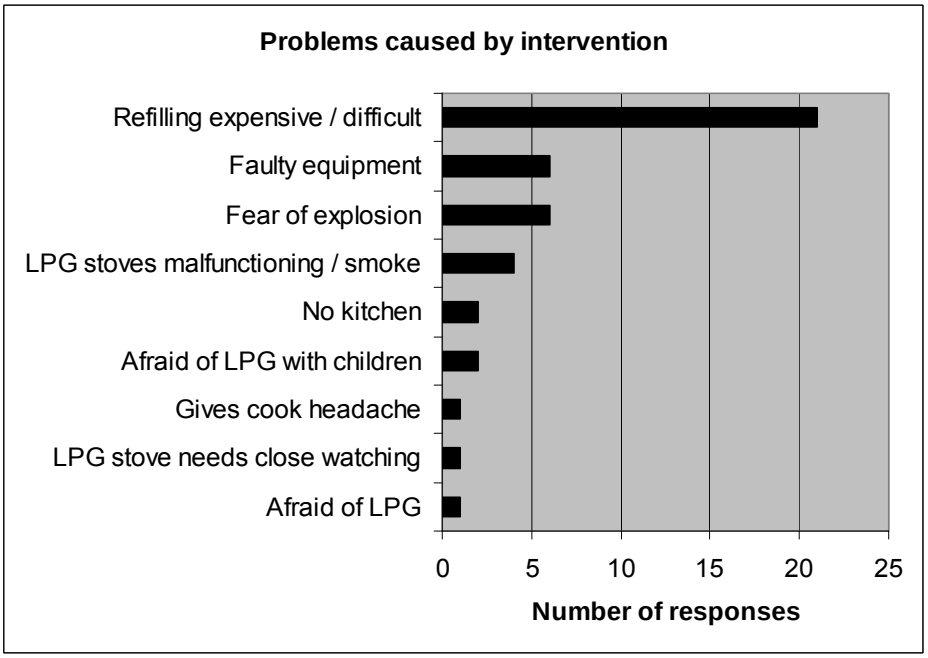
Almost all those interviewed speak about LPG as if they are still using it. Asked what intervention they had in their homes, they cited LPG. The benefits of LPG to the women are very clear. They save time and money, with reduced pollution and the comfort factor coming high in their perceptions.

Figure 8.13: Responses to open question about benefits of intervention



The problems listed reiterate those highlighted in the additional monitoring recorded in Figure 8.11. Gender is an issue insofar as most women depend on their husbands for money. Those who earn money through seasonal farming activities describe husband's being unwilling to share the repayments of either the stove or the refill, which made repayments problematic when there are no goods to sell. This issue has now been addressed, as discussed earlier in this chapter.

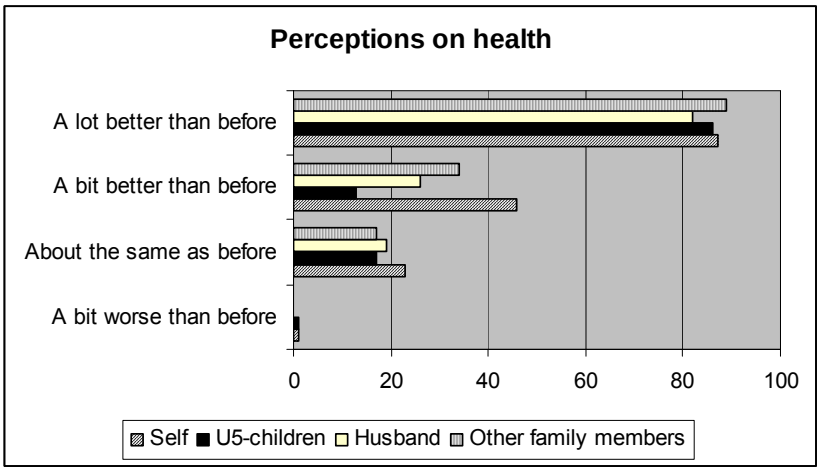
Figure 8.14: What are the problems?



The switch back to charcoal by many households was unexpected and unwelcome. In some instances, where the question asks about 'the intervention' it is likely that people have responded for LPG use otherwise the very positive responses do not make sense, as nothing has changed. The Sudan independent review of the research makes it clear that the trend is very much towards an increasing use of LPG.

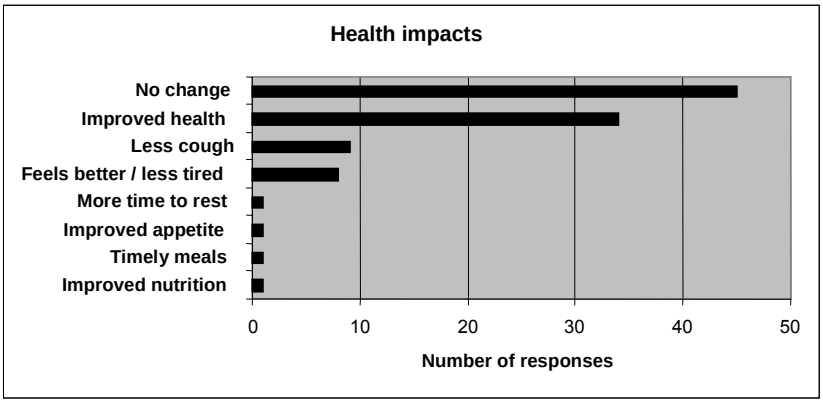
Observations on health

Figure 8.15: Changes in health for various family members



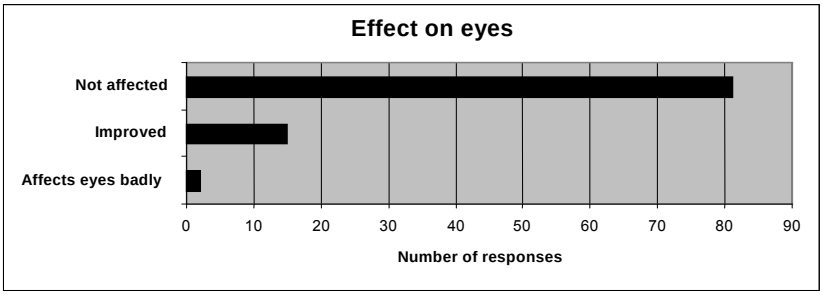
In Figure 8.15, the question referred to how the intervention (LPG) had affected people's health. It can be seen that most of the households noted a marked improvement in the health of every family member.

Figure 8.16: Ways in which health status has changed



By contrast, the next question asked if the person felt that their own or their family's health has changed and no mention was made of the intervention. It can be seen from Figure 8.16 that many of the households witnessed little change in their own health or eye health (Figure 8.17).

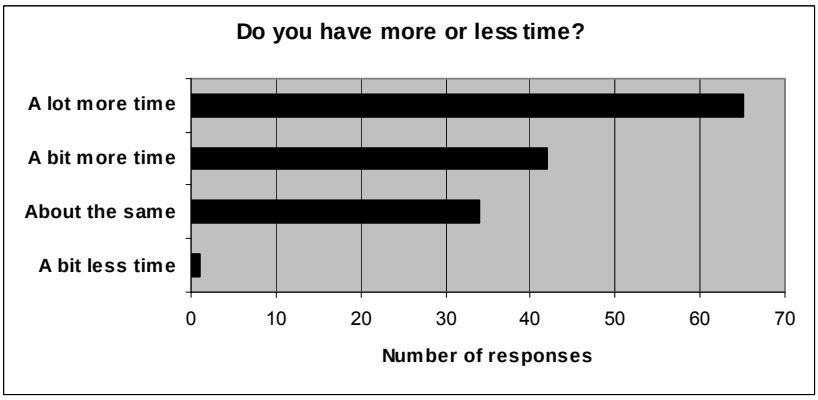
Figure 8.17: Affect of interventions on eye health



Observations on time

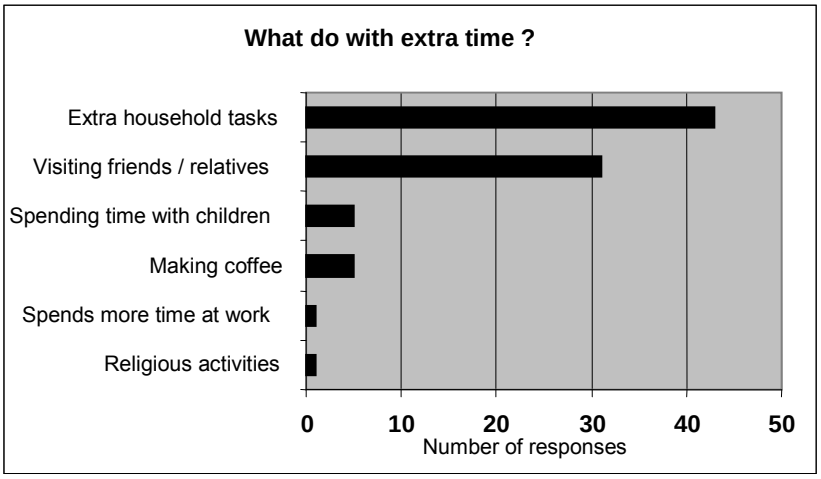
Several respondents felt that they had a lot more time, even those not using LPG. All report that this is caused by 'faster cooking'. This either reflects the use of charcoal, which cooks faster than woodfuel, or they are referring to using LPG.

Figure 8.18: Changes in available time



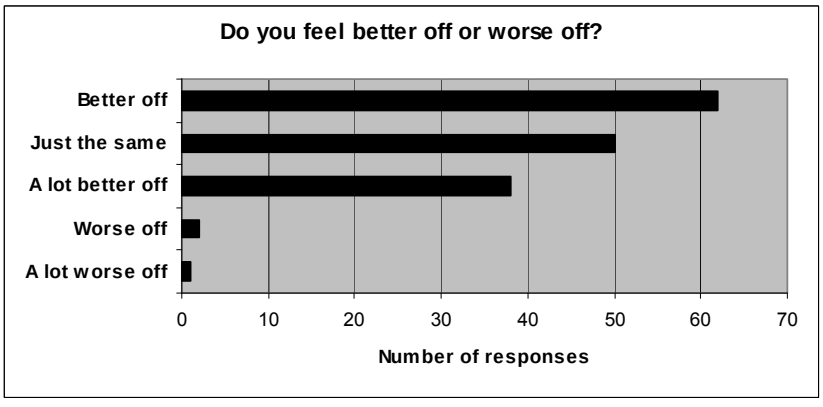
Figue 8.19: Uses of additional time

Unlike in Kenya and Nepal, the activities in Sudan centre around the home, with only one person spending extra time on paid work.



Savings and income

Figure 8.20: Changes in savings / income



Around 60 of the 160 households felt that they were better off, and nearly 40 said they were a lot better off , around 50 said that they felt the same with the remaining three feeling worse off. However, the positive responses were largely due to an understanding of 'better off' –into which they included time and comfort, as noted in Figure 8.24.

Further, a few benefits were reported in the past tense, as people reported the positive impacts they had experienced 'we had no smoke' and 'am not using LPG stove these days'. This contrasts sharply with a mid-project review where households were using LPG and the savings in fuel costs were around 70 per cent - around £75 per annum. LPG is marginally cheaper than any other fuel in Kassala, even at the present time, and none of the households using this fuel reported an increase in costs. However, many of the households using both charcoal and kerosene also reported a saving.

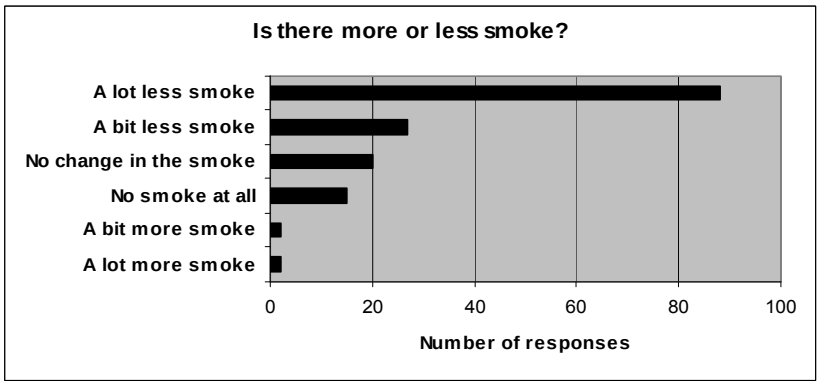
Many of the respondents said that they were saving 350SD (£0.86) or 700SD, (£1.70) per week, which is likely to be 50SD or 100SD per day. , which may reflect a reduction in the cost of charcoal. However, it does tally well with the savings indicated by those using LPG of around £63 per annum.

Family life

Smoke

The table shows that most people feel there is a lot less smoke. This would be the case for both LPG and charcoal. Levels of personal CO declined markedly in this round, suggesting that for whatever reason, the levels of pollution experienced by the cooks have come down.

Figure 8.21: Changes in the levels of smoke



Is the kitchen worse or better?

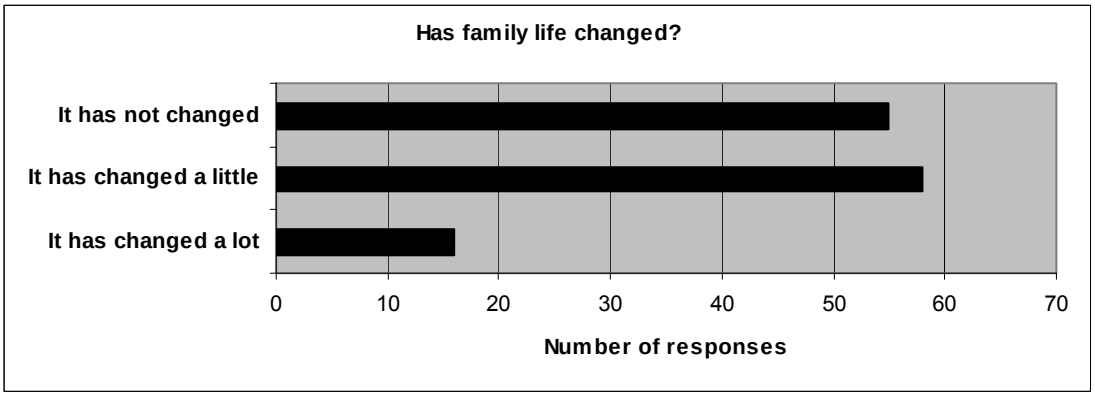
There was virtual consensus that the kitchen was not worse, though over 50 noted little change and an equal number thought it was a bit better. Over 40 households thought their kitchen was a lot better.

Figure 8.22: Changes in the kitchen environment

Has family life changed?

More people felt that family life had been affected by the interventions than felt it had not changed at all.

Figure 8.23 Changes in family life as a result of smoke alleviation interventions



Impacts of intervention on family life

There was some misunderstanding about the expression 'Worse off or better off' and these impacts are all reported in this section. They proved very similar to the observations made later in the questionnaire by the cook. These two tables will be looked at together.

Figure 8.24: Changes to family life (Worse or better off)

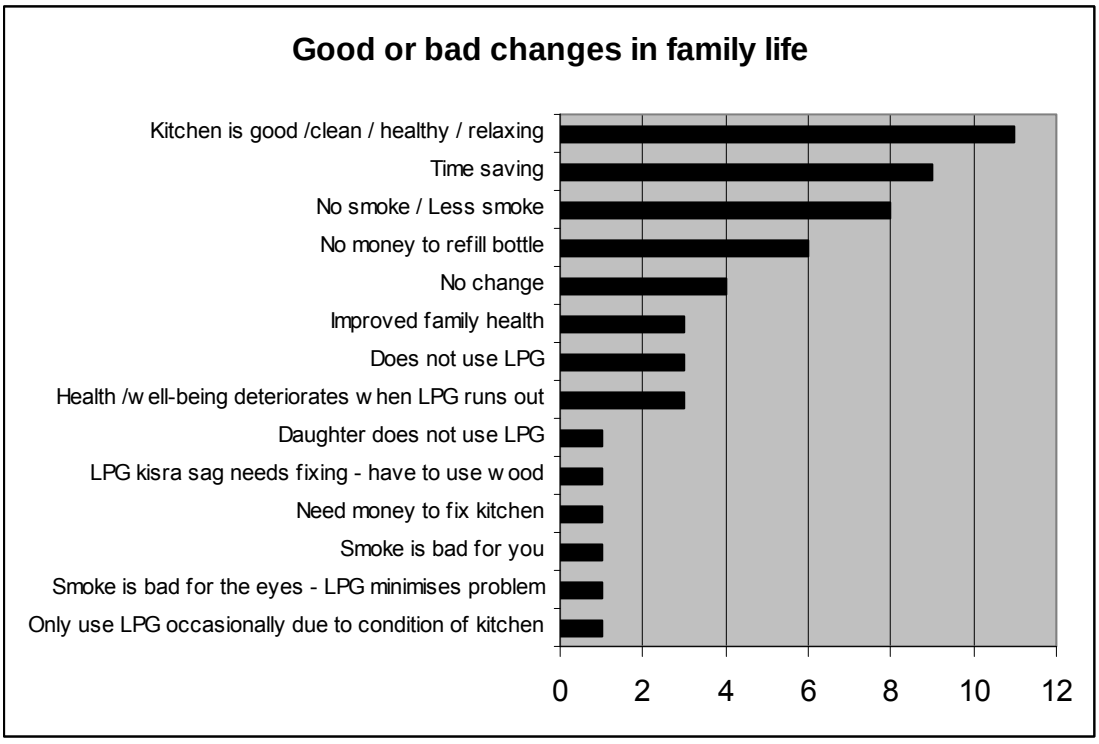
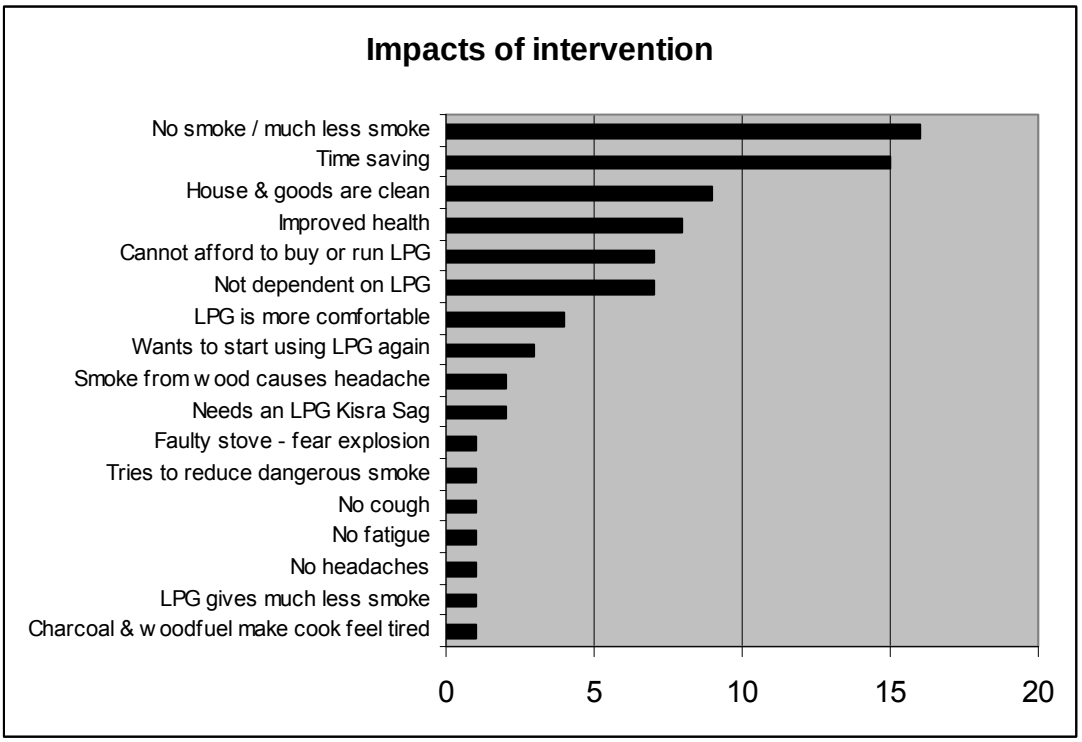


Figure 8.25 shows that time-saving, cleanliness, lack of smoke on the positive side are counterbalanced by a lack of savings to buy or run LPG. LPG is viewed positively from every perspective other than the need to save for it. This may explain why, despite the low usage figures, everyone still aspires to use it as their primary fuel.

Figure 8.25: Final observations made by the cook



Chapter 9: The research process - did it work?

For the research to reach definite conclusions, several components were dependent on each other, and complemented each other. The key components comprised:

- Identifying potential mechanisms for sustainable growth in alleviation of kitchen smoke
- Monitoring to make sure the interventions were effective in reducing smoke, for the growth to be effective in impacting on health
- Ensuring that there was adequate supply of interventions for growth in demand
- Creating demand and monitoring demand
- Monitoring the impacts on the quality of life for those making the changes

At the same time, it was recognised that there was a rare opportunity to look at the impacts on women's health directly, across three countries, through questionnaires and lung function testing through:

- Monitoring respiratory symptoms (cough, wheeze, phlegm)
- Monitoring lung function in women cooks

The findings from this study have been analysed using the approach recommended by the WHO in recently compiled methodology for cost-benefit analysis from reductions in IAP, and using data from the recently completed work in Guatemala (RESPIRE) on the links between indoor air pollution and Acute Lower Respiratory Infections (ALRI) in small children.

Each of these elements will be examined in turn – not for the outcomes, but to discuss whether the research methodology was effective.

Identifying mechanisms for sustainable growth

Market surveys

The plan was to have two market surveys with an interim period in which to create awareness through promotion of the message that smoke was dangerous, and that ways existed to reduce the risks. To try to move early to a more commercial focus, the plan was to use a locally available market survey organisation to run the study.

Kenya
In Kenya, the first survey was very evidently flawed. Various aspects (such as fuel use) were seriously mismatched against the knowledge of the project team, and also against the very recent demographic survey in the area. The company agreed that there had been 'problems' with the data, and new data was presented. When this contained data that was not mathematically possible, the survey was abandoned. Considerable time was lost, and in the meantime, the survey became meaningless as promotional activities had to begin. The second survey was undertaken managed by the project staff, but using experienced and trusted enumerators and was well done.

Nepal
There are no market survey companies in the high hills of Gatlang, and since the local language, Tamang, was needed, the survey was completed by a local teacher. This person is well known and trusted by community members, and both surveys were completed accurately and on time. However, an NGO moving into an area and seeking permission to do this sort of work creates its own promotion – so again, a single survey in the early stages would have been adequate.

Sudan
In Sudan it was agreed that only one survey was needed, as the level of demand had already moved into several hundred requests for LPG sets. Useful data was compiled in terms of willingness to pay etc.

Other surveys were undertaken as needed during the research. In Sudan there had been a baseline study on numbers of people using LPG; in Kenya, a survey was put in place when the demand for LPG started to rise during the project period. Nepal benefited from a needs assessment conducted during the project period, and a skills survey was conducted when seeking artisans.

These findings suggest that two market surveys with a small time interval between them are very dependent on everything running to plan. A single survey would have been more useful, with perhaps one at the end of the research project to identify the levels of awareness that had been generated during the project.

