

**Changing Well-being and Livelihoods:  
An Examination of the Impacts of  
Smokeless Metal Stoves on Individuals  
and Communities in Humla, Nepal**

**By Gavin Naylor**

**Dissertation towards the fulfilment of the degree of**

**BSc Human and Physical Geography, University of Reading**

**Supervisor Reading University: Dr. Sally Lloyd-Evans**

**Local Nepal Supervisor: Visiting Professor Kathmandu University &  
RIDS-Nepal Director Alex Zahnd**

**Submitted February 2009**

**Word Count: 10,250**

## **Contents Page**

<b>List of Figures.....</b>	<b>3</b>
<b>Abstract.....</b>	<b>4</b>
<b>Acknowledgements.....</b>	<b>5</b>
<b>1. Introduction.....</b>	<b>6</b>
1.1 Background and Wider Context of Research	6
1.2 Rural Integrated Development Services-Nepal	9
1.3 Aims of this research	10
1.4 Smokeless Metal Stove	11
<b>2. Literature Review .....</b>	<b>13</b>
<b>3. Methodology.....</b>	<b>15</b>
3.1 Qualitative research	15
3.2 Questionnaires	16
3.3 Other research Methods Used	17
3.4 Limitations of Research	19
<b>4. Results and Discussion.....</b>	<b>20</b>
4.1 Reduction of Indoor Air Pollution and Improving Health	20
4.2 Cleanliness of the Home and Provision of Hot Water	24
4.3 The Effect of the SMS on Fuel Consumption	27
4.4 Negative Impacts of the SMS	29
<b>5. Conclusions and Recommendations for Further Research.....</b>	<b>30</b>
5.1 Conclusions	30
5.2 Limitations of Research	31
5.3 Recommendations for Further Research	32

<b>References.....</b>	<b>33</b>
<b>Appendices.....</b>	<b>36-42</b>

### **List of Figures**

Figure 1: Humla district showing the village where we stayed	8
Figure 2: Family cooking a meal using a Smokeless Metal Stove	11
Figure 3: A Smokeless Metal Stove in the project office in Dharapori	11
Figure 4: 24 Hour Comparison of Indoor PM 2.5 and CO level between SMS and Open fire cooking	21
Figure 5: Number of Responses regarding reduction in Health Issues.	22
Figure 6: Family Cooking using traditional methods	24
Figure 7: Family using and SMS and clean house	24
Figure 8: Pie Chart depicting responses to changes in wood consumption with SMS	27

## **Abstract**

The problem of Indoor Air Pollution is an extensive one throughout the developing world with an estimated 1.6 million dieing annually. This research will be focused on the NGO RIDS-Nepal, which runs long term holistic community development projects in the north west of Nepal. The research will be focused on the impacts that smokeless metal stoves have on individuals and communities. In the project area people cook using open fires in their homes. This is not only dangerous but also expels large volumes of pollution into the home. In order to combat this RIDS-Nepal has developed a smokeless metal stove, which has a chimney as well as three burners to cook food. This increases efficiency as it allows a whole meal to be cooked at the same time rather than each dish one after the other. This impacts women's daily schedules in a positive way and frees them up for other activities. The chimney is excellent at expelling pollutants from the home and this provides a clean and smell free living environment. This has produced one of the major benefits of the stove, which is the reduction of health problems including a lessening of respiratory problems, eye problems and burns. Another key positive impact is the reduction of fuel that is needed to run the stoves as they burn cleaner and more efficiently because the fire is contained within the stove and the oxygen flow can be regulated. This has lead to a decrease in deforestation. Overall the projects have been highly successful in providing improvements to the communities.

## **Acknowledgements**

I would like to acknowledge Mr. Alex Zahnd for all his help in the completion of this research and for his dedication and support to me as well as his valuable experience and insights into the community development projects in which I was working. I would also like to thank all the staff of RIDS-Nepal for their hospitality, support and help in the field as they enabled me to do this research. I would like to acknowledge the financial contribution of my parents, Reg and Barb Naylor, which enabled me to travel out to the project area and complete my research. I would also like to thank them for their love and encouragement.

# **1.Introduction**

## **1.1 Background and Wider Context of Research**

Indoor Air Pollution (IAP) is a large problem throughout the developing world, especially in the rural least developed parts of sub-Saharan Africa and South Asia. It is estimated that 1.6 million die annually due to the direct causes of IAP (Smith K. 2002). This is linked to the fact that rural households still use traditional fuels such as animal dung and wood from local surroundings to provide their daily energy services such as cooking, heating and lighting. They burn this in open fires places inside their homes. These activities have a direct chronic impact on the health and the low life expectancy of women and children as well as having devastating effects on deforestation. Due to the burning of these materials inside the home a large quantity of indoor smoke pollution is generated which can lead to respiratory diseases, asthma, blindness, and heart disease. Women and children are the worst affected as they are the ones who spend most of their time in and around the home.

In completing my research I will be working with Rural Integrated Development Services-Nepal (RIDS-Nepal), (see Appendix 1). They are a social non-government non-profit organisation that works in partnership with individuals and communities, to improve their living and livelihoods through long-term community development projects. RIDS-Nepal is working to improve the quality and standard of life through long-term, integrated rural holistic community development projects. They focus on applying renewable energy technologies to help them achieve their goals. RIDS-Nepal focuses on poor, marginalised and disadvantaged people in remote, difficult to reach mountain communities. They work with communities in the upper Humla district, which is located in the north west of Nepal and is one of the least developed regions of the country.

I lived in Nepal for 12 years from the age of 4 to the age of 16. This has given me a rich knowledge of Nepali society, culture and traditions. While I was growing up in Nepal I lived in a remote village for 3 years and this gave me some insight into the daily

struggles, trials and joys of village life in the mountains of Nepal. Ever since leaving I have had a strong affinity for those people and fondly remembered my time there. Alex Zahnd is a close family friend and I have been fascinated by RIDS-Nepal and the work they do for a long period of time. This is my motivation for undertaking this research. I have a great personal interest in rural community development that can help people in similar situations to the ones I grew up with.



Figure 1: Humla district showing the village where we stayed. Source: Reading University Map Library

Figure 1 is a larger scale map of the Humla district including Simikot, which is the district headquarters and is the place we flew into. The arrow is pointing at Dharapori which is north-west of Simikot and is where the project office is located. We slept there and used it as our base. I undertook the research by making a 2-week trip to Humla in August 2008 to assist with their development project, gain some first hand experience and conduct my research.

## **1.2 RIDS-Nepal**

As part of their holistic community development approach RIDS-Nepal addresses all of the basic needs for communities and the most pressing ones, as indicated and requested by local communities. RIDS-Nepal have developed the “Family of 4” and the “Family of 4 PLUS ” community development concepts. The “Family of 4” concept reflects the 4 basic requirements of long-term sustainable development. This consists of:

- Pit latrines (one for each family)
- Smokeless metal stoves (SMS) (one for each family to cut down the indoor air pollution, to cook the local food and to heat their homes.)
- Light (Elementary indoor lighting using white LEDs through the installation of solar photovoltaic panels or very small hydro power plants called pico-hydro power plant). This is suitable for the local context as the villages are located at high altitude and if the panels are set at the correct angle they are able to receive a large amount of solar radiation, combining this fact with the low energy requirement and high output of the white LED lamps make this a viable option for the communities.
- Drinking Water (through tapping into local springs and the building of water tap stands in the villages as well as through the installation of indoor slow sand water filters.)

