Renewable Energy Micro-Financing in Rural Communities of Pakistan

By

Warda Ajaz

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Supervised by

Dr. Parvez Akhter

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Center for Energy Systems (CES)

National University of Sciences and Technology (NUST)

H-12, Islamabad 44000, Pakistan

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Certificate

This is to certify that work in this thesis has been carried out by **Ms. Warda Ajaz** and completed under my supervision in Centre for Energy Systems, National University of Sciences and Technology, H-12, Islamabad, Pakistan.

Supervisor: _____

Dr. Parvez Akhter
Centre for Energy Systems
NUST, Islamabad

GEC member # 1: _____

Dr. Zuhair S Khan
Centre for Energy Systems
NUST, Islamabad

GEC member # 2: _____

Dr. Faisal Jamil
School of Social Sciences and Humanities
NUST, Islamabad

GEC member # 3: _____

Dr. Ehsan Ali
Centre for Energy Systems
NUST, Islamabad

HoD-CES _____

Dr. Zuhair S Khan
Centre for Energy Systems
NUST, Islamabad

Principal/ Dean _____

Dr. M. Bilal Khan
Centre for Energy Systems
NUST, Islamabad

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List of Abbreviations

FINCA	Foundation for International Community Assistance
IDCOL	Infrastructure Development Company Ltd.
IEA	International Energy Agency
MDGs	Millennium Development Goals
MFI	Microfinance Institute
NGO	Non-Governmental Organization
NREL	National Renewable Energy Laboratory
PV	Photovoltaic
SBP	State bank of Pakistan
SEEDS	Sarvodaya Economic Enterprise Development Services
SHS	Solar Home System
SPSS	Statistical Package for the Social Sciences
WB	World Bank
WHO	World Health Organization

Journals/Conference Papers

W. Ajaz and Dr. Parvez Akhter, **"SHS Micro financing in On-Grid Rural Areas of Pakistan – What, Why, How!",** International Journal of Green Energy, Taylor & Francis Publishing. (Submitted)

(Attached as Annex C)

Abstract

In the twenty-first century, one of the utmost requirements for development and poverty reduction is energy. Yet, more than 1.6 billion people around the world do not enjoy access to modern energy. While providing access to energy for all has been the top priority of the governments around the world, it requires an extensive amount of capital and resources to achieve this goal. This is why in many developing countries including Bangladesh, India and Sri Lanka, this unmet need is being greatly fulfilled through renewable energy micro financing. However, in Pakistan, in spite of the ever worsening energy sector situation, this avenue remains largely untapped. In this context, this study aims to explore the prospects of renewable energy micro financing in rural communities of Pakistan. The study has followed different methodologies at various stages. Firstly, a specialized demand assessment questionnaire was prepared for conducting household surveys in a selected case study village. All 156 households from the case study village were surveyed and the results analyzed through Statistical Package for the Social Sciences (SPSS). The survey results established that majority of the households are willing to take micro-loans for switching to renewable energy technologies. However, most of them showed their reservations about the element of interest-rate in conventional microfinance and emphasized that the proposed micro-loan should be based on Islamic principles. Moreover, considering the locally available resources and the preferences of the survey respondents, it was assessed that solar home system is the most feasible renewable energy technology for the households. Subsequently, solar home systems sizing, designing, economic and environmental costing has been conducted through RETScreen simulation software and 3 different sized packages have been proposed for catering the needs of lower, middle and higher income households in the village. Since One-Hand model is currently the most successful implementation model for renewable energy microfinancing in the developing world, and Diminishing Musharakah financial model currently holds the largest share in Islamic finance industry of Pakistan, the study concludes that an interest-free renewable energy microfinance model established on the Islamic finance concept of Diminishing Musharakah and implemented under One-Hand Model is the most viable option for Pakistan.

Keywords: Renewable Energy, Microfinance, Musharakah, Solar Home System, Energy Poverty

Chapter 1

Introduction

In the twenty-first century, one of the utmost requirements for development and poverty reduction is energy [1, 2, 3, 4, 5]. Various studies and historical evidence suggest that access to energy holds a pivotal role in the development of any country and no country has ever achieved significant poverty alleviation without improving energy access for the inhabitants [4].

Yet, more than 1.6 billion people around the world do not enjoy access to modern energy services [6] and the majority of those lying on the lowest rung of the energy ladder lives in rural area [7,8]. On one hand, this employs impeded "opportunities for economic development [9]" while on the other hand, presents a serious hurdle in achieving the most important Millennium Development Goals (MDGs) of reducing energy poverty, improving access to clean water and sanitation facilities and enhancing education and health services [10].

However, providing energy access to the whole population requires huge amount of capital and resources, which in case of most developing countries is almost impossible to mobilize [11]. According to the statistics from the International Energy Agency (IEA), around USD 9.1billion were invested worldwide in 2009 for expanding energy access and this investment must increase to USD 48 billion a year in order to achieve universal access to modern energy services by the year 2030[6]. If seen in comparison to the global energy expenditures, this amount equals to only 3% of what the world spends on energy services per year. Nevertheless, especially in case of developing countries, mobilizing such huge amount of financial resources should not be under-estimated.

Considering the inadequate availability of public monetary resources for improving energy access, catalyzing private finance for serving the purpose seems to be the only viable option [12]. One of the most promising avenue in this regard is micro financing, which has shown great potential for enhancing access to modern energy services in many developing countries including Bangladesh, India, Nepal, and Sri Lanka.

Pakistan, located at a prime location in South Asia, enjoys enormous renewable energy resources including solar, wind, microhydro and biomass. Still, access to energy has been a contentious issue for Pakistan since decades. As per the IEA statistics, only 67% population of Pakistan has a grid-supplied electricity connection and around 93% of those reside in urban areas [13]. And even for those who do have access to the grid, the connection is unreliable, as generation is overwhelmed by supply and so power outages are common. Moreover, polluting fuels such as kerosene or mustard oil are widely used for lighting in homes and as many as 64% people use biomass for cooking[13]. The result is manifold; overall economic development is restrained, poor population cannot access their basic needs, and natural resources and the environment is depleted due to the use of traditional fuels.

Unfortunately, in spite of having the success stories of renewable energy micro financing in neighboring countries like Bangladesh, India and Nepal, there is no prominent renewable energy Microfinance scheme, offered by the government, NGOs, MFIs or banks.

In this context, this research study has been designed with the aim of assessing the social and economic feasibility of introducing renewable energy micro financing mechanisms in rural communities of Pakistan.

The study has been designed with the following main objectives:

1. To assess the social and economic feasibility of introducing renewable energy micro financing in rural communities of Pakistan, through household surveys in the selected case study village.
2. Based on the survey results, propose the most feasible renewable energy technology (ies) and/or appliance(s) to be Microfinanced.
3. To analyze different microfinance models in terms of their replicability in Pakistan

Moreover, the time and financial constraints of the study prompted the administration of certain limitations. Therefore, the scope of study was defined with the following points in mind:

1. The scope of this research is limited to consumer perceptions on renewable energy micro financing in a remote, on-grid village ‘Jajja’, located in the union

council Manghot, Tehsil Gujjar Khan, District Rawalpindi. The village is located at the Mandrah-Chakwal road, at a distance of 20 kilometers from Mandrah. (Around 70 kilometers from NUST).

2. A review of literature reveals that several studies focused on Renewable energy technology adoption have used 'Willingness to pay' as a primary element in assessing demand or feasibility of products and interventions, with demographic factors, baseline energy consumption trends and ability to pay being complementary information [14, 15, 16, 17]. Therefore, feasibility of renewable energy micro-financing in this study has been be assessed in terms of:
    a. Demographic factors
    b. Energy usage and consumption behaviors
    c. Ability to pay
    d. Willingness to pay
3. It is expected that the results of this study will be applicable on the average rural communities of Pakistan, as the living conditions and the perceptions of the people are similar.

The thesis has been structured according to the following framework:

Chapter 2 provides an elaborate review of the literature on various dimensions of energy access, need for renewable energy technologies, micro financing and its prospects in enhancing access to energy services in the whole developing world in general and in Pakistan in particular. Chapter 3 establishes a baseline of the available methodologies and defines the methodologies which have been adopted for various sections of this study. Chapter 4 discusses the statistical results of the household survey in detail and draws conclusion for the technology and microfinance model design. Chapter 5 deduces typical energy load profile based on the results of households survey and elaborates the recommended renewable energy technology design. Chapter 6 explains the recommended micro loan design and the microfinance model design, based on the outcomes of the study. Chapter 7 outlines conclusions of the whole study and outlines recommendations based on the findings of this study.

A flow chart outlining the activities conducted within the scope of this study are shown in the *Figure 1.*

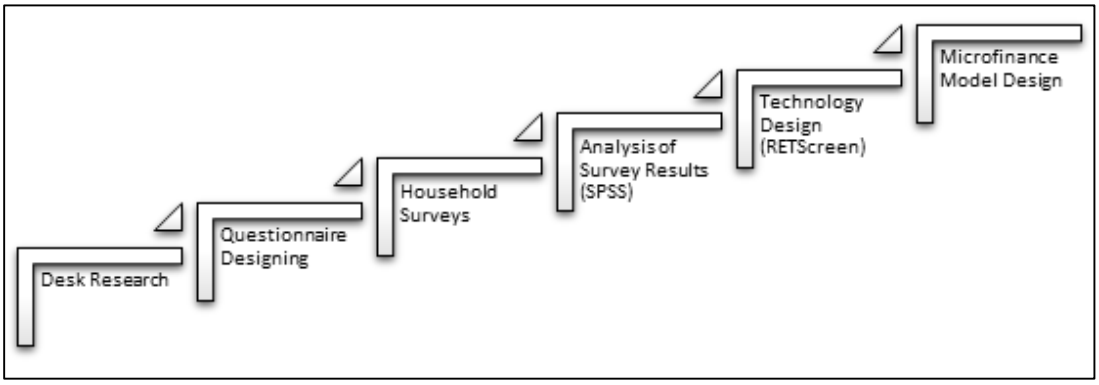

FIGURE 1: PROJECT METHODOLOGY

Summary

In the twenty-first century, one of the utmost requirements for development and poverty reduction is energy [1, 2, 3, 4, 5]. Yet, more than 1.6 billion people around the world do not enjoy access to modern energy services [6] and the majority of those lying on the lowest rung of the energy ladder lives in rural area [7, 8].

However, providing energy access to the whole population requires huge amount of capital and resources, which in case of most developing countries is almost impossible to mobilize [11]. Considering the inadequate availability of public monetary resources for improving energy access, catalyzing private finance for serving the purpose seems to be the only viable option [12]. One of the most promising avenue in this regard is micro financing, which has shown great potential for enhancing access to modern energy services in many developing countries including Bangladesh, India, Nepal, and Sri Lanka.

Nevertheless, In spite of all these success stories, Unfortunately in Pakistan, there is no prominent renewable energy Microfinance scheme, offered by the government, NGOs, MFIs or banks. In this context, this research study has been designed with the aim of assessing the social and economic feasibility of introducing renewable energy micro financing mechanism in rural communities of Pakistan.

The study has been designed with the following main objectives:

1. To assess the social and economic feasibility of introducing renewable energy micro financing in rural communities of Pakistan, through household surveys in the selected case study village.
2. Based on the survey results, propose the most feasible renewable energy technology (ies) and/or appliance(s) to be Microfinanced.
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Chapter 2

Literature Review

This chapter establishes a baseline for the study by providing a review of relevant literature.

2.1. Sustainable Energy Access

Energy poverty is one of the biggest challenges of the twenty first century. Today, more than 1.6 billion people around the world lack access to the modern energy services like electricity connection in their homes. Moreover, around 2.7 billion are those who depend on biomass for lighting, cooking and space heating purposes [1]. On one hand, the extensive use of biomass is causing far-reaching damage to the health of the 'energy poor' population [2]. While on the other hand, the experience economic consequences of inadequate energy supply for productive uses [3].

It has also been established that most of the energy poor belong to the rural communities. As of 2011, the rural electrification rate in developing countries was only 65.1%, with an individual rate of 28%% in Africa and 75%% in Developing Asia, while the urban electrification rate in these areas was recorded to be as high as 90.6% [4].

Various studies have pointed towards the connection between access to energy and human social and economic development. A study by Hosier [5] confirmed that there exists a positive relationship between energy consumption and household income in the developing nations. A study by Khandker [6] concludes that rural electrification in Bangladesh has brought considerable positive impacts on the community development such as increased in income, better educational outcomes etc. Another study by Dinkelmann [7] stated that increased access to electricity in South Africa positively impacted the female employment rates. However, the current large scale of energy poverty across the globe is retraining the economic and social growth of billions of people, making it difficult to achieve the Millennium Development Goals (MDGs) [8,9,10,11,12].

It is also worth mentioning here that while increasing the pace of providing access to energy to all is crucial, it is also equally important that this progress remains in the boundaries of sustainable development. Especially with climate change presenting itself as a huge challenge, it is extremely important to see access to modern energy services and climate change mitigation as twin challenges [13, 14, 15, 16]. With the increased economic viability of off –grid renewable energy technologies like Solar Home System (SHS), various studies have concluded that expanding the use of renewable energy sources is the most practical solution, for catering to the twin challenges of universal energy access and climate change mitigation [17,18,19,20,21]. The promotion of renewable energy technologies in developing countries does not only avoid lock-in into high carbon infrastructure but also reduces their vulnerability from fossil fuel import and price changes [8, 18, 16].

Realizing the importance of this issue, the United Nations launched the 'Sustainable Energy for All' initiative, with the aim for achieving universal energy access by the year 2030[11]. Nevertheless, considering the current practices it is estimated that by 2030, around 1.4 billion people will still lack access to electricity services, with most of them belonging to sub Saharan Africa and South Asia [1]. It is also predicted that the current figure of 2.4 billion people relying on biomass for cooking and heating will rise to 2.8 billion by 2030. On top of that, the global energy demand is also expected to double, with most of it contributed by the developing world [11].

