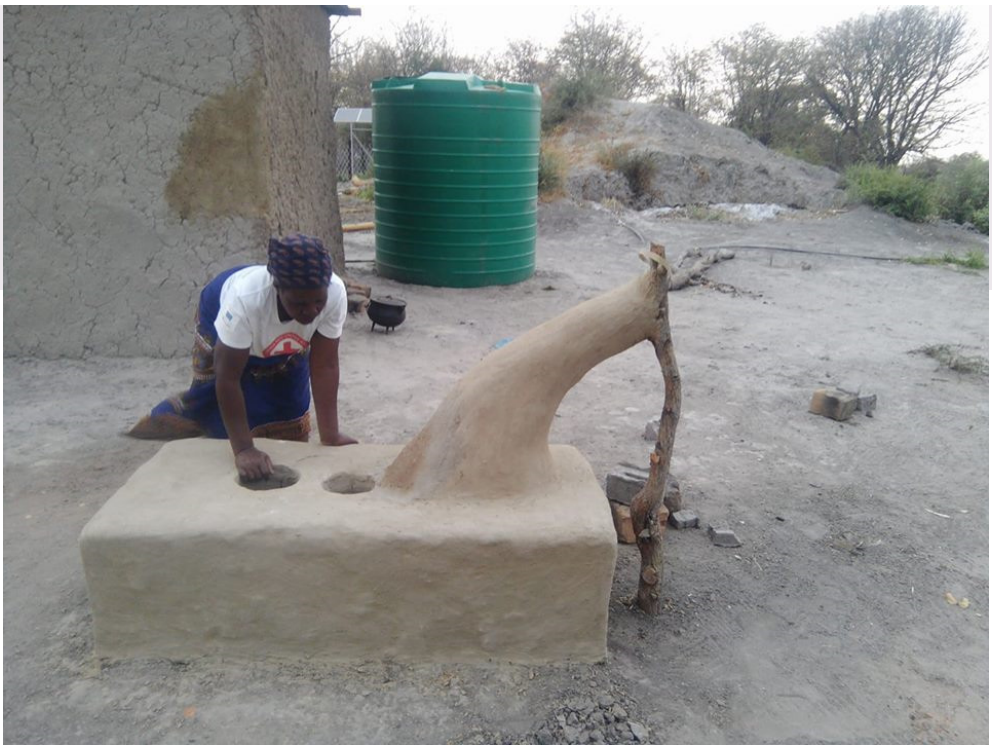
Case Study

Energy Efficient Stoves in Zambezi and Kavango regions, Namibia.



Beneficiary at Muyako-Zambezi Region inspecting her fully constructed Elephant Cook Stove.

I. Introduction/Background

Namibia is no exception to the adverse climatic conditions and it is considered to be one of the most vulnerable countries when it comes to the effects of climate change. Namibia's economy is highly dependent on natural resources and the expected production losses will potentially affect 70% of Namibia's population, who are dependent agriculture for on their livelihood. It is not easy to predict, with any level of certainty, the effects of climate change. However, Namibia's rural communities and the poor throughout the country are the most vulnerable to the negative impacts of climate change. Adaptive capacities amongst vulnerable groups are considered to be very low. The effect of climate change in Namibia is also worsened by the low population densities, long travel distances and the lack of infrastructure which further increase the countries vulnerability to climate change. Various pilot projects on climate change adaptation are underway, while very little has been done with regards to climate change mitigation focusing on the sustainable utilisation of renewable energy in the country. Namibia Red Cross Society (NRCS) in partnership with Spanish Red Cross have extensive experience in implementation of adaptation interventions including those of the humanitarian kind regarding disaster risk reduction, livelihoods and food security in order to enable vulnerable communities to adapt and mitigate major impacts affecting their livelihoods due to erratic rainfall and climate variability which is observed to generate important socioeconomic and environmental consequences. In the loop of addressing both components, adaptation and mitigation to climate change. Both National Societies implemented a European Union (EU) funded project with the objective of contributing to mitigate the negative impacts of climate change within rural vulnerable communities in Northern Communal Areas by "Promoting the use of renewable energy and energy efficient technologies in 9 targeted rural communities in Kavango and Zambezi regions.