In my research I focus on the Smokeless Metal Stoves (SMS) and the social, environmental and health effects it has on the women who use them and the local communities. The “Family of 4 PLUS” concept is an addition to the basic “Family of 4”



concept and is implemented after it or simultaneously. It also focuses on increasing the standard of living. The concept includes the building of a village based greenhouse and the introduction of the solar drier so that fruits and vegetables can be dried and stored during the winter months for increased food security. This helps to improve nutrition, which is a big problem as these people live at high altitude and struggle to get enough vitamins and minerals in their diet. Non-Formal Education programs are another aspect and are focus on women and girls as they are disadvantaged in Nepali culture. Additional, the nutrition program for mal nourished children under 5 years of age, the indoor installed Slow Sand Water Filters and the building and installation of a solar water heater bathing centre, to be used by the whole village, are also part of the “Family of 4 PLUS” concept. In order to have ongoing evaluations of these programs, base-line and re-surveys are carried out periodically. All of these projects are specially designed keeping in mind the context in which they are applied so that people of Humla get the maximum benefit from the projects.

### **1.3 Aims of the Research**

The aims of this research are to look at the health, social and environmental impacts of the smokeless metal stove project on individuals and communities in the Humla district of northwest Nepal. In order to examine and assess the impacts that the SMS have had on individuals and communities, I have constructed a series of questions, which will aid in the fulfilment of the aims of this research.

- Has the installation of the SMS led to a reduction in IAP?
- If this is the case has there also been a decrease in health problems linked to IAP?
- Does the SMS use less fire wood than the traditional, open fire place cooking methods and if so does this have any wider impacts?
- Are there any other benefits or impacts of having a SMS installed in the home?
- Are there any negative affects?

#### 1.4. The Smokeless Metal Stove



Figure 2: Family cooking a meal using a Smokeless Metal Stove, Source: Gavin Alex Zahnd



Figure 3: A Smokeless Metal Stove in the project office in Dharapori. Source: Gavin Naylor August 2008

Since 1999 RIDS-Nepal has installed about 4,500 SMS in 13 villages in the Humla district and Jumla district of north-west Nepal. As RIDS-Nepal is committed to holistic community development with participation from villagers and helping people to help themselves and not in handouts, they provide a subsidy for the stove once a household is committed to other aspects of their “Family of 4” project. RIDS-Nepal provides a 2,500 NRs subsidy (~75% of the total price) on the cost of the SMS if the family built a pit latrine which is the first of the pillars of the “Family of 4” approach. In order to reduce costs the stoves are made locally. The project staff fully train each household how to install and use the SMS. This is to ensure that they are used properly and this helps to extend the lifetime of the stove. Training also ensures that the stoves are used efficiently and this in turn cuts down on the level of consumption of wood, which has to be cut and carried by hand, and is a precious resource.

The stoves in Figures 1& 2 are the same design as the ones installed in the project area by RIDS-Nepal. As is visible from the above figures is that the stoves have a 9-litre stainless steel water tank, which heats water and provides clean hot water that can be used for drinking, cooking or washing. A fire is lit inside the stove and as the fire burns in a confined space it burns cleaner, hotter and is therefore more efficient. There are 3 burners on the top of the stove where pots and pans go. The provision of 3 burners allows for a traditional meal of rice, lentil soup and vegetables curry to be cooked at the same time, which has huge impacts on firewood consumption reduction. At the same time the fire is used to heat water in the attached tank. Traditional cooking methods involve building an open fire in the middle of the kitchen and using a metal stand or 3 stones, which could only hold one vessel at a time and was vulnerable to be knocked over. One of the vital components of the SMS is the chimney, which expels the smoke out of the home; this in contrast to the traditional cooking methods where there was no chimney so the smoke and other harmful smoke particulates are released direct into the living area, (see Appendix 4). In the front left corner of the stove next to the cooking hole is a slot to cook roti. Roti is a traditional circular, unleavened flatbread made from wheat or corn flour. The Humlis are unable to grow rice as they live at high altitude, so all the rice they consume must be brought in. Hence roti makes up a larger part of the diet of compared to the people living at lower altitude who would traditionally eat rice twice a day.

## **2. Literature Review**

‘Development’ can be ascribed to a great number of activities and can be coined by a wide body of academics and practitioners and can be used to describe any number of things. What exactly is development is a contested issue? UNDP offers their own suggestion of what Human Development is: “...about creating an environment in which people can develop their full potential and lead productive, creative lives in accord with their needs and interests. People are the real wealth of nations. Development is thus about expanding the choices people have to lead lives that they value. And it is thus about much more than economic growth, which is only a means – if a very important one – of enlarging people’s choices” (UNDP - The Human development Concept). Potter in his book offers a definition of development strategies, of the outworking of development theories which are highly contested and the way that people go about ‘development’ saying: “development strategies can be defined as the practical paths to development which may be pursued by international agencies... non government organizations and community based organizations, or indeed individuals, in an effort to stimulate change within particular nations, regions and continents” (Potter (2002) p. 61).

The term sustainable development was first coined in the “Our Common Future” report published by the World Conference on Environment and Development published in 1987. It defined it as ‘Development that meets the needs of the present without compromising the ability of future generations to meet their own needs’. This is the aim of RIDS- Nepal in conducting their initiatives. They are designed to be long-term and to benefit future generation as well.

RIDS-Nepal is the only organisation running holistic community development project in Humla’s remote and rural context. They provide initiatives on all areas of need as expressed by the local communities. They have not had any dedicated research solely on the impacts and benefits of the SMS to individuals and communities. This is a gap in the body of knowledge and provides an opportunity to focus more in depth on certain aspect of the impacts such as on the social and environmental. The problem of indoor air pollution and the health risks and deaths that are linked to it and to the idea that installing

stoves with chimneys so that the pollution is expelled for the house thereby providing cleaner air, is not a new area for researchers. Professor Kirk R. Smith, University of California Berkley is a world-renowned expert on the subject. There is a wide body of knowledge about IAP particularly the scientific side of it and experiments carried out measuring variations in CO and PM2.5 and PM10 levels in polluted air and the positive impacts that the stoves can have on human health such as Professor Smith's paper 'Case-Control study of indoor cooking smoke exposure and cataracts in Nepal and India' published in the International Journal of epidemiology. I was drawn to this article as it is related to Nepal and the negative health impacts of long exposure to smoke from cooking on open fires. However I feel that there is lack of research on the social side and especially in the Nepali context as this is a new area of practice. RIDS-Nepal has been working in the Humla region since 2002.