2.2. Financing for Universal Access to Modern Energy Services

As per the statistics from the International Energy Agency (IEA), approximately USD 9.1 billion were spent globally in the year 2009 for improving access to modern energy services. Of this amount, only $70million were spent for providing improved biomass cook stoves to around 7 million people, while the remaining amount was used in electrification for about 20 million people. IEA also predicts that in order to meet the 2030 target, this amount must increase five folds to around USD 48 billion per year [1]. Although this amount is not more than 3% of what the world already spends on energy services, mobilizing such huge amount of funds is not an easy task [22]. Therefore, an unprecedented level of effort and investment will be required to fulfill the target of achieving universal access to modern sustainable energy services by 2030[13]. To add to this, the case studies of various developing countries have shown that government investments and public funding is almost always insufficient to

provide sustainable energy access to the whole population. Therefore, mobilizing private financial resources is the need of the hour [23].

In this regard, various energy markets, especially in developing countries, are opening doors to private sector however, the high initial cost of renewable energy technologies hinders the way of progress in this avenue [3]. In fact, many recent studies have discussed that while micro level renewable energy projects face various financial and economic barriers, the most important and most deciding barrier is the high capital cost which makes it appear less attractive than the traditional energy projects [3, 24, 25]. With the per energy unit cost of renewable energy technologies declining at a rapid pace, they are becoming more and more competitive with the traditional fossil fuel based solutions [22]. However, the upfront cost of the decentralized energy systems is expected to remain as a major chunk of the total life cycle cost and hence the main bottleneck for achieving the goal of universal access to the modern energy services [22].

In order to address the issue of high upfront cost of renewable energy technologies, various market driven market models have been proposed in the literature, [22, 13, 26, 27]. Some of the most common models are:

1. Dealer/supplier credit-based sales.
2. Consumer credit through commercial bank.
3. Consumer credit through microfinance institutions.
4. Fee for service
5. Revolving fund credit schemes operated by public sector

However, at micro level, or to be precise village or household level, many studies have concluded that one of the most promising ways for mobilizing the funds for enhancing sustainable energy access could be the end-user energy micro financing, which can overcome the barrier of access to finance to the energy poor population [28, 29, 30, 31, 32, 33].

2.3. Renewable Energy Micro Financing

Microfinance is a development tool which provides access to credit for people "living in poverty who are not considered bankable" by the commercial banking sector due to a lack of collateral, steady employment or a verifiable credit history [34].

The pioneer and most celebrated Microfinance mechanism was introduced during 1974-1975 by Dr. Muhammad Yunus, in the form of the Grameen Bank, Bangladesh [35].

Microfinancing is considered to be an important intervention in poverty alleviation as it overcomes several informational, institutional and other barriers which otherwise limit the access to finance for the poor population [36]. The innovative approaches like social sanctions including loan guarantors, group lending, gathering information from neighbors, friends and family etc. substitute the need for collateral and hence in contrast to formal banks, allow the microfinance institutions to offers low loan transaction costs [37,38,39].

With the advancements in the global micro finance industry, it acknowledged the fact that the financial needs of poor are not limited to small business loans only. Therefore, gradually with time, the micro finance industry shifted from exclusively providing micro loans to entrepreneurs to a diverse range of financial services including but not limited to investments in education and health, insurance, savings etc. [40, 39]. Other major diversifications in the micro finance industry products are the quality of life loans which are aimed at non-income generating loans for housing and other goods and Micro-Loans for energy systems [41, 42].

The introduction of energy loans by micro finance sector, particularly for renewable energy technologies, has been widely appreciated in literature. This is because on one hand, it addresses one of the most challenging barrier for energy access by providing financial resources to the poor people [8, 31, 32, 42, 43]. On the other hand, the micro renewable energy micro finance has the capability of addressing the inter-related challenges of climate change and development, simultaneously [32, 44].

In the past, many studies have discussed the role of financing, especially micro financing in expanding access to energy services. For example [45] and [42] discuss the opportunities offered by the intergeneration of energy and micro financing. While some other studies [46, 23, 26, 31, 32, 33, 47, 48, 49] analyze the existing projects on energy micro financing and discuss the experience of micro financing institutes giving energy loans. These and many other related studies concluded that the microfinance institutes are the potential ‘key players’ [44] in enhancing micro energy access since

they have the required infrastructure, credibility, clientele as well as expertise to penetrate into the scattered rural markets [22].

Realizing the urgent need for enhancing energy access, especially rural energy access, and potential of micro financing for catering to it, many developing countries have started energy microfinance programs based on varied end-user energy microfinance models. Two most popular of them are [50]:

2.3.1.One Hand Model

This model, created by Grameen Shakti which is a subsidiary of Grameen Bank Bangladesh, follows a one-hand delivery mechanism. The basic concept is that in the regions where the energy provides are not available or are not interested in getting involved in microfinance schemes, the microfinance institute can build its capacities and offer energy products along with micro loans. This can be done either by forming specialized technical departments within the institute or establishing subsidiaries specializing in energy products.

While this model enjoys the perks of its simplicity, cost effectiveness and standardized solutions, there are many challenges that come along the way. The MFIs have to handle all parts of the schemes themselves including product installation, maintenance, end-user training, money collection etc.

2.3.1.1.Grameen Shakti Model

In spite of its drawbacks, this model has made Grameen Shakti (GS), Bangladesh, one of the fastest growing and largest renewable energy micro financing companies in the world. The success of their energy micro financing model can be assessed by the fact that they install on average 75,999 new solar home systems every month and till 2013, they had installed more than 2.2 million solar home systems [51, 52].

Grameen Shakti is a subsidiary of Grameen Bank, conceptualized by the noble Laureate Dr. Muhammad Yunus in 1976. The Grameen Bank aims to provide access to finance for the rural poor, with a special focus of women development. It works through a network of branches spread across the rural areas of Bangladesh. Each branch is run by a branch manager and several Centre managers which represent around 15 to 20 villages [53].

Currently, Grameen Shakti is offering the following financial packages for SHS purchase to the borrowers [51]:

- ✓ Model 1: The borrower is required to pay 15% of the system price as upfront payment. The remaining 85% can be re-paid in 36 monthly installments with a flat rate service charges (interest rate) of 6%.
- ✓ Model 2: The borrower is required to pay 25% of the system price as upfront payment. The remaining 75% can be re-paid in 24 monthly installments with a flat rate service charges (interest rate) of 4%.

The successful experience of Grameen Shakti has prompted many other organizations to adopt this model. One of the most notable example in this regard is of the Infrastructure Development Company Ltd. (IDCOL) project Bangladesh where the World Bank selected the Grameen Shakti model to enhance mass access to renewable energy in the country. Today, the SHS program of IDCOL is the largest off-grid electrification program in the world with more than 2.1 million SHS installed till March 2013 across Bangladesh [54, 55, 56].

2.3.2. Two Hand Model

The Two-Hand energy micro financing model involves a partnership between a microfinance institute and an energy service provider. The MFI is responsible for providing micro loan while the partner company takes care of the energy system design, installation, maintenance and end-user training.

This model has its own advantages since both partners remain in their respective core operation field, unlike in one-hand model. However, Two-Hand model is often expensive because each of the two companies charge their costs and profits.

The Two-Hand model is being successfully implemented by the Foundation for International Community Assistance (FINCA) in Uganda [57] and the Sarvodaya Economic Enterprise Development Services Ltd. (SEEDS) in Sri Lanka [58].

2.3.2.1.FINCA Uganda Model

Similarly, In Uganda, (FINCA) offers consumer credit for buying solar home systems. The loans are given at a monthly interest rate of 2.5% with bi-weekly installments requirement. The loan duration is flexible within the range of 4 to 12 months [59].

The two-hand model is employed by setting up and 'energy unit' which is responsible for SHS delivery, installation, maintenance and repair. The FINCA staff on the other hand handles financing, sales and marketing services.

2.3.2.2.SEEDS Model

SEEDS offers micro-loans to the end-users for purchasing SHSs. According to careful statistics, SEEDS financed approximately 80,000 solar home system installations between 1998 and 2010 [60].

However, while there is no denying to the efficiency and wide-spread replicability of these models, all of them are based on interest rates and hence are not Islamic Shariah complaint. In fact, various authors have argued that even though Bangladesh is pre-dominantly a Muslim country and the Grameen model is one of the most celebrated micro financing models in the world, it is not a Shariah compliant model as it charges interest on the loans and pay interest to the shareholders. Even though the bank calculates the interest rate in simple terms and not in the compounded rates, the element of 'Riba' remains [61, 62].

2.4. Prospects of Renewable Energy Micro financing in Pakistan

With only 67% population having a grid supplied electricity connection, only 20% having access to gas pipeline and around 64% depending on traditional biomass fuels for cooking, Pakistan presents a worrisome energy sector situation. Moreover, of those having an electricity connection, 93% is the urban population which means that currently only 7% rural population of Pakistan is connected to national grid [63, 64]. Even for those who do have access to the grid, the connection is unreliable, as generation is overwhelmed by supply, and therefore experience frequent power outages. The result is manifold; overall economic development is restrained, poor population cannot access their basic needs, and natural resources and the environment is depleted due to the use of traditional fuels [65].

The energy crisis of Pakistan has brought serious consequences to the society, economy as well as the environment. The country's power sector is the worst affected as it is plagued by the problems of circular debt, low recovery, old and inefficient distribution network and inappropriate tariffs which are not sufficient to cover the generation costs. In spite of having 23 GW of installed capacity, most of the power plants are running at a very low capacity due to high fuel costs. The results are

alarming; households, businesses and industries face worse power outages which can commonly last from around 12 hours a day in cities to 22 hours a day in the rural areas [66, 67, 68]. Moreover, due to lack of capital, the national village electrification program also had to face restraints, resulting in slowed growth going down from 10.9% in 2009/2010 down to 6.9% in 2011/2012[67].

The indoor burning of kerosene oil, mustard oil, burning gas, wood and dung for cooking and other purposes is also badly affect the air quality and hence causing increase in the risk of respiratory diseases. The World Health Organization (WHO) estimated that every year, more than 56,000 people die in Pakistan due to poor indoor air quality [69].

In addition, the IFAD [70] states that unavailability of lighting in the homes after dark causes certain social impacts. Productive hours are limited due to lack of illumination which does not only affect the adults but also the children's education. Moreover, women are often confined to their homes after sunset as it becomes increasingly unsafe for them to go out in complete darkness. This is one the major reasons why Pakistan holds the lowest rank in South Asia in terms of socio-economic indicators for women's welfare.

The environmental degradation is yet another dimension of Pakistan's poor energy sector situation. With majority of population relying on biomass and polluting fuels like mustard and kerosene oil for cooking and lighting, the International Energy Agency estimates that around 32.6 million tons of carbon dioxide is released every year, solely by the residential sector of Pakistan [63]. Furthermore, the extensive use of biomass also results in alarming rates of deforestation in the country [71]. As of 2007, the country was facing a deforestation rate of 0.75%, the highest in South Asia. It is also estimated that the consequences of such large scale deforestation, such as flooding, soil erosion and siltation is incurring an annual loss of 2.3 billion Rs. [72].

In this scenario, the following measures if taken can address the challenges faced by its energy sector of Pakistan [73].

1. Developing indigenous energy resources to reduce dependence on imported fuel.
2. Securing reliable and affordable sources for importing energy.

3. Reforming and restructuring the electricity sector to make it stand on its feet again.
4. Developing necessary infrastructure for extended distribution network of electricity and gas.
5. Investing in electricity generation infrastructure in order to meet the rapid increase in demand, while ensuring its reliability.
6. Improving energy efficiency to manage the growth in demand

Pakistan is blessed with rich renewable resources, including solar, wind and hydro etc. It has been established that in the South Western province of Baluchistan and North Eastern part of Sindh, the sun shines for around 7 to 8 hours daily, which makes around 2300 to 2700 hours per year. This presents an excellent opportunity for harnessing solar energy and using it to lessen the dependence on imported and non-renewable fuels for energy production [74]. Similarly, wind energy production is also feasible in many areas of Pakistan, especially in a natural corridor between Gharo and Keti Bandar which has the potential to produce 40,000 and 50,000 megawatts of renewable electricity [75].

However, being a Muslim country, the existing interest based models for renewable energy micro financing across the globe do not seem feasible in Pakistan. This can also be verified from the tremendous growth of Islamic finance industry in Pakistan that there is a huge potential and market for interest free Islamic micro financing and it is more likely to penetrate deep into the energy poor population of Pakistan.

The foundations of Islamic finance are based on avoidance of interest based finance, i.e. 'Riba'. In other words, the main goal of Islamic financing is to provide riba-free financial services to the communities [61].

[61] has also provided reference to Imam Fakhruddin Razi's book 'al-Tafsir al-Kabir', where he has mentioned 3 reasons why Riba is prohibited in Islam. Firstly, Riba exploits the borrowers since it makes the lenders better off, at the expense of the poor borrower. Secondly, since the lender knows that he is going to get a certain amount, this might tempt him into relying solely on the income acquired without any hard work and prevent him from making efforts for earning his living. Finally, the practice of Riba can lead to borrowing and squandering and can eliminate the sense of responsibility and feelings of mutual sympathy.

Various authors have pointed out the need, importance and significance of Islamic finance. Studies conducted by [76, 77, 78, 79, 80, 81] concluded that equity financing intrinsically holds better stability than the interest based financing. Khan [82] mentions that the equity and participation based Islamic financing models have many similarities to the banking reform proposals made in USA and many other countries. Another study by Chapra [83] stated that interest based finance generates indiscipline in the market while only equity and risk sharing can bring the stability back. Chapra [84, 85] also mentions that immunity from loss is a fault line in the financial system. [86] maintains," Only a financial system along Islamic principles is immune to instability." A recent study by Askari, H. [87] prompts the policy makers to encourage the equity finance and risk sharing while Shafique [88] concludes that since the Islamic banks performed better than the conventional banks during the recent global financial crisis, this is a sufficient proof that Islamic finance models are more stable.