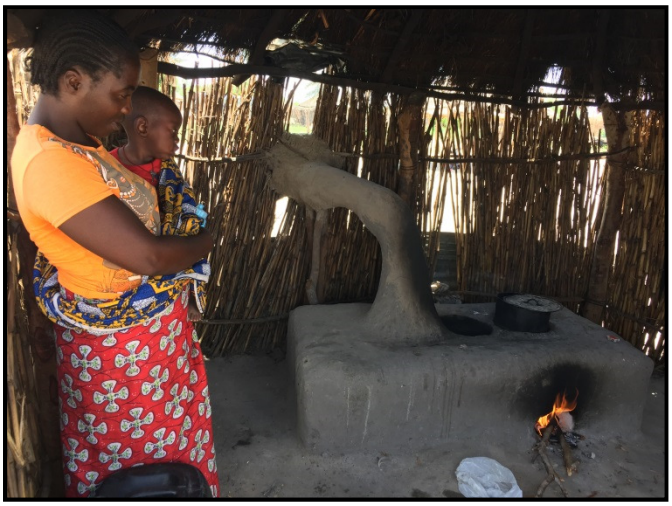
Starting in March 2017, with a budget of almost N$7.500.000 (500.000€), 80% EU contribution and 20% Spanish Red Cross contribution, the intervention aimed at introducing solar powered irrigation infrastructure systems in 8 selected community

gardens in both Kavango (East & West) and Zambezi Region and increasing the use of selected renewable forms of energy and integrating energy efficiency technologies at household level in 9 communities in the above mentioned regions. During 26 months of the implementation more than 2.000 people benefited directly from the intervention which encapsulated the following main components:

- Installation of solar-powered water infrastructure in community gardens.
- Constructions of energy efficient cooking stoves demos and promote replication.
- Distribution of solar lamps to households.
- Capacity building on renewable energy and energy efficient technologies through awareness sessions and training.

The Action was successfully implemented with the support of Ministry of Agriculture, Water and Forestry (MAWF) and the Namibia Energy Institute-Namibia University of Science and Technology (NEI-NUST).

This case study focused on energy efficient stoves and their impact at community level.



Energy Efficient Stove in Sharukwe-Kavango West Region

II. Achievements/Results

The design of the action was framed around 2 main results: 1) Households and small scale farmers increase the use of selected renewable forms of energy and energy efficiency technologies in their daily life; and 2) Vulnerable communities of the targeted regions have increased awareness about the integration of renewable forms of energy into the rural community system. One of the components of Result 1 was the construction of energy efficient stoves based on positive experiences from neighbouring countries such as Zimbabwe where Zimbabwe Red Cross Society developed a similar intervention. The majority of the rural population in the targeted areas of the action relied on biomass for cooking, much of which is done using an open fire. The traditional cooking practices had tremendous environmental, human health and economic costs. This is especially the case in the targeted areas of Zambezi, Kavango East and West Regions. The use of poorly performing cooking practices contributes towards the increased deforestation causing significant erosion of fertile topsoil and creating a perfect environment for flooding and poor yields which has plagued these communities in recent years. This poor use of cooking practices results in unsustainable fuel gathering practices which are a major contributor to greenhouse gas emissions. The cooking practices with poor combustion and significant particulate emissions also result in respiratory illness. Significant time and money was also spent on gathering fuel for cooking purposes, which was devastating to the rural women and children. Improved energy efficient stoves continue to be a necessity for much of the rural communities, where access to alternative fuels is not an option. This need has become more pronounced in the wake of the current climatic change variability in the country. There is a greater strain on fuel resources requiring more efficient use of the limited biomass available. The utilisation of the limited biomass and reduction of greenhouse emissions formed the centre of this action. Through this action activity was implemented in close collaboration the Namibia Energy Institute from the Namibia University of Science and Technology (NEI-NUST) who provided technical support and played a crucial role in the development and improvement of the stove. First step of the activity started analysing local available stove alternatives that replace the traditional 3 stone fires.