The article by Laczó M. about depriving women citizenships opportunities, specified in a Nepali cultural context caught my interest. This because it is relevant for my research but also talks about the women and how they are discriminated against, as they have to have a father or a husband sponsor their citizenship application. Laczó starts the article by stating the importance of citizenship and that is it a basic human right. This is backed up by the Universal declaration of Human rights. She then goes on to talk about how the allocation of citizenship is highly gendered in favour of males and the high amount of bureaucracy that women face in attempting to obtain citizenship. She also highlights the tragic case where women are trafficked and their personal documents taken away, which is a serious case of human rights abuse. She talks about the problems of obtaining citizenship without a birth certificate; hence in rural areas there is little understanding. "In rural areas of Nepal, it is the norm for people to have limited information about their legal rights to citizenship, and little understanding of how citizenship could contribute to their independence and empowerment" Laczó M. (2004) p.78. This quote is of interest as my research is focused on females and sadly this quote touches on the experience of the women whom I was interviewing in Humla, which is an extreme rural area. I assume that the women are not aware of the benefits of citizenship as their identity is tied to their husbands.

### **3. Methodology**

#### **3.1 Qualitative Research**

“Research, quantitative and qualitative, is scientific. Research provides the foundation for reports about and representations of “the other”. In the colonial context, research becomes an objective way of representing the dark-skinned other to the white world” (Denzin and Lincoln 2005 p.1). This is an interesting view put forward by the authors and certainly a different way of thinking about research than is usually applied. Remembering this view when thinking about my background and my position as the researcher and what affect the fact that I have white skin will have on the villagers. As my research is focused on people and their wellbeing and quality of life my research will mainly use qualitative methods. What constitutes qualitative research is a contested issue, it has been used by a range of subject and disciplines and each have added their own techniques and views. Denzin and Lincoln argue that there is a complex historical field surrounding qualitative research and it rise in prominence of the past 30 years. This view is backed up by other authors in the field such as Mason (1996) and Silverman (2005). Many bodies of thought have influenced what constitutes qualitative research and how it is carried out including, postmodernism, feminism and positivism. However Denzin and Lincoln (2005) p.2 offer an initial generic definition, “Qualitative research is a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings and memos to self.” Mason (1996) p.4 takes a less rigid view. Qualitative research is “grounded in a philosophical position which is broadly ‘interpretivist’ in the sense that it is concerned with how the world is interpreted, understood, experienced or produced... based on methods of data generation which are flexible and sensitive to the social context in which data are produced”.

### **3.2 Questionnaire**

One of the methods of gathering data will be by using a questionnaire; this will be used to gather information regarding people's experience with the SMS. The questionnaire fulfils RIDS-Nepal's need for follow up data on the installations of their SMSs. It also aimed to obtain people's views and ideas for improving the stove. They did this as they are considering redesigning the stove so it better suits the needs of the user and to make it more suited for the unique situation in which the Humlis live as high altitude, subsistence farmers.

Please see Appendix 2 for a copy of the blank questionnaire. From Simikot, the district headquarters, I will trek with project staff 5 hours north along the valley towards Tibet to the village of Dharapori where we will stay in the project office. It is from here that I will walk each day to the different villages where I will conduct interviews with women who use the stoves and complete my questionnaires. In addition to this I will be observing them as they go about their daily chores. We were often invited inside peoples homes to look around or to share some food with the family (see Appendix 4), this is extraordinary and showcases the villagers generosity and gratefulness to the project as the people are desperately poor and do not have much food to share. My knowledge of the Nepali language and culture will be beneficial in my ability to do this effectively and therefore add to my research. Dharapori was chosen as a base because there is a project office and its "close" (reaching these villages involved approximately a 2 hours walk up and down steep valleys) proximity to the 3 other villages I visited, Tulin, Kholsi and Pamlatum. I visited 23 homes throughout the 4 villages (6 each in Tulin, Kohlsi and Pamlatum and 5 in Dharaphori.) and conducted questionnaires, held conversations with the house owners and observed. In some cases I shared food or tea with them or chatted with them as they completed their house hold tasks. I decided to visit and gather data from 4 different villages as this would give me a broader perspective of the impacts of the SMS on the local community and I believe gives me a wider, more valuable data set. The number of questionnaires conducted is lower than specified by the research proposal, as there was a

time limit on the amount of data I could collect since I was going with project staff and they had their own objectives for the trip.

In order to fulfil the requirement of RIDS-Nepal's need for the evaluation of the SMS project the first set of questions obtained the name of the household, the number of the stove installed (as each stove has a number), the year of installation and the model. The questionnaire also contains a question about any problems with the stove or technical issues. To ascertain the different benefits and impacts of the SMS a series of questions followed covering topics such as the level of wood consumption, the overall level of satisfaction with the stove, any changes in health, the frequency of use, as well as any additional comments. On return to Reading the questionnaires were coded and analysed.

### **3.3 Other Research Methods Used**

During my stay in the project area we stayed in the project office in the village of Dharapori. It was from here that we hiked each day about 2 hours to surrounding villages to collect data. Living, working, cooking and eating everyday with the project staff not only gave me great first hand experience of using the SMS but also enabled me to gain inside knowledge about the ins and outs of the project and about the project and the staff. While I was staying with the staff I carried out informal interviews with 7 of the project staff on various aspects of the SMS initiative and the level of participation from the local community. I found out that RIDS-Nepal would only start working in a village if the village come to them with a request and after RIDS-Nepal has met with the village council.

“Ethnographic research methods attempt to study social life as it unfolds in the practices of day-to-day life. These methods avoid as much as possible artificial research situations” (J. Kees van Donge (2006) p.180). I am attempting to conduct ethnographic style research by spending time interacting with villagers in their homes and observing their lifestyles. A major limitation to this approach is that I was in the field for only 2 weeks



although considering my previous experience with living in rural Nepal; this helps to negate this limitation.

During my 2-week stay in the project area I kept a personal diary each day in which I recorded personal thoughts and reflections and used it to process the conversations and experiences I had with the people I encountered during my time there. It helped me to reflect on the projects and the benefits and effects they had on the local communities and also the gratitude of the local villagers and their enthusiasm to undertake new programs and their pride in what RIDS-Nepal has helped them to achieve for themselves. In preparation for my research I learned as much as possible about RIDS-Nepal, this included looking on their website ([www.rids-nepal.org](http://www.rids-nepal.org)), and watching a video they had prepared about their projects. Several conversations with Alex Zahnd about how the project started and about his experiences of development also helped to gain a deeper understanding. After my trip I met with Alex Zahnd in Kathmandu and discussed my research and findings and my experiences and reflections on a very beautiful but very poor area of Nepal and the good that RIDS-Nepal is trying to do in helping people to better their own lives. Alex Zahnd provided valuable insights and contribution in interpreting data from the local context as well as explaining some of the cultural and contextual nuances that may have affected the quality and quantity of the data I collected. During my research I took photographs of people and their homes (with consent) in order to attempt to convey their lifestyles and traditions and the joys and struggles of everyday life.

In addressing the question of Indoor Air Pollution (IAP) and the reduced levels of this that goes along with using the SMS, scientific and extensive measurement is needed. This is not feasible for me to carry out due to time constraints and lack of equipment and expertise. However RIDS-Nepal has conducted extensive measurements of Carbon Monoxide, PM 2.5 (particulate matter under 2.5 micrometer diameter size), PM 10 (particulate matter under 10 micrometer in diameter size) and Total Suspended Particles (TSP) levels emitted from both the traditional cooking methods and the SMS. They also conducted 24-hour tests to take into account the different levels of IAP encountered

throughout the day and night in line with people's daily cooking and eating habits. RIDS-Nepal has kindly allowed me to use their data as well as the graphs drawn to show the comparison between the levels of IAP of the traditional methods and the SMS (see e.g. Figure 4).