Broadly, the literature suggests that Islamic microfinance presents the following Shariah compliant financing instruments [61, 89, 90, 91] *(Table 1)*

TABLE 1: ISLAMIC MICROFINANCE INSTRUMENTS

Instrument	Methodology	Suitability
Mudarabah	The MFI provides the capital while the borrower is responsible for managing the capital in the business. In case of loss, the Lender holds full responsibility of financial loss while the borrower faces loss of time and effort.	Suitable for project financing, working capital financing and fixed assets purchases.
Musharakah	MFI and the borrower enter into a partnership agreement where both hold responsibility of financing and managing the venture. In case of loss, the share of loss is divided according to equity of each party.	Suitable for working capital financing, project financing and Fixed assets purchases.
Murabahah	MFI and the borrower sign a sale agreement, with fixed profit margin. Payment can be done as a lump sum or in installment. Being easier and simpler, it is more widely adopted than Mudarabah and Musharakah.	Suitable for working capital financing and fixed assets purchase.

	MFI holds the ownership of the asset and hence is responsible for all risk and liabilities associated with it.	
Ijarah	MFI and the borrower enter into a leasing agreement for a physical asset. The ownership of the asset remains with the lender during the Ijarah period.	Suitable for all kind of income generating physical assets, especially fixed assets.
Qard Hasan	The financer lends money to the borrower with zero nominal return. The main purpose is helping others and charity.	Suitable for all purposes.

Among these instruments, the profit and loss based instruments i.e. Mudarabah and Musharakah, have been most widely encouraged by the scholars and practitioners since they can prove to be most helpful in the socio economic stability and development of Islamic communities [91, 92, 93]. In fact, [94] states that as opposed to conventional microfinance which has been widely criticized for charging high interest rates in its debt-based approaches, the profit and loss sharing modes of Islamic finance offer a more moral approach which saves the borrowers from drowning further into the debt.

Digging into further detail, it is well established in the studies of various authors that a further refined form of Musharakah, called Diminishing Musharakah (Musharakah Mutanaqisah), is the best mechanism for financing assets like house or machinery [61, 95, 96].

As per the recent statistics from the state bank of Pakistan (SBP) [97], the Islamic banking in Pakistan has shown an exponential growth over the past few years, showing the assets of Rs. 1016 billion in the first quarter of fiscal year 2014 as compared to Rs 1014 billion in the last quarter. Moreover, the number of Islamic banking institutions also increased from 19, with 1304 branches, in December 2013 to 20, with 1314 branches, in March 2014. As for the financing trends in the Islamic banking industry of Pakistan, the latest statistics show a decline in Murabahah's share while for the first time, Diminishing Musharakah has acquired the highest share in financing. *(Table 2)*

TABLE 2: SHARE OF VARIOUS ISLAMIC FINANCE MODELS IN PAKISTAN'S ISLAMIC BANKING INDUSTRY

Financing Instruments	Share (billion Rupees)	Share (%)
Murabahah	106.7	33.0
Ijarah	27.1	8.4
Musharakah	27.9	8.6
Mudarabah	0.6	0.2
Diminishing Musharakah (DM)	107.2	33.2
Salam	18.6	5.8
Istisna	19.5	6.0
Qard/Qard-e-Hasan	0.0	0.0
Others	15.5	4.8
Total	323.2	100.0

Moreover, the microfinance sector in Pakistan is also growing at encouraging rates. In the first quarter of 2014, Pakistan's microfinance sector stood at gross loan portfolio of PKR 57,068 Millions, showing an increase of PKR 4,976 Million since the last quarter of 2013. Moreover, during this period, the number of active borrowers in the country also showed an increase of around 5.9%, mounting from 2,832,715 to 2,999,186. The penetration rate in the country also showed an increase of 0.61%, reaching a figure of 10.94%. Trade, agriculture and livestock/poultry remained the 3 biggest sectors representing the percentage of active borrowers as 29%, 23% and 16% respectively [98, 99].

According to a 2012 study conducted by the Pakistan Microfinance Network [100], there is a market for Islamic Microfinancing in Pakistan, with nearly 98% of the 180 million population being Muslim. However, the report states that since the global Islamic micro financing industry itself is in its embryonic stage, the industry in Pakistan will also take some time to reach the level.

Currently, there are various microfinance banks and institutions offering Shariah compliant micro loans to the small and medium enterprises (SMEs) as well as individuals. Although, the trends in the financing provided by banks hint towards the favourability of Diminishing Musharakah, some NGOs and other institutions are offering various other models including Waqf, Qard ul Hassan and Takaful, Salam, but their commercial implementation and sustainability is debatable [100].

Moreover, in spite of some recent developments which show a hope of improvement in situation in the near future, for example in 2010, the International Finance Corporation sponsored a visit of prominent microfinance stakeholder in Pakistan to XacBank in Mongolia and Grameen Shakti in Bangladesh, in order to assess the feasibility of clean energy micro financing in Pakistan[101], a local organization, Buksh Foundation, has announced to initiate a clean energy lending program [102] and in a more recent development, Khushhali bank announced in February 2014 to step in the energy microfinancing sector by joining hands with a local solar home system provider [103], energy micro financing remains a pre-dominantly new and un-tapped avenue in Pakistan.

In this context, this research study has been designed with the aim of assessing the social and economic feasibility of introducing renewable energy micro financing mechanism in rural communities of Pakistan.

Summary

Energy poverty is one of the biggest challenges of the twenty first century. Today, more than 1.6 billion people around the world lack access to the modern energy services like electricity connection in their homes. Moreover, around 2.7 billion are those who depend on biomass for lighting, cooking and space heating purposes [1]. The case studies of various developing countries have shown that government investments and public funding is almost always insufficient to provide sustainable energy access to the whole population. Therefore, mobilizing private financial resources is the need of the hour [23].

One of the most promising ways of overcoming this barrier at micro level, or to be precise village or household level, could be the end-user energy micro financing [28, 29, 30, 31, 32, 33]. Microfinance is a development tool which provides access to credit for people “living in poverty who are not considered bankable” by the commercial banking sector due to a lack of collateral, steady employment or a verifiable credit history [34]. Today there are 2 most popular models for renewable energy microfinancing being implemented in developing countries [50]:

1. One-Hand Model: Being Implemented by Grameen Shakti, Bangladesh [51, 52, 53] and IDCOL, Bangladesh [54, 55, 56].

2. Two-Hand Model: Being Implemented by Foundation for International Community Assistance FINCA, Uganda [59] and SEEDS, Sri Lanka [60].

However, while there is no denying to the efficiency and wide-spread replicability of these models, all of them are based on interest rates and hence are not Islamic Shariah complaint [61, 62].

With only 67% population having a grid supplied electricity connection, only 20% having access to gas pipeline and around 64% depending on traditional biomass fuels for cooking, Pakistan presents a worrisome energy sector situation [63, 64]. Even for those who do have access to the grid, the connection is unreliable, as generation is overwhelmed by supply, and therefore experience frequent power outages [65]. However, In spite of the success stories of renewable energy microfinancing in developing countries, it remains a pre-dominantly new and un-tapped avenue in Pakistan.

On the other hand, according to a 2012 study conducted by the Pakistan Microfinance Network [100], there is a market for Islamic Microfinancing in Pakistan, with nearly 98% of the 180 million population being Muslim. Currently, a refined form of Musharakah called, 'Diminishing Musharakah' holds the biggest share in Pakistan's Islamic Banking Industry [97] and is also most favoured by scholars and practitioners for asset financing [61, 95, 96].

Therefore, a review of existing literature shows that there is a huge potential for exploring diminishing Musharakah model for renewable energy microfinancing in Pakistan.

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Chapter 3

Methodology

This section discusses a review of available methodologies and outlines the specific methodologies used in this study.

3.1. Review of Available Methodologies

A review of literature reveals that several studies focused on Renewable energy technology adoption have used 'Willingness to pay' as a primary element in assessing demand or feasibility of products and interventions, with demographic factors, baseline energy consumption trends and ability to pay being complementary information [1, 2, 3, 4].

Quite naturally, the demographic factors affect an individual's way of living and preferences. Similarly, knowledge of energy usage and consumption behaviors are crucial for developing a baseline energy load profile for appropriate renewable energy technology system designing. The other two parameters, i.e. Ability to pay and Willingness to pay also play an important part while designing microfinance schemes because if the end-user does not, for any reason, pay back the loan, the scheme will not sustain. While the former two parameters are relatively easier to assess, the latter two are quite complicated. Therefore, ability to pay is usually assessed through factors like monthly income and expenses of the households, reliability and frequency of income, savings, wealth and current loans. While willingness to pay is assessed by directly asking their willingness and preferences about the proposed scheme [2, 5, 6].

3.2. Project Methodology

The methodologies followed in this study are explained in the following sub-sections.

3.2.1. Data Collection

As a first step, basic demographic information and statistics were obtained from the Manghot Union Council Office. Based on this information, as well after conducting a through literature search, a specially designed questionnaire was prepared for

obtaining the data required for assessing feasibility of renewable micro financing in the selected case study village.

In accordance with the existing literature, the households survey questionnaire for this study was designed to cover all of these four parameters i.e. Demographic factors, Energy usage and consumption behaviors, Ability to pay and Willingness to pay.

The questionnaire comprised of the following major sections:

1. Personal and Demographic Information
2. Household Income and expenses
3. Basic Living Conditions
4. Financial Situation of the Household
5. Information Regarding Previous Loans
6. Agriculture and Livestock
7. Energy Consumption
8. General Use of Electricity
9. Perceptions about Renewable Energy and Micro Financing Schemes

The designed questionnaire was then pre-tested in the field to check its appropriateness and then accordingly, the changes were made in the final version.

The finalized version of the questionnaire used for this study has been attached as *Annex I.*

After finalizing the revised questionnaire, all 140 households located in the village were surveyed. In addition, 16 households were found to be residing in the suburbs. So they were also included in the sampling list. All the respondents were first briefed about the purpose of the survey.

3.2.2.Data Analysis

A database for the statistical analysis was prepared in SPSS. After the household surveys were conducted, the data was cleaned, coded and entered into the SPSS database.

The following methods were then used, as and where required, to analyze the results of the survey:

1. Descriptive Analysis
2. Frequency Distribution
3. Cross Tabulation

3.2.3.Technology and Micro Loan Design

Based on the results of data analysis the most preferred renewable energy technology system was simulated in RETScreen. The micro loan packages were calculated using established formulas acquired through literature. The details on approaches utilized are outlined in the respective subsections of the report.

In addition to data obtained from the household surveys, additional inputs were acquired through desk research and international project references to compliment the technical SHS and loan design.

Summary

The methodology followed in this study comprises of the following steps:

1. Data Collection
    a. Household Survey through comprehensive questionnaire
2. Analysis of Survey Results
    a. Software: Statistical Package for Social Sciences (SPSS)
    b. Techniques
        i. Descriptive Analysis
        ii. Frequency Distribution
        iii. Cross Tabulation
3. Technology Design
    a. Software: RETScreen
4. Microfinance Model Design
    a. Literature Review
    b. Mathematical formulas

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Chapter 4

Results and Discussion

This section details the results of the household surveys conducted in the case study village.

4.1. Demographic Information

The section 1 of the questionnaire was designed to assess the demographic information of the surveyed households. The section comprised of the following sub-sections:

4.1.1. Number of Residents

The survey results depict that majority of households in the village i.e. 22.4%, have 6 residents in their house. This was followed by a percentage of 21.8% for those having 5 residents and 16% for the households having 4 residents. Overall, we can conclude that around half of the households in the surveyed village have 5-6 residents in the house. The detailed breakdown of the number and percentage of households with respect to the number of residents is given in the *Table 3.*

TABLE 3: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF RESIDENTS

Number of Residents	Number of Households	Percentage of Households
1	5	3.2
2	18	11.5
3	20	12.8
4	25	16.0
5	34	21.8
6	35	22.4
7	10	6.4
8	7	4.5
9	1	0.6
10	1	0.6
Total	156	100

4.1.2.Number of Residents with respect to Gender

Around 37% of the surveyed households had 3 male members in their family, while 27% had 2 male members. On an overall basis, more than 60% households reported 2-3 male members in the family. The detailed analysis of percentage and number of households with respect to the number of male residents in the house is presented in *Table 4.*

TABLE 4: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF MALE RESIDENTS

Number of Residents	Number of Households	Percentage of Households
0	3	1.9
1	22	14.1
2	42	26.9
3	57	36.5
4	23	14.7
5	5	3.2
More than 5	4	2.6
Total	156	100.0

The survey results also showed that there are 2 female residents in around 42% of the surveyed households. This was followed by a figure of 23.7% for the households having 3 female members in the house. The detailed breakdown of the number and percentage of households with respect to the number of female residents is given in the *Table 5.* A graphical representation of the gender wise distribution of number of residents is given in F*igure 2.*

TABLE 5: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF FEMALE RESIDENTS

Number of Residents	Number of Households	Percentage of Households
0	5	3.2
1	36	23.1
2	65	41.7
3	37	23.7
4	6	3.8
5	6	3.8
More than 5	1	0.6
Total	156	100.0