From the beginning, the acceptance of the energy efficient stove by community members was an indispensable criteria taken into consideration, therefore, local targeted communities were also engaged to investigate if there were existing knowledge regarding the use of energy efficient

stoves and other forms of renewable energies. The communities' engagements were meant to gauge current communities experiences including using local materials that could enable NRCS consider communities knowledge in order to ensure that actions were implemented on informed grounds. Among the key findings indicated that some energy efficient stoves were constructed with materials not affordable by communities; beside, it required high technical skills and tools to construct. The aim of the activity was to identify a model which could be constructed with locally available materials, at zero cost and which would allow Red Cross volunteers and community members to be easily trained on the construction to facilitate the roll-out of the stoves to other community members. While mapping the intervention of NEI-NUST, successful experiences in Zimbabwe Red Cross Society (ZRCS) opened the possibilities of bringing the expertise to Namibia as the environmental conditions and traditional cooking practices have a lot of similarities.

Beneficiaries constructing a stove with local materials in Lichaba, Zambezi region

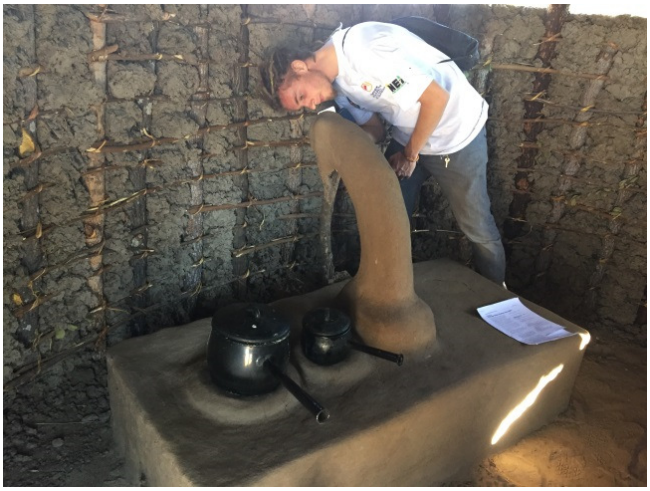
The energy efficient stove which was bringing such successful acceptance and use at community level was originally designed in Uganda. It was then introduced in Zimbabwe in 2014 through the Zimbabwe Red Cross Society (ZRCS) and the Uganda Red Cross exchange learning arrangement. In 2018 a volunteer from ZRCS and a project officer were seconded to Namibia to construct demo energy stoves in selected areas, 2 in Zambezi and 2 in Kavango while building the capacities of selected Namibia Red Cross Society volunteers and community members in the construction while raising the awareness on the benefits of the stove which is designed to achieve maximum transfer of heat and help the users to have firewood saving of 50-60% when compared to the traditional open fire stove.

Beneficiaries progressing with the construction in Lichaba, Zambezi Region

This implies that the same amount of firewood used by a family in one day with a traditional open fire stove can be used for 4-5 days with the energy efficient stove. It was named Elephant Cook Stove by the beneficiaries. Another benefit of this stove type is its affordability as it is built using local materials, such as clay and anthill soil for the main structure. Insulating materials include grass and sawdust which are also found locally thereby making it almost cost free to build. Thanks to the essential support of NEI-NUST, the demo stoves were tested to prove the efficiency. A team of experts from the mechanical