### **3.4 Limitations of Methodology**

Due to the unusual nature of the location and setting of my research for an undergraduate dissertation there were a number of limitations to the scope and depth of the research that I was able to carry out. One of the main limitations was that I was going as part of the RIDS-Nepal team and they had their own schedule of work that was needed to be done in relation to the other projects that they were carrying out such as the installation of photo voltaic lighting systems and a pico-hydro generator.

We were also on a tight time schedule as we had tickets booked to fly out of the project area. Therefore time was one of the limiting factors, as I would have liked to do more interviews. In order to have a better participant observation more time should have been spent with each household, learning about their daily routines and how their use of the SMS affected and improved their day-to-day lives. Another significant limitation was the language barrier that existed between myself, as the researcher and villagers whom I interviewed and observed. The villagers spoke a rural dialect of Nepali, which is the national language of Nepal. The translators which were provided for me by RIDS-Nepal were of great help as they could translate the village dialect into simple Nepali which I could understand. The translators spoke no English.

There are obvious limitations in the quality of the data I could collect, as the participants were illiterate, subsistence farmers. There are other limitations in conducting research in a different language and culture; one example of this is that concepts and ideas may get lost in translation. As with any piece of research and whenever data is collected one must consider the position of the researcher in relation to the participants. This is particularly

relevant in this situation as there are a number of factors, which could affect the information given during the research. The fact that they had never met me before and that I am a foreigner with white skin would all have huge impacts on their level of trust and on their general uneasiness. It must also be taken into account that fact that I am a male and all of the people whom I interviewed were female. Some of this would have been negated by the fact that I was with a female member of RIDS-Nepal's staff who was from the local area and therefore spoke the local dialect and knew many of the women I interviewed. Another factor, which may have reduced the women's unease, is the fact that I spoke Nepali and chatted to them. In order to make the participant feel comfortable and therefore ensure richer data, I spoke Nepali to them and drew on my knowledge of Nepali culture and conversation.

A further limitation was the time of year that the research was carried out. It took place at the end of August; this is the monsoon season and busy time as people were tending their crops. This meant there were people around during the day to interview, but the limiting factor was the amount of time that the women could take to sit and be interviewed and answer questions during their daily field works.

## **4. Results and Discussion**

### **4.1 Reduction of Indoor Air pollution and Improving Health**

One of the major features of the SMS in comparison to the traditional cooking methods is the inclusion of a metal chimney, which goes through the roof and expels the pollutants out of the home unlike the traditional methods where the smoke stays inside the home. This is one of the most important aspects of the stove and has a huge benefit to people's health but this will be considered later on in this section. Below is a graph produced by RIDS-Nepal from the data they collected during one of the many experimental data recording and logging.

## 24 Hours Comparison of Indoor PM<sub>2.5</sub> Air and CO Level between Smokeless Metal Stove (SMS) and Open Fire Cooking

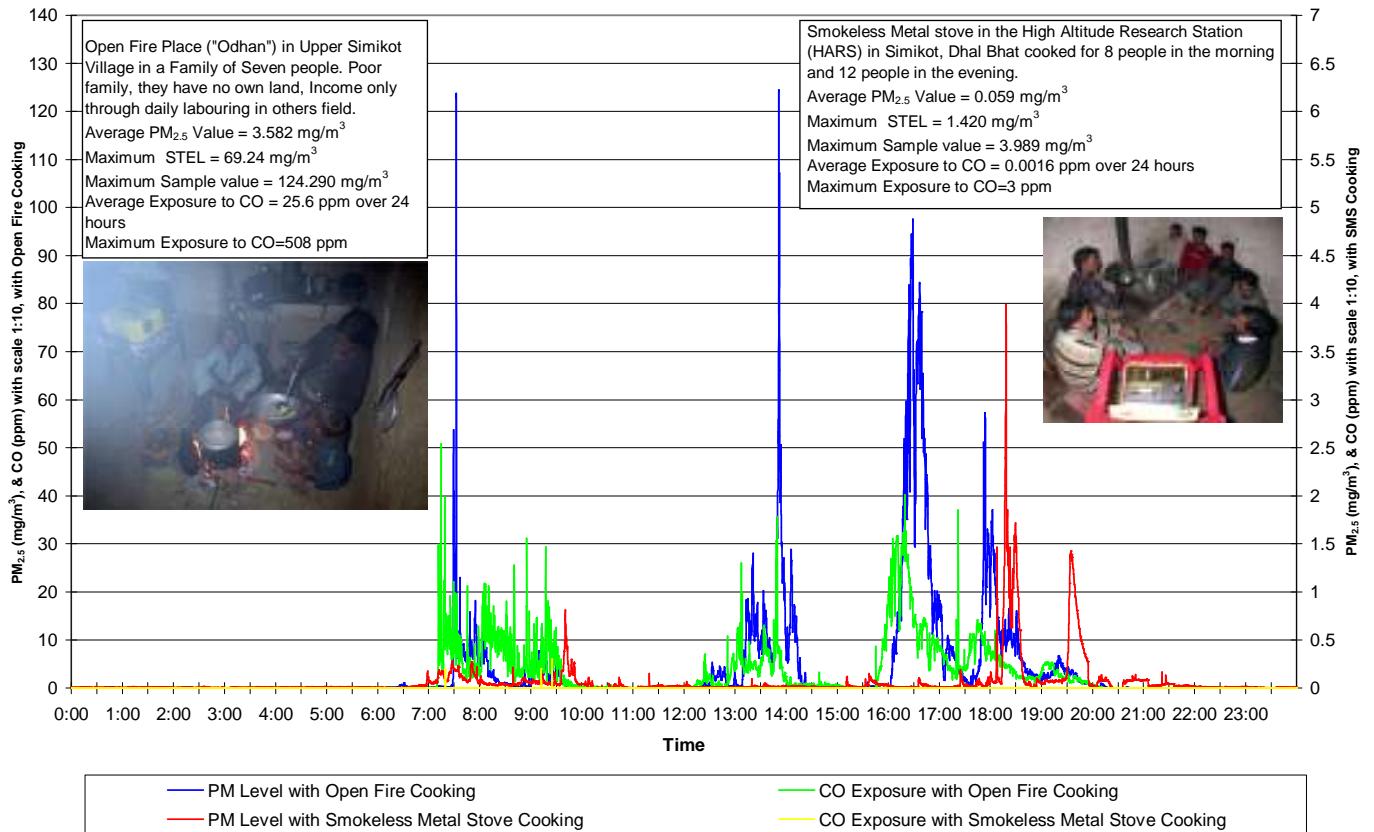


Figure 4: 24-hour Comparison of Indoor PM 2.5 and CO level between SMS and open fire cooking