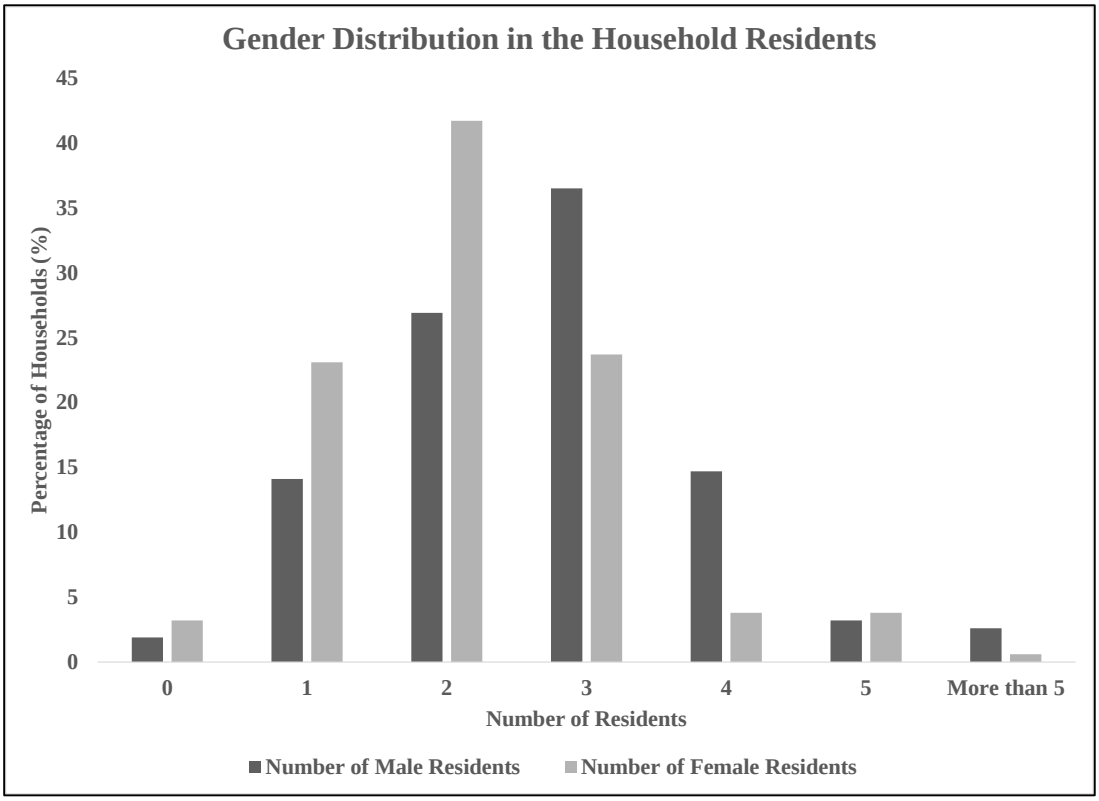

FIGURE 2: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO GENDER DISTRIBUTION OF NUMBER OF RESIDENTS

4.1.3.Education Qualification of Residents

The results showed that in around 49% households, no family member was illiterate, while in 32% households, only 1 illiterate family member was reported. In 47.5% households, 1 to 2 family members had education upto the primary school level, 64% had 1 to 2 secondary school educated residents while the percentage of households reporting higher secondary school and university educated family members was very low. This trend shows that in the surveyed village, most of people are either primary or secondary school qualified.

The detailed results for the number and percentage of households with respect of the educational qualification of residents is given in *Tables 6, 7, 8, 9, 10.*

TABLE 6: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF ILLITERATE RESIDENTS

Number of Illiterate Residents	Number of Households	Percentage of Households
0	77	49.4
1	50	32.1
2	24	15.4

3	4	2.6
4	0	0.0
5	1	0.6
Total	156	100.0

TABLE 7: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF PRIMARY SCHOOL EDUCATED RESIDENTS

Number of Primary School Educated Residents	Number of Households	Percentage of Households
0	27	17.3
1	40	25.6
2	39	25.0
3	33	21.2
4	13	8.3
5	3	1.9
More than 5	1	0.6
Total	156	100.0

TABLE 8: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF SECONDARY SCHOOL EDUCATED RESIDENTS

Number of Secondary School Educated Residents	Number of Households	Percentage of Households
0	24	15.4
1	49	31.4
2	51	32.7
3	21	13.5
4	7	4.5
5	3	1.9
More than 5	1	0.6
Total	156	100.0

TABLE 9: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF HIGHER SECONDARY SCHOOL EDUCATED RESIDENTS

Number of Higher Secondary School Educated Residents	Number of Households	Percentage of Households
0	96	61.5
1	37	23.7
2	17	10.9
3	5	3.2
4	1	0.6

5	0	0.0
More than 5	0	0.0
Total	156	100.0

TABLE 10: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF UNIVERSITY EDUCATED RESIDENTS

Number of University Educated Residents	Number of Households	Percentage of Households
0	127	81.4
1	16	10.3
2	9	5.8
3	3	1.9
4	1	0.6
5	0	0.0
More than 5	0	0.0
Total	156	100.0

A graphical representation of the percentage of households with respect of the educational qualification of residents is given in *Figure 3*

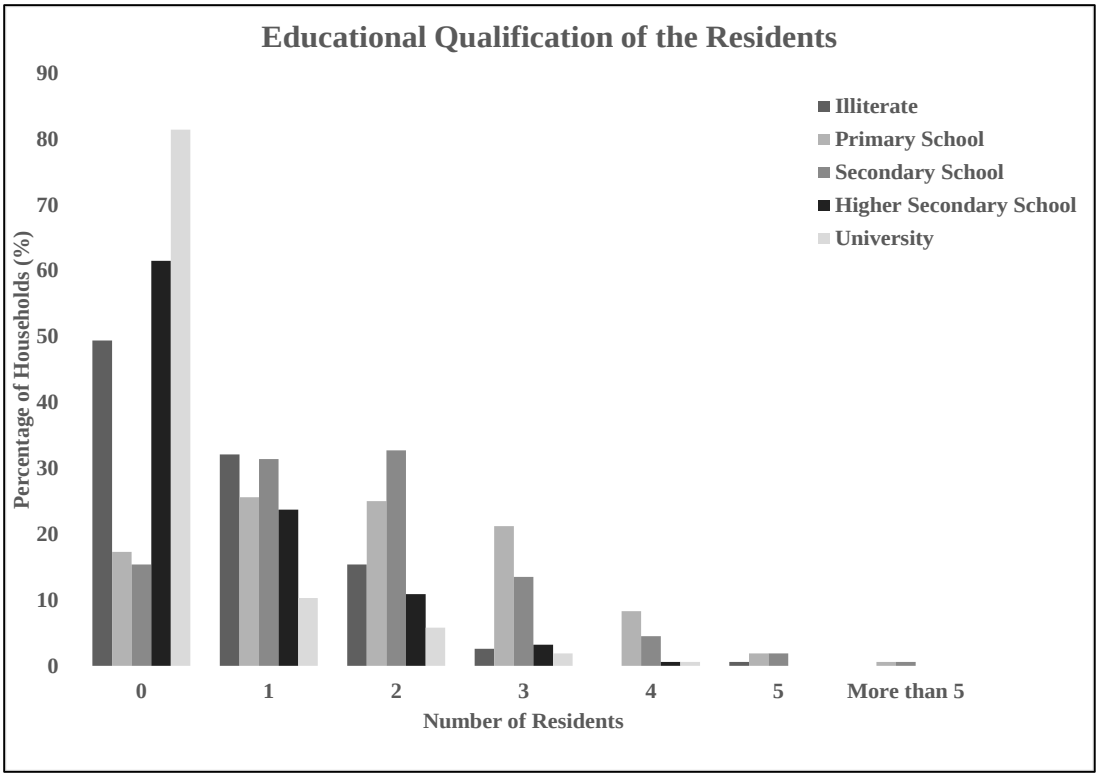

FIGURE 3: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO EDUCATIONAL QUALIFICATION OF THE RESIDENTS

4.1.4.Employment status of Residents

Around 81% households in the surveyed village had 1 to 2 bread earners while more than half had 3 to 4 un-employed family members.

Table 11 and 12 provides a detailed breakdown of the number and percentage of households with respect to the number of employed and un-employed residents.

TABLE 11: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF BREAD EARNERS

Number of Residents who are Employed/Self-Employed	Number of Households	Percentage of Households
0	26	16.7
1	75	48.1
2	51	32.7
3	4	2.6
4	0	0.0
5	0	0.0
More than 5	0	0.0
Total	156	100.0

TABLE 12: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF UN-EMPLOYED RESIDENTS

Number of Residents who are Un-Employed	Number of Households	Percentage of Households
0	5	3.2
1	16	10.3
2	20	12.8
3	30	19.2
4	53	34.0
5	20	12.8
More than 5	12	7.7
Total	156	100.0

Figure 4 shows a graphical representation of the percentage of households with respect of the employment status of residents.

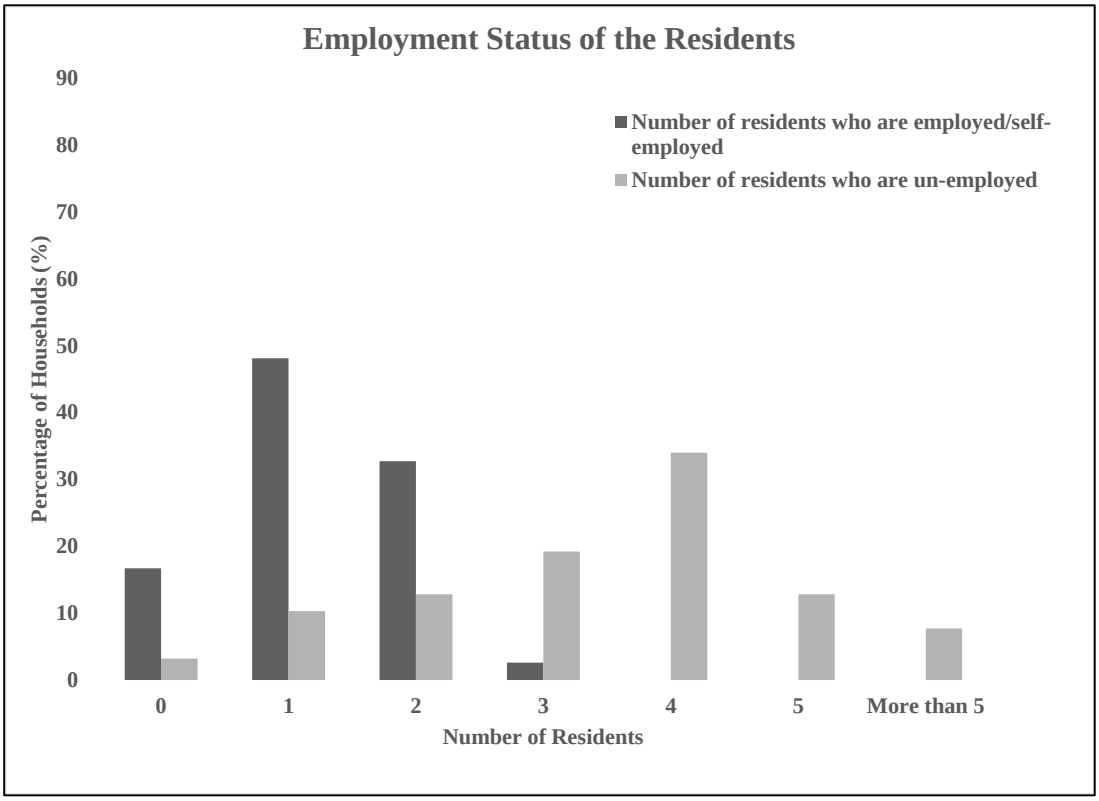

FIGURE 4: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO EMPLOYMENT STATUS OF THE RESIDENTS

4.2. Household Income and Expenses

The section 2 of the questionnaire asked the information on the income and expenses status of the surveyed households. The section comprised of the following sub-sections:

4.2.1. Source of Income

The respondents were also asked about the major sources of their family income. 122 households listed regular employment as their major source of income. This was followed by agriculture with 96 households earning a major part of their income through it. A detail of the results is shown in *Table 13.*

TABLE 13: NUMBER OF HOUSEHOLDS WITH RESPECT TO THEIR MAJOR SOURCE(S) OF INCOME (MORE THAN ONE ANSWER POSSIBLE)

Major Sources of Income	Number of Households
Regular employment	122
Trade	8
Agriculture and/or Livestock	96
Other	22

4.2.2.Frequency of Income

According to the survey results, majority of households in the village received their income monthly or seasonally. *Table 14* shows the number of households with respect to their frequency of income.

TABLE 14: NUMBER OF HOUSEHOLDS WITH RESPECT TO THEIR FREQUENCY OF INCOME (MORE THAN ONE ANSWER POSSIBLE)

Frequency of Income	Number of Households
Daily	13
Weekly	9
Monthly	127
Seasonal	88

4.2.3.Total Monthly Income

Out of 156 households, 80 reported that their average household monthly income is between Rs. 20,000-30,000. Only 8 surveyed households had the monthly income above Rs. 40,000. Graphical representation of the results is shown in *Figure 5.*

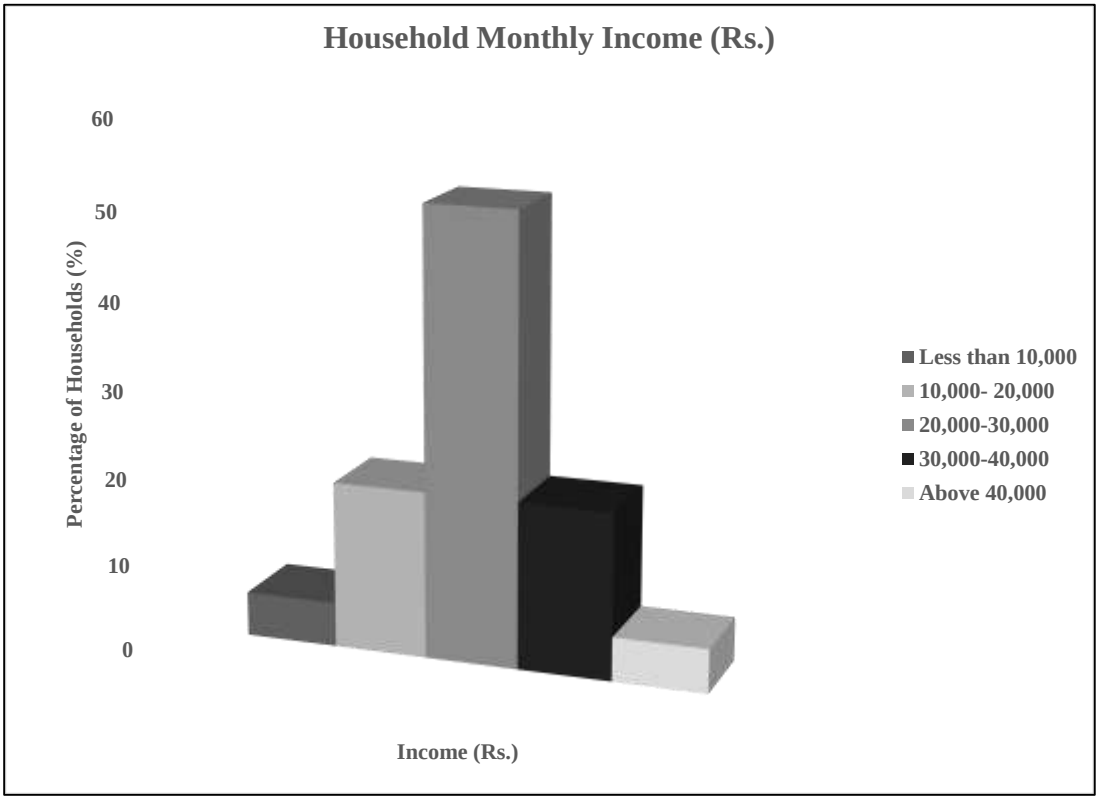

FIGURE 5: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR AVERAGE MONTHLY HOUSEHOLD INCOME

4.2.4.Monthly Expenses

After the monthly household income, the respondents were asked about the monthly household expenses. 53% households reported that their monthly expenses match their monthly income i.e. they spend Rs. 20,000 to 30,000 per month. *Figure 6* shows a detailed breakdown of results.