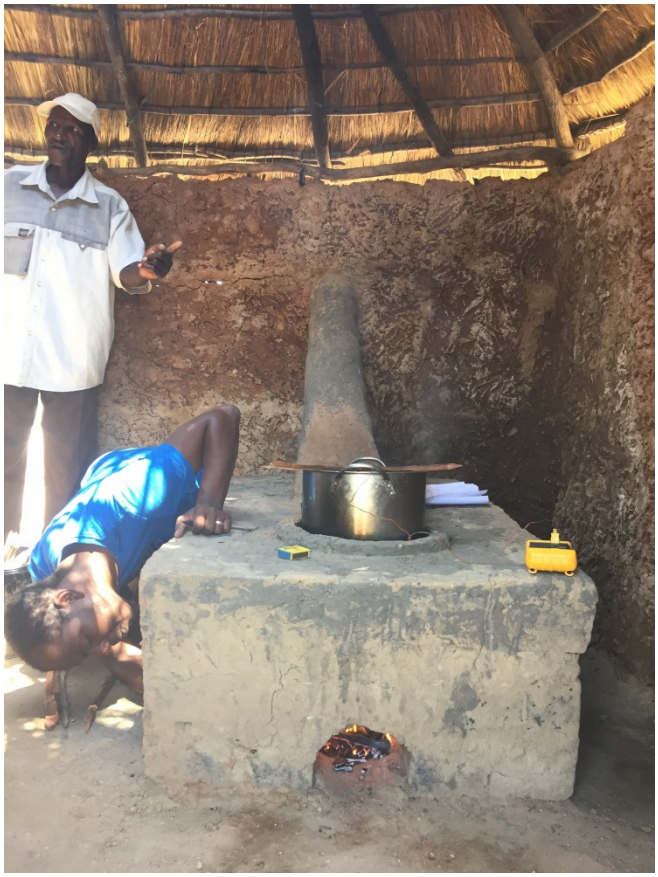
engineering unit of the NEI-NUST conducted a field assessment to technically test the efficiency. The report conclusion revealed that the *Elephant Cook Stove is a very fuel-efficient mud stove which is suitable to most rural household needs of Zambezi and Kavango regions. One of the key features for its relevance to rural settings is that it is constructed from easily available local materials such as clay soil, sand, ash and straws. An average of 11% of thermal efficiency was obtained for both cold start and hot start, and the average specific fuel consumption of 295g/litre.* The report also gave the following recommendations: *To improve the efficiency of the stove it would be recommended the following:*

- *Introduction of a wood tray in the combustion to prevent accumulation of charcoal which would block the air supply and compromise the performance of the stove.*
- *Increase the size of air inlet by 50% to admit adequate quantity of air for combustion.*
- *The chimney to be constructed facing in the opposite direction of the predominant wind direction.*
- *The stove should be placed in an indoor environment to minimise heat losses by convection from the pot and heat loss to environment from the stove.*
- *Upon building of the wall, they should make sure that the door of the room is direct to the stove air inlet*
- *Increase the size of the combustion chamber by 50% to accommodate wood of large diameter hence this will increase heat output and making cooking faster.*



Student from NEI-NUST testing the efficiency of a stove in Mpacha, Zambezi region.

Taking into consideration those recommendations, two (2) new improved stoves were constructed with the support and supervision of the mechanical engineers from NEI-NUST Again, the new improved stove was tested and the new assessment conducted by the engineers showed that the *Elephant Cook Stove is a very fuel-efficient mud stove which fits to most rural household needs of Zambezi and Kavango region. One of the key features for its relevance to rural setting is that it is constructed from easily available local materials such as clay soil, sand, ash and straws. The reading of the new assessment showed that even the efficiency was improved with an average of 21% of thermal efficiency obtained for both cold start and hot start, and the average specific fuel consumption of 168g/litre which represent less amount of fuel needed to boil 1 litre of water.*



Lecturer from NEI-NUST testing the energy efficiency of the improved stove in Sikondo, Kavango East region.

With evidence already in place, the roll-out and the cascade started in the communities. The demonstration (demo) stoves, the initial ones and the efficient improved ones were constructed in houses selected by community members and accessible to anyone who was interested,, most of those houses where the demo stoves were constructed were either at the Headman/Headwomen's house, which at the

same time guaranteed the commitment and acceptance of the traditional leaders. A huge number of trained volunteers and community members facilitated the roll out construction which towards the end of December 2018 reached **319 stoves** in both regions (124 in Zambezi and 195 in Kavango East and West) benefiting as follow

2.505 beneficiaries

51,18%

48,82%

The acceptance of the stove is so high that despite the end of the project, roll-out construction continues to be active beyond the implementation period. Red Cross Volunteers continue to play a crucial role supporting the construction when needed. An improved manual from the one used in Zimbabwe was developed to guide the construction and it was also translated into local languages, Silozi and Rukwangali.