Source: RIDs-Nepal, October 2008

The time that runs along the bottom of the graph is the 24-hour period in which the monitoring took place. It runs from midnight to midnight. This time period was chosen so that the test could capture a family's usage during a whole, 24-hour, day. The unique thing about this graph is that it contains data from the SMS and the traditional open fire place. This makes it easy to compare and to visually recognize the benefits of the SMS and its role in reducing IAP and therefore improving health. This graph measures two aspects of IAP, Carbon Monoxide (CO) and Particulate matter under 2.5 micrometer diameter in size, simple called PM2.5. These are particles which are small enough to get trapped in the lower respiratory tract (Zahnd Sep. 2008) and cause severe respiratory problems like chest infections and bronchitis. The three major spikes in level of CO and PM 2.5 represent the three times when people cook and heat. The periods in the morning

and evening represent the cooking of the morning and evening meals of rice, lentil soup and curried vegetables are being prepared, the period in the middle of the day represents when tea was made and therefore the levels were not as high as the other periods. It can be noticed that the levels of pollution were higher and last longer in the evening. This is due to the fact that people socialise around the stove and in the kitchen and drink tea, thus prolonging the need for the fire or stove to be burning. In both the cases of the PM 2.5 and the CO the levels emitted from the SMS (right axis and red line) were much lower than those from the traditional open fire (left axis and blue line), with the CO levels from the SMS (right axis and yellow line) almost non-existent except for a small rise during the morning cooking period in contrast to the open fire place CO emitted (left axis and green line). Whilst for the PM 2.5 the levels emitted from the SMS are much lower and peaks are less frequent than with the traditional methods.

Please refer to Appendix 6 for the “National Ambient Air Quality Standards” set by the US Government. According to the graph the average level of CO with traditional methods was 25.6 parts per million (ppm) over 24 hours although this is below the level set by the US Government which is 35 ppm, this level is not to be exceeded except for 1 day a year, yet the Humlis are exposed to levels close to this everyday day. This poses a very serious problem. The average for PM 2.5 level of the 24-hour period for the open fire place is 3,582 micro-grams which is a 1,000 times over the recommended limit of 35 micro-grams per metre squared over a 24-hour period. This also poses a serious health problem. Average outputs for the SMS on both the CO and PM 2.5 fell well below the recommended levels.

	Less respiratory problems & Less eye problems	Less Respiratory problems, eye problems & Burns
Number of responses	6	17

Figure 5: Number of Responses regarding reduction in Health Issues.

When I asked the women I was interviewing about the impacts that the SMS has thus far had on their health, they always responded enthusiastically, this happened in every single

case. It can be seen by this response to the question posed that this was an issue that was close to their hearts and in their perspective one of the most important benefits of the SMS. As it can be seen from the table above that every women mentioned a reduction in respiratory problems and a reduction in eye problems which are caused by the smoke irritating the eye. Three quarters of the women that I talked to mentioned that their children had benefited from improved health as well. These issues mainly pertain to women with young children, as they are the ones who are most often in and around the home. Some of the most common health problems, which use to occur when traditional cooking methods were used, were: respiratory disease, chest infections, asthma, blindness and heart disease. While I was in the villages I only witnessed a handful of people who were coughing or showed any outward sign of sickness. This is testament to the improvement that the SMS has brought.

When I was living in my village growing up in western Nepal I had many experiences sitting in a smoky kitchen finding it difficult to breath, tears rolling down my cheeks as the pollution irritated my eyes, and finding it difficult to see someone across the room because of the thickness of the smoke, jostling for position by the door. It is not a pleasant experience. My personal experience helped me to connect with people in Humla and empathise with their position. It was evident that they were very grateful not to be experiencing those same conditions anymore. Houses in Humla tend to have no windows as they are built into the sides of hills (see appendix 3) if they do have one it is small, this is also because of the bitterly cold winters that they experience in Humla.

Referring to the above table it is observed that three quarters of women interviewed mentioned a reduction in the number of burns (they previously had with open fire places), most of these were regarding their children. This can be attributed to the fact that the fire is contained whereas in the traditional methods of cooking the fire was open and so fire wood logs could easily fall over and someone could be accidentally knocked on to the edges not to mention flying sparks or the eventuality that the cooking pot could tip over. A reduction in these health issues already mentioned no doubt bring an improved quality of life and the villagers can draw greater satisfaction from that.

## 4.2 Cleanliness of the Home and Provision of Hot Water



Figure 6: Family Cooking using the traditional open fire place method. Source: Alex Zahnd 2006



Figure 7: Family using and SMS, resulting in a clean house. Source: Alex Zahnd 2006

Figure 6 depicts a family cooking using the traditional methods and the Indoor Air Pollution that it creates. This picture was taken in the home of a family in one of the villages before RIDS-Nepal started to work with the local people and the installation of the SMS. The thickness of the smoke is easily visible and this naturally causes a great

deal of discomfort in day-to-day living. Figure 7 in contrast depicts a family cooking using the SMS. It is evident from a comparison between the pictures that there is marked improvement of the air quality that comes with using the SMS. It is also important to point out that the main fuel is pinewood which has a high resin content, thus doesn't burn cleanly, but produces a thick dark coloured smoke, which stains the wall and ceiling of homes as well as their clothes and their lungs likewise. This problem is negated in the case of the SMS. One must also consider the unpleasant smell of the smoke that is emitted. This settles on clothes and hair and bedding which is a discomfort.

Faced with the question, "what have been some of the greatest benefits of having the SMS installed in your home?" 17 out of 23 women interviewed gave answers that related to the fact that the SMS had a chimney and that therefore the smoke and ash particles were ejected from the home. The responses were spread almost evenly throughout the 4 villages in which I visited, this shows that this benefit was a common one and not just down to local conditions or factors. Almost all of the 17 women who talked about this subject mention the fact that their homes and clothes were cleaner and free from smoke and the smell that accompanies it. 6 of the 17 women brought up the fact that their children and their own skin and hair were cleaner and it was easier to keep clean, as the smell didn't permeate their clothes. The benefits of this improvement are obvious. Before the SMS was installed it was time consuming and difficult to obtain hot water for washing themselves and their children. This is because only one pot of water could be heated at a time and the traditional cooking methods involved open fires with no way of controlling the oxygen flow it required a large quantity of wood and it burned inefficiently.

The SMS has a 9-litre, stainless steel, water tank attached so that water could be heated simultaneously to cooking and preparing food without any extra effort or significant amount of wood. So in theory if a family filled the tank up they could have hot water for drinking and washing twice a day after they cook their morning and their evening meal. Some quarters may raise the objection of the need for hot water is washing the human body but taking into consideration that this is a high altitude mountain environment that



experiences freezing temperatures and deep snow for 5 months of the year, it is crucial that families have a source of hot water to wash with and there is the added benefit of having this in ones own home which is convenient and saves time.

Whilst the benefits of having a clean home and clothes and hot water for washing yourself and your children may seem obvious, I would now like to explore some of the deeper more hidden benefits that I only realised after interacting with the women and seeing them operate in their own homes. That is the benefit of women taking pride in being able to operate and maintain a clean home and having the freedom to wash yourself and your children regularly. This is a deeper impact of the SMS and one which is hard to measure or quantify as it can be hidden and is a hugely personal thing, the villagers may not even be aware of these feelings or may acknowledge these feelings but be unable to express these because of language deficiencies or lack of education. But it can be evident when watching and interacting with the villagers in and around their homes. These feelings are attached to people's self worth and self satisfaction in the knowledge that they are able to provide for their children in some small way by keeping them clean and taking pride from enabling their children to be well presented and making themselves beautiful and giving the women pride in their homes which are clean and presentable. This effect is more pronounced in women and children as they are more closely tied to the home and spend a larger proportion of the day in and around it. If one is provided with nicer surroundings this will impact on their happiness and satisfaction.