Revolving finance

The market surveys had shown that very few people would be able to alleviate smoke through more costly interventions such as LPG or smoke hoods unless some form of financing was available. The approach to implementing this finance was decided locally in each country, in consultation with the communities on what would be acceptable. Revolving finance is very powerful tool, and this work has shown that provided there are good measures for monitoring and a high level of interaction with those buying through this type of finance, it can be very successful.

All three country teams experienced some problems right at the start, but went on to work with community members in running successful schemes, and learning through this achievement.

However, relative to the massive scale of the problem, more seed capital and other initiatives (perhaps including some form of subsidy) would be needed for interventions to reach large numbers of people quickly. As a tool, it continues to be useful in the project areas, it empowers the household to be in charge of their situation, rather than be a passive recipient. From a sustainability perspective, the funds continue to revolve and so many more people have been reached, and will continue to be reached, than in the case of a 'hand out'.

In terms of sustainability, the funds will continue to revolve within those areas that have already accessed the funds, and this provides ongoing employment as well as access to finance.

However, where new revolving funds need to be set up, additional seed capital will be required, and it is not clear that those running the funds will have the necessary networks to access these funds. Action has been taken during the research to facilitate this happening in each country.

- KIAPNET, in Kenya, are already looking towards the future and seeking ways to approach government departments to seek development funds.
- The District Development Committee in Rasuwa have access to government funds and are expressing interest in using them. However, the finance is also being used for enterprise development, where they can get interest on the credit provided, so time will show whether they are committed to expanding access to smoke hoods.
- Finally, in Sudan, support will continue to be given to the WDAs to expand access to LPG stoves. There is a strong move to LPG in Sudan, and the long-term prognosis is excellent. Both the WDAs and Practical Action have a good agreement with the Nile Petroleum, which is very supportive of the initiative and is facilitating improved access to LPG – including loan finance. This is a commercial decision and as such is rooted in a belief that the future is with this fuel.

Sustainability ssues and challenges identified by the research

Kenya

In Kenya the community groups are running the schemes for the whole community. This is a very positive approach insofar as the Community Resource Persons will be continuing to run the schemes, through the community groups, after the project has ended. What is perhaps less successful is the rate at which new people are opting to use revolving finance –around

18 per annum over the next three years. However, revolving finance is only used for the more costly options, so this does not mean that smoke alleviation itself is growing at this rate. LPG and smoke hoods are something to which people will aspire as long as the mechanism itself exists.

Another issue in Kenya are the very serious poverty levels. To run a commercially viable revolving fund scheme would require payments to be made exactly on time so that the money, and the small profits, would provide a steady income for the person doing the work. The current perception is that people pay back on time if they can, but pay back late if other priorities (such as lack of food) prevent payment on time. Provided that the Community Resource Persons are not depending on this money for their own livelihoods, but rather as additional welcome income, this agreed way of working might be the best option.

Now that KIAPNET is running the scheme independently of the project, it is up to them to make decisions on whether to try to put the loans on a more formal footing, or whether to market the finance scheme more aggressively to reach larger numbers of people. A lot of time and energy is put into promoting the lower-cost interventions that people can make themselves, or can purchase without credit. There are plans to open up the revolving finance scheme to allow members to use the finance for other initiatives, such as income-generation, and this will be their decision.

As with Sudan, the important issue is to ensure that those collecting the finance are properly recompensed for their time and effort as this goes into the longer term. Recent changes provide for the Community Resource Persons to receive 20 per cent of all they collect, which will adequately pay them for the time spent collecting.

Nepal

The Nepal scheme uses a completely different mechanism to sustain the initiative. Groups of people form a community group and once they have reached twenty members, they are entitled to request revolving finance. The scheme works well, with almost 100 per cent repayment on time.

The main problem with the scheme early on was having worked to give people a sense of ownership of it, the small group benefiting from the first tranche of seed capital became very committed to this ownership. They were unwilling to allow anyone who had not borrowed and repaid money in the first place to access the right to use it. This issue has now been clarified and resolved.

The scheme has been handed over to the District Development Committee who have made a commitment to continue to provide the 35 per cent subsidy required until such time as it can be phased out. However, the committee is also keen to use the funds for loans to people for enterprise, and for this they charge interest. To keep the revolving finance scheme live, it is therefore in their financial interests to provide other enterprise loans rather than for smoke hoods that they would also have to subsidise. It could be argued that if people would prefer the credit for income generation, this may be another route to them being able to afford smoke hoods at a later date. As the project closes, there is already a full order book right through the summer for the hood manufacturers, so demand still exists for smoke hoods.

Sudan

The greatest challenge in terms of revolving finance for Sudan was the scale of demand. Before this project started, there was a growing order book from the end of the original study, when promotion was begun. The decision was taken that loans would be serviced through the branches of the Women Development Association (WDA), co-ordinated through the WDA main branch in Kassala town, as they already had experience in micro-finance.
However, not all WDA members have shown themselves to be very suited to the business environment; microfinance, management, monitoring and follow up, provision of after-sales services and running of the LPG shop on commercial basis

With growth rates much higher than had been anticipated, there were insufficient project staff from Practical Action to monitor project activities. The inefficient monitoring and follow up of repayment of loan instalments exhibited by some WDA groups reduced the pace of revolving fund turn over, and increased the time lapse between batches. Moreover, it consumed the

revolving fund money available for future batches, as loan payments on the LPG cylinders had to be paid first to the external supplier. A completely separate account was set up within the bank to resolve this issue.

The scaling up phase of the project has only been in existence for three years. The adopted scaling up strategy is functioning well, but its sustainability resides in the ability and capacity of the WDA to further carry on with the revolving fund system to enable all those households in Kassala State to have access to LPG if they so wish.

The present capacity and capability of the WDA to handle the project management is still questionable. The management tended to regard the revolving finance money as WDA money in its own right, rather than as a completely separate financial undertaking. This has meant that on occasions it was spent on WDA requirements, such as office equipment, rather than on smoke alleviation products. Practical Action undertook effective measures to correct past mistakes with WDA–Kassala. These measures involved the creation of Kassala State Women Development Network, KSWDN. The new organ, KSWDN represents all the WDAs in Kassala State. The KSWDN will partner Practical Action for the implementation of the Smoke Project in the short term until such time as it is ready to run it independently.

It has been recommended that the KSWDN committee should take a consultative role (policy, strategy, planning, and advocacy) rather than executive role. Any member willing to take an executive role would have to compete for the specific post. Such arrangements will put KSWDN in a better position to serve the interest of women in Kassala State, particularly in the rural areas rather than solely concentrate the activities in Kassala town.

Practical Action Kassala has shifted the project work to KSWDN and has provided support from project staff and implemented a recovery plan. Warning letters to smoke project beneficiaries were issued from Practical Action-Kassala's legal adviser and distributed to project beneficiaries from 6 WDA branches. This campaign resulted in the collection of about more than SDD 750,000 by the end of February 2007. Some WDA branches kindly rejected the warning letters, stated there was no need for it, and promised to collect the remaining instalments. This was found to be because many of the women in the area had loans without the knowledge of their husbands. Once they realised that the repayment was 'serious' – and not 'NGO money' they were prepared to pay it back, albeit slowly.

The team paid a visit to New Halfa, where they discovered that the WDA was collecting the money, but not transferring it to Kassala, so the New Halfa repayments were actually very good – one reached 100 per cent repayment exactly on time. During this campaign, the team was able to have direct conversations and discussions with project beneficiaries. Almost all beneficiaries indicated their satisfaction with the project interventions and their willingness to pay the remaining instalments.

The failure of some poor households to refill their LPG cylinders, once empty, has led to a return to firewood and charcoal usage among some of the 200 research target group. Some very few beneficiaries indicated they were unable to pay the remaining instalments and would willingly have handed over the LPG appliances to the project as they did not like being in debt although they would prefer to use LPG. However, the team took a decision not to take the appliances, and reported the cases for further investigation as to whether the said beneficiaries were really unable to pay or simply believe that the project would make a grant. In one or two cases, people surrendered their bottle due to very low payment, but kept the stove so that they could get back to using it at some time in the future.

As the project reaches its conclusion an eighth batch of interventions will be distributed. The project will take the occasion to launch a new system and regulations, particularly the legal side regarding the guarantees, for the smoke revolving fund. This will improve the situation for everyone, the process will be more open and formal, and the whole family will understand their commitment.

Whilst these changes take place, Practical Action will remain in an advisory role. The business is very close to being a commercial venture, and with just a little growth, will be a viable and effective small business. There was just not enough time within a research project timeline for this to happen.

Issues in creating demand

Unlike a standard advertising campaign, creating involvement was vital to achieving ownership of the problem rather than just buying the product. At the same time, entrepreneurs had to be trained sufficiently fast to meet demand.

Kenya
Kenya ran a very successful campaign through engaging local groups as described earlier. The issue that remains after the project end is whether people have the very small amount of money needed to travel to venues and campaign through theatre and dance. The project staff were a focal point, helping to facilitate these events. Although it will continue to take an active interest in KIAPNET, the network will have to try to find resources if they wish to grow the business of smoke intervention finance, and also to fund the opportunities to teach others about the risks of smoke. The process itself, involving teams from the community to promote smoke alleviation, has been very successful.

Nepal
The society in Nepal is made up of small villages with mountains separating them. Virtually all of the women are illiterate, most people do not venture far from their village. Radio is available, but only to those who can afford it.

The most successful routes to dissemination were by demonstration, house-to-house visits and erecting hoardings on the routes out of town. Community meetings were held, to which well-respected people from the local community were invited. Although men tend to run things, the society is much more even in terms of decision-making, and both women and men were involved in discussions and smoke alleviation.

Formal exchange visits were set up between villages with smoke hoods and those without – and the society is such that there is a lot of movement between households, so reputation is an important dissemination tool.

Hoardings on the roads out of town promoted the smoke hood.

Sudan
The Sudan situation was unexpected with demand far outstripping supply in terms of revolving finance, and the skills needed to run it. This led to some of the early problems discussed in this chapter. It takes time and money to train people to run the groups, and where Trust funding is sought, there is a careful balance between what is acceptable to the donor, and what can be achieved geographically. Funds that go into training cannot also go into seed capital.

In a completely commercial market, the approach would be to increase the unit cost until demand and supply were matched. In this case, the target population would have been the first to be adversely affected. Thus, although not a lot was done to promote demand, neither was the price of the appliance increased to balance the market.

In the light of the numbers who have reverted to charcoal, more needs to be done to promote an awareness of the need for regular daily savings, and to promote the LPG sets to the husbands, many of whom can afford the capital costs of an LPG set.

If bottles are given away, it has been found in other studies that they tend to be sold on at market – but based on the strong desire of people in the study to keep their LPG sets, some form of subsidy by the gas suppliers could provide them with a much larger profit margin as their profit comes from gas sales, not bottle sales. Once all the repayments have been made, LPG is the cheaper fuel, and the demand for LPG stoves and fuel would increase. More people using LPG would lead to more depots, improved access, and thus create the best conditions for growth in the market.

Technology issues

Kenya

The large number of interventions available in Kenya is testimony to the participatory approach working within a very low-income community; 'starting where people are at, rather than where one would wish them to be' – according to the project team. The reductions in pollution have been impressive - with CO levels coming down by over 70 per cent and median levels by around the same amount.

There is very little difference between the emission reductions in those able to afford more costly interventions and those adopting low-cost interventions. This may reflect additional energy use among those who can afford to buy the higher cost interventions – savings ploughed back into improved energy provision.

Rocket stove development
As mentioned in Chapter 6, there is an order of magnitude step change between the lower-cost interventions and the very efficient LPG and smoke hoods. In the last few years, rocket stoves have drawn a lot of attention, and a small 'sub-project', funded by trust funds, is developing a Rocket stove suitable for the Kisumu district which will complement the Upesi stove, and can be manufactured by those potters currently involved in stove making.

A design was built, and further funds have now been focused on making the insulative lining so that the stove will burn with very little smoke. It is anticipated that this stove will cost less than £10 and will substantially reduce the use of fuel as well as significantly reducing levels of indoor smoke. Once substantial smoke reductions are achieved (as has been the case in other locations where rocket-type stoves are in use) it is anticipated that this initiative can be scaled up through carbon finance.

Nepal

The Nepal smoke hood designed with a great deal of community input during the first project did not alleviate sufficient smoke for the team to wish to disseminate it further.

A lot of trust was built up between the team and the community, so that when the team suggested that much more could be achieved, the community was willing to accept and discuss new ideas. The design was modified to the version seen in this book – and has very significantly reduced the smoke, with both CO median and mean levels reduced by more than 85 per cent.

Upgrading current smoke hood

The main complaint – water leakage – has now been resolved in the newer designs of smoke hood. Action has been taken to reduce blow-back by introducing a restriction in the neck of the flue to create a venturi effect. This is still being researched.

Darkness is an issue for two reasons. Firstly, the hoods restrict the light shining sideways out of the hood – and building around the tripod to make the stove more efficient also blocks the low-level light. If people open the hood for light they will reduce its effectiveness – so other options for lighting should be considered.

However, over recent months, a chimney stove that generates electricity to run an electric light has been introduced somewhere near the project area. Although very few of those in this study have seen the stove, it is an attractive addition that they therefore feel they would like. The project team are aware of this stove, but do not feel that it would fulfil the needs of households in long-term. As light is only available when it is burning, it is perhaps better to address the lighting issue separately, particularly as chimney stoves do not fulfil other needs of the community (such as seeing the fire).

Space heating is an issue as, undoubtedly, hot smoke is leaving the room. However, other households have stated that once the walls are insulated, the room feels much warmer – wind

does not blow through the walls. Low-cost room heating stoves are available, but have not been widely adopted.

Smoke hood for households living at low altitudes
The high cost of the smoke hood relative to the income of the people of Rasuwa has led the team to produce a lower-cost version for low-lying areas, where the walls can be made of brick as they do not need to radiate space heating. This will reduce the costs.

This type of hood has not yet been disseminated, as there are fears that if it were widely available in the high hills, people would tend to opt for the lower cost version without realising that it lacks one of the key attributes of the metal hood – that of radiating heat. The new design also lacks the facility to open the side walls when the weather is particularly cold, as this is not needed. As the market expands down the valley, both options will be available.

Sudan

The LPG stoves are 'off the shelf' models that are well-regarded in Sudan. Some development took place on producing a locally-made kisra sag, but the models from Khartoum was better regarded, and they continue to be imported from Khartoum.

In the first study of thirty households, the introduction of LPG seemed like a perfect solution. The fuel was cleaner and much cheaper than woodfuel or charcoal at the time – and people could repay the cost of the LPG set from their fuel savings. Since that time, the relative costs of fuel have become closer, and the anticipated change in behaviour for people to save regularly did not happen. Feedback from the first study (where again people paid for the appliances), indicated that they were committed to LPG.

The overwhelming problem is not the price of the fuel. It is comparable to, or cheaper than, charcoal. The reason for choosing the larger gas bottle was the journey to purchase refills. Most people, including the project team, felt that a long walk into town to refill the smaller bottles each week would be a disincentive. It was better to save up during the month to buy a refill every four to six weeks. This is where the problem seems to have arisen. People have little money and no tradition of saving. It is almost inevitably the woman who is paying for the stove – and for the fuel – from an allowance given to her by her husband. When she does not have an immediate need to buy fuel – because the bottle is not empty – the cook will spend her allowance on more pressing needs. Some of the women did not tell their husbands that they were buying the stove on credit – so the money for repayments has to be found.

Once the bottle is empty there are three lots of money to find:
- Money for immediate energy needs – a bag of charcoal for the next day is cheaper than a month's supply of gas (even though charcoal for a month would cost more)
- Money to repay the loan on the LPG set; people are still repaying the cost of the stove
- Money for the next refill.

In May 2007, Nile Petroleum gave a commitment, during a workshop in Kassala involving both community representatives and policy makers, that it would make two positive changes:
- Setting up more depots so that people could access refills more easily
- Setting up a mobile shop to reach villages that are not within the town.

This decision has two implications – firstly, people can use smaller (4.6Kg) bottles rather than 12Kg bottles, as they will be able to swap the cylinders more easily. Secondly – even if they have not saves enough, there is far less to save before they can afford a new bottle.

The other aspect of this announcement is that the supplier sees the project communities as long-term purchasers and this is a commercial decision based on his business acumen. It is likely that the project study area has a higher number of households reverting to charcoal as it was selected because of the low incomes. Places, such as New Halfa, where all the shrubland (mesquite) has been cleared by the government are likely to switch entirely to LPG – as witnessed by their 100 per cent repayment of LPG sets.

Practical Action is currently looking at ways to enable people to restart using their stoves. This could be by supplying the next lot of fuel on credit, and working very hard to inculcate a savings habit, by involving the husbands more in the process, and/or by swapping the larger (empty) bottle for a smaller (full) bottle, and adjusting the loan accordingly.

Baseline and impact monitoring issues

Monitoring had three components:

- Questionnaires
- Room CO monitoring
- Lung function measurement

Questionnaires

Three sets of questionnaires were used – the first to provide baseline data; the second, a much smaller study, to inform the project of anything missing which was of importance to the communities, and the third was to look at the costs and benefits of what had been done.

Most of the questions worked well – although there were one or two questions that were misunderstood, due to poor wording. The only real problem was a question 'What interventions is the woman having in her home to reduce smoke?' – this was intended to find out her plans, but was interpreted as 'What interventions does the woman already have in her house.' Although the questionnaire was piloted, this one slipped through the net.

Another issue was asking what time women did the cooking. Once data was returned, it was noted that this meant different things to different people – so to some, it would involve all the preparation etc. whilst to others it would be the time spent at the stove. It proved much more straightforward to look at the amount of time for which the CO monitor was registering high levels of CO – although this was also subject to some error if people cooked away from their stove.

The main surveys were around one year apart. There was one person in the whole study who did not want to take part in the follow up round – so she was omitted.

Health data was sought on cough, phlegm, wheeze, headaches and child health, as well as the cost of health provision. Questions relating to smoking, which could be a confounding factor when measuring levels of CO, were also asked. A method for determining the level of CO exhaled from a person's lungs was being tested as part of this study. Measures to do with the time spent since last in contact with smoke were asked in the first round, but when they did not yield useful results they were abandoned (apart from smoking) in the third round of monitoring. A question on pregnancy was asked for those doing lung function tests.

Room CO monitoring

Room CO monitoring was used to check whether the interventions were working in practice and providing the necessary levels of smoke alleviation to benefit health. In the event, it was a useful tool to monitor the effects of moving away from LPG in Sudan, as the scale of use of charcoal would not otherwise have been so apparent. Despite the reversion to charcoal, levels of particulates still appear to have dropped between pre-intervention and post-intervention. Full details of monitoring methodology can be seen in Part 1 of this publication.

CO monitoring also proved useful in observing the effect of households fasting during Ramadan in Sudan. Several of the households were monitored during this period, and the emissions were very much lower during this period than for those monitored at other times. In future, it is recommended that monitoring does not take place at this time.

In previous surveys, the CO monitors provided a very clear trace of the time spent cooking. For those who moved exclusively to LPG, the emissions were so low that the cooking time was imperceptible on the emissions trace. For the cost benefit analysis, it was necessary to use a conservative estimate of the post-intervention time spent cooking. Although the time savings were very large, they tallied well with the cook's own observations on time saving and could be clearly accounted.

Lung function measurement
Two ways of monitoring the lungs were undertaken. The first was a standard spirometry test, which measures how effectively the lungs work in terms of their capacity, and their ability to exhale air effectively. The second test was to check 'breath-CO' – the amount of carbon monoxide exhaled by those who have inhaled CO from either a fire or a cigarette or similar source. These methodologies are discussed in Chapter 10.

In Kenya, during the 'lean' season when food is scarce, the team felt that measuring lung function using spirometry took a great deal of energy for those taking little food. They provided a glass of milk a few minutes prior to doing the spirometry.

Monitoring demand

Some of the low-cost interventions grew through demonstration leading to natural adoption, such as wall insulation in Nepal, and both types of fireless cookers in Kenya. For these interventions, the team observed what they could, but any attempt to quantify the numbers would have been too costly to justify. Most households in the Nepal project area have now insulated their walls. Less households have adopted the changes to the tripod stove, and this could be a major time cost saving in terms of fuel collection. In Kenya, around one third of those monitored purchased fireless cookers (as opposed to making them) and all had installed upesi stoves. Many households that could not afford the 'major' monitored interventions in the sample have also installed fireless cookers.

The higher-cost interventions were monitored through the revolving finance. Even where households bought the goods outright, this data was collated at the same time as the goods bought on credit. Since there were very few items bought in this way, the approach enabled teams to keep good control of the financial situation and monitor the growth in the market at the same time.

In Sudan, the rapid start, range of technologies and geographic distances made it difficult to control until the project manager in that country developed a more detailed management structure. This structure is now being used successfully.

Other issues

Monitoring growth
Where growth of the market was very rapid, as in Sudan, the number of people eligible to be invited for monitoring was large. Once enough batches of LPG sets had been delivered, then monitoring could begin for those willing to be involved. Even in Sudan, though, there was an urgency to get batches installed for monitoring purposes that could perhaps have been avoided if the time frame had been longer.

In Kenya, this was more problematic. The team have worked with women's groups in Kisumu area for years, and the relationship was very cordial. Staff in Kenya believe that some households made the decision to adopt interventions sooner than they would otherwise have chosen, as they had committed to being part of the study. It also meant that some of the monitoring was left till very late in order to allow people to establish their cooking regimes. In the event, a smaller number of households than was planned could be monitored. Whilst around 340 households had benefited from the scheme, they were not necessarily those who had taken part in the baseline survey.

This is a difficult balance, because it was necessary to monitor what was happening in terms of impacts (both positive and negative) at the same time as trying to monitor growth. Because of the poverty situation, uptake had to be done in a staged manner.

Peace
One of the risks highlighted in the research document stated 'Political situation may make monitoring problematic at some times'. The unexpected way in which this happened in Sudan was a peace treaty that allowed many people to return home. This included 42 of the 200 households monitored in the first round. One can only wish them well, and hope that they have access to gas supplies once they get home.

Chapter 10: Health findings

Introduction

One of the key objectives of this study has been to address Millenium Development Goal 4 – to reduce child mortality. Although a key focus of the study, direct assessment of child deaths or incidence of conditions such as pneumonia which are linked to IAP and among the most important causes of child mortality, requires study design of a size and complexity well beyond the scope and resources of this project.

The approach taken has been to use the change (reduction) in IAP levels as the main indicator of expected impact on child health, by relating measured reductions in pollution to the best available and emerging evidence on the association between exposure levels and incidence of pneumonia. This is discussed further in Chapter 11, which discusses the cost benefit analysis (CBA).

The opportunities provided by the project were taken to study health measures that were deemed feasible, given the design and resources. These focus mainly on the women interviewees, in particular their respiratory health assessed through symptoms (cough, phlegm, wheeze) and lung function (FEV1, FVC, and Peak Flow Rate). Headaches were also assessed. For households with young children less than 5 years, the study enquired about recent illness episodes with respiratory symptoms, and burns over the previous 12 months. Use of health services and expenditure were also studied.