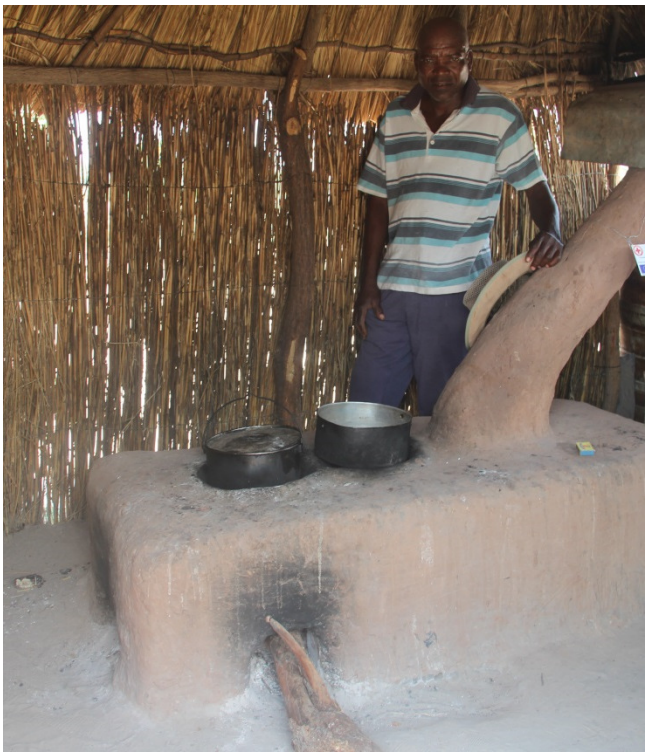
Once the stoves were in use by the community, another delegation of NEI-NUST comprises of experts in environmental science, energy efficiency, health and a mechanical engineer conducted another field trip with an Emission Analyser Machine to test the emission and relate the efficiency with the emission and the health issue. The machine was purchased thanks to funds facilitated by the Ministry of Mines and Energy which shows the commitment of the Government towards the research component of the energy efficient stove developed by Red Cross.

Testo 350 portable flue gas analyser

Findings of the emission testing reveals as follows: *The results for Sulphur Oxide (SO2) and Nitrogen Oxide (NO2) obtained from sampling were compared to the occupational health and safety standards or exposure limits. The mean concentration of NO2 and SO2 were all below the prescribed WHO and OSHA standards of 200 µg/m3 one-hour mean and 500 µg/m3 ten minutes mean respectively. Meaning that chances of prolonged exposure are very limited, also taking into consideration that the stove is efficient and reduces cooking to approximately 30 minutes when compared to traditional-open fire cooking stoves, which used more wood and less energy efficient. Also, the concentration of pollutants in the ambient environment decrease drastically within 15 minutes of residual testing up to zero ambient pollutant concentration at some site. This may be due to wood ventilation which allows for effective diffusion dilution and dispersion of pollution from the source. The average concentrations of gases recorded at the chimney were are at least 20 times more concentrated than the ambient air quality. The mean average concentrations for Open Fire were at least 2 times higher than the ambient air quality. This, therefore, signifies the importance of the chimney in directing combustion emission from the ambient environment and reducing human exposure to hazardous gaseous pollutants. The NO2 mean concentration for the four tested stoves ranged between 0.1 ppm and 2.7 ppm. While the NO2 average concentration for open fire was 0.4 ppm. The highest mean concentration for SO2 was 22 ppm from phase 2 ambient air sampling at Saili, whilst the lowest was ppm at 1.7 ppm at Lichaba. Whilst the mean concentration from the Open Fire (Hot start measurement) was 4.8 ppm. The combined average concentration of NO2 and SO2 emission from all four stoves tested was 0.22 ppm and 4.98 ppm respectively. The NO2 average was slightly lower than that hot start open fire measurement (with mean concentration was 0.38) ppm whereas SO2 mean concentration was 4.75 ppm. Comparing the Hot-start mean concentration for Open Fire and Elephant Cook Stove all pollutant concentration for the energy efficient stove were zero, except for CO2 whose concentration was 0.03%. This signifies (although not statistically affirmed) that the exposure from the Elephant Cook Stove is lower than that of traditional open fire cooking. Also judging by the fact that the stove uses less wood, less cooking time and concentrate the heat to ensure efficient combustion.* ***Thus the stove has a potential to contribute to preserving both environmental and human health***.