The practical benefits of a clean home and the ability to wash must also be considered, such as hygiene consideration, this coincides with the other activities that RIDS-Nepal are operating such as building pit latrines and building water taps in the village.

100% of women interviewed responded that they used all the components of the SMS regularly. This includes the 3 burners, the roti slot and the hot water tank. This shows that that the stove was designed and developed with the local context in mind. Before designing and implementing the stoves, RIDS-Nepal carried out surveys and ask villagers what components they wanted in a stove in order to meet their needs effectively. This is

coupled with trials of this stove in the neighbouring district of Jumla, that took places before RIDS-Nepal began working in the Humla district. This shows their commitment to participatory development. The fact that all components were used regularly correctly reflects well on the training that the villagers received from the project staff and proves that the training was effective.

### **4.3 The Effect of the SMS on Fuel Consumption**

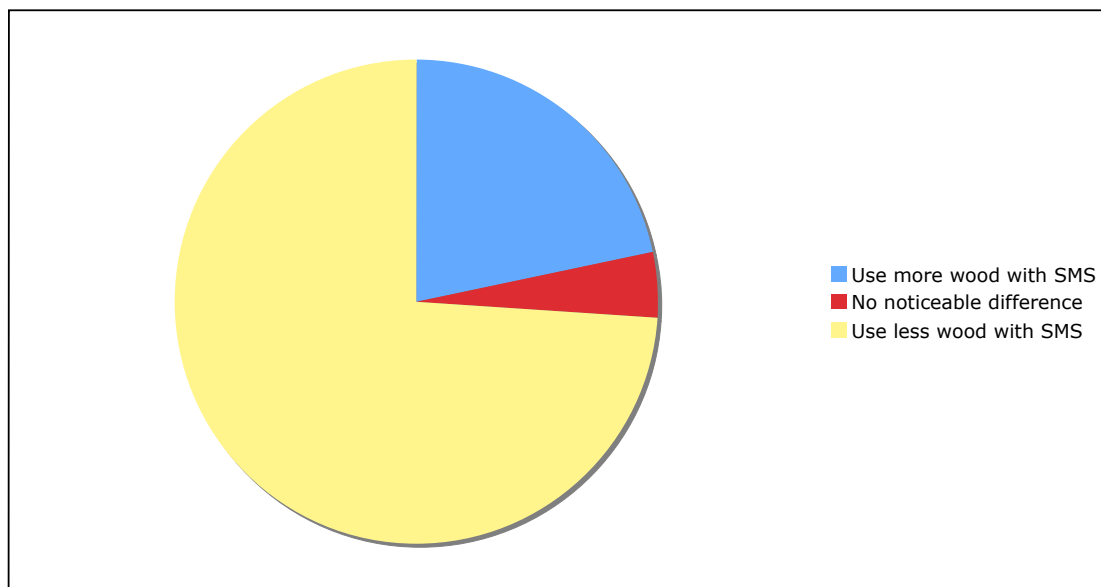


Figure 8: Pie Chart depicting responses to changes in wood consumption with SMS

From the graph in Figure 8 it is possible to say that in a large number of cases the SMS took less wood to run than the traditional cooking methods. The above graph was compiled using the answers obtained from the questionnaires that were carried out. 17 of the women responded that they used less wood with the SMS than they had done when using traditional methods. 1 woman responded that there was no noticeable difference in the amount of wood used, 5 women answered that they used more wood than they had than when they used traditional methods. It is interesting to note that these 5 answers came from one each from 3 villages and 2 from one village, which seemingly negates any local differences between the villages. This may reflect the fact that these women were

not trained properly or are perhaps using the stove wrong i.e. leaving the front door of the stove open when cooking, this allows extra oxygen to get in the combustion chamber and therefore the fires burn more fiercely and use up more fuel. The SMS, if used properly, uses less wood because the fire is taking place in a confined space where the oxygen flow is controlled so the fire burns less fiercely and thus less fuel is consumed. Burning in a confined space (the closed combustion chamber) means that the temperature of the fire will be hotter which means the fuel will burn cleaner and more efficiently. This is not the case with the traditional methods.

From the baseline surveys that the project staff carried out in the villages before the “Family of 4” project started, it was estimated that on average of 15 and 30 kilograms of wood were used in cooking for 5 to 6 people when traditional cooking methods were employed. From a 6 month survey that was carried out at the RIDS-Nepal office in Simikot which monitored consumption of firewood everyday on the basis of cooking for 6 people I obtained the data that the average daily usage of firewood with an SMS is 10 kilograms, this is between a half and a two thirds reduction in the amount of firewood consumed. The less firewood consumed means the less deforestation of the local pine forest that takes place. The effects of deforestation are well known: soil erosion leading to landslides which cause the rivers to flood and the loss of soil leads to a reduction in the productivity of the land for growing crops, these effects are more pronounced in Nepal as there are steep slopes and heavy monsoon rains.

The reduction in firewood and the efficiency of burning means that women spend less time cooking and preparing meals and also they spend less time collecting and carrying the wood from the forest to their homes. This alters their daily schedule in a positive way and frees up more time for other activities. The benefit of this must not be underestimated and plays an important role in improving the quality of life for these women and improving their well-being. These women work hard each day cooking and maintaining the house, collecting firewood, caring for children as well as tending vegetable gardens and carrying out other activities around the home and in the fields so the provision of this extra time is extremely beneficial to them.

#### **4.4 Negative Impacts of The SMS**

From the questionnaires and interviews and discussions with villagers and users of the SMS and from my own observations of women using the stove to cook and heat their homes, the overwhelming majority of impacts on daily life and the effects the stove has added to their well being and thus have been positive. The stove has brought major improvements. The information used in the following section was obtained from conversations with villagers and with the local project staff.

It is impossible in any situation for all the impacts to be positive and in endeavouring to provide a balanced view of all of the effects one must consider some of the possible negative impacts of the SMS. One of the negative effects of the SMS is the cost that the villager has to pay and whilst RIDS-Nepal subsidises the cost of the stove by about 75% for families who have built a pit latrine this cost is still a factor. As the villagers are subsistence farmers and produce most of the products they consume themselves it is difficult to obtain an exact annual income, which is estimated at about £100 per person. Most of their annual income comes from the sale of agricultural produce and fir wood. Another common source of income is as day labourers in the district head quarters or as porters for trekking expeditions and pilgrimages to Mount Kailash in Tibet, which has religious significance for Hindus and Buddhists. After a 75% subsidy from RIDS-Nepal each SMS costs the villager about £20, although this may not seem a lot to foreigners, this is a huge sum of money to the Humlis especially taking into account the annual income. The Humlis usually raise the necessary funds by selling agricultural produce, such as fruit, vegetables such as cucumber or pumpkin, which are widely cultivated there. They will also sell firewood or products they make themselves such as oil pressed from walnuts. In some cases family will sell a cow or a goat or possibly a small plot of land. RIDS-Nepal will only consider launching their “Family of 4” initiative (which the SMS is part of) when there is a large amount of interest from a village and all the household agree to the programme. Villages are often eager to have a project in their village when they see other villages participating and when they see the benefits that those people gain from the initiatives.