The study design, that is a 'before and after' design, was selected as being the most practical and acceptable option for this development project, but it does constrain interpretation due to lack of a comparison group and the possibility that any observed changes in outcomes might be due to factors unrelated to the intervention. This limitation was recognised at the outset of the study, and has been taken into account in the analysis strategy and interpretation of results. One approach to analysis that helps with this confounding problem is to study changes in outcomes (e.g. presence of symptoms, lung function, etc.) for individual subjects by the level change in the same person's exposure. It would be expected that, if the effects were the result of the intervention (and mediated through a reduction in IAP), then the larger the reduction in a woman's exposure, the larger would be the improvement in outcome for that woman. Hence, if such findings are identified, we can have more confidence in the result and the conclusion that improvements in outcome really are due to the intervention. This approach to analysis has been used for all three countries, where there were sufficient data: in practice, this was most useful for the Nepal dataset due to this study having the most complete follow-up.

For each country, results are reported first for the baseline studies to describe key characteristics including smoking rates, respiratory symptoms, and lung function. The relationships between symptoms and lung function are also explored. The second section of the report for each country deals with changes between baseline and follow-up, including in pollution and exposure, symptoms, lung function, headaches, respiratory illness episodes and burns (children), and use of and expenditure on health care.

Kenya health summary

Baseline survey:
None of the women in the study sample from Kenya were smokers. Symptoms of cough and phlegm were common, and around 10% reported that these respiratory symptoms were chronic, persisting for at least 3 months per year, for the last two years. Some 13% had FEV1/FVC ratios less than 70%, but rather few of these subjects also reported chronic respiratory symptoms. There were no consistent associations between lung function and respiratory symptoms: the reasons for this are unclear. It is possible that the symptom questions were not interpreted by respondents in the same way as for the other countries, or that there were other reasons for the cough and phlegm reported. It is also possible that the lung function tests were was not performed as consistently, thus introducing more random variation into the analyses.

Follow-up
In the follow up study, 112 households were monitored, with 59 households monitored for CO levels. Kitchen IAP levels were reduced by around 70%, and breath CO was reduced by around one-third. Respiratory symptoms were markedly reduced at follow-up, with very little reporting of chronic cough or phlegm, while lung function (FEV1 and PEFR) were increased. Due to the relatively small numbers with exposure and survey data, it was not possible to study the relationship between individual reduction in IAP (or breath CO) and changes in symptoms or lung function. The observed overall increase in lung function is of interest, but in the absence of the individual-based association with exposure reduction should be interpreted cautiously, as these measures can improve with repeat assessment as subjects become more familiar with the procedure.

Headaches were common at baseline, but women mostly thought these were related to fever and/or malaria. Nevertheless, both frequency and severity of headaches were reduced at follow-up. For children less than 5 years, there was a marked reduction in the prevalence of illness episodes with cough. Burns to children in the previous year occurred in 18 out of 77 homes with young children at baseline, and were very substantially reduced at follow-up. Visits for adults and children to health providers were mainly to health posts and other/private providers, and (along with expenditure on health care), were also substantially reduced at follow-up.

Kenya baseline data
These results are based on all respondents in the baseline survey

Age of respondents

A wide range of ages were included in the study, from 17 to 57 years, although generally this was quite a young group of women - with a mean (SD) of 32.9 (9.0) and median (IQR) of 32.0 (25.0 to 38.0).

Smoking

None of the women in the sample currently smoked tobacco, although 2 were ex-smokers who gave up more than one year ago.

Respiratory symptoms

Prevalence of cough, phlegm and wheeze
Although the majority of respondents reported cough and phlegm symptoms, less than 10% had the most chronic definition, that is, most days, for at least 3 months of the year, and for two years or more (Table 10.1).

Table 10.1: Respiratory symptoms at baseline - Kenya

Symptom	Definition		
		N	%
Cough	First thing and/or other times	126	79.2
	First thing and/or other times, most days	56	35.2
	At least 3 months in last year	48	30.2
	At least 3 months and for 2 years	32	20.3
	At least 3 months, most days and for 2 years	20	12.7
Phlegm	First thing and/or other times	93	58.5
	First thing and/or other times, most days	37	23.3
	At least 3 months in last year	33	20.8
	At least 3 months and for 2 years	22	13.8
	At least 3 months, most days and for 2 years	15	9.8
Wheeze	Wheeze over the last 12 months	54	33.8
	Wheeze with a cold	48	30.0
	Wheeze without a cold	17	10.6
	Wheeze for 2 years or more	25	15.7

Symptoms of cough and phlegm

There was a reasonably close relationship between the reporting of cough and phlegm. For most of the definitions in Table 10.2, around 60 to 70% of those reporting a cough symptom, also reported phlegm of similar severity and duration. For the most chronic definition, however, only 50% of those with cough also reported phlegm most days for at least 3 months of the year and for 2 or more years.

Table 10.2: Presence of both cough and phlegm symptoms - Kenya

Cough symptom	Equivalent phlegm symptom (same definition)	
	N	%
Cough first thing and/or other times	87	69.0
Cough for at least 3 months	23	67.6
Cough at least 3 months, for 2 or more years	15	62.5
Cough most days, at least 3 months, for 2 or more years	7	50.0

Episodes of cough and phlegm

74 women reported at least one episode of illness with cough and phlegm lasting 3 or more weeks in the last year, and 24 of these had experienced such episodes for 2 years or more.

Cough and wheeze

Of the respondents with wheeze, almost all also had cough first thing and at other times, but only 20% reported the most chronic cough symptom (Table 10.3). A similar result was seen for phlegm, with 76% reporting phlegm first thing and at other times, but with only 20.5% reporting the most chronic definition of phlegm. This pattern also seen in Nepal and Sudan, and indicates that much of the wheeze reported is not associated with the more chronic respiratory symptoms normally associated with COPD.

Table 10.3: Presence of wheeze (2 or more years) with other respiratory symptoms - Kenya

Cough or phlegm symptoms	n	%*
Cough first thing and/or other times	52	96.3
Cough at least 3 months, for 2 or more years	16	32.7
Cough most days, at least 3 months, for 2 or more years	10	20.4
Phlegm first thing and/or other times	41	75.9
Phlegm at least 3 months, for 2 or more years	11	27.5
Phlegm most days, at least 3 months, for 2 or more years	8	20.5

* Percentage of those reporting wheeze who also have the specified cough or phlegm symptom

Lung Function

Lung function values
Among non-smokers, 158 (98.8%) cases were reported to have valid FEV1 measurements, 157 (98.1%) valid FVC measurements, and 158 (98.8%) valid PEFR measurements. 21 women (13.1%) had an FEV1/FVC ratio of less than 70%. These low ratios may be suggestive of COPD, although it should be noted that bronchodilator was not used as part of the measurement procedure. However, only 5 (24%) of the 21 women with FEV1/FVC ratio < 70% also had chronic symptoms of cough and only 1 (5%) also had chronic phlegm.

Relationship between lung function and symptoms
It is useful to study the relationship between lung function and symptoms, as this provides some assessment of how valid the questions (and responses by the women) are, and the extent to which the symptoms reported may be affecting their lungs. In order to allow for the possible 'confounding' effects of age and height - both of which are related to lung function values – these analyses are carried out using multiple linear regression. There were no consistent or statistically significant findings for these relationships in the data for Kenya. One reason could be that respondents did not interpret the symptom questions in the same way as for the other countries, or that there were other reasons for the cough and phlegm symptoms reported. It is also possible that the spirometry was not performed as consistently.

Kenya follow-up data

Results based on comparison of households included in both the baseline and follow-up study. Of the original 160 in the sample at baseline, 59 (36.9%) had complete follow up survey and examination (lung function, room and breath CO), and a further 53 (33.1) had the follow up survey. The remaining 48 (30.0%) were not followed up.

Indoor pollution

There was a large, highly significant reduction of 72% in the mean room CO between baseline and follow-up (Table 10.4). A similar proportionate reduction of 69% in the median room values was also seen, and this was also statistically significant. Non-parametric tests used confirmed the results for both of these comparisons.

Room CO

Table 10.4: Mean and median room CO at baseline and follow up - Kenya

Measure	N	Round 1	Round 3	Difference	SEM	95% CI	p-value*
Mean	59	8.99	2.51	6.48	1.34	0.23, 7.00	<0.0005
Median	59	6.08	1.88	4.2			0.045

* T-test. Results for Wilcoxon paired test are (i) <0.0005 for room mean (ii) <0.0005 for room median. This is the median of the room means

Exposure
There were quite substantial reductions in breath CO of 32% for the mean value and 44% for the median value. Comparisons of both of these measures were highly statistically significant. .

Table 10.5: Mean breath CO (and median values) at baseline and follow up - Kenya

Measure	N	Round 1	Round 3	Difference	SEM	95% CI	p-value1
Mean	59	7.66	5.22	2.44	0.76	0.92, 3.95	0.002
Median	59	6.75	3.75	3.00			0.001

[1] Paired t-test for comparison of means, Wilcoxon paired rank test for comparison of medians

Changes in symptoms

Symptom prevalence: cough

There was strong evidence of a reduction in the prevalence of the general cough symptom ('First thing and at other times') (Table 10.6). For the more chronic symptoms, very respondents reported this symptom at follow-up, similar to Nepal.

Table 10.6(a): Numbers (%) of subjects reporting cough at baseline and Round 3 (post-intervention) - Kenya

Cough first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	18 (81.8)	4 (18.2)	22
	Yes	46 (52.9)	41 (47.1)	87
	Total	64	45	109

McNemar's test; p<0.0005

Table 10.6(b): Numbers (%) of subjects reporting cough lasting 3 months or more at baseline and Round 3 (post-intervention) - Kenya

Cough lasting at least 3 months	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	73 (98.6)	1 (1.4)	74
	Yes	35 (100)	0 (-)	35
	Total	108	1	109

McNemar's test; p<0.0005

Table 10.6(c): Numbers (%) of subjects reporting chronic cough (most days, at least 3 months, for 2 or more years) at baseline and Round 3 (post-intervention) - Kenya

Cough most days, 3 months, 2 or more years	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	94 (100)	0 (-)	94
	Yes	14 (100)	0 (-)	14
	Total	108	0	108

McNemar's test; N/A

Symptom prevalence: phlegm

For phlegm, there was a very similar pattern of changes as was seen for cough, with a large reduction in the general phlegm symptom ('First thing and at other times'), very few respondents reported this symptom at follow-up of the more chronic symptoms.

Table 10.7(a): Numbers (%) of subjects reporting phlegm at baseline and Round 3 (post-intervention) - Kenya

Phlegm first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	37 (80.4)	9 (19.6)	46
	Yes	52 (81.3)	12 (18.8)	64
	Total	89	21	110

McNemar's test; p<0.0005

Table 10.7(b): Numbers (%) of subjects reporting phlegm lasting 3 months or more at baseline and Round 3 (post-intervention) - Kenya

Phlegm lasting at least 3 months	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	87 (98.9)	1 (1.1)	88
	Yes	22 (100)	0 (-)	22
	Total	109	1	110

McNemar's test; p<0.0005

Table 10.7(c): Numbers (%) of subjects reporting chronic phlegm (most days, at least 3 months, for 2 or more years) at baseline and Round 3 (post-intervention) - Kenya

Phlegm most days, 3 months, 2 or more years	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	96 (100)	0 (-)	96
	Yes	10 (100)	0 (-)	10
	Total	106	0	106

McNemar's test; N/A

Relationship with change in IAP (room CO)

In view of the small numbers of subjects available for analysis with data on respiratory symptoms and room CO (maximum n= 59), it was not expected that there would be sufficient power to carry out useful analysis of the relationships between change in room CO and reported symptoms at follow-up.

Relationship with change in breath CO

The same consideration of available numbers with information on exposure and respiratory symptoms at follow-up as discussed in 3.3 for room CO, also applies to breath CO.

Changes in lung function

Comparison of lung function values*:*

Comparison of baseline and follow-up lung function results for those women who took part in both surveys, showed increases for FEV1, FEV1/FVC ratio and PEFR (Table 10.8). The difference (74 ml) for FEV1 was small, and marginally statistically significant (p=0.085), while that for PEFR was 27.2 litres/second and statistically highly significant (p=0.001). Improvements in lung function over the follow-up period need to be interpreted carefully, as familiarity with technique and various other factors could influence this. It is of interest however, that while FEV1, ratio and PEFR improved, there was no evidence of an improvement in FVC – which is consistent with what would be expected.

Table 10.8: Lung function at baseline and follow-up- Kenya

Measure	Baseline		Follow-up		Difference (R3 – R1)	p-value*
	Mean	SD	Mean	SD		
FEV1	2.55	0.44	2.63	0.40	0.074	0.085
FVC	3.38	0.77	3.34	0.52	-0.046	0.659
FEV1/FVC	77.3	10.1	79.3	5.1	2.03	0.186
PEFR	365.3	65.4	392.5	71.3	27.2	0.001

* paired t-test

Lung function and air pollution

Again, as with respiratory symptoms, insufficient numbers of subjects with data on lung function and CO (room and breath) were available to carry out meaningful regression analyses.

Headaches

Women were asked about the occurrence of headaches, including frequency, strength and causes. Among the whole sample at baseline, the majority (95.6%) said they did suffer from headaches, of which around one-third experienced these most days or every day, and for the majority (83%) these were 'fairly strong' or 'very strong'. A wide range of responses were given by the women as causes of the headaches, with 'fever/malaria' being the single most common reason and stated by 51 (38%). Smoke from the fire was not stated as a reason for headaches.

To examine the changes over the course of the study, information on headaches was coded into two categories, as shown in Table 10.9 for frequency of headaches, and in Table 10.10 for strength of headaches.

Frequency of headaches

There was a marked and highly statistically significant reduction in headaches as determined by frequency, and this was the case for both definitions of 'frequent' as shown in the Table 10.9.

Table 10.9(a): Numbers (%) of subjects reporting frequent headaches (version 1) at baseline and Round 3 (post-intervention) - Kenya

Headaches	Status	Round 3 (post-intervention)		Total
		Few days per week or less	Most days or every day	
Round 1 (Baseline)	Few days per week or less	79 (94.0)	5 (6.0)	84
	Most days or every day	24 (85.7)	4 (14.3)	28
	Total	103	9	112

McNemar's test; p=0.001

Table 10.9(b): Numbers (%) of subjects reporting frequent headaches (version 2) at baseline and Round 3 (post-intervention) - Kenya

Headaches	Status	Round 3 (post-intervention)		Total
		Once per week or less	Every few days or more often	
Round 1 (Baseline)	Once per week or less	47 (95.9)	2 (4.1)	49
	Every few days or more often	56 (88.9)	7 (11.1)	63
	Total	103	9	112

McNemar's test; p<0.0005

Strength of headaches

For strength of headaches, there was also evidence of a marked and highly statistically significant reduction over the course of the study, for both definitions shown in Table 10.10.

Table 10.10(a): Numbers (%) of subjects reporting strong headaches (version 1) at baseline and Round 3 (post-intervention) - Kenya

Headaches	Status	Round 3 (post-intervention)		Total
		Mild	Fairly or very strong	
Round 1 (Baseline)	Mild	17 (70.8)	7 (29.2)	24
	Fairly or very strong	55 (63.2)	32 (36.8)	87
	Total	72	39	111

McNemar's test; p<0.0005

Table 10.10(b): Numbers (%) of subjects reporting strong headaches (version 2) at baseline and Round 3 (post-intervention) - Kenya

Headaches	Status	Round 3 (post-intervention)		Total
		Mild or fairly strong	Very strong	
Round 1 (Baseline)	Mild or fairly strong	52 (83.9)	10 (16.1)	62
	Very strong	40 (81.6)	9 (18.4)	49
	Total	92	19	111

McNemar's test; p<0.0005

Child health

At baseline, 109 (69.4%) of the homes reported that they had children under 5 years of age.

Respiratory illness

At baseline, 82 (75.2%) of the children were reported to have had illness with cough in the prior two weeks, and of these 66 (80%) had breathing that was noticeably faster than usual (if more than one child in household, this refers to the youngest).

For those households that took part in both surveys, there was a similar percentage with children under 5 years (slightly less at follow-up). Of these, a lower percentage at follow-up reported that the child had and illness with cough in the prior 2 weeks, and a lower proportion of those with such illness had noticeably faster breathing.

Table 10.11: Illness with cough in prior two weeks, baseline and follow-up - Kenya

Symptoms	Baseline		Follow up	
	N	%	N	%
Number of households with children under 5 years	77	70.0	69	61.6
Illness with cough in last 2 weeks	60	77.9	32	46.4
Breathing faster than normal*	47	78.3	13	40.6

*Number and percent of those with illness with cough in last 2 weeks

Burns

At baseline, 27 respondents stated that a child under 5 years had suffered a burn or scald in the last year, that is, 24.8% of those with children under 5 years. For most (24) there had been only one episode, but one child had been burned as many as six times. For 10 children (37%), the burn had been severe enough to leave a 'large' scar (larger than a 1cm coin). The most common cause was the child touching a hot object (n=10), although scalding when a pot fell over was almost as common (n=11).

For those households that took part in both surveys, there were 18 households where children had experienced burns in the previous year at baseline (Table 10.12), of which 8 suffered a large scar. At follow-up, just 2 respondents reported that a child under 5 years had been burned in the previous year. Although based on relatively small numbers, this does strongly suggest that risk of burns and scalds had been reduced.

Table 10.12: Burns and scalds in previous year, baseline and follow-up - Kenya

`Symptoms	Baseline		Follow up	
	N	%	N	%
Total of matched households	112	70	112	69
Number of households with children under 5 years	77	70	69	69
Number of households where burns have taken place	18	25	2	3
Number of kitchens where burns have taken place	8	11	1	1
Total number of children <5yrs	138		123	
Total number of burns last year	19		2	
Severe (large scar)	>8		0	

Utilisation and costs of health care

Visits

Among households taking part in both surveys, at baseline, most visits were made to the other (including private) providers, with the health post being second most important (Table 10.13). Very few visits to the traditional healer were reported. Half of the households made at least three visit to the other/private provider for adults and for children during the previous year, while half made at least one visit to the health post for adults and two for children. Only a minority (less than one quarter) visited the traditional healer for either adults or children.

At follow-up, there was a very marked reduction in the reported visits to both the other/private providers and to the health post for adults and for children. There was also a reduction in visits to the traditional healer, but from a very low level to begin with.

Table 10.13(a): Adult visits to health providers, baseline and follow-up (n=112) - Kenya

	Health post		Traditional healer		Other (Private)	
	Round 1	Round 3	Round 1	Round 3	Round 1	Round 3
Mean	2.40	0.38	0.05	0.01	12.8	0.47
SD	3.83	0.78	0.32	0.09	21.1	1.43
Median	1.0	0	0	0	3.0	0
IQR	0.0, 3.0	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 13.5	0.0, 0.0

Table 10.13(b): Child visits to health providers, baseline and follow-up (n=112) - Kenya

	Health post		Traditional healer		Other (Private)	
	Round 1	Round 3	Round 1	Round 3	Round 1	Round 3
Mean	3.79	0.28	0.11	0.02	11.7	2.27
SD	4.57	0.66	0.61	0.13	20.5	18.9
Median	2.0	0	0	0	3.0	0
IQR	0.0, 6.0	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 12.0	0.0, 1.0

Change in overall costs

The total expenditure on all three types of health provider reduced markedly from a baseline mean (median) of 422.3 (300) KSh/- for the year, to 167.6 (45.0) KSh/- at follow-up. The difference of 254.7 KSh/- (95% CI: 147.1 to 362.3) was highly statistically significant, on both paired t-test and the non-parametric Wilcoxon signed rank test ($p<0.0005$).

Nepal health summary

Baseline survey
Around one-third of the women in the Nepal sample were smokers – these women were older than non smokers, and as expected, had higher levels of breath CO. Analysis of the Nepal study required separate treatment of smokers throughout. Respiratory symptoms were common, and more so among smokers than non-smokers. Chronic symptoms were seen in 15-20% of non-smokers and about 10% had both chronic cough and chronic phlegm. 11% had FEV1/FVC ratio less than 70%, and three-quarters of these also had chronic phlegm. Women with symptoms had lower levels of FEV1 and FEV1/FVC ratio, independent of age, height and smoking status.

Follow-up
There was a large reduction in kitchen CO of nearly 90%, and about 25% in breath CO (the reduction in breath CO was greater among smokers than non-smokers). Respiratory symptoms were greatly reduced, and remarkably, none of the women reported symptoms persisting for as long as 3 months at the follow up study. There was some evidence that the individual reductions in respiratory symptoms were associated with individual reductions in kitchen CO. The absence of chronic cough and phlegm at follow-up implies that those with chronic symptoms at baseline did not have established chronic bronchitis, but perhaps had persistent symptoms that had the potential to be relieved when smoke exposure was substantially reduced. There was quite strong evidence of a relationship between the individual reduction in IAP and individual improvements in FEV1 and FEV1/FVC ratio, equivalent to about 2% of the baseline value for the IAP reduction observed in the study homes. This improvement in lung function is likely to be the result of a fairly short-term reduction in airways inflammation following reduced exposure, rather than a change in rate of decline in FEV1 which is seen after (for example smoking reduction/cessation) as this would not be detected in a study of this size and duration.

Headaches were common at baseline, and women said that the most common cause was smoke from the fire. At follow-up, there was large reduction in frequency, and a small reduction in severity. For children less than 5 years, there was a large reduction in illness episodes with cough, but from a high rate at baseline. Burns occurred in the prior year in 10/82 homes at baseline, with a substantial reduction in the follow-up survey. Health care was sought most commonly from the health post, followed by the traditional healer. At follow-up, there was a large reduction in the number of visits and expenditure

Overall, there was a large reduction in IAP following the intervention, and improvements in symptoms and lung function – independent of smoking. There was good evidence that individual reductions in IAP were associated with individual improvements in lung function, and to some extent with symptoms. This provides important, corroborative evidence. This evidence however was not seen in any consistent way for the improvements reported for headaches, child respiratory illness, or health service use, so some caution should be exercise in the interpretation of these changes.

Nepal baseline data
Results based on all respondents in the baseline survey

Age of respondents

A wide range of ages were included in the study, from 11 to 79 years, with a mean (standard deviation) of 34.4 (12.0). The age distribution was slightly positively skewed, with a median of 32 years, and inter-quartile range of 25.0 to 42.75 years.

Smoking

As found in other studies of rural Nepal, cigarette smoking is quite common among women. In this sample, just over one-third were current smokers, although the majority smoked less than ten cigarettes per day. Smokers were older ($p<0.0005$), and although there was some evidence of a trend of increasing room CO across the categories of smoking, these

differences were not statistically significant. On the other hand, as expected, there was a marked difference in breath CO measurements between smokers and non-smokers, with the heaviest smokers having the highest levels (p<0.0005). The breath CO levels recorded in non-smokers are similar to those seem among light, active smokers.