Sulphur dioxide was the primary gas measured at all stoves. The SO2 is known as an indicator pollutant, meaning that its presence in a sample may indicate

the presence of other pollutants such as particulate matter (carbon soot), carbon monoxide amongst others. Also, its exceedance of exposure limits may also be used as a general assumption that other pollutants in the air are also in excess. Therefore, based on SO2 mean concentration, a general assumption can be made that the concentration of other pollutants such as particulate matter and carbon monoxide are generally low. Although their concentration could not be qualified in this assessment, their emission could have further explained the issue of emission from the cook stove and their health implications.



Beneficiary at Mayana, Kavango East region showing off his constructed and functional Elephant Cook Stove

III. Challenges/Opportunities

The design and integration of the energy efficient stove in the target communities was part of a bigger project on the Climate Change Mitigation Initiatives, aimed at promoting the use of renewable forms of energy and energy efficient technologies in rural communities. Integrating all components into a unique objective diverted the impact into different elements. While this activity had a huge impact, efforts were needed in all targets of the project. Therefore the funding aspect of the activity was majorly for the design and construction of the efficient cook stoves and did not include the scientific research component associated with the long use of the cook stove in terms of optimization, flexibility, durability, user friendliness and adaptation for use in other environment. The cascade construction of the stove is resulting into a multiplier effects and it goes beyond the control of the red cross volunteers which cannot monitor the proper construction of the stove which either follows the direction guided in the manual or it may result in risk not only for not achieving the efficiency expected but to have severe consequences on health and burns. It has become imperative opportunity that research is conducted on the cook stoves to carter for priority issues of concern that haven not been covered in the project hitherto to address among others:

- Re-design and improve on existing wood stove model for wider user-friendly.
- Evaluate alternative biomass energy sources for cost effectiveness and high energy generation.
- Investigate the composition of gaseous emission from the biomasses for environmental and human health consideration.
- Conduct a pilot study of the developed and redesigned stove in the laboratory and rural settings.
- Explore copyright/patent pathway of the design for commercial and job creation potentials for rural dwellers.

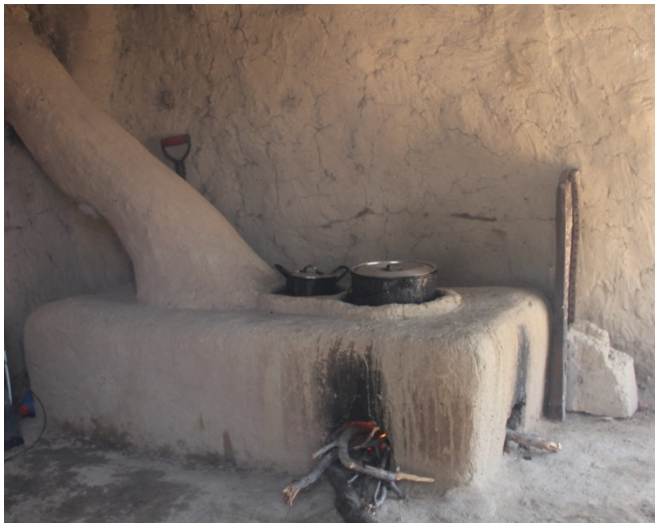
IV. Impact

Impact of the solar-irrigation system was assessed using a set of different criteria that gave evidences on how the intervention benefited the target population:

- Environmental outcomes
- Economic/social outcomes
- Technical outcomes
- Institution building potential
- Project sustainability
- Dissemination/replication potential.