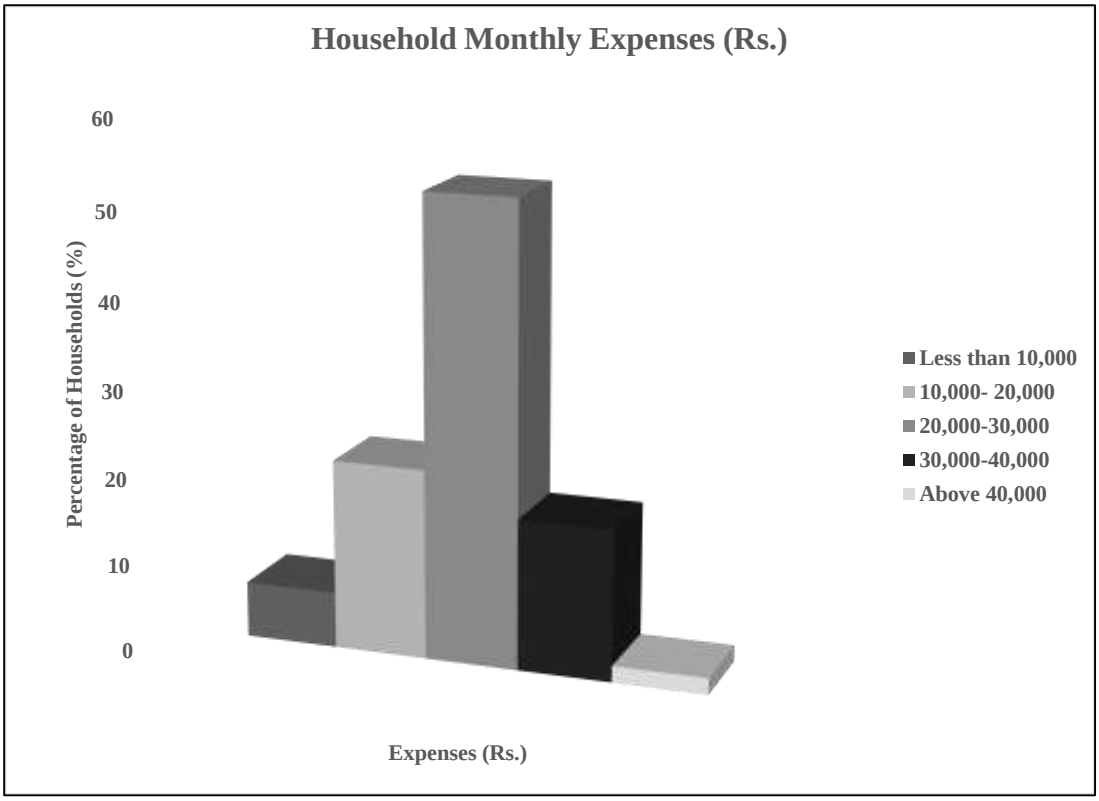

FIGURE 6: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR AVERAGE MONTHLY HOUSEHOLD EXPENSES

4.3. Basic Living Condition

The section 3 of the questionnaire was designed to assess the basic living conditions in the surveyed households. The section comprised of the following sub-sections:

4.3.1.Bread and Butter

The respondents were asked if there current income is enough to provide food for the whole family. Around 64% respondents reported that they get enough food for the family while 36% answered 'no' to this question. The results of this question are presented in detail in *Table 15.*

TABLE 15: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR BREAD AND BUTTER CONDITION

Response	Number of Households	Percentage of Households
Yes	100	64.1
No	56	35.9
Total	156	100.0

4.3.2.Ownership status of the House

99.4% respondents in the village were living in the house owned by themselves or their families. Only 1 household was living in a rental house. *(Table 16)*

TABLE 16: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE OWNERSHIP STATUS OF THE HOUSE THEY LIVE IN

Ownership Status	Number of Households	Percentage of Households
Owned/Family Owned property	155	99.4
Rental property	1	0.6
Total	156	100.0

4.3.3.Number of Rooms in the House

Around 54% households lived in a 3-room house. This was followed by 28% who lived in a houses having 4 or more rooms. The detailed results are shown in *Table 17.*

TABLE 17: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER OF ROOMS IN THE HOUSE

Number of Rooms	Number of Households	Percentage of Households
1	2	1.3
2	27	17.3
3	84	53.8
4 or more	43	27.6
Total	156	100.0

4.4. Household Financial Situation

The financial situation of the surveyed households was assessed through targeted questions of section 4 in the questionnaire. The section comprised of the following sub-sections:

4.4.1.Household Wealth

In order to assess the financial situation of the household, the respondents were asked about the ownership of cattle, vehicles, radio, TV, Refrigerator, phone, savings etc.

The results showed that 120 out 156 households owned a refrigerator, 104 owned a TV, almost all the households owned atleast one mobile phone but only 44 had savings in home or bank. *(Table 18)*

TABLE 18: NUMBER OF HOUSEHOLDS WITH RESPECT TO THE OWNERSHIP OF VARIOUS OBJECTS

Owned Objects	Number of Households
Cattle	82
Car Truck Tractor	39
Motorbike	73
Cycle	32
Radio	32
TV	104
Refrigerator	120
Landline phone	25
Mobile Phone	150
Savings at home	12
Savings at bank	32

4.4.2.Status of Family Income in Last 12 Months

Around 76% households reported that their family income has been the same since last 12 months, while around 10% said it has decreased. *(Table 19)*

TABLE 19: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE STATUS OF INCOME SINCE LAST 12 MONTHS

Status of Income	Number of Households	Percentage of Households
Increased	22	14.1
Stayed constant	119	76.3
Decreased	15	9.6
Total	156	100.0

Those who reported a decrease in their family income, were asked what they did to overcome the decrease in their income. More than half of the respondents said that they borrowed money at no cost, in order to meet their household expenses. Detailed breakdown of the answers is shown in *Table 20*.

TABLE 20: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR STEPS TO OVERCOME THE SHORTAGE OF MONEY

Action	Number of Households	Percentage of Households

Borrowed money at no cost	8	53.3
Borrowed money with interest	1	6.7
Migration of a family member for employment	1	6.7
A family member got new employment	5	33.3
Total	15	100.0

4.4.3.History with Loan

45 out of 156 respondents had taken a loan in the past while 111 respondents said they had never taken a loan in their life. *(Table 21)*

TABLE 21: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR HISTORY WITH LOANS

History with Loan	Number of Households	Percentage of Households
Yes	45	28.8
No	111	71.2
Total	156	100.0

4.5. Loan Information

The section 5 was designed for the households who had a history with loans. As established in the previous section, only 45 households out of 156 had acquired loan for some purpose in the past. Therefore the total number of respondents for this section is 45. The section comprised of the following sub-sections:

4.5.1.Source of Loan

When asked about the source of loan, more than half of the respondents said that they borrowed money from a friend, while around 31% said they took loan from an immediate relative. *Table 22* depicts the result in an elaborate way.

TABLE 22: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE SOURCE OF LOAN

Source of Loan	Number of Households	Percentage of Households
Immediate relative	14	31.1
Distant relative	5	11.1
Institution/Bank	3	6.7
Friend	23	51.1
Total	45	100.0

4.5.2.Purpose of Loan

Consumption and unexpected events turned out to be two major purposes for taking loan, with 11 households reporting each. *(Table 23)*

TABLE 23: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PURPOSE OF LOAN

Purpose of Loan	Number of Households	Percentage of Households
Consumption (appliances, food, etc.)	11	24.4
Business	8	17.8
Education	5	11.1
Health reasons	8	17.8
Unexpected events	11	24.4
Other(Daughter's Marriage)	2	4.4
Total	45	100.0

4.5.3.Amount of Loan

Around 76% respondents reported that the amount of their loan was less than Rs. 25,000, followed by 18% having Rs. 25,000-50,000 as loan. *Table 24* provides a detailed breakdown of the results.

TABLE 24: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE AMOUNT OF LOAN

Amount of Loan	Number of Households	Percentage of Households
Less than 25,000	34	75.6
25,000-50,000	8	17.8
51,000-100,000	2	4.4
Above 100,000	1	2.2
Total	45	100.0

4.5.4.Payback status

Around 71% respondents said that they currently have a loan on their heads while 29% said they have already paid it back. *(Table 25)*

TABLE 25: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE STATUS OF LOAN

Currently Having a Loan	Number of Households	Percentage of Households
Yes	32	71.1
No	13	28.9
Total	45	100.0

Moreover, those who currently have a loan, were asked if they are finding it difficult to pay the loan back. The results are depicted in *Table 26.*

TABLE 26: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE DIFFICULTIES IN PAYBACK

Facing Difficulty in Payback	Number of Households	Percentage of Households
Yes	20	62.5
No	12	37.5
Total	32	100.0

4.6. Agriculture and Livestock

The section 6 of the questionnaire inquired about the involvement of the households in agriculture and livestock. This section holds critical importance for determining the potential of using biomass as a source of renewable energy generation. The section comprised of the following sub-sections:

4.6.1. Involvement in Agriculture and Livestock

In total, 146 households were involved in agricultural activities, while only 85 were involved in livestock farming. Detailed breakdown of the results is given in *Table 27, 28 and Figure7.*

TABLE 27: NUMBER AND PERCENTAGE OF HOUSEHOLDS INVOLVED IN AGRICULTURE

Household's Involvement in Agriculture	Number of Households	Percentage of Households
Yes	146	93.6
No	10	6.4
Total	156	100.0

TABLE 28: NUMBER AND PERCENTAGE OF HOUSEHOLDS INVOLVED IN LIVESTOCK

Household's Involvement in Livestock	Number of Households	Percentage of Households
Yes	85	54.5
No	71	45.5
Total	156	100.0

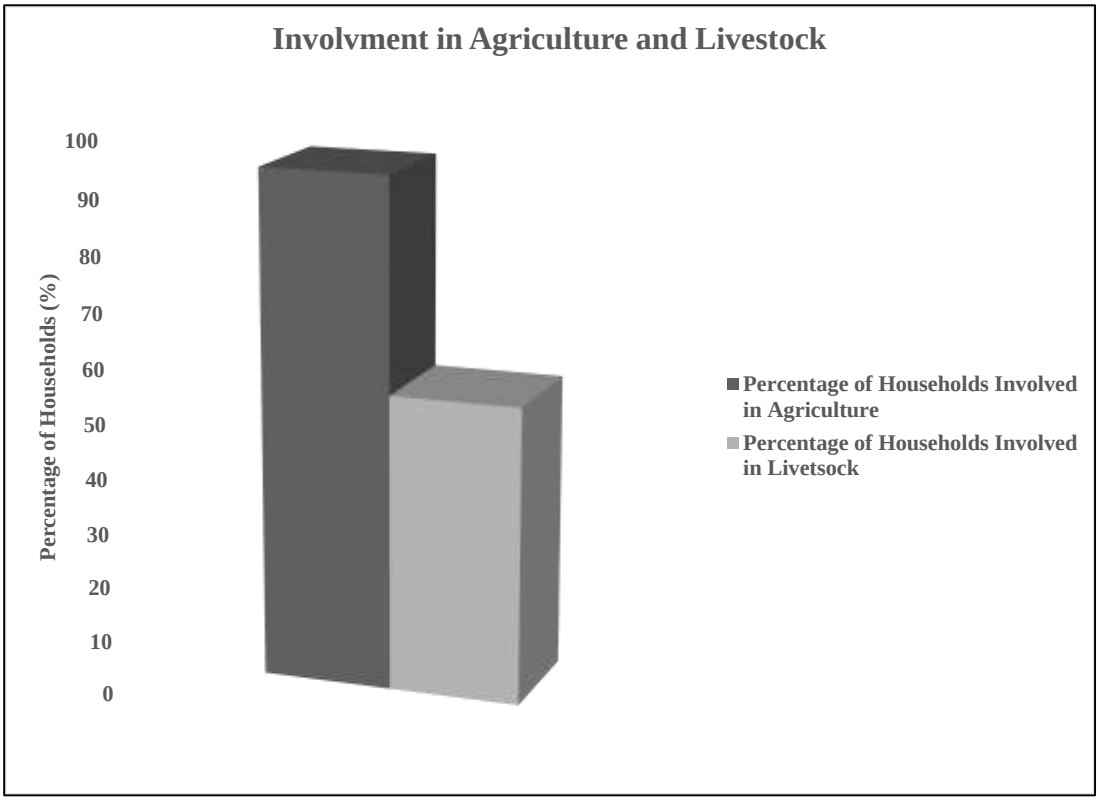

FIGURE 7: PERCENTAGE OF HOUSEHOLDS INVOLVED IN AGRICULTURE AND LIVESTOCK

4.6.2.Ownership Status of Agricultural Land

Of the households involved in agriculture, around 97% reported that they own the agriculture land, 1.4% said they work as tenants, while others worked on Government owned agricultural land. The detailed breakdown is presented in *Table 29.*

TABLE 29: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE OWNERSHIP OF AGRICULTURAL LAND

Status	Number of Households	Percentage of Households
Owner	143	97.9
Tenant	2	1.4
Government land	1	0.7
Total	146	100.0

4.6.3.Area of Agricultural Land

Around half of the households had agricultural lands with area less than 1 acre. This was followed by 40% of those who reported having 1 to 5 acres of agricultural land. *Table 30* presents a clear picture of this trend.