Table 10.14: Age, room CO and breath CO by category of smoking - Nepal

Status	Number	(%)	Mean age and SEM[1]	Mean[2] CO room values (ppm) and SEM	Mean CO breath (ppm) and SEM
Never smoked / Ex-Smoker**	107	56%	30.7 (1.04)	11.56 (1.72)	5.3 (0.20)
Current: <10/day	48	25.0	36.3 (1.65)	12.7 (2.08)	12.4 (0.70)
Current: 10+/day	37	19.3	42.5 (1.94)	18.17 (5.19)	15.0 (0.93)
Total	192	100.0	34.4 (0.87)	13.14 (1.48)	9.0 (0.41)
P-value (ANOVA)			<0.0005	0.265*	<0.0005**

[1] SEM: standard error of the mean
[2] This is the arithmetic mean of the values of the mean CO reading from each household over the 24 hour monitoring period
** Result of Kruskal-Wallis test p=0.115
Based on comparison of log(n) transformed values

Respiratory symptoms

Prevalence of cough, phlegm, wheeze by smoking status

There was a high prevalence of respiratory symptoms, with rates overall being higher for all symptom definitions among current smokers, as compared with ex- or never smokers. Around 15% on non-smokers and 25% of smokers reported chronic cough, that is, on most days, for 3 months or more for at least 2 years. The corresponding figures for chronic phlegm were 19.6% and 56.5%, respectively. In addition to the well-recognised effect of smoking on respiratory symptoms, it is also important to note that smokers in this sample were also older (Table 10.15).

Table 10.15: Respiratory symptoms at baseline - Nepal

Symptom	Definition	Ex/never smoker (n= 107)		Current smoker (n=85)	
		N	%	N	%
Cough	First thing and/or other other times	100	93.5	82	96.5
	First thing and/or other other times, most days	45	42.1	32	37.6
	At least 3 months in last year	33	30.8	62	72.9
	At least 3 months and for 2 years	29	27.1	60	70.6
	At least 3 months, most days and for 2 years	16	15.0	22	25.9
Phlegm	First thing and/or other other times	95	88.8	80	94.1
	First thing and/or other other times, most days	88	82.2	74	87.1
	At least 3 months in last year	27	25.2	51	60.0
	At least 3 months and for 2 years	24	22.4	52	61.2
	At least 3 months, most days and for 2 years	21	19.6	48	56.5
Wheeze	Wheeze[1] over the last 12 months	78	72.9	70	82.4
	Wheeze with a cold	76	71.0	67	78.8
	Wheeze without a cold	13	12.1	27	31.8
	Wheeze for more than 2 years	65	60.7	61	71.8

[1] In Nepal this means that there is a sound come from the air pipe during breathing - like a small whistling sound. There is a Nepali word for it 'ghyaar ghyaar' - it is near to the lung, not high up in the throat - from deep inside

Symptoms of cough and phlegm
There was a generally high number of women reporting phlegm among women with cough, with both symptoms being present in slightly higher percentages of smokers than non-smokers. For the most chronic definition (cough most days, at least three months, for 2 or more years), there was a substantially higher percentage of smokers with both symptoms than non-smokers.

Table 10.16: Presence of both cough and phlegm symptoms - Nepal

Cough symptom	Equivalent phlegm symptom (same definition)	
	Ex or non smokers	Current smokers
Cough first thing and/or other times	95%	94%
Cough for at least 3 months	87%	92%
Cough at least 3 months, for 2 or more years	85%	90%
Cough most days, at least 3 months, for 2 or more years	69%	87%

These results indicate that around 70% of the non-smokers with chronic cough (n=16, 15%, Table 10.16) also have chronic phlegm, thus around 10% meet the criteria for symptoms of chronic bronchitis. For current smokers, 87% of those with chronic cough (n=22, 25.9%, Table 10.17) also have chronic phlegm, this around 23% meet the criteria for symptoms of chronic bronchitis.

Episodes of cough and phlegm
Among non-smokers, 39 (36.4%) had experience at least one episode of worse cough and phlegm which last 3 or more weeks, over the last 2 years. Among smokers, 49 (57.6%) had experience one or more of such episodes over 2 or more years.

Cough and wheeze
Of the respondents with wheeze, almost all reported they experienced cough, with no difference by smoking status. For more chronic respiratory symptoms the picture was different, indicating that this symptom of persistent wheeze was associated less with chronic respiratory symptoms. It was notable however, that for both chronic cough and chronic wheeze, there was a considerably higher percentage of smokers who experienced both symptoms than was the case for non-smokers.

Table 10.17: Presence of wheeze (2 or more years) with other respiratory symptoms- Nepal

Co-existing respiratory symptom	Wheeze two or more years			
	Ex or non-smokers		Current smokers	
	N	(%)*	N	(%)*
Cough first thing and/or other times	81	98.8	72	98.6
Cough at least 3 months, for 2 or more years	22	34.4	46	75.4
Cough most days, at least 3 months, for 2 or more years	11	17.7	14	23.3
Phlegm first thing and/or other times	77	93.9	70	95.9
Phlegm at least 3 months, for 2 or more years	19	30.6	39	66.1
Phlegm most days, at least 3 months, for 2 or more years	16	26.7	35	60.3

*Percentage of those reporting wheeze who also have the specified cough or phlegm symptom

Lung Function

Lung function values
There were 149 (77%) cases with valid lung function measurements. Of these, 21 (10.8%) had an FEV1/FVC ratio of less than 70%. These low ratios are also suggestive of COPD, although it should be noted that bronchodilator was not used as part of the measurement procedure. Those subjects with FEV1/FVC ratio < 70% were very much more likely to report chronic symptoms of cough and phlegm (Table 10.18), although this was not the case for 'Cough most days, at least 3 months, for 2 or more years'.

Table 10.18: Presence of respiratory symptoms in subjects with and without FEV1/FVC ratio less than 70% - Nepal

Respiratory symptom	FEV1/FVC ratio				p-value and test
	Less than 70%		70% or more		
	N	(%)*	N	(%)*	
Cough at least 3 months in the last year	18	85.7	60	49.6	0.002
Cough at least 3 months, for 2 or more years	17	81.0	56	46.7	0.004
Cough most days, at least 3 months, for 2 or more years	3	15.0	25	20.8	0.548
Phlegm at least 3 months in the last year	17	85	49	41.2	<0.0005
Phlegm at least 3 months, for 2 or more years	16	80.0	44	37.0	<0.0005
Phlegm most days, at least 3 months, for 2 or more years	14	73.7	40	33.6	0.001

* Percentage of those in FEV1/FEV ratio category who also have the specified cough or phlegm symptom

Smoking

The values of lung function according to smoking status are shown in Table 10.19, and confirm that those smoking more have lower lung function. As with symptoms, however (Table 10.15), as smokers are on average older, it would be expected that lung function would be somewhat lower. The effect of age is addressed in the regression analyses, discussed in the following section.

Table 10.19: mean (and standard deviations) for lung function measures, by smoking status – Nepal

Smoking status	FEV1		FVC		FEV1/FVC ratio		PEFR	
	Mean	(SD)	Mean	(SD)	Mean	(SD)	Mean	(SD)
Ex/never smoker	2.58	0.43	3.16	0.49	81.9	8.49	302.2	68.1
Current <10 per day	2.39	0.42	3.04	0.48	78.7	10.2	267.6	57.1
Current 10+ per day	2.18	0.39	3.03	0.58	73.6	8.4	273.8	59.2
Total	2.46	0.45	3.10	0.51	70.5	9.5	287.9	65.4
ANOVA (p-value)	<0.0005		0.327		<0.0005		0.003	

Relationship between lung function and symptoms

It is useful to study the relationship between lung function and symptoms, as this provides some assessment of how valid the questions (and responses by the women) are, and the extent to which the symptoms reported may be affecting their lungs. In order to allow for the possible 'confounding' effects of age, height and smoking – all of which are related to lung function values – these analyses is carried out using multiple linear regression. The results are shown in Table 10.20.

The regression coefficient shows the effect on the lung function measure of having the symptoms compared to not having the symptom. For example, for chronic cough (at least 3 months, for 2 or more years), the effect on FEV1 is a reduction of 0.226 litres (with a 95% CI of 0.079 to 0.0374 litres), a statistically significant relationship (p=0.003).

The regression model allows for any confounding effect of smoking, age and height: for the majority of these analyses, the effects of all three of these variables were statistically significant – as would be expected.

These results show that those respondents with symptoms had consistently lower FEV1 and FEV1/FVC ratios than those without symptoms. There was some evidence of similar effects on FVC and PEFR, but these findings were less consistent or strong, and mostly not statistically significant.

Table 10.20(a): Impact of presence of symptoms on FEV1 - Nepal

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	-0.278	0.072	-0.421, -0.134	<0.0005
	Cough at least 3 months, for 2 or more years	-0.226	0.075	-0.374, -0.079	0.003
	Cough most days, at least 3 months, for 2 or more years	-0.037	0.086	-0.206, 0.133	0.67
Phlegm	Phlegm at least 3 months in the last year	-0.217	0.075	-0.366, -0.068	0.005
	Phlegm at least 3 months, for 2 or more years	-0.184	0.076	-0.335, -0.033	0.017
	Phlegm most days, at least 3 months, for 2 or more years	-0.189	0.078	-0.343, -0.036	0.016

Table 10.20(b): Impact of presence of symptoms on FVC- Nepal

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	-0.117	0.090	-0.296, 0.062	0.197
	Cough at least 3 months, for 2 or more years	-0.115	0.089	-0.291, 0.061	0.197
	Cough most days, at least 3 months, for 2 or more years	-0.228	0.098	-0.421, -0.034	0.022
Phlegm	Phlegm at least 3 months in the last year	0.001	0.090	-0.176, 0.179	0.988
	Phlegm at least 3 months, for 2 or more years	0.006	0.090	-0.173, 0.184	0.951
	Phlegm most days, at least 3 months, for 2 or more years	-0.028	0.092	-0.210, 0.154	0.761

Table 10.20(c): Impact of presence of symptoms on FEV1/FVC ratio - Nepal

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	-5.32	1.72	-8.73, -1.91	0.002
	Cough at least 3 months, for 2 or more years	-4.16	1.76	-7.64, -0.70	0.019
	Cough most days, at least 3 months, for 2 or more years	5.28	1.94	1.38, 9.06	0.008
Phlegm	Phlegm at least 3 months in the last year	-6.89	1.68	-10.21, -3.57	<0.0005
	Phlegm at least 3 months, for 2 or more years	-5.85	1.72	-9.25, -2.45	0.001
	Phlegm most days, at least 3 months, for 2 or more years	-5.12	1.76	-8.60, -1.63	0.004

Table 10.20(d): Impact of presence of symptoms on PEFR - Nepal

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	-1.15	10.67	-22.2, 19.9	0.482
	Cough at least 3 months, for 2 or more years	-7.18	11.65	-30.2, 15.9	0.539
	Cough most days, at least 3 months, for 2 or more years	0.911	13.01	-24.8, 26.7	0.944
Phlegm	Phlegm at least 3 months in the last year	-15.58	11.50	-38.33, 7.17	0.178
	Phlegm at least 3 months, for 2 or more years	-15.28	11.57	-38.16, 7.61	0.189
	Phlegm most days, at least 3 months, for 2 or more years	-17.61	11.74	-40.84, 5.61	0.136

Nepal follow-up data

Results based on comparison of households included in both the baseline and follow-up study

Indoor pollution

There were substantial reductions of almost 90% in the levels of 24 hour kitchen CO between the baseline and follow up rounds (Table 10.21), which were highly statistically significant. It was interesting that very similar levels, and reductions, were seen in all categories of smoking, showing that the stoves were by far the most important contributor to room CO levels, and that any reduction in smoking that may have occurred had no important effect on levels of smoke pollution in the kitchens.

Table 10.21: Changes in the average 24-hour room CO value (ppm) between baseline (R1) and follow-up (Round 3) - Nepal

Measure	Smoking	N	R 1	R 3	Difference	SEM[1]	95% CI	p-value[2]
Change in **mean** room CO	Ex/never	65	13.2	1.6	11.5	2.36	6.8, 16.3	<0.0005
	Current <10/day	34	11.6	1.6	9.9	1.24	7.5, 12.5	<0.0005
	Current 10+/day	25	13.6	1.3	12.3	5.5	1.0, 23.6	0.034
	All	124	12.8	1.6	11.3	1.68	7.9, 14.6	<0.0005

[1] SE: Standard error of the mean difference between R1 and R3
[2] Paired t-test used as the differences between means are not markedly skewed

Exposure

Measures of exposure are available from two sources (i) directly from the CO breath measurements taken during the Phase 2 studies, and (ii) indirectly, using the relationships studies in Phase 1 between room CO and women's personal CO exposure measured using the IS T82 monitors.

Direct measure: changes in breath CO

Although there was a highly statistically significant (p<0.0005) reduction in mean CO breath (averaged over Day1 and Day 2), the difference of 2.1 ppm was only 23% of the baseline value, proportionately much less than that observed for the reduction in room CO (88.3%). There were statistically significantly larger reductions seen among smokers than non smokers, which suggests that smoking behaviour may be an important determinant of these findings. Further analysis will be carried out on the extent and timing of recent exposure to smoking (active and passive), and to fires, in order to permit further interpretation.

Table 10.22- Changes in breath-CO Nepal

Measure	Smoking	N	R 1	R 3	Difference	SEM[1]	95% CI	p-value[2]
Change in mean breath CO	Ex/never	66	5.39	4.78	0.71	0.27	0.16, 1.26	0.012
	Current <10/day	35	12.25	9.24	3.01	0.82	1.33, 4.68	0.001
	Current 10+/day	25	15.06	10.53	4.53	0.97	2.52, 5.53	<0.0005
	All	126	9.21	7.11	2.11	0.36	1.40, 2.81	<0.0005

[1] SE: Standard error of the mean difference between R1 and R3
[2] Paired t-test used as the differences between means are not markedly skewed

Respiratory symptoms

Change in symptom prevalence

In Nepal, while cough and phlegm symptoms were reported fairly commonly (although by a minority) at follow-up, no subject stated that these symptoms persisted for 3 months or more in the last year at the follow-up survey. Further consideration of the possible reasons for this is given following presentation of the results.

Cough

Whereas 119 of 126 94.4%) reported cough at baseline, only 48 (38.1%) did so at follow-up (Table 10.23(a)). Of the 119 subjects with cough at baseline, 48 (40.3%) reported this symptom in Round 3, while none of the 7 subjects who were asymptomatic (without symptoms) at baseline reported cough at follow-up (p<0.0005).

Table 10.23(a): Numbers (%) of subjects reporting cough at baseline (Round 1) and at follow-up (Round 3) - Nepal

Cough first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	7 (100)	0 (0)	7
	Yes	71 (59.7)	48 (40.3)	119
	Total	78	48	126

McNemar's test (P<0.0005)

For cough most days (Table 10.23 (b)), while 43 (35.0%) reported this symptom at baseline, only 26 (21.1%) did so at follow-up. Of the 43 with cough most days at baseline, only 8 (19%) reported it at follow-up, but a similar proportion of those without cough most days reported this at follow. However, all of the women with cough most days at follow-up reported cough 'first thing and at other times' at baseline.

Table 10.23(b): Numbers (%) of subjects reporting cough most days at baseline (Round 1) and at follow-up (Round 3) - Nepal

Cough first things and at other times, most days	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	62 (77.5)	18 (22.5)	80
	Yes	35 (81.4)	8 (18.6)	43
	Total	97	26	123

McNemar's test (P<0.0005)

Phlegm

Of the 126 subjects, 112 (88.9%) reported phlegm112 at baseline, but only 38 (30.1%) did so at follow-up(Table 10.24(a)). Of the 112 subjects with phlegm at baseline, 38 (33.9%) reported this symptom in Round 3, while none of the 14 subjects who were asymptomatic at baseline reported phlegm at follow-up (P<0.0005).

Table 10.24(a): Numbers (%) of subjects reporting phlegm at baseline and Round 3 (post-intervention) - Nepal

Phlegm first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	14 (100)	0 (0)	14
	Yes	74 (66.1)	38 (33.9)	112
	Total	88	38	126

McNemar's test (P<0.0005)

For phlegm most days, there was again a marked reduction in the number of women with the symptom from 92.0% at baseline to 28.6% at follow-up. As with cough most days, there were some subjects who reported phlegm most days at follow-up but not at baseline, but again, all of the respondents with phlegm most days at follow-up had reported phlegm 'first thing and at other times' at baseline.

Table 10.24(b): Numbers (%) of subjects reporting phlegm most days at baseline and Round 3 (post-intervention) - Nepal

Phlegm first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	5 (55.6)	4 (44.4)	9
	Yes	75 (72.8)	28 (27.2)	103
	Total	80	32	112

McNemar's test (P<0.0005)

Relationship between presence of symptoms and change in IAP (room CO)

Regression analysis were carried out to examine the effect of individual changes in mean room CO between Round 1 (baseline) and Round 3 on the presence of symptoms at follow-up. The differences in CO level were calculated as Round 1 minus Round 3, so that an odds ratio of less than 1.0 implies that a reduction in CO is associated with a reduction in risk of having the symptom. The analysis has been carried out adjusting for the presence of symptoms at baseline, although as many subjects reported these anyway, this does not have a large effect on the conclusions.

The strength of this method of analysis lies in two key factors (i) each subject acts as her own control so that confounding is minimal, and (ii) since individual changes in exposure are related to individual changes in presence of symptoms, any variations are controlled for, such as, for example, weather conditions over the period that could effect both exposure and symptoms (e.g. cold weather may increase use of fires and affect lung function).

We interpret these results as follows: the odds ratio (OR) shows by how much the risk is altered by a 1 ppm reduction in room CO. Thus, for 'Cough first thing and at other times', the risk is reduced by 0.3% per 1 ppm. In order to determine how much effect the 11 ppm reduction seen the study would have, the OR is raised to the power of this difference, that is, $(0.997)^{11}$ which is 0.97, or a 3% reduction in risk. The results for these calculations are shown in the last two columns. None of the odds ratios (OR) is significant at $p<0.05$, but all are less than 1.0 apart from phlegm first thing and at other times. Calculations for the expected effect on symptoms given the mean 24-hour room CO reduction of 11 ppm observed in the study show effects of around 30 to 40% reduction for 'cough most days' and for 'phlegm most days', but it should be noted that the confidence intervals are fairly wide and do include no effect.

Table 10.25 Analysis of changes of symptoms and changes in room CO level - Nepal

Symptom	Regression analysis			OR for 11 ppm change in room CO	
	OR	95% CI	p-value	OR	95% CI
Cough first thing and at other times	0.997	0.976, 1.019	0.793	0.97	0.77, 1.23
Cough first thing and at other times, most days	0.969	0.912, 1.030	0.309	0.71	0.36, 1.38
Phlegm first thing and at other times	1.000	0.978, 1.022	0.965	-	-
Phlegm first thing and at other times, most days	0.959	0.898, 1.023	0.201	0.63	0.31, 1.28

Adjustment for age, smoking (ex/never, light and heavy current), and the same symptom at baseline

Interpretation of change in symptoms

The large reductions in reported symptoms is a positive result, but should be interpreted somewhat cautiously. It is surprising that, at follow-up, none of the respondents reported either cough or phlegm lasting 3 months for more, during the previous 12 months. This raises the possibility of under-reporting of the severity and/or duration of symptoms, possible in response to the very real improvements in the home environment that were experienced. On the other hand, if the reporting is correct, it implies that the 'chronic' symptoms at baseline (lasting 3 months or more) were not in fact chronically established symptoms, but persistent symptoms that had the potential to be relieved when smoke exposure was substantially reduced.

The analysis of risk of symptoms according to the change in room CO level (Section 3.2) provides some evidence that the overall reductions are the result of the intervention, but the very large overall reductions in symptom prevalence between baseline and follow-up will tend to limit the usefulness of this analysis.

Changes in lung function

Impact of reduced IAP on lung function

Similar regression analysis was carried out to examine the effect of individual changes in mean room CO between Round 1 (baseline) and Round 3 on the change in lung function between Round 1 and Round 3. For the differences in lung function, the calculation has been made as Round 3 minus Round 1, so that an improvement has a positive value. Thus, a positive regression coefficient is interpreted as meaning that a reduction in exposure has the effect of increasing the lung function measure concerned.

In order to allow for possible effects related to smoking, the status of smoking (in 3 categories) has been included in the regression model using dummy variables.

Table 10.26 Analysis of changes of measured lung function and room CO level - Nepal

Lung function measure	Coefficient	SE	95% CI	p-value
FEV1	0.005	0.002	0.001, 0.008	0.011
FVC	0.001	0.002	-0.003, 0.006	0.621
FEV1/FVC ratio	0.127	0.044	0.040, 0.214	0.005
PEFR	-0.294	0.301	-0.891, 0.303	0.331

Adjusted for age and smoking (ex/never, light and heavy current)

These results show that individual reductions in exposure are associated with improvements in FEV1 and the FEV/FVC ratio, but did not affect FVC or Peak Flow rate.

We interpret these findings as follows. For FEV1, the regression coefficient of 0.005, means that for each 1 ppm reduction in mean room CO, there was a 5ml increase in FEV1. Thus, given that the overall difference found in the study was around 11 ppm, we conclude that the average effect of the interventions would be to increase FEV1 by around 55 mls over the period of the study. As the mean baseline FEV1 was 2.46 litres, this represents a change of 2.2%.

Similarly, for the FEV1/FVC ratio, the regression coefficient shows an increase of 0.13% per 1 ppm reduction in room CO, or around 1.4% for the 11 ppm change observed in the study (almost 2% of the baseline value).

In order to be sure that the effects of smoking did not persist despite adjustment, these analyses were also carried out separately by smoking status (smoker/non-smoker), and showed similar results in both groups indicating that these changes are not the result of reduction in active smoking.

Interpretation

In terms of long-term impacts, the interpretation of these results should keep in mind two issues. First, the duration of follow up was relatively short and in all cases less than one year. Second, this study does not have the statistical power nor duration to detect any impact on the long-term rate of decline in FEV1 that is seen if, for example, people give up smoking. Although this could contribute a small part to the observed difference, it is most likely that these findings result from a relatively acute reduction in airways inflammation resulting from the large reduction of indoor air pollution from the very high pre-intervention levels. This acute effect had also been reported following smoking cessation.

Nevertheless, these are important findings because of the clear relationship seen between two ‘objective’ measures, one of pollution and the other of health. A number of the other outcomes, for example symptoms, are more subjective, and reporting of these can be biased by the expectations of respondents (and to an extent interviewers), and the desire to please, etc. It is difficult to see how such bias could have influenced the measurements of room CO and lung function reported in this analysis of individual changes over the study.

Since it is not possible to draw conclusions about the long-term impact on development of COPD cases from this study due to the (relatively) short duration, estimates of COPD cases prevented used for cost-benefit analysis (Chapter 11) will rely instead on combining data from this study on exposure reduction, and what is known more generally from the scientific literature on the impact of indoor air pollution on risk of developing COPD.

Headaches

Women were asked about the occurrence of headaches in the previous twelve months, and about frequency, strength and causes. Around 20% said they experienced headaches most days or every day, and 22% said their headaches were ‘very strong’. The most common reason given for headaches was smoke from the stove (55%), followed by ‘having a cold’ (28%) and ‘weakness of sight (7%).For ease of comparison of the baseline and follow up, headache frequency and strength were recoded into two categories.

