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Measuring the impact of low carbon technologies and products on domestic fuel consumption

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ABSTRACT

With financial assistance from the U.S. Environmental Protection Agency (EPA), BACIP implemented a project on the "Promotion of Market-Based Mechanism for Adoption and Replication of Energy Efficient and Home Improvement Products and Technologies in Northern Pakistan". This project was aimed at improving the socio-economic and environmental well-being of poor communities inhabited in Gilgit Baltistan and Chitral, Pakistan. These products mainly include including Energy Efficient Stoves (EES), Water Warming Facilities (WWF), Roof Hatch Windows (RHW), Floor Insulation (PE Foam), Double Glazed Windows (DGW) and Wall Insulation Techniques (WIT).

Kitchen Performance Test (KPT) [1–3] was carried out in 40 households of 18 villages at altitudes ranging from 6000 ft to 13,000 ft. using paired sample method. KPT was consist of the collection of baseline data, firewood monitoring through developing inventories and recording the daily wood consumption and consumer satisfaction survey to collect the feedback on the efficiency of the installed products from the households. The Kitchen Performance Test results show plausible reduction in the consumption of fuel wood that varies due to product type and altitude of the village. Floor Insulation, installed in 15 houses show 29% reduction in fuel wood consumption. Similarly with the help of RHW and WWF, firewood acna be saved 32% and 28% respectively. Altitude wise the daily wood savings are 31% at 6000 ft. and 29% at 8000 and 9000 ft. To meet the Firewood requirement, the main fuel of all households, 50% households chopped down yearly 1–2 trees, 19% 3–4 and remaining 50% chopped down 5+ trees yearly. The wall in 50% households is built with cement, which has a high coefficient of heat loss and cold transmission resulting in high amount of firewood to be used for heating the house. Indoor smoke and air pollution is another issues identified during the test, which shows that 95% households get smoke while cooking in winters. This contributes to heat loss since doors are kept open during cooking. This study concludes that there is substantial reduction in Firewood consumption due to BACIP EE & HI products. Firewood is the second highest expenditure followed by food in the region.

1. Introduction

Like other rural areas of Pakistan, the Gilgit Baltistan region that contains some of the remotest and highest-altitude settlements in Pakistan, face a chilly six-month winter season, is stricken by poverty, limited employment opportunities, and poor access to markets. Throughout the winter households in the region are restricted one room in the house, huddling around wood-burning stoves to withstand with the below zero (0 °C) temperature. The level of poverty can be witnessed from the living and housing conditions which are cold, dark, damp, dusty, smoky, non-ventilated, unhygienic, structurally unstable and congested. The unhygienic indoor environment of the houses severely harms the health people in the Northern Areas, as most of their time is spent indoors, particularly in winter. The elderly, disabled persons, women and children are most severely affected. Pneumonia, acute respiratory infection, eye infection (BACIP 2009), joint pains and diarrhea/dysentery are among the common health issues associated with the poor housing and living environment.

The Building and Construction Improvement Program (BACIP) of Aga Khan Planning and Building Service, Pakistan (AKPBS,P) since 1997, is working closely with mountain communities in the region, to improve their living conditions by introducing a variety of appropriate Energy Efficient and Housing Improvement (EE & HI) products, including Energy Efficient Stoves (EES), Water Warming Facilities (WWF), Roof Hatch Windows (RHW), Floor Insulation (PE

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Foam), Double Glazed Windows (DGW) and Wall Insulation Techniques (WIT). Internal and external reports show that these products have significantly contributed to improved quality of life. Along with the social and environmental impacts these products have alleviated health conditions of families, particularly of women and children, which were caused by the poor living environment of the houses. *BACIP Products' benefits are: 50 % reduction in fuel-wood purchase costs (about $ 40/year), 25 % reduction in health bills, 50 % reduction in house repair expenditures, 50 % reduction in smoke related diseases, and a reduction in women's and children's workload.*

The firewood practice and structure of the cooking area from space and constructional point of view is not alike across different regions. Open fires are in the majority in some regions while closed muddy and iron stoves predominate in others. For example, in Hunza region, along with cooking and heating the stove is also used for baking bread in the ash. In Ishkoman region there are still households where an open fire system exists using a traditional stove made up of mud and stone known as a *Dildung* (open fire). During the summer in some regions, a temporary kitchen is established. In winters the majority of the household members – an average of 8.5 people per household – live together in the traditional house, a common place that is used for cooking, dining and living purposes. In all seasons, wood is the dominant fuel for all domestic activities. *Open fire cooking and heating practices using biomass, which is the norm in the region, result in high fuel-lighting costs (highest expenditure after food) and smoke-related diseases (most prevalent health problem* [4]*).*

With financial assistance from the U.S. Environmental Protection Agency (EPA), BACIP is implementing a project on the "Promotion of Market-Based Mechanism for Adoption and Replication of Energy Efficient and Home Improvement Products and Technologies in Northern Pakistan." The project aims to improve the socio-economic and environmental well-being of poor communities in Northern Pakistan. The specific objectives include; disseminate proven BACIP EE&HI products and technologies more widely throughout the target area, establish a business enterprise and improve the efficient value chain to support entrepreneurs, artisans and other involved in marketing, distributing and selling BACIP EE&HI products on a market-driven and commercially viable basis, increase household energy efficiency, and decrease the incidence of environment-related health conditions (i.e. Acute Respiratory Infection, pneumonia etc.).