Occasionally there will be a situation where one or two of the households in a particular village are so poor that they aren't able to afford the approximate £20 for the cost of the subsidised stove. In some cases this is due to the fact that there is no male in the household. In such cases project staff will sit down with the village committee and the elders to discuss whether the household in question really are in need and then they discuss viable options. One common solution is to discern the maximum that the family can contribute and then encourage the other households in the village to give a little extra perhaps 50p. and then RIDS-Nepal covers the rest of the cost of the SMS. This is also the case when the family cannot contribute anything to the cost of the stove. In either case the family has to write an application for the full subsidy with the village committee's agreement and their signatures.

It is important to note that in all cases transparency with the rest of the village is of paramount importance. The whole village knows that a family will get a discounted rate, it is important that these things are not hidden as this would cause problems in the village. The whole process is carried out with the knowledge and agreement of the village committee and the elders.

## **5. Conclusions and Recommendation for Further Research**

### **5.1 Conclusion**

The installation of a SMS in households has drastically reduce the amount of IAP produced. This can be seen by a visual comparison of homes with and without the SMS. This is backed up by technical measurements of the levels of carbon monoxide and total suspended particles (PM2.5, PM10 and TSP). There has been a huge reduction in the amount of health problems with all the women interviewed reporting a reduction. Some of the most common reductions were in respiratory problems, eye problems and fewer incidents of burning both for themselves and their children. There is evidence that the SMS use a significantly smaller amount of wood compared to the traditional, open fire

place cooking methods. This positive effect not only brings decreased levels of deforestation but it also decreases the amount of cooking time, as the SMS burn cleaner and thus more efficiently. That because the oxygen flow to the fire can be controlled via the air intake adjustment and thus the heat is contained within the stove and can therefore be directed to the cooking pots and to the hot water tank more directly. There is also positive impact on the amount of free time women have during the day as cooking time and the amount of time spent gathering fuel wood is reduced. This will lead to some improvement in the quality of life.

From the results it can be said that the installation of the SMS has had also other, less quantifiable, impacts on peoples happiness and quality of life and self worth. These include a cleaner home and clothes and the removal of the smell of smoke form their homes, as the SMS has a chimney which ejects the smoke out of the home. This in contrast to the traditional cooking methods which involved building an open fire place in the midst of the home and so the smokes stays in the immediate environment. The fact that the SMS has a hot water tank attached is of a great benefit especially for washing themselves and their children. The importance of this cannot be under estimated as the villages are situated at a high altitude, around 3,000 metres, and experience freezing temperatures and deep snow for 5 months of the year. There is also some pride and self worth that is derived from being able to wash regularly and be presentable not just for the women but their children as well. Most of the impacts and effects that the SMS has had have been very positive and a huge improvement for the quality of life for the Humlis. The only negative effect is the cost of the stove and it is difficult for some families to raise this. But the participatory amount each family has to pay (about 25% of the stove full value) helps strongly to increase the ownership feeling and thus motivates the families to use the SMS properly and to care for it.

In summary the installation of the SMS has had huge positive impacts on the lives of he Humlis and shows on the whole a large improvement in the health of the villagers. It has also led to a decrease in the amount of deforestation and provided improvements in cleanliness in the home.

## **5.2 Limitations of this Research**

The main limitation of this research is related to the site of the research, which is rural and very remote, in the villages of northwestern Nepal. These villages are notorious difficult to travel to, and the distances between the villages where data was collected are great. Other limits were imposed by the fact that I had limited time in the field as we booked flights in and out of Simikot, the district head quarter. This limited the amount and the scope of the research and the level of observation I was able to conduct. I was attempting to use participant observations and ethnographic methods so the time limitation will have had a large impact on this. There was also a significant cultural and language barrier between the participants and myself. The time of year must also be taken into consideration, as it was a season where villagers were busy in their fields and in some cases had already left home for their high altitude meadows, where they stay and graze their animals for 3 months from July – September, by the time we had arrived in the villages.

## **5.3 Recommendation for Further Research**

Taking into consideration the limitations of the depth and scope of this research I would recommend that further, and more in depth research into the impacts and benefits of the SMS on the villages and indeed the impact of the other initiatives run by RIDS-Nepal, is undertaken. I would recommend a longer-term research endeavour of 6-12 months so that the impacts on the daily life of the local people can be fully understood in that specific context. The researcher would also benefit from gaining knowledge about some of the long-term more hidden benefits such as the impacts on mental health issues and family dynamics. An ideal situation would be if the researcher is of Nepali nationality. This would remove some of the language and culturally barriers that existed in this piece of research. In future research, ethnographic methods should be adopted and this will be the most effective tool for gaining deeper knowledge about the benefits of the SMS. Another important area in which more research should be undertaken is the health benefits that

come from cooking on the SMS and from the fact that smoke is expelled from the home and not retains inside the home's environment. Further research should be conducted looking into the health advantages of children and advantages in their development as they grow. Another important, almost untouched and interesting area where further research needs to be conducted is the long term effects in particular relating to pregnant women and the effects to the baby before and then after it is born and as it grows up. In an environment where the SMS is used and the IAP is greatly reduced the baby will be able to obtain more oxygen from the mother's blood stream. The hypotheses goes that the "normal" (or for that sake for the local condition increased) flow of oxygen may have long-term benefits for the yet unborn baby as it grows up in the mother's womb and thus could prevent mental disability and therefore increase a child's ability to learn later on in his growing up. I would recommend a long term study of a group of children from before they are born and for the first few years of development, some of them in homes that use traditional methods with high a level of IAP and some from homes that use SMS. There are obviously some ethical issues which need to be considered and dealt with in this kind of study and also feasibility issues.

## **References**

- Blewill J. (2008) *Understanding Sustainable Development*, Earthscan London
- Denzin N. and Lincoln Y. ed. (2005) *The Sage Handbook of Qualitative Research*, Sage: London (p.1, 2, 7-27)
- Desai V. and Potter R. ed. (2006) *Doing Development Research*, Sage: London pg 94-104
- Desai V. and Potter R. ed. (2002) *The Companion to Development Studies*, Hodder Arnold
- Dincer I. and Rosen M. (2007) *Exergy Energy, Environment and Sustainable Development*, Elsevier pg. 36-58
- Elliot J. (2006) *An Introduction to Sustainable Development*, Routledge: London pg 7, 43
- Ellis F. (2000) *Rural Livelihoods and Diversity in Developing Countries*, Oxford University Press, Oxford