For frequent headaches (that is, every few days or more often), there was a very large reduction in reported symptoms between baseline and follow-up, with none of the 24 subjects with this symptom at baseline also reporting it at follow up (Table 10.27 (a)).

Table 10.27(a): Numbers (%) of subjects reporting frequent headaches at baseline (Round 1) and at follow-up (Round 3) - Nepal

Headache frequency	Status	Round 3 (post-intervention)		Total
		None or once per week or less	Every few days, most days or every day	
Round 1 (Baseline)	None or once per week or less	91 (94.8)	5 (5.2)	96
	Every few days, most days or every day	24 (100)	0 (0)	24
	Total	115	5	120

For strong headaches (fairly or very strong), there was a much lesser reduction from 87% to 67% reporting the symptom (Table 10.27(b)). On the other hand, taking 'very strong' alone, while there were only 21 at baseline, only 7 reported these at follow-up (not shown in table).

Table 10.27(b): Numbers (%) of subjects reporting strong headaches most days at baseline (Round 1) and at follow-up (Round 3) - Nepal

Headache strength	Status	Round 3 (post-intervention)		Total
		None or mild	Fairly or very strong	
Round 1 (Baseline)	None or mild	9 (60.0)	6 (40.0)	15
	Fairly or very strong	24 (23.1)	80 (76.9)	104
	Total	33	86	119

Child health

At the baseline survey, 116 (55.3%) of the households had one or more child under 5 years of age, 58 (30.5%) with a child under 1 year.

Respiratory illness

Mothers were asked about recent respiratory symptoms, specifically an illness with cough in the prior two weeks, and 107 (92%) reported that this had occurred. Mothers were also asked if the child had been breathing more rapidly than usual, and this was reported to be the case for the great majority of these sick children. These very high proportions of children with these symptoms and signs would suggest that mothers are reporting very non-specific respiratory complaints.

At the time of the follow-up study, 82 (71.9%) of the respondents had children under 5 years. The mothers were again asked about recent illness (last 2 weeks) with cough. Among respondents in both baseline and follow-up surveys, while 67 (91.8%) had reported recent illness with cough at baseline, only 18 (24.7%) of the mothers did so at follow-up. 14 (19.7%) had also had cough with faster breathing.

As noted above, it seems likely that mothers are reporting non-specific respiratory problems in these children. The marked reduction in reported illness with cough at follow-up may be a genuine reflection of the effect of less smoke on running noses and airway irritation, but other factors that may influence reporting should also be taken into account.

Burns

Table 10.28 shows the numbers of homes with children under 5 years among those households that took part in both baseline and follow-up surveys. At baseline, the main causes of burns were 'Fell in fire' (5) & 'touched hot object' (5). There was a marked reduction in the number of burns to children reported for the preceding 12 months.

Table 10.28 – Nepal causes of burns and scalds

Symptoms	Baseline		Follow up	
	N	%	N	%
Total of households	127		127	
Number of households with children under 5 years	82	70	82	69
Number of households where burns have taken place	10		1	3
Number of kitchens where burns have taken place	8		1	1
Total number of children <5yrs	177		108	
Total number of burns last year	10		1	
Severe (large scar)	1		0	

Utilisation and costs of health care

Visits

Respondents were asked at baseline about the number of visits made in the last year, for adults and children (separately), to three potential providers: (i) the health post (ii) the traditional healer, and (iii) Other, which was mainly private care. They were also asked about the approximate total cost of seeking care from each of these three providers. They were asked again at follow-up.

For adults, most visits were made to the health post, with the traditional healer being the second most frequently visited. For children, there was very little difference between the three providers, but with each provider, at least half of the children made no visit.

Table 10.29: Baseline numbers of visits to three main health providers - Nepal

Measure	Health post		Traditional healer		Private/other	
	Adult	Child	Adult	Child	Adult	Child
Mean	2.35	1.04	1.34	1.04	0.96	0.98
Median	1.00	0.0	0.0	0.0	0.0	0.0
IQR	0 – 2.25	0 – 2.0	0 – 2.0	0 – 2.0	0 – 2.0	0 – 1.0

Table 10.29 shows the mean numbers (and 75th percentiles, as the distributions are skewed, and medians are zero) of adult and child visits for the three type of provider at baseline and follow-up, for those respondents who participated in both surveys. For both adults and children, there have been marked reductions in the number of visits to both the health-post and the traditional healer. There is also a reduction in visits to private services, but this is less marked.

Table 10.30: Mean (and 75th percentile) numbers of visits to three main providers at baseline and follow-up among household participating in both surveys - Nepal

(a) Adults

Measure	Health post		Traditional healer		Private/other	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Mean	2.69	0.52	1.44	0.07	0.95	0.62
75th PC	2.0	1.0	3.0	0.0	2.0	1.0

(b) Children

Measure	Health post		Traditional healer		Private/other	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Mean	1.17	0.38	1.20	0.03	1.11	0.50
75th PC	2.0	0.0	1.25	0.0	2.0	1.0

Costs

The expenditure on each of the three providers was highly positively skewed, with many families spending little or nothing (Table 10.31). The highest median cost, reflecting what was

more typical, was at the health post, while the highest actual expenditure was with the private providers.

Table 10.31(a): Baseline costs of visits to three main health providers - Nepal

Measure	Health post	Traditional healer	Other/Private
Mean	43.5	37.1	358.7
Median	4.0	0.0	0.0
IQR	0 - 17	0 – 50.0	0 – 455.0

The changes in expenditure between baseline and follow-up are presented in Table 10.31(b), and show large reductions for all three providers.

Table 10.31(b): Changes in expenditure between baseline and follow-up visits to three main health providers - Nepal

Measure	Health post		Traditional healer		Private/other	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Mean	54.72	8.95	33.23	2.13	345.28	50.02
75th PC	20.0	6.0	50.0	0.0	500.0	80.0

Sudan health summary

Baseline survey
Few of the women in the Sudan sample smoked, and of the 6% who did, most were very light smokers. Nevertheless, analysis of respiratory health excluded smokers. Of the three country studies, the Sudan sample had the lowest prevalence of chronic symptoms at between 5% (phlegm) and 8% (cough). Three women (1.6%) had FEV1/FVC ratio <70%, but just one of these had chronic symptoms. There was some evidence of a relationship between presence of chronic symptoms and poorer lung function (FEV1, Ratio, PEFR), particularly for phlegm.

Follow-up
There was minimal difference in kitchen CO between baseline and follow-up due to the large number of households reverting the charcoal, but breath CO was significantly reduced – by 44% in non-smokers. This provides useful corroborative evidence that reductions in women's exposure were achieved. Respiratory symptoms were reduced, especially the chronic symptoms, with some evidence that individual reductions in CO breath were associated with individual changes in presence of symptoms. For lung function, values for FEV1 and FVC at follow-up were significantly lower than at baseline, which was unexpected. Values for FEV1/FVC ratio were a little higher. These somewhat inconsistent findings may have resulted from different circumstances and/or variations in technique, as there was more variability in the data at follow-up, even though the protocol was unchanged. There was no consistent association between individual reductions in breath CO and lung function changes between baseline and follow-up. For children, there was no change in frequency of illness episodes with cough. For burns, 13% of households reported burns in the previous 12 months, but there was no change at follow-up. Most visits for health care were to the health post, for which there was a reduction at follow-up for both adults and children. There was a small, significant reduction in expenditure on health care.

The number of households for which complete data was available was limited due to around 50 interviewees and their families leaving the area following the peace treaty, and omissions of room CO monitoring for those households which were monitored during Ramadan in the first round, as the effect of changes in cooking patterns on the levels of room CO were considerable.

Sudan baseline data

Results based on all respondents in the baseline survey

Age of respondents

A wide range of ages were included in the study, from 12 to 66 years, although generally this was quite a young group of women - with a mean (SD) of 32.0 (11.4) and median (IQR) of 30.0 (22.0 to 40.0).

Smoking

Only 12 (6.0%) of the women smoked tobacco, and of these 6 smoked less than 5 per day and 2 smoked 10-19 per day. For most analyses, in particular those involving respiratory symptoms and lung function, and measures of pollution and exposure, the small number of smokers are excluded.

Respiratory symptoms

The prevalence of cough, phlegm and wheeze are shown in Table 10.32. Between one quarter and one third of the women reported cough and phlegm respectively, but just 8.1% and 5.4% respectively for chronic cough and phlegm.

Table 10.32: Respiratory symptoms at baseline (smokers excluded) - Sudan

Symptom	Definition		
		N	%
Cough	First thing and/or other times	60	32.3
	First thing and/or other times, most days	23	12.4
	At least 3 months in last year	23	12.4
	At least 3 months and for 2 years	20	10.8
	At least 3 months, most days and for 2 years	15	8.1
Phlegm	First thing and/or other times	49	26.3
	First thing and/or other times, most days	21	11.3
	At least 3 months in last year	27	14.5
	At least 3 months and for 2 years	21	11.3
	At least 3 months, most days and for 2 years	10	5.4
Wheeze	Wheeze over the last 12 months	25	13.4
	Wheeze with a cold	22	11.8
	Wheeze without a cold	8	4.3
	Wheeze for 2 years or more	19	10.2

Symptoms of cough and phlegm

There was a reasonably close relationship between the reporting of cough and phlegm. For all of the definitions in Table 10.33, around 60% of those reporting a cough symptom, also reported phlegm of similar severity and duration.

Table 10.33: Presence of both cough and phlegm symptoms (non-smokers) - Sudan

Cough symptom	Equivalent phlegm symptom (same definition)	
	N	%
Cough first thing and/or other times	36	60.0
Cough for at least 3 months	14	60.9
Cough at least 3 months, for 2 or more years	12	60.0
Cough most days, at least 3 months, for 2 or more years	8	53.3

Episodes of cough and phlegm

Among the non-smokers, 11 women reported at least one episode of illness with cough and phlegm lasting 3 or more weeks in the last year, and 6 of these had experienced such episodes for 2 years or more.

Cough and wheeze

Of the respondents with wheeze, about half overall also had cough or phlegm symptoms. Despite small numbers, there was a trend for the more chronic patterns of cough and (particularly) phlegm to be reported less (around 30-40%) than was the case for the less specific general cough and phlegm symptoms (around 60%). This suggests that much of the wheeze reported is not associated with the more chronic respiratory symptoms normally associated with COPD.

Table 10.34: Presence of wheeze (2 or more years) with other respiratory symptoms (non-smokers) - Sudan

Cough or phlegm symptoms	n	%*
Cough first thing and/or other times	14	56.0
Cough at least 3 months, for 2 or more years	8	42.1
Cough most days, at least 3 months, for 2 or more years	8	42.1
Phlegm first thing and/or other times	16	64.0
Phlegm at least 3 months, for 2 or more years	9	47.4
Phlegm most days, at least 3 months, for 2 or more years	6	31.6

* Percentage of those reporting wheeze who also have the specified cough or phlegm symptom

Lung Function

Lung function values

Among non-smokers, 169 (91%) cases had valid FEV1 measurements, 155 (83%) valid FVC measurements, and 152 (82%) valid PEFR measurements. Three women (1.6%) had an FEV1/FVC ratio of less than 70%. These low ratios may be suggestive of COPD, although it should be noted that bronchodilator was not used as part of the measurement procedure. However, only one of the three women with FEV1/FVC ratio < 70% also had chronic symptoms of cough and phlegm.

Relationship between lung function and symptoms

It is useful to study the relationship between lung function and symptoms, as this provides some assessment of how valid the questions (and responses by the women) are, and the extent to which the symptoms reported may be affecting their lungs. In order to allow for the possible 'confounding' effects of age and height - both of which are related to lung function values – these analyses is carried out using multiple linear regression. Smokers are excluded from the analysis. The results are shown in Table 10.35 (a) to (d).

The regression coefficient shows the effect on the lung function measure of having the symptom, compared with not having the symptom. For example, for chronic phlegm (most days, at least 3 months, for 2 or more years), the effect on FEV1 of having the symptom, is a reduction of 227 mls (with a 95% CI lying between an increase of 9 mls and a decrease of 464 mls), a relationship which is marginally statistically significant (p=0.059).

The findings for cough are that there is no large or consistent effect of chronic cough symptoms on FEV1, FVC or the FEV1/FVC ratio. However, there is some evidence of a more consistent effect on Peak Flow rate, amounting to around 50 litres/second, which is statistically significant (p=0.035). For chronic phlegm, there is more evidence of consistent effects, particularly for the most chronic definition 'Phlegm most days, at least 3 months, for 2 or more years' on FEV1 (around 230 mls), FEV1/FVC ratio (around 7%) and PEFR (around 60 litres/second).Overall, these results provide some modest, but useful, evidence that the questions were effective in detecting the symptoms and severity/chronicity described, in the Sudan sample.

Table 10.35(a): Impact of presence of symptoms on FEV1- Sudan

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	0.086	0.083	-0.078, 0.251	0.301
	Cough at least 3 months, for 2 or more years	0.005	0.089	-0.170, 0.180	0.957
	Cough most days, at least 3 months, for 2 or more years	-0.054	0.102	-0.256, 0.148	0.598
Phlegm	Phlegm at least 3 months in the last year	-0.097	0.077	-0.249, 0.055	0.211
	Phlegm at least 3 months, for 2 or more years	-0.058	0.086	-0.228, 0.113	0.505
	Phlegm most days, at least 3 months, for 2 or more years	-0.227	0.120	-0.464, 0.009	0.059

Table 10.35(b): Impact of presence of symptoms on FVC- Sudan

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	0.077	0.099	-0.199, 0.272	0.440
	Cough at least 3 months, for 2 or more years	0.022	0.105	-0.186, 0.229	0.835
	Cough most days, at least 3 months, for 2 or more years	0.013	0.121	-0.226, 0.252	0.917
Phlegm	Phlegm at least 3 months in the last year	-0.043	0.092	-0.224, 0.139	0.641
	Phlegm at least 3 months, for 2 or more years	0.002	0.102	-0.200, 0.204	0.984
	Phlegm most days, at least 3 months, for 2 or more years	-0.058	0.143	-0.341, 0.225	0.688

Table 10.35(c): Impact of presence of symptoms on FEV1/FVC ratio - Sudan

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	0.173	1.827	-3.438, 3.784	0.925
	Cough at least 3 months, for 2 or more years	-1.050	1.935	-4.873, 2.773	0.588
	Cough most days, at least 3 months, for 2 or more years	-3.041	2.216	-7.420, 1.338	0.172
Phlegm	Phlegm at least 3 months in the last year	-2.798	1.705	-6.169, 0.572	0.103
	Phlegm at least 3 months, for 2 or more years	-2.874	1.872	-6.573, 0.826	0.127
	Phlegm most days, at least 3 months, for 2 or more years	-7.829	2.564	-12.90, -2.763	0.003

Table 10.35(d): Impact of presence of symptoms on PEFR - Sudan

Symptom	Definition	coefficient	SE	95% CI	p-value
Cough	Cough at least 3 months in the last year	-8.482	18.71	-45.43, 28.46	0.651
	Cough at least 3 months, for 2 or more years	-30.45	19.75	-69.44, 8.54	0.125
	Cough most days, at least 3 months, for 2 or more years	-48.02	22.61	-92.66, -3.37	0.035
Phlegm	Phlegm at least 3 months in the last year	-4.11	17.38	-38.43, 30.21	0.813
	Phlegm at least 3 months, for 2 or more years	6.19	19.39	-32.10, 44.48	0.75
	Phlegm most days, at least 3 months, for 2 or more years	-63.08	26.68	-115.77, -10.40	0.019

Sudan follow up

Results based on comparison of households included in both the baseline and follow-up study

Indoor pollution

Overall, there was no change in mean room CO between baseline and follow-up, in either non-smokers or smokers. More detailed breakdown of these data by type of fuel used did show some reductions where charcoal was not used as the main fuel – see Chapter 5 for presentation of these results and further discussion of the reasons.

Room CO

Table 10.36: Mean room CO at baseline and follow up, by smoking status- Sudan

Measure	Smoking	N	Round 1	Round 3	Difference	SEM	95% CI	p-value
Mean	Non-smoker	85	4.54	4.64	-0.096	0.363	-0.82, 0.63	0.791
	Smoker	7	5.07	5.77	-0.704	1.761	-5.01, 3.60	0.703

Exposure

For both non-smokers and the small number of smokers, there were quite substantial reductions in breath CO, amounting to 44% for the 146 non-smokers. These changes were statistically significant in both groups. It is of considerable interest as to why there are marked reductions in breath CO, but not in overall room CO. This is clearly not the result of a reduction in cigarette smoking, as a large effect is seen in non-smokers. One possible explanation is that women were spending less time close to the source(s) of CO, which would include main charcoal and wood stoves.

Table 10.37: Mean breath CO (and median values) at baseline and follow up, by smoking status- Sudan

Measure	Smoking	N	Round 1	Round 3	Difference	SEM	95% CI	p-value[1]
Mean	Non-smoker	146	5.54	3.09	2.45	0.44	1.59, 3.31	<0.0005
	Smoker	11	36.59	17.25	19.34	7.54	2.54, 36.15	0.028
	Smoker	11	35.25	16.25	19.0			0.026
Median[2]	Non-smoker	146	4.13	1.88	2.25			<0.0005
	Smoker	11	35.25	16.25	19.0			0.026

[1] Paired t-test for comparison of means, Wilcoxon paired rank test for comparison of medians

Changes in symptoms

Symptom prevalence: cough

There was no evidence of change in the general cough symptom ('First thing and at other times'). Similar results for cough first thing and at other times, most days. For the more chronic symptoms however, there were marked reductions in prevalence at the follow-up survey.

Table 10.38(a): Numbers (%) of subjects reporting cough at baseline and Round 3 (post-intervention) – non smokers - Sudan

Cough first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	76 (78.4)	21 (21.6)	97
	Yes	30 (63.8)	17 (36.2)	47
	Total	106	38	144

McNemar's test; p=0.262 (NS)

Table 10.38(b): Numbers (%) of subjects reporting cough lasting 3 months or more at baseline and Round 3 (post-intervention) – non smokers- Sudan

Cough lasting at least 3 months	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	123 (98.4)	2 (1.6)	125
	Yes	17 (89.5)	2 (10.5)	19
	Total	140	4	144

McNemar's test; p=0.001

Table 10.38(c): Numbers (%)reporting chronic cough (most days, at least 3 months, for 2 or more years) at baseline and Round 3 (post-intervention) – non smokers- Sudan

Cough most days, 3 months, 2 or more years	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	131 (98.5)	2 (1.5)	133
	Yes	10 (90.9)	1(9.1)	11
	Total	141	3	144

McNemar's test; p=0.039

Symptom prevalence: phlegm

As with cough, there was no evidence of change in the general phlegm symptom ('First thing and at other times'), while for more chronic symptoms however, there were also marked reductions in prevalence at the follow-up survey.

Table 10.39(a): Numbers (%) of subjects reporting phlegm at baseline and Round 3 (post-intervention) – non smokers- Sudan

Phlegm first thing and at other times	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	95 (86.4)	15 (13.6)	110
	Yes	24 (68.6)	11 (31.4)	35
	Total	119	26	145

McNemar's test; p=0.200 (NS)

Table 10.39(b): Numbers (%) of subjects reporting phlegm lasting 3 months or more at baseline and Round 3 (post-intervention) – non smokers- Sudan

Phlegm lasting at least 3 months	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	126 (99.2)	1 (0.8)	127
	Yes	17 (94.4)	1 (5.6)	18
	Total	143	2	145

McNemar's test; p<0.0005

Table 10.39(c): Numbers (%)reporting chronic phlegm (most days, at least 3 months, for 2 or more years) at baseline and Round 3 (post-intervention) – non smokers- Sudan

Phlegm most days, 3 months, 2 or more years	Status	Round 3 (post-intervention)		Total
		No	Yes	
Round 1 (Baseline)	No	136 (99.3)	1 (0.7)	137
	Yes	7 (87.5)	1(12.5)	8
	Total	143	2	145

McNemar's test; p=0.070

Relationship with change in IAP (room CO)

In view of the lack of change in room CO between baseline and follow-up, and the limited numbers of households in which room CO data are available, no further analysis of respiratory symptoms and change in indoor air pollution has been carried out.

Relationship with change in breath CO

As there were quite substantial (44%) reductions in breath CO among non-smokers, logistic regression analysis was used to explore the relationship between a reduction in breath CO, and the risk of reporting respiratory symptoms. Due to the very small numbers of women reporting chronic cough or phlegm (that is, lasting more than 3 months), these analysis have been carried out on the general symptom (First thing and at other times), and for most days.

Among non-smokers, there was evidence that a reduction in exposure, as measured by breath CO, was associated with a reduced risk of cough and phlegm (Table 10.40). The second column (odds ratio) shows the reduction in risk for a 1 ppm reduction in breath CO. The last two columns show that the effect of a 2.5 ppm reduction (as found in the Sudan sample of women) on risk of symptoms was around 15-20%. Although only one symptom (cough first thing and at other times) is marginally statistically significant, all the estimates are in the same direction – that is reduced risk, which indicates consistency in the findings.

Table 10.40: Risk of cough and phlegm symptoms at follow up associated with the change in breath CO from baseline to follow-up (non-smokers) - Sudan

Symptom	OR	95% CI	p-value	Effect of reduction of 2.5 ppm	
				OR	95% CI
Cough first thing and at other times	0.918	0.841, 1.001	0.053	0.807	0.649, 1.002
Cough first thing and at other times, most days	0.940	0.850, 1.040	0.231	0.857	0.666, 1.103
Phlegm first thing and at other times	0.948	0.864, 1.040	0.257	0.875	0.694, 1.103
Phlegm first thing and at other times, most days	0.914	0.823, 1.017	0.098	0.799	0.614, 1.043

OR = Odds ratio

Adjusted for age and the same symptom at baseline

Changes in lung function

Comparison of lung function values*:*

Lung function results for Round 3 are all lower than Round 1, and these differences were statistically significant. There could be a number of reasons for this. The seasonal conditions were similar at basleine and follow-up, but although field staff were re-trained and the identical protocol and equipment were used, they were not the same field staff who carried

out spirometry at baseline. The standard deviation values for lung function in Round 3 are all somewhat higher than in Round 1, which may indicate more variability due to technique.

Table 10.41: Lung function (non-smokers) at follow-up – non-smokers- Sudan

Measure	Baseline		Follow-up		Difference	p-value
	Mean	SD	Mean	SD		
FEV1	2.22	0.41	1.91	0.50	0.325	<0.0005
FVC	2.49	0.51	2.05	0.57	0.436	<0.0005
FEV1/FVC	90.35	7.90	93.02	9.56	-2.68	0.012
PEFR	293.1	80.5	234.0	92.5	59.0	<0.0005

Lung function and air pollution
Regression analysis to explore whether a change in room CO, or breath CO was associated with lung function (among non-smokers) showed only weak and generally inconsistent relationships, none of which approached statistical significance.

Headaches

Women were asked about the occurrence of headaches, including frequency, strength and causes. Among the whole sample at baseline, the majority (79%) said they did suffer from headaches, of which one-quarter experienced these most days or every day, and for about half these were 'fairly strong' or 'very strong'. A wide range of responses were given by the women as causes of the headaches, with smoke being the reason for 16%. The most common reasons were 'exposure to the wind' (31%) and 'carrying heavy loads' (14%).