This report includes results of a Kitchen Performance Test (KPT) carried out in 40 households in 18 villages at altitudes ranging from 6000 ft to 13,000 ft. The objectives were to determine the effects of stoves and energy efficient interventions on household fuel consumption and to find out the qualitative aspects of BACIP Energy Efficient and House Improvement (EE&HI) products' performance. Some of the high impact products of BACIP include:

Fuel Efficient Stove (FES): The stoves replaced traditional three-stone open hearths reducing smoke emission and fuel wood use.

Floor Insulation (FI): Floor insulation has been encouraged in project households. People traditionally sit directly on their cement floors. BACIP has been successfully introducing P.E. foam in the villages as an effective option for floor insulation.

Roof Hatch Window (RHW): RHW was developed by BACIP as a needed improvement, replaces the opening in the center of the ceiling of the traditional houses. It improves brightness in the house, sustains the internal heat, and protects the house from the dust.

Water Warming Facility (WWF) and Fuel Efficient Stove: To facilitate domestic firewood savings, BACIP designed a Water Warming Facility (WWF) connected to the FES. This helps in heating the water on the same amount of firewood consumed for cooking purpose. This is one of the best-selling BACIP products due to its efficiency and usefulness.

2. Methodology

Randomly sampling of 40 households from Gilgit, Ghizer and Hunza Nagar districts, altitudes ranging from 6000 ft to 13,000 ft and with a different cultural contexts, households' consents for KPT, collection of baseline information on family size, income and expenditure levels, firewood practices, sources of Firewood and consumption, water and sanitation facilities and practices and effects of poor living environment on health. Firewood inventories at each house were developed to keep the records of daily wood consumption by household in both pre and post-intervention scenarios. BACIP EE & HI products were placed or installed in the houses monitoring and recording daily firewood consumption. For this purpose one of the literate family members was given training on weighing firewood and maintaining the records. As a token of appreciation for the households to take part in the test, the EE&HI products were provided to the households at 50% of the original price of the products. At the end consumer satisfaction survey consisting of both open- and close-ended questions for household representatives was conducted on the effectiveness of the products.

3. Results

3.1. Socio-economic condition of households

The baseline data shows that the total population of the 40 households is 409 (average family size of 10.4). Out of the total population 206 are male and 203 are female. Out of the 40 households, in 25 (63%) households at least one family member is gainfully employed and rest of 25% has no anyone in the family who is engaged in any employment. Out of the total households (30) that have any gainfully employed member; 67% have 1–2, 27% have 3–4 and 6% households have 5–6 members with gainful employment. The 37% households without employment depend on subsistence farming for their living. The data shows that average monthly income is PKR 15013/Household (USD 179) with an average family size of 10.4. The data shows that 29% of households have income ranging from PKR 1200 to 5000, for a per capita monthly income of PKR 300 (USD 3.50).

The data reveals that for 37% of the families consider farming is their basic source of income while 31% families have a permanent employment source which is their basic source of income. Those households for whom agriculture is the basic source of income, majority (66%) grow mainly potato which is considered as the key cash crop of the region. Similarly wheat comes next to potato which is also grown to earn some amount for the family. Among the fruits, apples and apricots (44% for each) also support the families to earn some amount while selling them in markets. The earning that comes from agriculture starts from PKR: 2000 – above 10,001 monthly for these households and average income from agriculture for these households is PKR: 13,000. As far as health related status of study houses is concerned, the data shows that during last 12 months families have suffered from various diseases associated with poor indoor conditions (cold, dark, damp, dusty). 54% houses reported having cough and cold, 21% stated having rheumatism, 18% reported acute respiratory infection (ARI), and 5% complained about eye irritation and diseases. Fig. 1 gives the details.

When the respondents were inquired about the negative effects of smoke, cold and dust on them and their children, 97% agreed that it does affect them. 60% reported that dust and cold cause cough and cold, 33% reported it causes Rheumatism while 6% reported that it causes ARI related diseases. Table 1 portrays the smoke-related diseases identified by the respondents that affect them and their children.