- Grills S. (1998) *Doing Ethnographic Research*, Sage, London
- Hobley M. (1996) Participatory Forestry: The Process of Change in India and Nepal, in *Rural Development Forestry Study Guide 3*, Overseas Development Institute
- Holland J. and Campbell J. (2005) *Methods in Development Research*, ITDG Publishing
- James V.U. and Etin J. (ed) (1999) *The feminization of development processes in Africa: current and future perspectives*, Praeger
- Kees van Donge J. 'Ethnography and Participant Observation' in Desai V. and Potter R. (2006) *Doing Development Research*, Sage (p180-188)
- Kuchli C. (1997) Changing Forest Use and Management in the Alps and the Himalayas: A comparison between Switzerland and Nepal, in *Rural Development Forestry Network*, Overseas Development Institute
- Laczo M. (2004) Deprived of an Individual Identity: citizenship and women in Nepal in *Gender, Development and Citizenship*, Sweetman C. (ed.) Oxfam Great Britain p.76-82
- Leonard H.J. et al. (1989) *Environment and the Poor: Development Strategies for a Common Agenda*, Overseas Development Council Washington DC
- Marchand M. and Papart J (ed.) (1995) *Feminism-Postmodernism-Development*, London: Routledge
- Mason J. (1996) *Qualitative Researching*, Sage, London (p.9-35, 60-82)
- Punch K. (2005) *Introduction to Social Research*, Sage: London
- Pokhrel A. and Smith K. (2005) Case-Control study of indoor cooking smoke exposure and cataracts in Nepal and India, *International Journal of Epidemiology* 2005; 34:702-708, Oxford University press.
- Rogers P. et al, (2008) *An Introduction to Sustainable Development*, Earthscan
- Siddiqui A. et. al (2008) Prenatal exposure to wood fuel smoke and low birth weight, *Environmental Health Perspectives* Volume 116, number 4
- Silverman D. (2005) *Doing Qualitative Research*, Sage, London
- Sweetman C. ed. (2004) *Gender, Development and Citizenship*, Oxfam Great Britain
- UNDP (2008) *The Human Development Concept* [Online] available: <http://hdr.undp.org/en/humandev/> [29.01.09]
- Whyte W. (1991) *Participatory Action Research*, Sage
- World Commission on Environment and Development (1987) *Our Common Future*, Oxford University press, Oxford.

## Appendices

Appendix 1: The confirmation letter from RIDS-Nepal that I carried out my research.



Date: 27 September 2008

### To whom it may concern

This is to certify that Gavin L. Naylor worked as an intern with RIDS-Nepal project from 20 Aug 2008 to 04 September 2008.

Gavin made a visit to the RIDS-Nepal's project in Humla and assisted in the installation of photovoltaic solar equipment in village locations. Gavin also collected data in Humla that will contribute to understanding the positive impact on villager's, especially women's health, by using smokeless stoves for cooking and heating.

Regards



Alex Zahnd  
RIDS-Nepal Director , [www.rids-nepal.org](http://www.rids-nepal.org)

Appendix 2: The Village of Dharapori with the project office pictured bottom centre, Source: Gavin Naylor August 2008



Appendix 3: Typical Humla style housing with chimney from SMS Source: Gavin Naylor August 2008.



Appendix 4: Sharing a meal with a family using a SMS to prepare it Source: Gavin Naylor August 2008

Tulin SMS Follow-up Program

Date (dd/mm/yy): ...../...../.....

House Owner Name: .....

Household No: .....

10. Health Changes

Increased Respiratory Problems, Eye Problems & Burns	
Increased Respiratory Problems & More Eye Problems	
Increased Respiratory Problems & More Burns	
More Eye Problems & More Burns	
Increased Respiratory Problems Only	
More Eye Problems Only	
More Burns Only	
No Noticeable Health Changes	
Less Respiratory Problems Only	
Less Eye Problems Only	
Less Burns Only	
Less Respiratory Problems & Less Eye Problems	
Less Respiratory Problems & Less Burns	
Less Eye Problems & Less Burns	
Less Respiratory Problems, Eye Problems & Burns	

Additional Comments:

11. Technical Issues

Difficulty Closing Front Door, Adjusting Chimney Flue & Sharp Edges on SMS	
Difficulty Closing Front Door & Adjusting Chimney Flue	
Difficulty Closing Front Door & Sharp Edges on SMS	
Difficulty Adjusting Chimney Flue & Sharp Edges on SMS	
Difficulty Closing Front Door Only	
Difficulty Adjusting Chimney Flue Only	
Sharp Edges on SMS Only	
No Technical Issues	

Tulin

House Owner Name: .....No. of Residents: .....

Appendix 5: Copy of Blank Questionnaire used in the Research.

## National Ambient Air Quality Standards

Pollutant	Primary Standards		Secondary Standards	
	Level	Averaging Time	Level	Averaging Time
Carbon Monoxide	9 ppm (10 mg/m <sup>3</sup> )	8-hour <sup>(1)</sup>	None	
	35 ppm (40 mg/m <sup>3</sup> )	1-hour <sup>(1)</sup>		
Lead	1.5 µg/m <sup>3</sup>	Quarterly Average	Same as Primary	
Nitrogen Dioxide	0.053 ppm (100 µg/m <sup>3</sup> )	Annual (Arithmetic Mean)	Same as Primary	
Particulate Matter (PM <sub>10</sub> )	150 µg/m <sup>3</sup>	24-hour <sup>(2)</sup>	Same as Primary	
Particulate Matter (PM <sub>2.5</sub> )	15.0 µg/m <sup>3</sup>	Annual <sup>(3)</sup> (Arithmetic Mean)	Same as Primary	
	35 µg/m <sup>3</sup>	24-hour <sup>(4)</sup>	Same as Primary	
Ozone	0.075 ppm (2008 std)	8-hour <sup>(5)</sup>	Same as Primary	
	0.08 ppm (1997 std)	8-hour <sup>(6)</sup>	Same as Primary	
	0.12 ppm	1-hour <sup>(7)</sup> (Applies only in limited areas)	Same as Primary	
Sulfur Dioxide	0.03 ppm	Annual (Arithmetic Mean)	0.5 ppm (1300 µg/m <sup>3</sup> )	3-hour <sup>(1)</sup>
	0.14 ppm	24-hour <sup>(1)</sup>		

<sup>(1)</sup> Not to be exceeded more than once per year.

<sup>(2)</sup> Not to be exceeded more than once per year on average over 3 years.

<sup>(3)</sup> To attain this standard, the 3-year average of the weighted annual mean PM<sub>2.5</sub> concentrations from single or multiple community-oriented monitors must not exceed 15.0 µg/m<sup>3</sup>.

<sup>(4)</sup> To attain this standard, the 3-year average of the 98th percentile of 24-hour concentrations at each population-oriented monitor within an area must not exceed 35 µg/m<sup>3</sup> (effective December 17, 2006).

<sup>(5)</sup> To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.075 ppm. (Effective May 27, 2008)

<sup>(6)</sup> (a) To attain this standard, the 3-year average of the fourth-highest daily maximum 8-hour average ozone concentrations measured at each monitor within an area over each year must not exceed 0.08 ppm.

(b) The 1997 standard—and the implementation rules for that standard—will remain in place for implementation purposes as EPA undertakes rulemaking to address the transition from the 1997 ozone standard to the 2008 ozone standard.

<sup>(7)</sup> (a) The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above 0.12 ppm is  $\leq 1$ .

(b) As of June 15, 2005 EPA revoked the [1-hour ozone standard](#) in all areas except the 8-hour ozone non attainment [Early Action Compact \(EAC\) Areas](#).