TABLE 30: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE AREA OF AGRICULTURAL LAND

Area	Number of Households	Percentage of Households
Less than 1 acre	72	49.3
1 acre - 5 acres	58	39.7
5 acres - 10 acres	7	4.8
Above 10 acres	3	2.1
Not Sure	6	4.1
Total	146	100.0

Almost the same result can be seen in case of total agricultural land area under cultivation as 52% households reported that they have less than 1 acre of land under cultivation. *(Table 31)*

TABLE 31: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE AREA UNDER CULTIVATION

Area Under Cultivation	Number of Households	Percentage of Households
Less than 1 acre	76	52.1
1 acre - 5 acres	55	37.7
5 acres - 10 acres	7	4.8
Above 10 acres	3	2.1
Not sure	5	3.4
Total	146	100.0

4.6.4.Cultivated Crops

The respondents were further asked about the type of crops they usually grow. The highest number of households were reported to grow wheat while barley came as a close second. *Table 32* shows the results in detail.

TABLE 32: NUMBER OF HOUSEHOLDS WITH RESPECT TO THE CULTIVATED CROPS (MORE THAN ONE ANSWER POSSIBLE)

Crops	Number of Households
Wheat	134
Barley	119
Maize	101
Millets	6
Pulses	113
Vegetables and fruits	7
Others	9

4.6.5.Crop Residue

When asked about the amount of crop residue generated, the respondents were not sure as they had never tried to quantify it. However, on a rough estimate, most of them said they collect around 4 to 6 Mann of crop residue per crop reason. They were further asked what they usually do to the collected residue, the responses are summarized in *Table 33.*

TABLE 33: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE USE OF CROP RESIDUE

Use of Crop Residue	Number of Households	Percentage of Households
Burn it	18	12.3
Use it for Fodder	76	52.1
Sell it	52	35.6
Total	146	100.0

4.6.6.Changes in Production

47% households reported that their agricultural production has increased as compared to the last season, while 41% said there has been no change since last season. *(Table 34)*

TABLE 34: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO CHANGES IN AGRICULTURAL PRODUCTION

Changes	Number of Households	Percentage of Households
Yes, it increased	69	47
Yes, it decreased	2	1
No	60	41
Don't know	15	10
Total	146	100.0

4.6.7.Number of Livestock Animals

Among the 85 households who are involved in livestock farming, more than 28% said they owned 2 cows, while around 24% had 3 cows.

Moreover, around 51% reported that they do not own any goats and 49% said they do not have chickens. *Table 35, 36 and 37* provides details of the results.

TABLE 35: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF COWS

Number of Cows	Number of Households	Percentage of Households
None	5	5.9
1	15	17.6
2	24	28.2
3	20	23.5
4	9	10.6
5	5	5.9
6	4	4.7
10 or more	3	3.5
Total	85	100.0

TABLE 36: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF GOATS

Number of Goats	Number of Households	Percentage of Households
None	43	50.6
1	9	10.6
2	9	10.6
3	7	8.2
4	3	3.5
5	3	3.5
6	5	5.9
8	4	4.7
10 or more	2	2.4
Total	85	100.0

TABLE 37: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO NUMBER OF CHICKENS

Number of Chickens	Number of Households	Percentage of Households
None	42	49.4
1	2	2.4
2	5	5.9
3	2	2.4
4	7	8.2
5	4	4.7
6	7	8.2
7	1	1.2
8	2	2.4

10	13	15.3
Total	85	100.0

4.6.8.Income from Livestock

Out of the 85 households involved in livestock farming, 75 said that they get additional income from livestock. *(Table 38)*

TABLE 38: NUMBER AND PERCENTAGE OF HOUSEHOLDS EARNING ADDITIONAL INCOME FROM LIVESTOCK

Income from Livestock	Number of Households	Percentage of Households
Yes	75	88.24
No	10	11.76
Total	85	100.00

Among them, 58 get the income by selling animal products while around 38 sell the animals. *(Table 39)*

TABLE 39: NUMBER OF HOUSEHOLDS WITH RESPECT TO THEIR SOURCE OF INCOME FROM LIVESTOCK (MORE THAN ONE ANSWER POSSIBLE)

Source of Income	Number of Households
Selling animals	38
Selling animal products	58

The respondents earning additional income from livestock were further asked how much do they usually earn through the animals. The results are summarized in *Table 40.*

TABLE 40: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE AMOUNT OF INCOME FROM LIVESTOCK

Income	Number of Households	Percentage of Households
Less than 2000	57	76.0
2000 – 4000	12	16.0
4000 – 6000	3	4.0
Above 6000	3	4.0
Total	75	100.0

4.6.9.Livestock Waste

When asked about the amount of livestock waste generated, the respondents were not sure as they had never tried to quantify it. They were further asked what they usually do to the animal waste, the responses are summarized in *Table 41*.

TABLE 41: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE USE OF ANIMAL WASTE

Use of Livestock Waste	Frequency	Percentage
Use it as fertilizer	85	100.0
Other	0	0.0
Total	85	100.0

4.7. Energy Consumption

The existing energy consumption trends of the surveyed households were assessed through questions of section 7 in the questionnaire. The section comprised of the following sub-sections:

4.7.1. Knowledge about Energy Sources

The respondents were inquired about their knowledge of energy sources, both primary and secondary. The results showed that there was ample knowledge about electricity, kerosene oil, firewood, LPG and biomass, however, the number of households having knowledge about the renewable energy sources was very less. *(Table 42)*

TABLE 42: NUMBER OF HOUSEHOLDS WITH THEIR KNOWLEDGE OF ENERGY SOURCES (MORE THAN ONE ANSWER POSSIBLE)

Energy Sources	Number of Households
Electricity	156
Natural Gas	93
Kerosene Oil	156
Liquefied Petroleum Gas (LPG)	145
Firewood	156
Dung	133
Coal	7
Solar	81
Hydro	4
Wind	5

4.7.2. Most Important Energy Sources

When asked which energy source/sources you need the most, the majority of respondents, said they need electricity the most. *Table 43* depicts are clear picture of the results.

TABLE 43: NUMBER OF HOUSEHOLDS WITH RESPECT TO THE MOST NEEDED ENERGY SOURCE(S) (MORE THAN ONE ANSWER POSSIBLE)

Energy Sources	Number of Households
Electricity	144
Natural Gas	16
Kerosene oil	2
Liquefied Petroleum Gas (LPG)	117
Firewood	82
Dung	13
Coal	2
Solar	50
Hydro	3
Wind	0

4.7.3.Energy Used for Lighting

All 100% households reported that they use electricity for lighting their homes. *(Figure 8)*

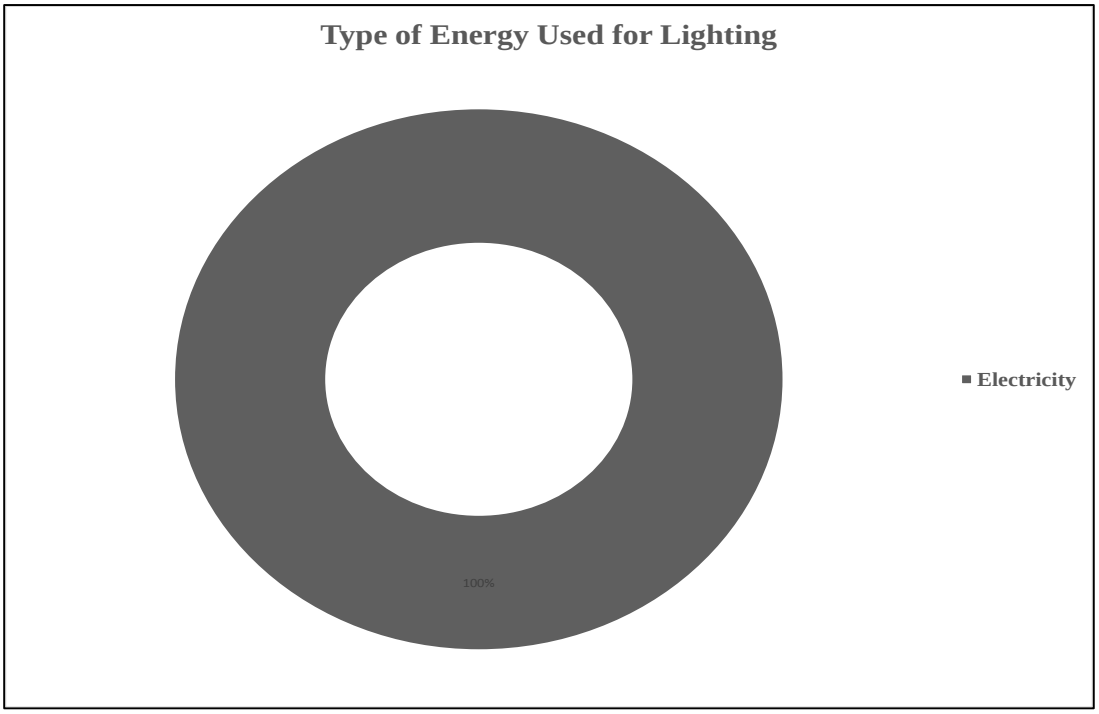

FIGURE 8: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE ENERGY SOURCE USED FOR LIGHTING

4.7.4.Energy Used for Cooking

75% households in the surveyed village used Liquefied Petroleum Gas (LPG) for cooking. This was followed by firewood with around 14% households using it. The detailed results are shown in *Table 44.*

TABLE 44: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE ENERGY SOURCE USED FOR COOKING

Energy Sources	Number of Households	Percentage of Households
Natural gas	8	5.1
Dung cake	10	6.4
Liquefied Petroleum Gas (LPG)	117	75.0
Firewood	21	13.5
Total	156	100.0

4.7.5.Energy Used for Space Cooling

Just like lighting, space cooling in the surveyed village was also done through electricity as 100% respondents reported this. *(Figure 9)*

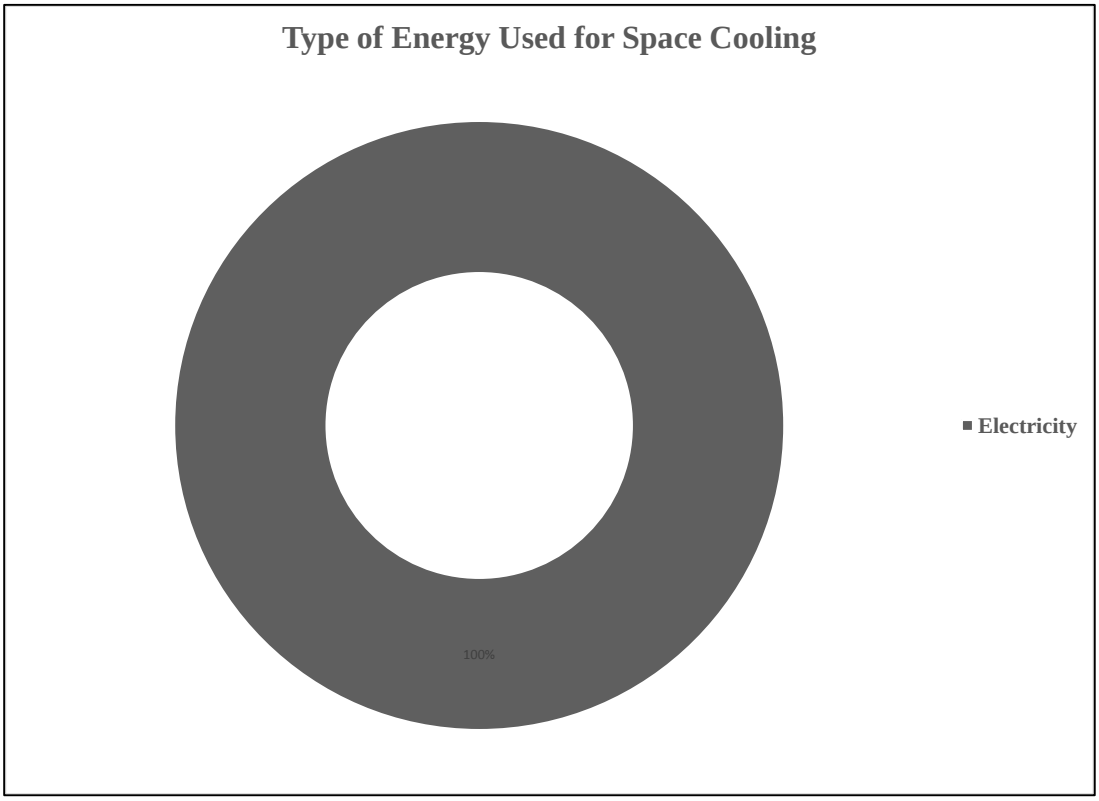

FIGURE 9: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE ENERGY SOURCE USED FOR SPACE COOLING

4.7.6.Energy Used for Space Heating

Around 76% respondents used firewood to heat up their homes during winters, while around 14% said they do not heat up their homes. *Table 45* shows a detailed breakdown of the results.