Main highlights of the results of the assessment shows the relevance of the impact on the economic and social criteria beyond the environmental one as the access to efficient cooking contributed to improve access to and participation of rural children in education as a main impact. Children, as well as women, are responsible for collection of wood for the

conventional three-stone cooking fire. With the adoption of the Elephant Cook Stove less time is needed for energy sourcing. Secondly, women are engaged in more income generating activities as time dedicated to collect firewood and cooking have been reduced drastically. The use of the improved cooking stove also reduced health related issues pertaining to emissions associated with open fire cooking in rural households. The firewood at Northern Communal Areas in Namibia is either collected in the local environment or sold at the local market within the community. Since the fire wood is being used largely by the population, it has effects to the community by causing deforestation, global warming and emission of unknown toxic gases to the terrestrial environment. This has harmful affected to the inhabitants. Integrating the Elephant Cook Stove versus traditional 3 stones fires have a crucial environmental friendly impact contributing to mitigate the negative effects on climate change. There is also a positive impact on the institution building potential as bringing the technical expertise of a research institution as the NUST upgraded the approach and the consideration on the importance of counting with the local available expertise to build synergies that address a common objective. Namibia Red Cross Society is a community based organisation with a limited knowledge on the renewable energy and energy efficiency sector, NEI-NUST is a research organisation with a limited access to communities. The combination was perfect to integrate both components, access to communities and integration of energy efficient technologies which without differing from the traditional practices, contribute to mitigate the negative effects of climate change.



Elephant Cook Stove fully constructed and operational at Saili, Zambezi region

V. Lessons Learnt

Lessons learnt of this activity are based on experience, in a manner that facilitates the use in future areas and applications. Special attention was given to the fact that the communities were closely involved and the stoves are made utilising affordable, locally available resources with simple moulds. Lessons learned from similar projects in Zimbabwe was the starting point as it showed that local technology developed using local materials appeared to be highly successful. This is a result of the good coordination and synergies of Red Cross National Societies facilitating the exchange mechanisms to upgrade the capacity building and unity at it is own. A duly coordination mechanism among Zimbabwe Red Cross Society, Namibia Red Cross Society, Spanish Red Cross Society and the Namibia Energy Institute-Namibia University of Science and Technology, the communities and local stakeholders facilitated the perfect combination to reach the goal of integrating energy efficient technologies into rural communities in Namibia. Experiences from Zimbabwe showed evidences of the efficiency of the stove based on testimonies of the beneficiaries but it was not tested or proved technically. NEI-NUST, studies and assessments reaffirm academically the evidences provided by beneficiaries. There was no need to design a well organised dissemination and replication plan, the acceptance at the community level is so high that neighbouring villages, constituency offices, regional governments and organisations are requesting Namibia Red Cross Society to conduct demo stove constructions so it can be replicated everywhere.

VI. Conclusions/The way forward

The intervention has the potential to be replicated due to the following facts; the first one is the huge number of trained and capacitated Red Cross volunteers in the ground able to support and facilitate the construction of Elephant Cook Stove in their vicinity. There is also an income generating component. The stove was designed to be constructed at zero cost for communities; it does not imply that community members that can afford the stove to be constructed on their behalf could count with the assistance of some volunteers or community members at a cost. Secondly, a number of selected volunteers and community members from both Zambezi and Kavango (East and West) were deployed to Windhoek to provide testimonies at the Final Conference of the Project and to construct an Elephant Cook Stove at the outside area of the NEI-NUST to allow the university to continue the research, improve and adapt the stove to different environments and test different combustion material. The commitment of local authorities of replicating the model is their agenda and the Manual for Construction, available in English, Silozi and Rukwangali, contribute to facilitate it.