To examine the changes over the course of the study, information on headaches was coded into two categories, as shown in Table 10.42 (a) for frequency of headaches, and in Table 10.42(b) for strength of headaches.

Frequency of headaches
There was no evidence of any change in headaches as determined by frequency, and this was the case for both definitions of 'frequent' as shown in the tables below.

Table 10.42(a): Numbers (%) of subjects reporting frequent headaches (version 1) at baseline and Round 3 (post-intervention) - Sudan

Headaches	Status	Round 3 (post-intervention)		Total
		Few days per week or less	Most days or every day	
Round 1 (Baseline)	Few days per week or less	118 (89.4)	14 (10.6)	132
	Most days or every day	17 (65.4)	9 (34.6)	26
	Total	135	23	158

McNemar's test; p=0.720

Table 10.42(b): Numbers (%) of subjects reporting frequent headaches (version 2) at baseline and Round 3 (post-intervention) - Sudan

Headaches	Status	Round 3 (post-intervention)		Total
		Once per week or less	Every few days or more often	
Round 1 (Baseline)	Once per week or less	94 (81.0)	22 (19.0)	116
	Every few days or more often	24 (51.7)	18 (42.9)	42
	Total	118	40	158

McNemar's test; p=0.883

Strength of headaches
For strength of headaches, there was evidence of a reduction over the course of the study, which was most marked when comparing the change in 'very strong' headaches (p=0.04).

Table 10.43(a): Numbers (%) of subjects reporting strong headaches (version 1) at baseline and Round 3 (post-intervention) - Sudan

Headaches	Status	Round 3 (post-intervention)		
		Mild	Fairly or very strong	Total
Round 1 (Baseline)	Mild	70 (76.1)	22 (23.9)	92
	Fairly or very strong	37 (56.1)	29 (43.9)	66
	Total	107	51	158

McNemar's test; p=0.067

Table 10.43): Numbers (%) of subjects reporting strong headaches (version 2) at baseline and Round 3 (post-intervention) - Sudan

Headaches	Status	Round 3 (post-intervention)		
		Mild or fairly strong	Very strong	Total
Round 1 (Baseline)	Mild or fairly strong	105 (86.8)	16 (13.2)	121
	Very strong	31 (83.8)	6 (16.2)	37
	Total	136	22	158

McNemar's test; p=0.040

Child health

At baseline, 113 (56.5%) of the homes reported that they had children under 5 years of age.

Respiratory illness

At baseline, 68 (60%) of the children were reported to have had illness with cough in the prior two weeks, and of these 17 (25%) had breathing that was noticeably faster than usual (if more than one child in household, refers to the youngest).

For those households that took part in both surveys, there was a very similar percentage reporting child illness with cough in the prior two weeks at baseline and follow-up (Table 10.44). The proportion of ill children with noticeably faster breathing was higher at follow-up, but recall of this sign is known to be unreliable, and overall there is no evidence to suggest any important change.

Table 10.44: Illness with cough in prior two weeks, baseline and follow-up- Sudan

Symptoms	Baseline		Follow up	
	N	%	N	%
Number of households with children under 5 years	84	53.2	93	58.8
Illness with cough in last 2 weeks	51	60.1	57	61.2
Breathing faster than normal	11	21.6	37	64.9

Burns

At baseline, 15 respondents stated that a child under 5 years had suffered a burn in the last year, that is, 13.3% of those with children under 5 years. For most (12) there had been only one episode, but one child had been burned as many as five times. For 6 children ((40%), the burn had been severe enough to leave a 'large' scar (larger than a 1 cm coin). Half of the burns occurred in the respondents kitchen, the rest elsewhere. The most common cause was the child touching a hot object, and other reasons were the pot falling over (scalding), falling onto clothes iron, and charcoal from the fire.

For those households that took part in both surveys, there were 7 children with burns in the previous year at both baseline and follow-up (Table 10.45). These small numbers mean that no formal comparison can be made, but a general conclusion would be that there is no strong evidence that the children were at any markedly greater risk, not was there evidence of any reduction in risk.

Table 10.45: Burns and scalds in previous year, baseline and follow-up- Sudan

Symptoms	Baseline		Follow up	
	N	%	N	%
Total of households	108		108	
Number of households with children under 5 years	84		93	
Number of households where burns have taken place	7		7	
Number of kitchens where burns have taken place	2		5	
Total number of children <5yrs	165		182	
Total number of burns last year	7		7	
Severe (large scar)	4		4	

Utilisation and costs of health care – visits

Among households taking part in both surveys, at baseline, most visits were made to the health post, with much fewer to the traditional healer or other (mainly private) providers (Table 10.46). Half of the households made at least one visit to the health post for adults and for children during the previous year, but only a minority visited the traditional healer or other provider.

At follow-up, there was generally quite a marked reduction in the reported visits to the health post and the traditional healer for adults, and to the health post for children. There was some evidence however, of an increase in visits to the private provider for both adults and children, although this may have resulted from greater emphasis in the question being added to elucidate visits to private providers as opposed to other providers in general (as was the case at baseline).

Table 10.46(a): Adult visits to health providers, baseline and follow-up

	Health post		Traditional healer		Other (Private)	
	Round 1	Round 3	Round 1	Round 3	Round 1	Round 3
Mean	1.66	0.13	0.17	0.01	0.09	0.33
SD	2.43	0.61	1.26	0.11	0.43	0.92
Median	1.0	0.0	0.0	0.0	0.0	0.0
IQR	0.0, 2.0	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 0.0

Table 10.46(b): Child visits to health providers, baseline and follow-up

	Health post		Traditional healer		Other (Private)	
	Round 1	Round 3	Round 1	Round 3	Round 1	Round 3
Mean	2.32	0.13	0.02	0.02	0.06	1.2
SD	4.17	0.54	0.24	0.18	0.30	2.79
Median	1.0	0.0	0.0	0.0	0.0	0.0
IQR	0.0, 4.0	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 0.0	0.0, 1.0

Change in overall costs

The total expenditure on all three types of health provider reduced slightly from a mean of SD6007 for the year, to SD5809 (p=0.020, Wilcoxon signed rank test).

Chapter 11: Cost benefit analysis

Introduction

The economic evaluation of interventions being considered for wider implementation is of growing importance in the policy field. There have previously been papers written, discussing the results of a global cost-effectiveness analysis (CEA) for household energy interventions, which has suggested that in poor countries in Africa and Asia, interventions such as improved stoves can yield cost-effectiveness of around 15-20 US$ per healthy year gained (Bruce et al. 2006). CEA however is limited to considering the costs and benefits in terms of direct health gains, and therefore other approaches to economic evaluation including cost-benefit analysis (CBA) have been suggested as being particularly appropriate to environmental interventions such as in the fields of households energy (Bruce, Rehfuess, Mehta, Hutton, & Smith 2006), and water, sanitation and hygiene (Cairncross & Valdmanis 2006). WHO has recently published guidelines for CBA of household energy interventions (Hutton 2006), and a global/regional study (Hutton et al. 2006). Some examples of CBA of specific programmes, such as that supported by GTZ in Uganda, have also been subjected to CBA (Habermehl 2007).

The value of CBA for household energy interventions is that the analysis compiles all of the costs associated with the intervention, and balances these against all of the important benefits. In order to permit this comparison of costs and benefits, the latter are usually valued in the same monetary units as the costs. This process involves making a series of critical assumptions: since there will often be cause for debate about such assumptions, these should to be clearly stated. All assumptions made in the context of the current study are described in the following sections.

CBA can also typically be conducted by way of comparison, so that the financial value of the benefits that result from the intervention, with the current situation as the starting point, are compared with the additional costs required to realise the intervention.

Another important question that arises in all economic analysis is that of 'who pays?' This is particularly relevant to interventions such as those used to reduce IAP, as current approaches increasingly look to the establishment of sustainable markets for a range of devices and services that are affordable to the target populations – albeit with the possibility of various forms of financial support. For the current study, two approaches are taken.

One approach is to take a 'Household perspective', which looks at the costs and benefits from the point of view of the household. This can provide insight into how households might value the intervention, and how much they might be willing to pay.

A second approach, the 'Societal perspective' determines overall costs and benefits. This gives an overview of whether society as a whole gains an economic benefit from the investment, whoever pays for or gains from the various costs and benefits. Due to constraints of time following completion of fieldwork and data collection, the analyses reported here are restricted primarily to the household perspective. Further work on the societal perspective will be conducted in due course and reported separately.

The work described in this Chapter draws substantially on the guidelines and global study published by WHO (Hutton, Rehfuess, Tediosi, & Weiss 2006;Hutton 2006). Although the methods and assumptions used are described in the following section, reference should be made to these documents for further details.

Key assumptions

Time horizon
The time period for the analysis is 10 years. This means that costs for obtaining and maintaining the interventions for a period of 10 years from the present are included. Similarly, benefits accruing from the presence of the intervention for the same period of 10 years are included.

Discounting
Discounting of costs and benefits is an important part of economic analysis, and takes account of the fact that a cost or benefit experienced, say, five years from now, has less value that costs and benefits experienced immediately. This reflects two factors, first the effect of inflation in the economy of each country, and second the fact that individuals and society tend to 'value' a cost or benefit experienced now more highly that one experienced some years in the future.

For the current study, all costs and benefits are discounted at 10 per cent per year for the household perspective CBA.

In addition, the internal rate of return (IRR) is calculated, which indicates the discount rate required to obtain a zero net present value (NPV). This is particularly useful where there is uncertainty about the most appropriate discount rate to apply, as is the case with this project.

Study populations

The populations identified for the purposes of the cost-benefit analyses relate closely to the areas in which the development work has been carried out, and the households for whom the programmes have been developed – that is, poor, mainly biomass-dependent homes. The tables below show the numbers of people in the age groups considered in respect of health benefits, and the percentages of the total populations that they constitute. The reasons for selecting these age groups are discussed further in the costs section.

Kenya
The target programme area has a total population of 63 330, and includes the peri-urban and rural communities in which the project has been located, but excludes the urban areas of Kisumu city. The area does not cover the whole geographical area of Kisumu district as this was felt to be too large for consideration at this stage. The great majority of homes in this area are primarily dependent on biomass for their household fuel.

Age/sex group	Number in specified group in programme area	per cent of total population in programme area
Children < 5 years	9297	14.7 per cent
Males 30 years and over	7922	12.5 per cent
Females 30 years and over	8657	13.7 per cent

Nepal
The target programme area has a total population of 44 730, and is in effect the District of Rasuwa. The great majority of homes in this area are primarily dependent on biomass for their household fuel, almost all of which is wood.

Age/sex group	Number in specified group in programme area	per cent of total population in programme area
Children < 5 years	5214	14.8
Males 30 years and over	7246	16.2
Females 30 years and over	7291	16.3

Sudan
The target programme area has a total population of 79,000, and covers the communities of poor, displaced people living in and around the town of Kassala. The great majority of homes in these communities are primarily dependent on biomass for their household fuel, although using a mix of charcoal and wood.

Age/sex group	Number in specified group in programme area	per cent of total population in programme area
Children < 5 years	11,248	14.8 per cent
Males 30 years and over	12,160	16.0 per cent
Females 30 years and over	12,563	16.5 per cent

Costs included

All potential costs considered, and those included in the analyses, are summarised in Annex 3 Table 1. This also shows the sources of information from the current study, and external sources, that could be drawn on. Those costs included in the analysis reported in this Chapter are highlighted in bold in Annex 3 Table 1.

Costs
These are separated into investment and recurrent costs. For the household perspective analysis, the following are included:

Investment
Cost of purchasing and installing the intervention. This is the actual cost to the household. Where LPG was used, this includes the cost of the stove and the gas bottle and associated equipment (connection, pipe). Data on costs was obtained directly from the country projects.
Recurrent

(a) Cost of fuel, if purchased, with data obtained from the surveys. For LPG users, this included the cost of refilling the gas bottle.

(b) Maintenance and repair. The anticipated costs of maintaining and repairing the interventions so that these would function effectively during each year of the10 years of the study time period is included. This was obtained from the level of repair and maintenance reported in the survey.

Benefits included

All potential benefits considered, and those included in the analyses, are summarised in Annex 3 Table 1. This also shows the sources of information from the current study, and external sources, that could be drawn on. Those benefits included in the analysis reported in this Chapter are highlighted in bold in Annex Table 1.

Direct health benefits

Approach and sources:
The WHO guidelines focus on Acute Lower Respiratory Infections (ALRI) for children of less than five year), Chronic Obstructive Pulmonary Disease (COPD) for males and females aged 30 years and older, and lung cancer (where coal used), as the evidence for the impacts of IAP on these diseases is considered sufficiently robust. As none of the countries concerned use coal for domestic energy needs, no further consideration is given to lung cancer. Evidence for a range of other health outcomes is still considered tentative, and is therefore not included in these analyses.

Table 11.1 shows the age groups for which robust evidence is available, together with the relative risk (a comparison of incidence rates in those exposed to indoor air pollution from solid fuels, with those who are not exposed), and 95 per cent confidence interval. The same age groups have been used in the current CBA study.

Table 11.1: Summary of point estimates and 95 per cent confidence intervals of relative risk for health outcomes*.

Health outcome	Age and sex group	No. of studies	Relative risk	95 per cent CI
ALRI	Children < 5 years	8	2.3	1.9 – 2.7
COPD	Women > 30 years	8	3.2	2.3 – 4.8
	Men > 30 years	2	1.8	1.0 – 3.2
Lung cancer (coal)	Women > 30 years	9	1.9	1.1 – 3.5
	Men > 30 years	3	1.5	1.0 – 2.5

*Sources (Desai, Mehta, & Smith 2004;Smith, Mehta, & Feuz 2004)

As discussed in Chapter 10, this study was not designed to measure the impact of the intervention directly on either ALRI incidence rates, or the development of COPD. Consequently, the impact on these outcomes is assessed by using a combination of the reduction in IAP that was actually measured in the study, with published risk estimates (shown above), and also emerging information on the relationships between exposure levels/reduction and risk of ALRI, based on the recently completed randomised controlled trial from Guatemala (Smith et al. 2007), and (McCracken JM personal communication).

Calculation of cases prevented by the intervention

Exposure reduction

The changes in exposure are based on the 24-hour kitchen CO data, reported in Chapter 5. The derivation of the resulting reduction in personal exposures for women and children is derived from the relationships between 24-hour kitchen and personal CO reported in Phase 1 of this project (Bates, 2005). It has been assumed that the levels of exposure and changes in exposure for women and children under 5 years are the same. Details of the exposure levels used are presented in Annex 3 Table 2 for each country.

ALRI

For ALRI in child under 5 years of age, two approaches were used for purposes of comparison:

a. Using the preliminary analysis from the RESPIRE study of the relationship between reduction in child exposure (as measured by 48-hour average carbon monoxide) and incidence of clinically assessed pneumonia (diagnosed by a physician).
b. Using the method described by Desai et al (Desai, Mehta, & Smith 2004), based on the relative risks shown above, which were derived from a systematic review and meta-analysis used for the WHO comparative risk assessment (World Health Organisation 2002).

Both approaches required estimates of ALRI incidence in the three programme areas: the incidence rates used are shown in Annex 3 Table 2. These were estimated from two sources: (i) a recently published global review of pneumonia incidence in developing countries which includes two studies from Nepal and one from Kenya (Rudan et al. 2004), and (ii) national data from the Department of Evidence and Information for Policy, WHO, Geneva. More weight has been given to the global review paper by Rudan et al, particularly for Kassala, since the EIP estimates for Sudan were extremely low and did not appear consistent with the level of poverty prevalent in the displaced person communities concerned.

It can be seen from Figure 11.1 that a growth in interventions up to 25% coverage of the population in each of these relatively small populations over the next ten years would lead to significant reductions in the number of cases of ALRI, even if the more conservative estimate is adopted.

COPD cases prevented (deferred)

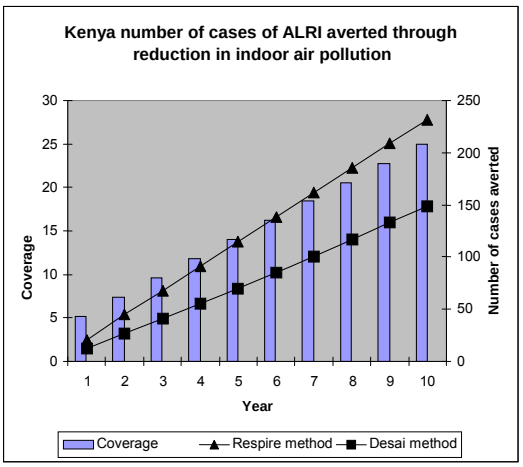
For COPD in women and men over 30 years of age, incidence data was obtained from EIP, WHO, as no other source was available. These incidence rates may be low, particularly for women, but were considered the best available. Averted cases were calculated using the method of Desai et al (Desai, Mehta, & Smith 2004).

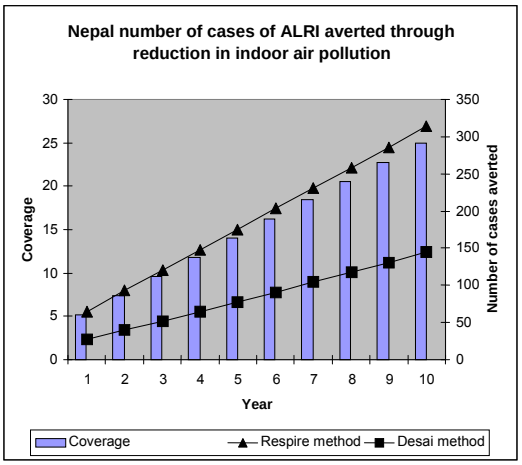
For COPD, unlike ALRI, averted cases over the ten years of the study are in effect delayed cases, as it would take up to 20 years (the 'typical' latent period for the disease) to prevent the occurrence of new cases. Thus, reduced exposure for a period of ten years is assumed

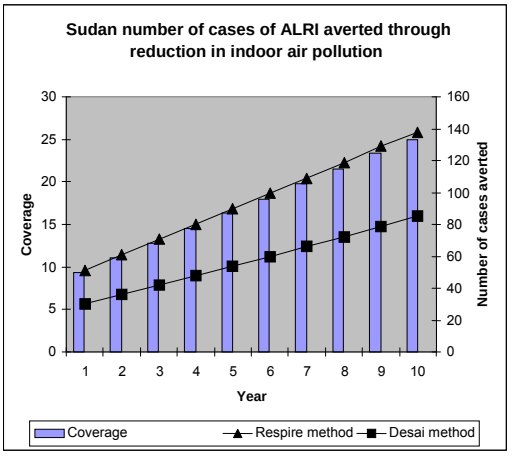
to have the effect of delaying onset of disease in those individuals who are at risk, for ten years.

Figure 11.1: Estimates of cases of ALRI averted using RESPIRE and Desai methods

Kenya			
Year of analysis	**Coverage (%)**	**Cases averted (RESPIRE)**	**Cases averted (Desai)**
1	2.3	21	12
2	4.8	45	27
3	7.3	68	41
4	9.8	91	55
5	12.4	115	70
6	14.9	138	85
7	17.4	162	100
8	19.9	185	117
9	22.5	209	133
10	25	232	149
Nepal			
Year of analysis	**Coverage (%)**	**Cases averted (RESPIRE)**	**Cases averted (Desai)**
1	2.3	65	27
2	4.8	93	40
3	7.3	120	52
4	9.8	148	64
5	12.4	175	77
6	14.9	203	91
7	17.4	231	104
8	19.9	258	117
9	22.5	286	131
10	25	314	145
Sudan			
Year of analysis	**Coverage (%)**	**Cases averted (RESPIRE)**	**Cases averted (Desai)**
1	2.3	51	30
2	4.8	61	36
3	7.3	71	42
4	9.8	80	48
5	12.4	90	54
6	14.9	100	60
7	17.4	109	66
8	19.9	119	72
9	22.5	129	79
10	25	138	85







Calculation of cost savings from cases averted

The calculation of cost savings resulting from prevented cases is based closely on the method used by Hutton et al for their global/regional study (Hutton, Rehfuess, Tediosi, & Weiss 2006), albeit with some local adaptation of data. A similar approach is taken for both ALRI and COPD.

For the ***societal perspective***, consideration is given to the distribution of disease severity, the anticipated uptake of modern health care, duration of illness (which is also a function of whether or not treatment is obtained), and costs of care at health facilities (outpatient and

inpatient), as well as medication and investigations (e.g. chest X-ray). In order to value time lost while caring for sick children with ALRI, the duration in days (which varies according to severity and treatment) is valued at 50 per cent of the daily rate based on per capita gross national income (see Table). For time lost as a result of COPD, 100 per cent of the daily rate is used, as it is the patient him/herself that is losing productive time.

Direct impacts not related to health
A range of other benefits, other than direct health outcomes, is included in the CBA. These are listed in Annex 3 Table 1.

Time collecting fuel
Information was obtained directly from the study surveys and valued by the time spent in fuel collection.

Time cooking.
This was estimated from the durations of time that kitchen CO exceeded 9 ppm, as measured by the 24-hour continuous T82 monitor. For homes cooking on LPG, an alternative approach was used as the above approach would not have registered cooking periods, based on the maximum time for which LPG stoves were used on a daily basis. As this was not part of the study, this was estimated conservatively at one hour of use per day based on the time between refilling for the gas bottles. In these (LPG using) homes, information from respondents on time saved was also taken into account. It was notable that in Kenya, particularly, there were very large reductions in time spent cooking reported by women, measured by either approach.

Indirect impacts related to the environment
Local and global environmental impacts (see Annex 3 Table 1) have not been included in the analyses, as reliable data on these was not available.

Cost Benefit Analysis results - household perspective

Cost benefit analysis from household perspective was undertaken to access the viability of investment by a household in an intervention to alleviate smoke. In the process, the net benefits to a household after having the intervention was assessed and translated into a monetary equivalent and this was compared with the intervention costs.

Costs
The market prices of the interventions and their installation costs have been considered as the initial capital investment. Likewise, recurrent fuel costs and maintenance cost have also been considered in the analysis.

Nepal
In Nepal, the households are investing in smoke hoods with stove improvement to keep their home free from indoor air pollution. The capital cost of a smoke hood comes about £46.00 with annual maintenance requirement of £1.00. The type of fuel, namely wood, did not change as a result of the intervention, and all of this was collected so that fuel costs are not considered.

Sudan
In Sudan, most of the households have opted to LPG, switching from firewood and charcoal use. To purchase a LPG stove, the initial investment was about £52.00 and the annual refilling cost around £38.00 per household. As most homes purchased most of their wood and/or charcoal, this led to a net saving of £30 per household, per year in fuel consumption costs.

Kenya
In Kenya, most of the households adopted LPG while a few households installed smoke hoods. Some households adopted lower cost combined options such as ‘fireless cookers’ and eaves spaces. The average investment cost for a household comes to about £25.00, with an annual fuel cost of £13.40. Some households also continued to collect firewood. Time saving from firewood collection amounted to around 64 hours per annum.