TABLE 45: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE ENERGY SOURCE USED FOR SPACE HEATING

Energy Sources	Number of Households	Percentage of Households
None	22	14.1
Dung cake	3	1.9
Liquefied Petroleum Gas (LPG)	12	7.7
Firewood	118	75.6
Electric Heater	1	0.6
Total	156	100.0

4.7.7.Energy Used for Water Heating

For water heating, as many as 80% households used firewood collected from nearby areas. Other sources used for this purpose include LPG, animal dung, natural gas and coal. *(Table 46)*

TABLE 46: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE ENERGY SOURCE USED FOR WATER HEATING

Energy Sources	Number of Households	Percentage of Households
Natural gas	5	3.2
Dung cake	6	3.8
Liquefied Petroleum Gas (LPG)	16	10.3
Firewood	125	80.1
Coal	4	2.6
Total	156	100.0

4.7.8.Collection of Firewood

The respondents were further asked that in case firewood needs to be used as an energy source, who in the household is usually responsible for collecting it. The results are being shown in *Table 47*, depicting that male members of the households are usually the ones to collecting firewood.

TABLE 47: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE MEMBERS RESPONSIBLE FOR COLLECTING FIREWOOD

Sources	Number of Households	Percentage of Households
Men	94	60.3
Women	58	37.2
Children	4	2.6
Total	156	100.0

4.8. General Use of Electricity

After determine the overall energy consumption situation in the households, the section 8 focused on the electricity consumption in particular. The section comprised of the following sub-sections:

4.8.1. Electricity Intensive Activities at Home

In order to get an idea of the electricity consumption trends in the surveyed village, the respondents were asked about the electricity intensive activities which are carried out in their household. As can be seen from *Table 48,* almost all the households used electricity for lighting and space cooling. The other major electricity consuming activities included watching TV and charging mobile phones.

TABLE 48: NUMBER OF HOUSEHOLDS WITH RESPECT TO THEIR ELECTRICITY INTENSIVE ACTIVITIES (MORE THAN ONE ANSWER POSSIBLE)

Activities	Number of Households
Lighting	156
Space Cooling (Fans)	154
Space Cooling (Air-conditioning)	4
Watching TV	145
Listening to Radio	20
Charging mobile phones	139
Using desktop computer	22
Charging laptop	8

4.8.2. Use of Electric Appliances

The electricity consumption behavior was further assessed by the questions directly targeted at the number and daily consumption of specific electric appliances in the household.

4.8.2.1. Tube lights

Around 21% households reported that they have 4 tube lights installed in their homes, while 26% said they do not have any tube light in the house. Moreover, more than 34% said that the average use of each tube light in their home is 3 hours per day. The overall situation is shown in *Figure 10.*

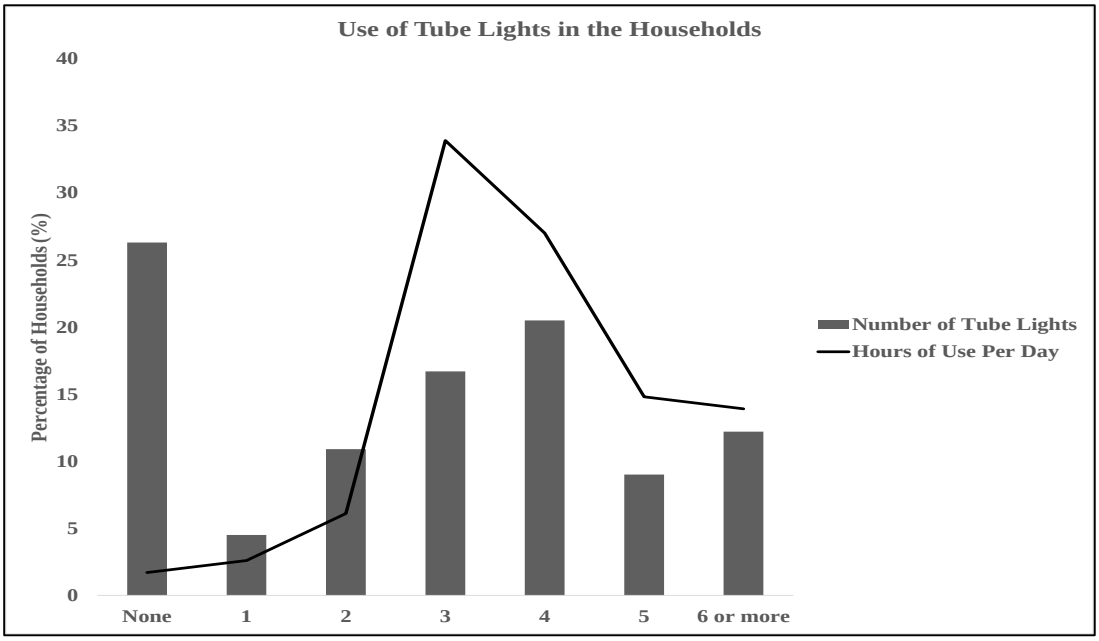

FIGURE 10: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF EACH TUBE LIGHT

4.8.2.2.Energy Saver Lights (Compact Fluorescent lights)

When asked about the energy saving compact fluorescent lights, 18.6% said they have 2 energy savers installed in their home. Also, 53% households stated that they use the energy saver light for around 5 hours per day. *Figure 11* presents a graphical overview of the results.

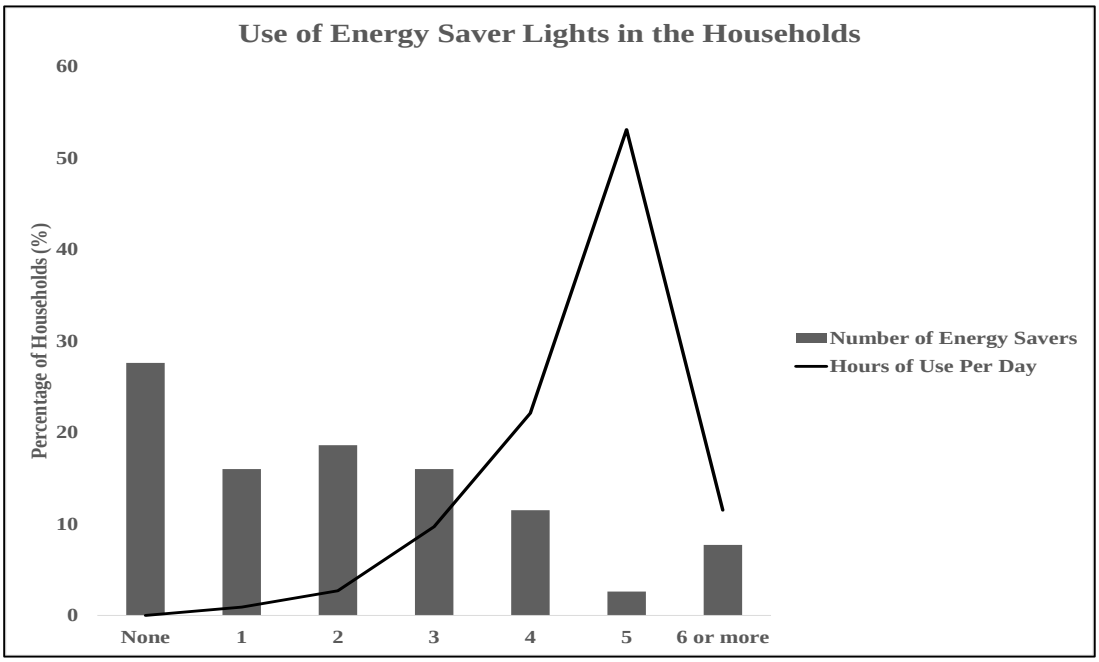

FIGURE 11: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF EACH ENERGY SAVER LIGHT

4.8.2.3.LED Lights

The survey results show that none of the households in the surveyed village was using LED lights, or was even aware of their benefit. *(Table 49)*

TABLE 49: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER OF LED LIGHTS

Number of LED Lights	Number of Households	Percentage of Households
None	156	100.0

4.8.2.4.Television

Only 7 households in the village owned a black and white television, which was being used for 1 to 2 hours per day *(Figure 12).*

However, 138 households reported owning colored TV and around half of them reported its use about 3 to 4 hours in a day *(Figure 13).*

4.8.2.5.Radio/Tape Recorder

Radios/Tape recorders were owned by only 20 households in the village, among which 13 had only one in their home. The average use of these devices was estimated to be 1 hour per day. *(Figure 14)*

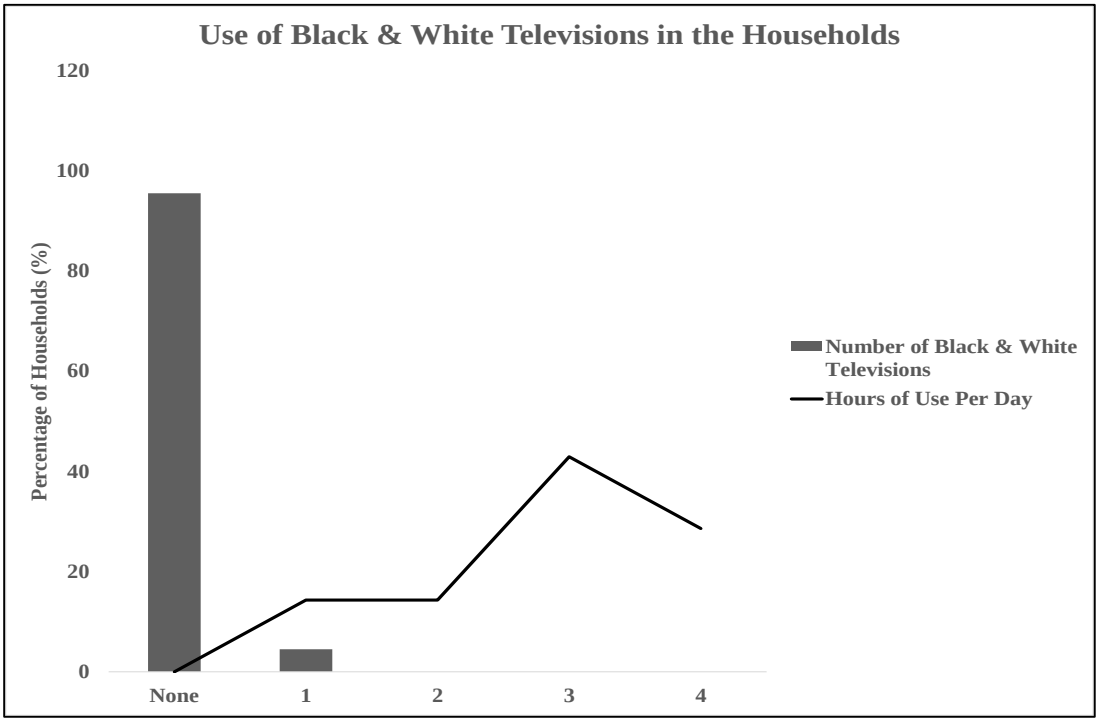

FIGURE 12: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF BLACK AND WHITE TVS