Benefits
Benefits of the interventions were observed under the following headings:

- Averted ALRI and COPD treatment expenditure
- Averted productive days loss due to caring for sick children, and directly from illness, bed rest, or hospitalization.
- Avoided fuel costs
- Reduced firewood collection time due to fuel savings
- Time saving due to reduced cooking time

In Nepal, a significant reduction of about 712 kg/HH in firewood consumption was observed after the intervention leading to 152 hours working hours saving per annum in firewood collection.

In Kenya, significant reduction (about 2.6 hours/day per HH) in cooking time was observed after the intervention. They switched from three-stone fires to LPG to cook quick foods - brewing tea etc. and used the upesi stoves and 'fireless cookers' for the long cooking periods. Likewise, significant net saving in fuel collection time and fuel was observed after the intervention.

In Sudan, there was a significant reduction of £30.00/HH in annual fuel cost observed after the intervention. Likewise, due to a shift to LPG or charcoal stove from the traditional biomass stove has resulted in the net cooking time saving of 119 hours/year per household.

Table 11.3 (a) : Net Incremental Costs and Benefits after Intervention (per HH)

	Headings	Kenya	Sudan	Nepal
A	Investment			
	Cost of intervention (in GBP)	25	52	46
B	Operation and maintenance cost			
	If purchased - Cost of the fuel	-13.4	-30	0
	If collected - Fuel collection time (Hrs)	-64	0	-152
	Cooking time (in hours)	-961	-119	-83
	Maintenance cost (in GBP)	1	8	1
C.	Health care cost and workday loss	-0.13	-0.08	-0.29
	Avoided ALRI cases	-0.12	-0.07	-0.28
	Avoided COPD cases	-0.01	-0.00	-0.01

Table 11.3 (b) : Net Incremental Cost and Benefits after Intervention (in UKP per HH)

	Headings	Kenya	Sudan	Nepal
A	Investment			
	Cost of Intervention (in GBP)	25.00	52.00	46.00
B	Operation and maintenance cost			
	Net saving in fuel purchase	13.40	30.00	0.00
	Net saving in fuel collection time (in GBP)	5.92	0.29	7.32
	Net saving in cooking time	88.87	10.34	3.99
	Maintenance cost	1.00	8.00	1.00
C.	Saving in Health care cost and workday loss	0.13	0.08	0.31
	Avoided ALRI cases	0.12	0.07	0.28
	Avoided COPD cases	0.01	0.00	0.03

Cost Benefit Analysis Findings
Investment in the interventions are justified on economic grounds with the estimated Internal Rate of Return (IRR) of 19 per cent, 429.3 per cent and 62.4 per cent respectively in Nepal,

Kenya and Sudan. The IRRs are much more than the cut-off discount rate (12 per cent) indicating viability of investment. The positive NPV and greater than 1 B/C ratio also indicate the efficient use of invested resources (Table 11.4)

Table 11.4: Cost Benefit Analysis Result from Household Perspective - Base Results all at 10 per cent discount rate assumption

Countries	PRESENT VALUE (UKP)		NPV @ 12 per cent Discount rate (UKP)	IRR	BC Ratio at 12 per cent discount rate
	Cost	Benefit			
Nepal	52.1	71.4	19.2	19.0 per cent	1.4
Kenya	31.1	665.6	634.4	429.3 per cent	21.4
Sudan	101.2	250.2	149.0	62.4 per cent	2.5

Discussion

Overall, these results show positive benefit to cost for all three countries, and a very high ratio for Kenya. Time saving is by far the most important component, but fuel cost savings are also substantial for Kenya and Sudan. The direct health benefits appear as a very small component, and although incidence rates for ALRI are likely to be quite representative, those for COPD may be underestimated as very few studies have been carried out to determine the true incidence in the community of COPD in settings such as these. The small size of the health benefit may be a reflection of the incomplete care-seeking which (realistically) is included in the model. Further, this analysis looks only at two major causes of ill-health and does not include the time spend addressing other less serious illnesses which have been extensively reported in the study. In the CBA, the effect is spread across all the households, whereas, for each household where a child suffers from ALRI, or where the caregiver is affected by ongoing COPD, the impacts on each household will be considerable. The valuation of illness is conservative, and is based on the minimum health care costs, a relatively low level of care seeking, and little real valuation of what illness/healthy children means to people. At time of carrying out this study, we do not have adequate data or methods to attempt to address these limitations, but this should be an important objective for future research work in this field.

Although there is some uncertainty about the appropriate discount rate, the IRR shows that to achieve zero NPV, this is well above the 10 per cent used, which is already high. The 10 per cent rate is used to reflect the way that most people's decision-making is based on their present scenario, with very low preference for future benefits. (Some studies in Nepal use 12 per cent as a more realistic figure but 10 per cent has been retained for uniformity across the study.) In an economy where uncertainty and risk are very high, and people's rate of time preference is high, a high discount rate is used. For the societal perspective the rate can be much lower, at 3 per cent.

Formal sensitivity analysis has not been carried out. As health impacts were a small component, variations in estimates of exposure reduction, disease incidence rates, health costs and time lost due to illness would make little difference to the overall results. Even a substantial reduction in estimated time and fuel savings costs (up to 50 per cent) would still yield positive cost-benefit ratios for Kenya and Sudan. For Nepal, fuel cost savings were not relevant, and it was fuel collection time that was more critical.These results are broadly in line with those reported in the WHO global/regional study by Hutton et al, although there are important differences in that their study was a societal perspective analysis, and assumptions of higher coverage are made (50 per cent, 50 per cent pro-poor, and 100 per cent in the various scenarios). One common conclusion is the importance of time saving, and relatively small contribution from direct health benefits.

The study of improved stoves in Uganda by Habermehl (2007), which used a broader societal perspective, a 10 year time horizon and 10 per cent discount rate, also reported a high benefit to cost ratio, and in that case fuel savings were particularly important.

In conclusion, this initial, household perspective CBA has shown positive benefit to cost ratios for households purchasing interventions that are achieving at least useful and often very substantial reductions in IAP. This should encourage efforts to assist prospective adopters with the financial arrangements needed for them to obtain these benefits.

Chapter 12: Smoke alleviation and poverty impact

In this chapter we look at findings from the research on people's livelihoods, and on how such interventions can contribute to the achievement of the Millenium Development Goals.

Socio-economic, environmental and institutional impacts of the research

Increased human capital

The numbers of households reporting improved health in each country is reflected in both the informal and formal health questions for all family members; the cooks themselves, husbands, under-5 year children and other non-specified family members. In Kenya, coughs, colds and headaches are listed, along with other less well-reported benefits of timely meals and reduced family conflict. The households in Nepal are more focused on reductions in coughs, and occasionally colds, and note improvements, particularly with regard to children. In Sudan, it was clear that those who had used, or were using, LPG noted improved health as a result. Several in the study also stated that their personal health has not improved. This suggests that they link improved well-being with the use LPG. More formal health measures are reported in Chapter 10. A reduction in burns and scalds was noted in both Kenya and Nepal – although the numbers are too small to be statistically significant.

Improving fuel efficiency is known to lead to some of the savings in fuel being ploughed back into improved energy provision; more cooked food (improved nutrition) , and people boiling water for drinking and washing (improved hygiene). These effects were not, however, reported by households in the study.

Time spent in cooking and household chores such as cleaning was reported as one of the key benefits. However, much of the time freed up from the effects using polluting fuels is reportedly spent on household tasks, leading to improved kitchen hygiene and a sense of well-being. Other productive activities include farming, small enterprise, childcare and leisure.

Those collaborating the project have learnt many new skills. In particular, the groups running the revolving finance have been involved in setting up and using bank accounts, book-keeping, sales, marketing, goods purchase. Others in the community have learnt new skills, manufacturing smoke hoods, eaves spaces, and fireless cookers.

The team themselves have developed skills in health-monitoring, room monitoring, data collection, and in the case of Nepal, the cost-benefit analysis is using the skills of one of the team to collaborate with the University of Liverpool in a cost-benefit analysis of the impacts of indoor air pollution alleviation. This work is using tools which have recently been developed by the WHO.

Impacts on social capital

Women's groups in Kenya have become talented performers and musicians in their own right, well known and respected for their work in alleviating kitchen smoke. They have campaigned in front of hundreds of people and are regularly invited to take part in major social gatherings.

In Nepal, one of the criteria for accessing revolving finance was to form groups of around twenty people. These groups relied on the repayments of their fellow members for the success of the work, and monthly meetings to collect the payments have themselves led to greater cohesion among the groups.

The Women Development Organisations in Sudan have moved from selling small low-cost items, such as packets of spice, into management of wholesale batches of stoves and bottles. Currently, they are still receiving some support from Practical Action in terms of monitoring and business skills, but with steady demand, it is important that the whole business is firmly

grounded before it is left to function unaided. The large numbers and the rate of expansion have lead to complex systems requiring close collaboration between the various groups.

Additional financial capital

Capital costs are the major reason why people cannot access technologies for alleviating smoke. The perceived wisdom is that revolving finance is only appropriate where it is used for income generation. However, this research has shown that it can work where people can reduce their costs (equivalent to generating income in real terms) or where the time savings allow them to make other positive changes to their lives.

Priorities, like poverty, are not absolute. Recognition of the major positive changes brought about by making the air clean can lead to indoor air pollution alleviation being prioritised. As one of the purchasers of a smoke hood explained 'when they told me it would cost the same as a buffalo, I did not really think it was that good an idea, but now I know it is worth more'…

It is this relative value that is important – a similar equation was used in a study working with the Maasai community in Kenya. A smoke hood was worth two goats – but the men owned the goats. It was necessary to convince the men that having improved levels of health and comfort are worth the risk of having two less goats (ITDG, 2002). This is particularly true where cost savings can accrue from the installation.

At the same time, money spent on interventions in Nepal and Kenya is staying within the community, increasing the spending power of those making the hoods and other items.

A recent publication by the WHO (2006) suggests that a massive investment in either clean fuels or clean stoves would repay itself many times over in reductions in ill-health and economic benefits. Time gains from reduced illness, fewer deaths, less fuel collection and shorter cooking times account for more than 95 per cent of these calculated benefits.

Around 2200 households have purchased goods through the revolving funds set up during the project. These funds have not diminished substantially through the project period. In Sudan the targets reflect 12 per cent mark-up on items sold on credit. Using revolving finance will allow many more homes to benefit from these technologies.

Kenya
Using less fuel does not always mean creating less smoke. Fuel-efficient stoves may work well because they direct all the heat to the pot, but in doing so, they may give rise to less efficient combustion and more smoke. In Kenya, efforts were made to reduce fuel costs whilst reducing emissions. Fireless cookers do not require fuel once the food has been heated and put into them; upesi stoves use less fuel, the emissions are marginally reduced, and the food cooks more quickly, so the woman spends less time at the stove.

Although project data on fuel costs does not reflect major savings, the respondents felt themselves to be better off overall, as they spent less on fuel, used their additional time for enterprise, spent less on medication and were able to grow more food.

All of these are adding to the financial capital of both the household and the community.

Sudan
Where people have to buy fuel, or where they have to spend many hours gathering fuel, then ways to reduce the amount of fuel used, or its unit cost, will have a positive impact on their finances. In Sudan, this can actually be seen in real terms, where burning charcoal on a traditional stove costs around 12 SDD per MJ, compared to around 9.5SDD for LPG. Where charcoal is burnt on an improved charcoal stove, then charcoal costs marginally less than LPG.

In Kassala, all those interviewed who used charcoal were using a traditional charcoal stove, so in terms of useful heat, they were paying more than when using LPG. The difference in fuel prices becomes even more evident in other parts of Sudan. For example, in the Darfur region, charcoal is more than twice the current price of charcoal in Kassala.

Fuel costs are only part of the equation, as the health and environmental costs have not been included. On the other hand, whilst women are still paying off the capital cost of the stove, finding the savings to buy a refill, when they can buy a day's worth of charcoal, is a big problem for those on very low incomes.

The fact that only one or two people wish to return their LPG sets suggests that women feel that there is a saving to be had, once they have repaid the upfront costs. Alternatively they may be aware of fluctuations in the charcoal market caused by many displaced persons returning home and the growth in the LPG market among the more affluent leading to lower charcoal prices in the short term.

Greater physical capital

This research has led to over two thousand households being able to access interventions that reduce the levels in their homes substantially. The interventions go beyond the actual goods as they leave houses, clothes and particularly cooking pots in much better condition than in the past. Smoke hoods are likely to last for many years. Hoods made from new steel sheet in Kenya several years ago are still in good condition. (Those from recycled sheet faired less well.) LPG burners will last about five years, but these are the low-cost part of a stove, and the gas bottles are constantly circulated once the investment has been made – so they are a one-off cost. Improved stoves can lead to improved combustion, and they also contain the fire in one place, adding to the comfort of the kitchen.

The kitchen environment has been greatly enhanced by the introduction of cleaner technologies and fuels.

Efficient use of natural capital

The kitchens and houses in which clean stoves or smoke hoods are used, are in much better condition than those without interventions. Many women have reported a desire to keep the place nice now that the smoke has been removed and maintaining the house, clothes and pots in good order requires far less drudgery.

Women spend far less energy gathering fuel if less fuel is burned. One of the main problems identified during the first survey was that of hunger in Nepal when gathering fuel. People have so little extra that using up energy to gather fuel caused them to suffer from lack of food.

Overall, the research will have reduced the production of greenhouse gases in Nepal and Kenya. It is likely to do so in future in Sudan. Compared to inefficient biomass burning, LPG produces substantially less GHGs. In Sudan, programmes to increase forest cover in areas supporting displaced populations further enhance this effect. During periods when charcoal was used, there are likely to have been no environmental benefits, as charcoal creates greenhouse gases in both the production and burning. This is another strong argument for improving the gas delivery systems for LPG to those living in poverty.

Biomass stoves that burn fuel more efficiently create less GHGs per megajoule of useful energy. Action was taken in both Kenya and Nepal to improve the combustion efficiency and heat transfer efficiency of each person's stove.

Targeting the Millennium Development Goals

The Millennium Development Goals (MDGs) are targets towards which all development activity should be focused. Reducing indoor air pollution is an important way of addressing the issue. This section looks at the different ways in which alleviating kitchen smoke, within this research environment, has benefited, and will continue to benefit, those living in poverty. The issues around the health of the child and mother are only touched on briefly in this section as they are considered in depth in Chapter 10.

Goal 1: Eradicate extreme poverty and hunger
Target: Halve the proportion of people living on less than a dollar a day and those who suffer from hunger.

Two factors affect this goal particularly. Savings in time and money can provide more money to buy food and more time to cultivate crops. This is particularly true in Nepal and Kenya where women reported cultivation as an activity that increased with additional time.
The questionnaire comprised two questions about income relevant to this goal:

1. Whether people felt better off, worse off or the same.
2. By how much per week they felt better or worse off (this was converted to an annual figure.

The two questions about time followed a similar pattern:

1. Whether people had more or less time, or just the same
2. How much more (or less) time did they have each week

The levels of savings reported in this research represent a substantial improvement in absolute terms in communities where many live below the poverty line. Importantly, the money is saved by the woman, so is more likely to go into improved household provision.

Studies have shown that where people are very poor, some of the energy 'saving' is in fact spent in further energy provision, leading to improved nutrition and hygiene.

The Cost Benefit Analysis demonstrated that interventions to reduce smoke lead to considerable time savings, and these in turn were translated into increased income generation and more time spent on agriculture by many households.

Goal 2: Achieve universal primary education
Target: Ensure that all boys and girls complete primary school.

Data from the study showed only a marginal change in the number of children collecting fuel between Round 1 and Round 3 and thus does not reinforce or contradict the idea that reducing the need to collect fuel has an impact on the number of children attending school.

However, around 50 households in Nepal, and over 100 households in Sudan described the kitchen as cleaner and more comfortable. Earlier studies by Practical Action have reported that children are more willing to do homework, supported by their mothers, when the kitchen environment makes this possible.

Good health is important for children to benefit from education. Respiratory illnesses early in children's lives are increased substantially by indoor air pollution, giving children a less than optimum start in life. Children of healthy mothers are more likely to attend school. Currently there is insufficient evidence on the effects of indoor air pollution on older children.

Goal 3: Promote gender equality and empower women
Target: Eliminate gender disparities in primary and secondary education preferably by 2005, and at all levels by 2015.

The project has worked exclusively with either women's groups or with groups where women are well-represented. Empowerment has come through knowledge sharing, training in skills and business skills, reduction in drudgery, improvement in working environment and improved health / quality of life.

Many issues were monitored in this study, although the dangers associated with fuel collection were only reported during the first research project (Bates, 2005) and in other work. The women in Kenya reported fear of being beaten when they are collecting fuelwood as they do not have enough land to grow the fuel they need. Reducing the amount of fuel that has to be collected can also mitigate dangers from wild animals, scorpions, and snakes – problems highlighted in Nepal.

Men will tend to plant cash crops, whereas women recognise that access to good quality fuel is important. Addressing the efficient burning of fuel thus has positive knock-on effects for women.

In Nepal, Fuel saving was one of the issues women wanted to have addressed. During the first project, hunger, tiredness and distances walked on rocky mountainous terrain came high in the list of problems.

The large numbers of people reverting to charcoal is a major setback to empowering women. Many of the women in the society where the project has been conducted rely exclusively on their husbands for their finance. Those who work are often engaged in seasonal activities, yet although there husbands see that they do not have goods to sell, they are reluctant to provide additional money for the family for clean fuel and appliances. Once bought, LPG provides a pathway towards more savngs as it is cheaper than other fuels in the market place. Gender equality would resolve many of these issues, and LPG would help to address these same issues:

- For those who are not able to go to work, greater responsibility by the husband in ensuring that his wife has access to clean fuels would improve the health of all the family
- For those able to work, reducing the time spent gathering, cooking and cleaning could provide the additional time for employment
- LPG can clean up the kitchen – even where there are houses with attractive sitting rooms, the kitchen may well be a dark, dismal place hiding around the back of the house – ‘ok for a woman’

There have been no serious accidents to those who have already bought LPG. There are no sparks, the family is healthier, yet people still have fears on its safety. This is an area where the excellent work done by the Civil Defence will continue after the project ends.

Goal 4: Reduce child mortality
Target: Reduce by two thirds the mortality rate among children under five

According to the World Health Report, 2002, studies estimate that indoor smoke from solid fuels causes about 35.7 per cent of lower respiratory infections (ALRI) . ALRI are the single most important cause of death of children under 5 years, responsible annually for approximately 20 per cent of the 10 million under-5 deaths (WHO, 2002).

Additionally, recent data (Boy et al, 2002) indicates that high levels of IAP may be responsible for low-birthweight babies and a greater number of stillbirths.

Chapters 10 analyses in depth the effects on reducing indoor air pollution on the burden of ill-health

Goal 5: Improve maternal health
Target: Reduce by three quarters the maternal mortality ratio

This aim is largely devoted to maternal mortality during childbirth. As referred to in Aim 4, there is growing evidence of the links between carbon monoxide and the effect that it is has on the foetus. It also leads to larger numbers of child deaths.

In most societies, fertility is reduced as infant mortality decreases. The risks associated with childbirth are consequently reduced by reducing the additional infant mortality caused by indoor air pollution.

Reducing the need to gather fuel frees the woman (and her husband during some seasons) from carrying these extremely heavy burdens in mountainous areas. Women who carry heavy burdens are believed to suffer more from prolapse (Pandey 1997).

Goal 6: Combat HIV/AIDS, malaria and other diseases
Target: Halt and begin to reverse the incidence of malaria and other major diseases.

Data from the WHO estimates that 80 million people suffer from moderate to severe Chronic Obstructive Pulmonary Disease (COPD) and three million people died of COPD in 2005. WHO predicts that COPD will become the fourth leading cause of death worldwide by 2030.

Indoor smoke from solid fuels leads to an increase of 22 per cent of chronic obstructive pulmonary disease COPD and 1.5 per cent of trachea, bronchus and lung cancer. Based on these figues, it can be seen that indoor air pollution causes 16million of these cases of COPD, and around 300 000 deaths in one year.

Now that a well-established link has been made for the dangers of smoke in terms of both ALRI and COPD, reductions such as those achieved in this research programme could make a major impact on the number of cases of these major diseases.

Indoor air pollution appears to be closely associated with tuberculosis, cataracts and asthma. (In the countries in this study, coal is not burnt, so cancers are less likely to be a major issue.)

The impacts on COPD are described more fully in Chapters 11 & 12.

Goal 7: Ensure environmental sustainability
Target: Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources

In all three areas, lack of fuelwood is an issue. One of the main project partners of the work in Sudan was the National Forestry Department. Their role is to try to reduce the impact on forests caused by the large influx of displaced people into the area. LPG is viewed very positively in Sudan in environmental terms. In its absence, charcoal is made using wood from farms many miles from the town, brought in by four-wheel drive vehicles, and wood is brought in on camels. Using LPG may not appear superficially to be supporting the environment, by it provides time for regeneration, and produces less greenhouse gases than inefficiently burnt biomass.

People need fuel, and people living in poverty are highly vulnerable to fuel shortages caused by commercial charcoal-making, a sudden increase in population, or farmers clearing land for crops. Both in Nepal and Kenya, improved stoves were part of the package, and although they were primarily introduced to reduce fuel costs, they also reduced the amount of fuel gathered.

Goal 8: Develop a Global Partnership for Development

Although not part of the DFID-funded project, in 2003, Practical Action embarked on a campaign to highlight the issues surrounding indoor air pollution, supported by the project team, in order to build up global awareness and action. The outputs from this initiative, run by the campaigns unit of Practical Action, achieved considerable success. The outputs from this campaign are described in Chapter 13.

Chapter 13: What has been achieved: what more is needed?

What has been achieved?

Kenya

The population in the districts in Kenya where the project worked is around 63300 people, just below 15000 households. Around 2.5 per cent of this population has already made use of revolving finance to purchase interventions at the 'top end' of the range of options provided. Many more have started on the process of alleviating smoke through lower-cost options.

Overall, average levels of carbon monoxide have dropped from 8.99ppm to 2.51ppm, a reduction of around 72 per cent. Repayment is running at around 67% against target, but this is caused by repayments being delayed due to poverty rather than default on payments.

All those using smoke hoods use them all the time. Nearly all those using LPG use it some of the time, but other fuels for extended periods of cooking. Fireless cookers reduce the numbers reverting to polluting fuels for this latter purpose.

Data from the Kenya Bureau of statistics indicates that Kisumu is one of the poorest districts in Kenya, with high levels of absolute poverty and high levels of ill-health. This influences the research in two ways:

- Lack of access to clean and affordable energy for the vast majority of people in the region is one of the major reasons for the high levels of ill-health, particularly among young children. This ill-health and poor quality of life inhibits people from finding ways out of their situation
- Despite the evident need for change, and because of the high levels of ill-health across the whole spectrum of disease, any approaches that can be self-sustaining are vital if the situation is to change.

Against this background, the research in Kisumu adopted a very specific approach to alleviating indoor smoke, starting from where people found themselves, not from where the project would wish them to be, and recognising that where money was spent on alleviating smoke, it was likely to be money that would otherwise be spent on other vitals good such as food or clothing.

A whole range of interventions was identified and introduced, alongside good kitchen management practices that not only alleviated smoke but also saved money to pay for the change.

Revolving finance has worked well and has enabled the same amount of money to reach more people, but in terms of reaching large numbers of people quickly, then it will not achieve this goal without more substantial investment in seed capital to set up more funds. However, the money that has gone into the funds has now recycled itself twice over, and is still working. Even using a system of repayments over one year, there is understandable reluctance for people to put themselves in debt. If money is insecure, and people are honest, it can be too great a risk.

For those who have bought goods through revolving finance, the benefits far outweigh the problems. People have a sense of ownership and pride with the goods they have purchased. Rather than making them more dependent, buying through revolving finance is giving them the route out of the dangers of indoor air pollution which they themselves have achieved.

Those who have purchased LPG sets are very clear that it is saving them money. Those who have installed an upesi stove are also saving money, as the stove is very fuel-efficient. For those who gather fuel, it has been time that is saved. Many report using this tie in farming and enterprise.

Revolving finance has other benefits. The KIAPNET group are now confident to run the bank account, and they will in future decide on the use for this finance. One role may be to provide finance for income-generating activities that will provide money for smoke alleviation.

One example of this is that a group that has been supported by a donor to buy some goods and appliances for an energy outlet, run by the Community Resource Person for that group. Once set up, people will not have to travel a long distance to purchase energy goods, fuel, and spare parts.

Part of the finance has also purchased a high power solar cooker that will be owned by the group and used by them to bake biscuits and snacks for sale. Thus part of the finance has gone into income generation whilst the remainder is providing improved access to energy goods for sale.

Theatre group singing about the dangers of smoke at a large community meeting

The low-cost interventions have allowed people who cannot afford the more expensive fuels to get rid of much of the smoke. They are also a stepping-stone, and allow people to take action at the time when they are most enthusiastic for change – when they first realise the dangers of indoor air pollution.

Revolving finance allows people to aspire to move forward. By adopting a stepwise approach, people are able to move forward at their own pace. This may take several years, and although one cannot predict for certain how far the initiative will continue into the future, projections show a continuity for the fund run in its current form. Knowledge on the dangers associated with smoke, coupled with a recognition of benefits that they have experienced in health and well-being through small changes should reinforce their resolve – they have taken ownership of the problem, and when the time is right, they know that there are funds that will enable them to make increasingly substantial changes.

Awareness of the need to alleviate smoke

Several thousand people in the Kisumu district have been made aware of the dangers of smoke. By working through intermediaries, Practical Action has left the Community Resource Persons with both the knowledge and skills to continue to disseminate messages within each of the communities. They also have the potential to run small businesses selling fuel, and selling stoves through revolving finance.

The theatre and music groups have gained skills in campaigning and have been invited on many occasions to take part in major rallies, through the invitation of local government. These activities take time, and although they provide focus for community meetings and activities, it remains to be seen whether they will continue to take place past the end of the project. Even the small amount of money to travel to performance venues is likely to be a constraint. As long as they are there, they are playing an important role encouraging people to take ownership of the problem of IAP in their own homes, and reinforcing it with a positive message that they can start making change. In doing so, they themselves benefit from improved status and confidence within their communities.

Technology sustainability

Fireless cookers have proved to be an important entry point for those on low incomes. Several women in the district now make the woven variety, and the number of people constructing built-in fireless cookers onto the side of their stoves is growing. They can be made at little cost and because they save fuel, they can start the household on the transition up the so-called ‘energy-ladder’ from polluting fuels to those that burn cleaner and hotter, and with less smoke.

Upesi stoves and Kenya ceramic jikos are widely disseminated in the region. Although charcoal burns more cleanly than wood in terms of particulates, it has not been promoted to alleviate smoke during this research, as charcoal has major disadvantages, particularly where there is a shortage of woodfuel. The Upesi stove saves time as it lights quickly and cooks food fast. Therefore, although the level of emissions is not substantially reduced, the woman is close to the stove for a shorter time, so her exposure is reduced. The Upesi stove and KCJ are made commercially and do not need support.

It is hoped that in the near future, a rocket stove, designed to reduce the overall levels of smoke substantially, will be added to the collection of low-cost interventions available in Kisumu district.

Nepal

The most significant impact of the project has been felt in the local communities where the project is being implemented. Here almost all the people are now aware of the impact of smoke in their kitchens and many have invested in measures such as smoke hoods, improved stoves and insulation, to reduce the smoke. Investment has resulted in CO levels decreasing from around 12.82ppm to 1.56ppm - a reduction of around 88 per cent in the concentration of pollution in their houses.

Overall the project has been able to achieve all the outputs mentioned in the log frame of the project proposal, in spite of the difficult terrain and the political environment in which the project was being implemented. Around 450 smoke hoods had been, or were being, installed by the end of the project, and repayment levels were running at around 90 per cent (if one excluded one village where the initiative failed to 'take root'. Apart from this village, default was not an issue, and the 10 per cent shortfall on payments was due to slow repayments against plan.

Improved air quality has lead to improved health of women and children. Almost all the people who have benefited from the improved technologies feel that their own, as well as their family's, health is better than before. The most common health improvement is felt in the reduction of cough among children as well as adults. According to the supervisor at the District Public Health Office at Dhunche, the hospital has also noticed a decrease in ARI patients coming from the areas where the project has been implemented. Other major health benefits are reduced eye problems and reduction in headaches.

Furthermore, the project has been able to build social capital by forming community groups and raising funds locally.

All of the households use smoke hoods all of the time, though some households hinge back the front opening when brewing alcohol – which seriously reduces its efficiency. Alcohol brewing, however, only takes place once per week. Levels of satisfaction are very high.

Besides improvements in indoor air quality and health, the project has been able to build the capacity of local smoke hood manufacturers and strengthen the supply chain for the manufacturing of smoke hoods. This is a major achievement because now the technology is accessible to the local people and it can be promoted locally through regular market mechanisms although some support may still be required as the cost of the technology is still fairly high.

- Five local entrepreneurs have been trained to build the smoke hoods and provide services related to installing the chimneys and maintenance if required.
- Awareness raising activities have been conducted to raise demand for the smoke hoods.
- Fifteen Revolving Fund Management Groups have been formed to mobilize local funds.
- A committee has been formed under the chairmanship of the Local Development Officer at the DDC to continue the project activities.

The project has improved the supply chain and created demand for the technology but the main barrier is the high cost of the technology and the need to engage continuously with the local communities to promote the technologies. Because subsidies have been provided to promote the technologies in a certain area, it will be very difficult to promote the same

technologies in the same area without any further subsidies. Therefore, although there is high level of awareness in the project area on the dangers of smoke and the benefits of smoke hoods, the project will probably not be able to maintain the current of scaling up of the technology if there is no further support. To promote the continuity of project activities and to expand in the future, Practical Action has been providing its support through building the capacity of the District Development Committee (DDC) and has slowly handed over the responsibility to the DDC. This process has already started and some level of support will be continued even as the project ends. With 450 hoods installed, and a high level of awareness of smoke, the DDC may well find that demand for smoke hoods will encourage them to continue to provide the subsidy and revolving finance on which this initiative now depends.

The entrepreneur leading the manufacture of the smoke hoods in Rasuwa is well aware of the need to market the smoke hood. He has taken a lead in improving the attributes of the hood to meet community needs and will be working towards gradually removing the subsidy. In the meantime, new designs are being developed to expand into the lowland regions with a less costly, part-brick hood.

Government support to provide some sort of ongoing subsidy in the middle term would be highly cost-effective, as reflected in the cost-benefit analysis. Such large reductions in smoke levels have a very positive impact on those living in the community.

As further encouragement, Practical Action continues to lobby at policy level through the South Asia Smoke Forum that was set up as part of the policy side of the project.

Sudan

Many factors have contributed to LPG adoption in Sudan. Growth of urban areas (residential quarters such as Shamal Elhalanga, Elshabi , Sheed, WauNur and Kadugli settlements were built at the expense of green cover) and consequently caused severe biomass shortages. Deforestation and poor green cover have resulted from population growth, as more forests were cut down to meet the increasing demand on wood for fuel, wooden furniture, traditional bakeries and shelter.

The original smoke research results helped in increasing awareness about the danger of indoor air pollution on mother and child health and the desire to own a clean and environmentally-friendly stove. This has created increased demand for LPG appliances manifested by an increased number of smoke microfinance credit beneficiaries from 200 to 1415 households during the research period.

Local production of LPG in the Sudan has resulted in a cheaper and cleaner source of energy being available compared to firewood and charcoal, and a supportive private sector that is willing to invest in this sector by supplying LPG appliances for clients in both cash and credit. Women concerned about their kitchen and personal hygiene have promoted its use.

The project has been supported by enthusiastic project partners such as ACORD (injecting money into seed capital and conducting training on revolving fund management), by the WDA, taking a lead in revolving fund management, by the Ministry of Health, which assisted with raising awareness of people on indoor smoke danger , and by the Civil Defence which assisted in raising the awareness and training women on the safe use of LPG sets.

LPG users in Sudan include households, cooks in restaurants and even blacksmiths. They recognize that LPG saves time, money and effort, compared to biomass fuels. Kisra plates are produced within Sudan and are abundantly available – encouraging the move to gas usage.

The Government encourages LPG use as an alternative to biomass fuels; incentives set by the Government are in terms of LPG price reduction and the exemption of LPG appliances from taxes.

The population of Kassala is currently changing as people move home following the peace agreement. Most reports suggest a current total population of around 1.2 million – around 250 000 households. Those who work for the government are able to access loans, and those

who work for multinationals are similarly well-provided. The research focused on those living in poverty, so although less than 1 per cent of the overall target population was reached, over 1400 households benefited.

The least satisfactory outcome is the unexpected downturn in LPG use towards the end of the research period, although the growing demand for appliances, desire to retain the equipment, and the decision by the supplier to open new depots, suggests that in the 'longer short term' people will return to using LPG as their fuel of choice. This is particularly true if efforts are successful in re-starting their use of LPG. Action has already started to tackle the problems that have led to this reduction in use.

Knowledge outputs

Annex 4 lists all the outputs that have come from this work. As well as presentations and publications, there have been several TV and radio documentaries. The work has fed into several policy documents, particularly through the 'Catalogue of methods' soon to be published by WHO, a paper on smoke alleviation to the Commonwealth Health Ministers Conference, and meeting with WHO representatives in each of the countries of the work.

The project culminated with an e-conference on 'Action to get rid of kitchen smoke' at the start of a new Clean Air Special Interest Group (CleanAirSIG) on the HEDON Household energy Network. The meeting was 'attended' by 84 subscribers, and 347 messages were sent by 45 contributors. Over the two-week conference there were twenty papers posted and the profile of this study was raised.

Smoke Forums
Within each country, actions have been taken to bring together policy actors with the project communities. The plan is to make policy-makers aware of the situation and work together to develop more equable policies to benefit those living in poverty.

Smoke campaign
Linked to the project was a substantial initiative in the North to run a campaign to highlight the problems associated with Indoor Air Pollution.

- In 2003, the publication 'Smoke – the Killer in the Kitchen'. This book led to significant media coverage of the issue including BBC online, New Internationalist, BBC News at Ten.
- In 2004 and 2005: Seminars were held with DFID (London), WHO (Geneva), and with USEPA in Washington and New York. DFID joined the Partnership for Clean Indoor Air following the London meeting.
- In 2005, at a reception organised by Practical Action in 2005 and hosted by the MP Fabian Hamilton, Hilary Benn delivered a speech highlighting the dangers of IAP. Following this meeting, Mr Hamilton tabled an early day motion which gained 70 signatures. A follow-up poster campaign was used to follow-up this message.
- The media were also involved. In 206, the TV celebrity and environmental campaigner Adam Hart-Davis visited Kenya to see the problem and how Practical Action are combating it, with substantial media coverage on return.
- Alongside partners such as GTZ and WHO, Practical Action organised several activities at CSD 14 and achieved high recognition of the problem of IAP.
- This initiative culminated in a position statement for the 15th session of the United Nation's Commission on Sustainable Development. The joint statement brought together Practical Action, the World Health Organization, the HEDON Household Energy Network, GTZ, Winrock, and the Partnership for Clean Indoor Air (PCIA). It highlighted the opportunity for governments to commit to action-oriented policies to tackle indoor air pollution and to improve household energy services.

To recognise the work done at both project and campaigns level, Practical Action was awarded the first Global Leadership Award for its vision, initiative and action to achieve the mission of partnership in improving people's health, livelihood and quality of life by reducing Indoor Air Pollution. The award was presented at the international PCIA Forum workshop in Bangalore, India in 2006.

Future actions

Internationally

The positive outputs from this study and the Cost Benefit Analysis have shown that it is highly cost-effective to alleviate smoke. Where people can afford to access clean energy, their lives are transformed. The most important saving is time – time spared from drudgery in collecting fuel, clearing soot, washing soot-stained pots, cooking over a smoky fire and attending to children with coughs and eye diseases. Through the research questionnaire, the project has highlighted benefits to large number of women and children, some of whom have been spared serious illness, and many of whom have been saved from relentless coughs and eye problems each year.

Smoke is becoming an increasingly well-understood issue. As shown in this publication, most of the problems are about cost, ownership and providing pathways to change. Revolving finance is more than a route to 'get more stoves out there' – it provides people with their own route out of poverty. This has been shown to be the case even for those on very low incomes. However, it is not a quick fix that will reach thousands at great speed, and this too has been demonstrated. Based on this work, it is clear that the approach works in terms of development and reaching many more people than an aid package. Revolving finance can create uptake without skewing the local market, and provide effective interventions that many more people can afford. However, it has also been shown that carefully targeted subsidy may be needed in some cases if change is to happen.

What is really important, however, is that the benefits have been demonstrated to be very large. For a comparatively small investment, the quality of life can be changed in terms of time, income, health and environment. The capital cost of an intervention that will last 5-10 years is holding back thousands of people from living in homes fit for raising children. A widespread programme of investment through revolving finance, supported where needed by careful government or carbon finance, could have a major impact on reaching several of the Millennium Development Goals.

New ways to access funding, such as carbon finance, a more flexible commercial approach and a pro-poor and well-informed policy environment could make alleviating smoke one of the key drivers to achieving the Millennium Development Goals.

Kenya

The project in Kenya has raised awareness and aspirations amongst those living in poverty that it is essential to alleviate smoke, and that there are ways to make it happen. There are four areas which have not yet been addressed fully and that are considered important.

- Development of a successful rocket stove could allow 'carbon money' to be used to scale up clean stoves to the whole region. Currently GTZ is working in a neighbouring area and the time is right for a new cleaner stove for those on low incomes.
- The project did not target schools and centres of education as a major target. Funding was sought to put together a child-to-child initiative so that trainers would have good resource material on which to draw. This proposal was not successful so the need is still there.
- The project team recognise that most people do not have access to transport to buy either energy goods or fuel. Given the opportunity, they feel that a set of energy outlets (or counters) within each centre, and probably as part of a local store, coupled with some community initiatives for income generation (such as baking foodstuffs) would create dynamism by stimulating the local economy and focusing the local communities on the need for smoke alleviation.
- One disappointment in Kenya was the lack of uptake of smoke hoods. Their success in Nepal in alleviating smoke shows their usefulness as a technology. They have been shown to last many years, so their cost per annum is around £3 per year, and where biomass can be gathered, they do not commit the person using them to the ongoing cost of LPG.Yet they suffer an image problem, where people are willing to spend an equal sum on a gas bottle and burner. Ways to make this technology more desirable and affordable could be of great value to those for whom the cost of gas is a problem, or who wish to continue to use biomass fuel.

Nepal

Nepal is already developing a lower-cost smoke hood. The levels of IAP reduction measured on two occasions (one for a different smaller study) have shown that smoke hoods are really effective. Reducing the cost would increase the size of the market.

This research has stayed technology and fuel neutral in its approach, and it may be that other types of smoke-alleviation technologies (such as rocket-type stoves or biogas) could be disseminated successfully at lower altitudes and different societies through similar methods.

The South Asia smoke forum has potential to address many of the issues needed for large scale dissemination. The last meeting was attended by government ministers, some of whom came to the launch of the meeting and stayed to learn more. Dr Pandey, one of the world leaders in smoke work, remains at the helm of this Forum.

The team has worked at household, local policy and national level. They now have considerable opportunity to roll out this programme to a wider geographic area.

Sudan

In Sudan, the role of the private sector in the coming months will be vital. The high level of demand that still exists for the LPG stoves, and the fact that repayments are being made suggests that peoples' aspirations are still to use LPG. As it is a cheaper fuel than wood and charcoal, efforts will be made to make provision for those who wish to return to LPG to do so. This may be through exchange of the larger empty cylinder for a smaller filled one which will be less of a hurdle to overcome when refilling is needed, and will reduce the overall cost of the loan.

Making gas cylinders available locally where customers can easily access them will enable choice and address the need of different income groups. Making community refilling centres available that charge uniform prices regardless of the physical distance of refilling centres from the centre of town will support uptake by those on low incomes. Private wholesalers have the capacity to deliver requests in time.

Setting the terms of credit over a longer duration (say one year) would encourage those with very little money to shift to LPG use. As the management fee is 1.5 per cent per month, increasing the repayment time would provide a bit more income for those collecting payments.

Some problems caused by the need for spare parts could be addressed by mobile maintenance service. It has been recommended to the WDA that they take back and replace impaired/damaged LPG sets for a guarantee period, to boost the mutual trust among beneficiaries and private dealers.

Regular check up services of LPG sets after use/upon refilling could reducing thereby fire risks, although no event/case of fire caused by LPG has been reported so far.The current WDA shop which sells LPG appliances should make credit available to a wider range of beneficiaries; currently those who are not WDA members have to buy goods outright.

In addition, efforts should be made by local enterprises to develop appropriate and affordable models for the Kisra plate. In this context, a workshop was recently held by Kassala Women Development Associations (KWDAs) to discuss the appropriateness of sample Kisra plates manufactured by two local enterprises. The forum provided an opportunity to the entrepreneurs to learn about opinions and concerns of users for consideration in further improvement of a locally-manufactured Kisra plate.

If Sudan is planning to address deforestation in a cost-effective way, the means for everyone to access LPG should be on the agenda. Suppliers of gas, already very supportive of the initiative, could help further by providing gas bottles on loan – it is the sale of gas which provides them with profit, and access to small gas bottles and local depots could create a much larger, and therefore more profitable, market for LPG.

References

Albalak, R., Bruce, N. G., McCracken, J. P., & Smith, K. R. 2001, "Indoor respirable particulate matter concentrations from an open fire, improved cookstove, and LPG/open fire combination in a rural Guatemalan community.", *Environmental Science and Technology*, vol. 35, pp. 2650-2655.

Aprovecho Research Centre – Advanced studies in Appropriate Technology: PO Box 156 Creswell, OR 97426 US – Private communication

Bates E. [Ed.] Smoke*, health and household energy Volume 1. Participatory methods for design, installation, monitoring and assessment of smoke alleviation technologies*, Practical Action, May 2005

Bruce,N. Delgado, H. Boy,E. Birth Weight and Exposure to Kitchen Wood Smoke during Pregnancy in Rural Guatemala Env. Health Perspectives, Vol. 110, No. 1 (Jan., 2002), pp. 109-114

Bruce, N. G., Rehfuess, E., Mehta, S., Hutton, G., & Smith, K. R. 2006, "Indoor Air Pollution," in *Disease Control Priorities in Developing Countries - Second Edition*, D. T. Jamison et al., eds., Oxford University Press/The World Bank, New York, pp. 793-815.

Cairncross, S. & Valdmanis, V. 2006, "Water Supply, Sanitation, and Hygiene Promotion," in *Disease Control Priorities in Developing Countries - Second Edition*, D. T. Jamison et al., eds., Oxford University Press/The World Bank, New York, pp. 771-792.

CBS2003 District level indicators of Nepal for monitoring overall development (based on selected socio-economic indicators). His Majesty's Government National Planning Commission Secretariat Central Bureau of Statistics Ramshah Path, Thapathali Kathmandu, Nepal 2003

Desai, M. A., Mehta, S., & Smith, K. R. 2004, *Indoor smoke from solid fuels: Assessing the environmental burden of disease at national and local levels*, World Health Organisation, Geneva.

World Bank 2001 Geographic Dimensions of Well-Being in Kenya - Where Are The Poor? - From Districts to Locations (Volume 1). [Accessed July 2007] http://www.worldbank.org/research/povertymaps/kenya/volume_index.htm

Habermehl, H. 2007, *Economic evaluation of the improved household cooking stove dissemination programme in Uganda*, GTZ, Eschborn.

Hutton, G. 2006, *Guidelines for conducting cost-benefit analysis of household energy and health interventions*, World Health Organisation, Geneva.

Hutton, G., Rehfuess, E., Tediosi, F., & Weiss, S. 2006, *Evaluation of the costs &benefits of household energy and health interventions at global and regional levels*, WHO, Geneva.

ITDG Reducing indoor air pollution in rural households in Kenya; Working with communities to find solutions. The ITDG Smoke and Health Project ITDG (2002)

Pandey MR. Women, wood energy and health. Wood Energy News. 1997;12(1):3–5

Rehfuess, E. *Fuel for Life, Household Energy and Health* WHO 2006 http://www.who.int/indoorair/publications/fuelforlife/en/index.html [accessed July 2007]

RESPIRE Abstracts from Presentations from Guatemala air pollution intervention trial (RESPIRE) at Professor Kirk Smith's website: http://ehs.sph.berkeley.edu/krsmith/page.asp?id=19

Rudan, I., Tomaskovic, L., Boschi-Pinto, C., & Campbell, H. 2004, Global estimate of the incidence of clinical pneumonia among children under five years of age *Bull WHO*, vol. 82, no. 12, pp. 895-903.

Smith, K. R., Bruce, N. G., Weber, M., Hubbard, A., Jenny, A., Dherani, M., Acevedo, R., & Arana, B. Impact of a chimney wood stove on risk of pneumonia in children aged less than 18 months in rural Guatemala: results from a randomized, controlled trial. Epidemiology 17[6 (Supplement)], S45. 2007

Smith, K. R., Mehta, S., & Feuz, M. 2004, "Indoor air pollution from household use of solid fuels," in *Comparative quantification of health risks: global and regional burden of disease attributable to selected major risk factors*, M. Ezzati, ed., World Health Organisation, Geneva.

UN Media Monitoring Report, 8 May 2007

UNDP (2006) Kenya National Human Development Report 2006 - Human Security And Human Development: - A Deliberate Choice UNDP, 2006 [Accessed July 2007] http://hdr.undp.org/reports/detail_reports.cfm?view=1180

UNDP_1 Nepal1 Programs run by UNDP at Rasuwa (UNDP undated) [Accessed July 2007] http://www.undp.org.np/regions/regions.php?type=district&DistrictID=31&RegionID=2

IDMC More than 5 million estimated IDPs in Sudan (April 2006) Internal Displacement Monitoring Centre http://www.internaldisplacement.org/idmc/website/countries.nsf/(httpEnvelopes)/CA38A0F0F269546F802570B8005AAFAD?OpenDocument

World Health Organisation 2002, *Reducing risks, promoting healthy life. The World Health Report 2002*, World Health Organisation, Geneva.

Practical Action

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

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

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

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

Website: **www.practicalaction.org.uk**

PRACTICAL ACTION
Technology challenging poverty