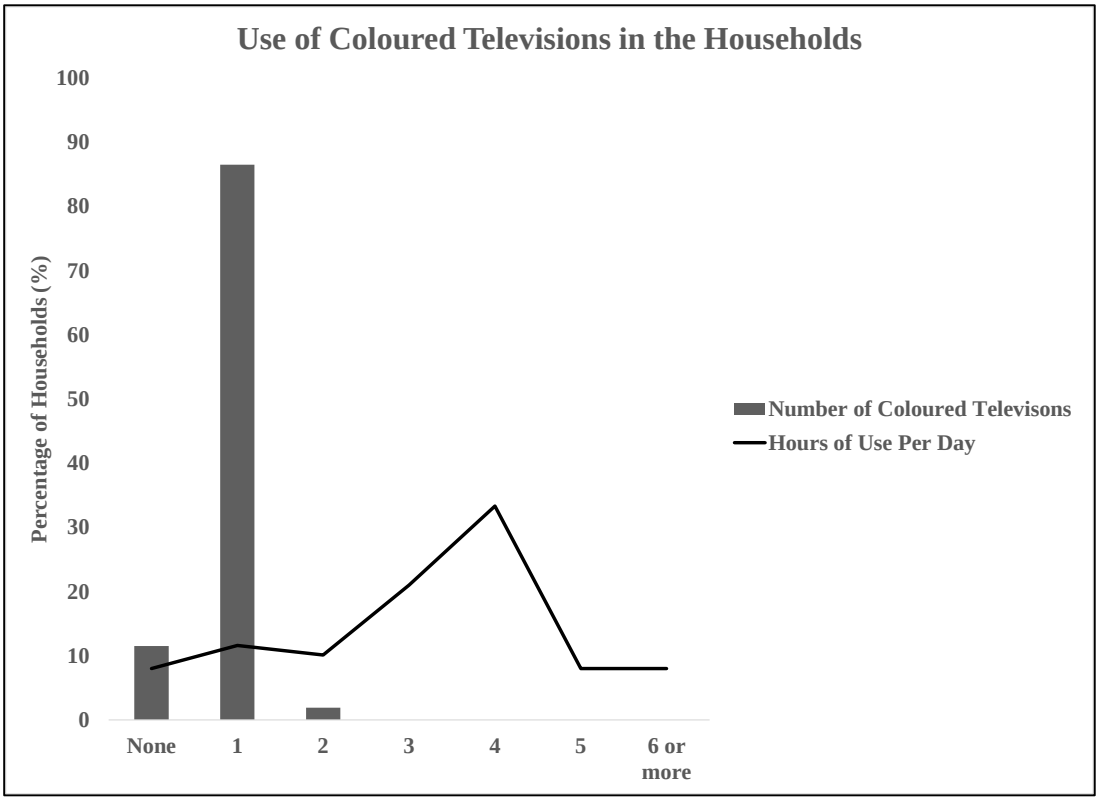

FIGURE 13: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF COLORED TVS

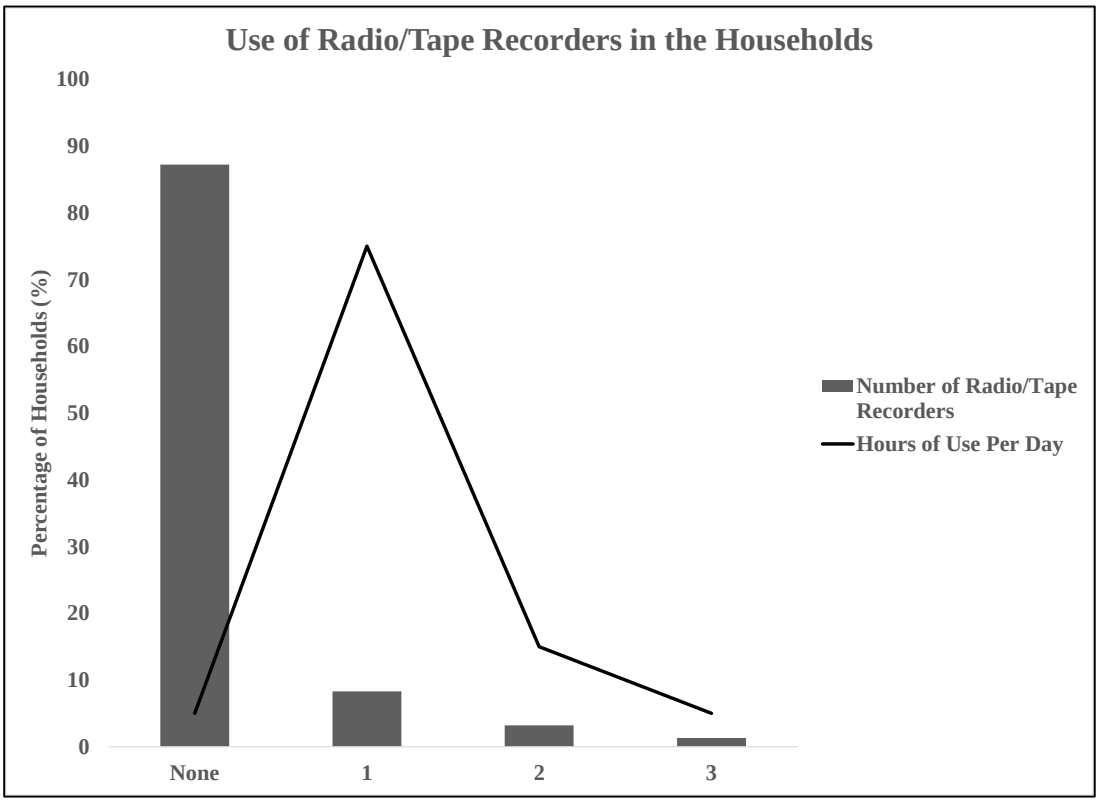

FIGURE 14: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF EACH RADIO/TAPE RECORDER

4.8.2.6.Fans

Due to the geographical and climatic conditions in the area, space cooling is needed in every house in the village. This is why 154 households, out of 156, reported using fans during summer season. Around half of the village households have 2 to 3 fans installed in their house. Moreover, the average use of each fan was reported by almost all of households to be more than 6 hours. *Figure 15* presents are graphical picture of the results.

4.8.2.7.Air conditioners

Only 4 households in the village owned an air conditioner, which they use around 1 to 3 hours per day. *(Figure 16)*

4.8.2.8.Mobile Phones

All except 17 households had atleast 1 mobile phone in their house. Around 47% reported 1 mobile phone, 22% reported 2 phones while 16% said they have 3 mobile phones in the house. The average use of a mobile phone charger was estimated to be 1 hour in a day. An overview of the results is shown in *Figure 17.*

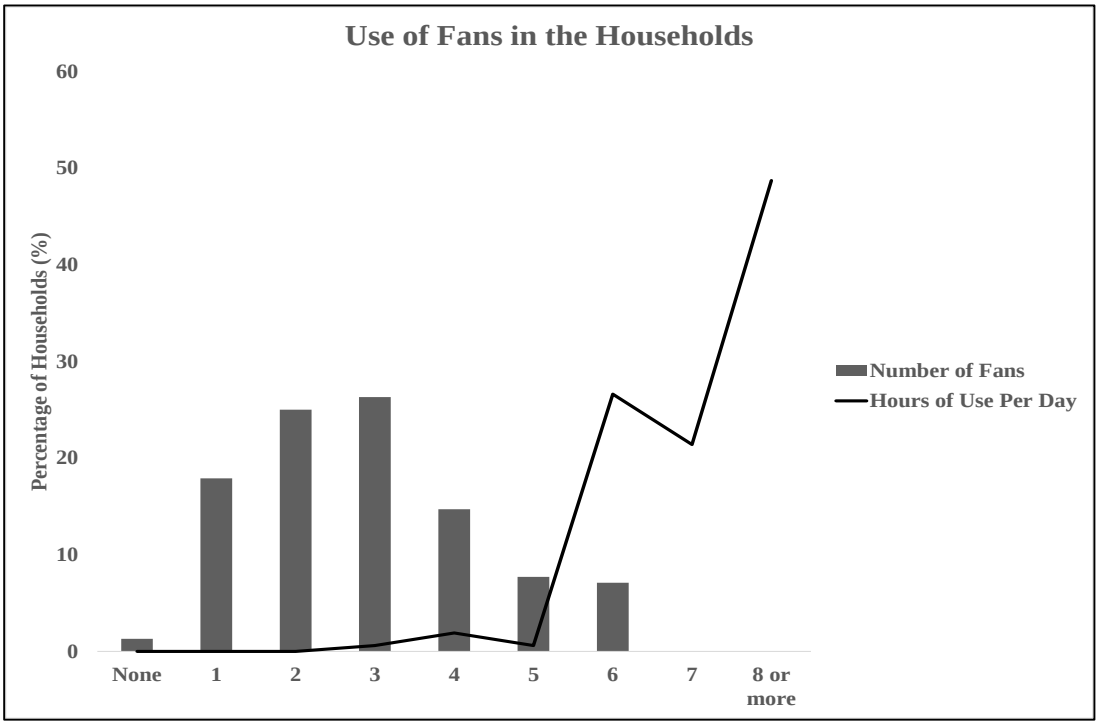

FIGURE 15: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER OF AND DAILY USE OF FANS

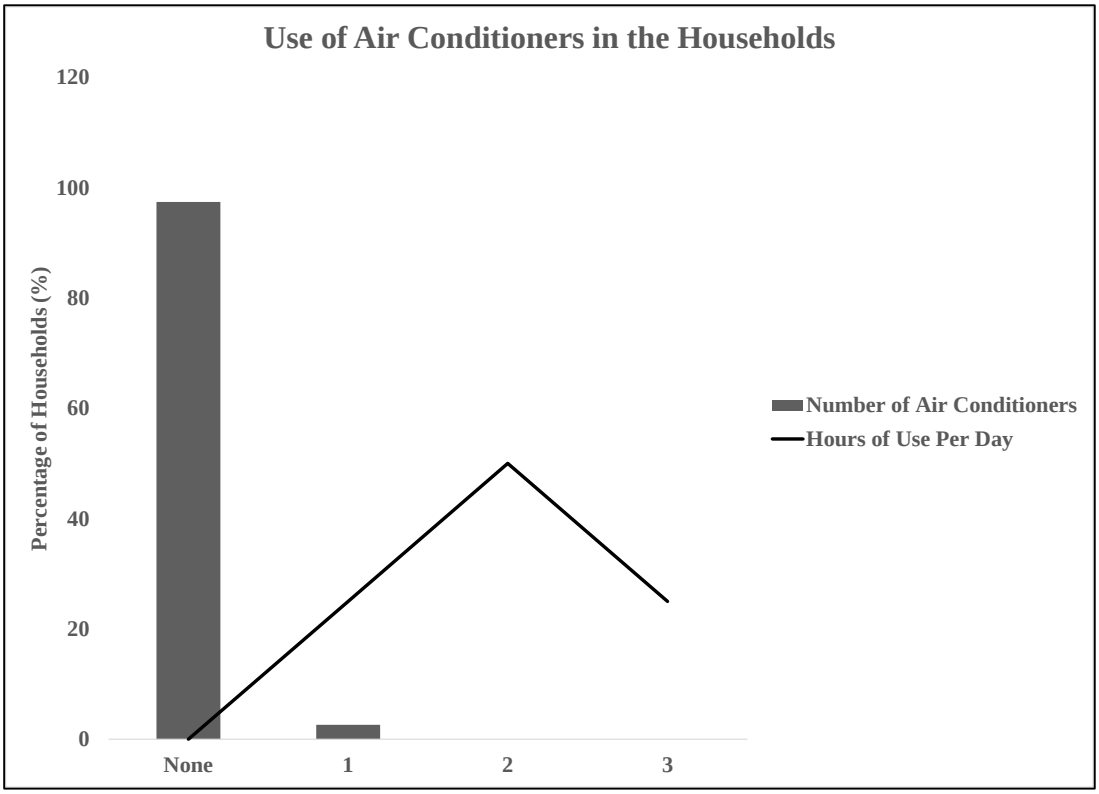

FIGURE 16: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF AIR CONDITIONERS

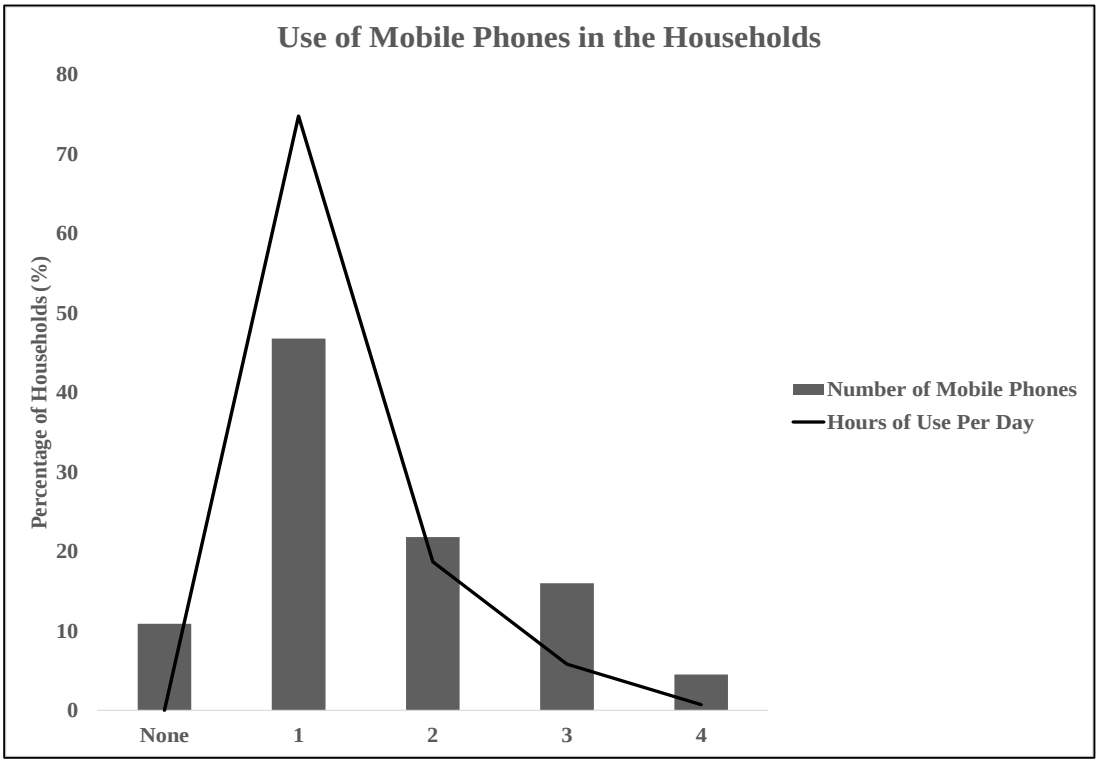

FIGURE 17: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF MOBILE PHONES

4.8.2.9.Laptops

The survey results show that 7 households in the village had 1 laptop computer and only 1 had 2 laptop computers in their house. Each laptop charger was reported to be used 1 to 2 hours per day. *Figure 18* is shows a graphical overview of results.

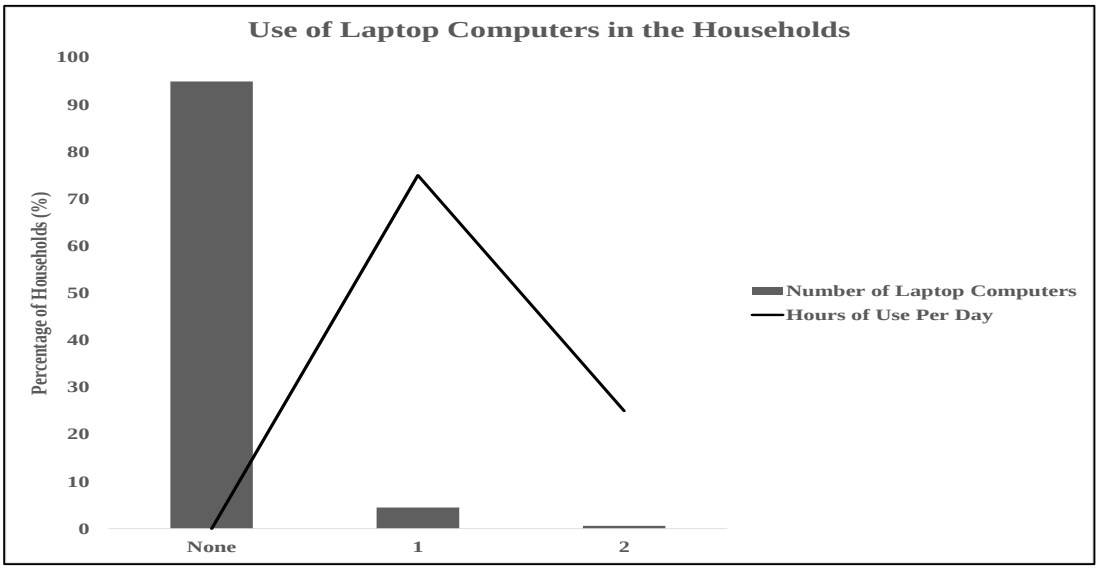

FIGURE 18: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF EACH LAPTOP CHARGER

4.8.2.10. Desktop Computers

21 Households owned desktop computers, which were being used 1 to 2 hours each day. *(Figure 19)*

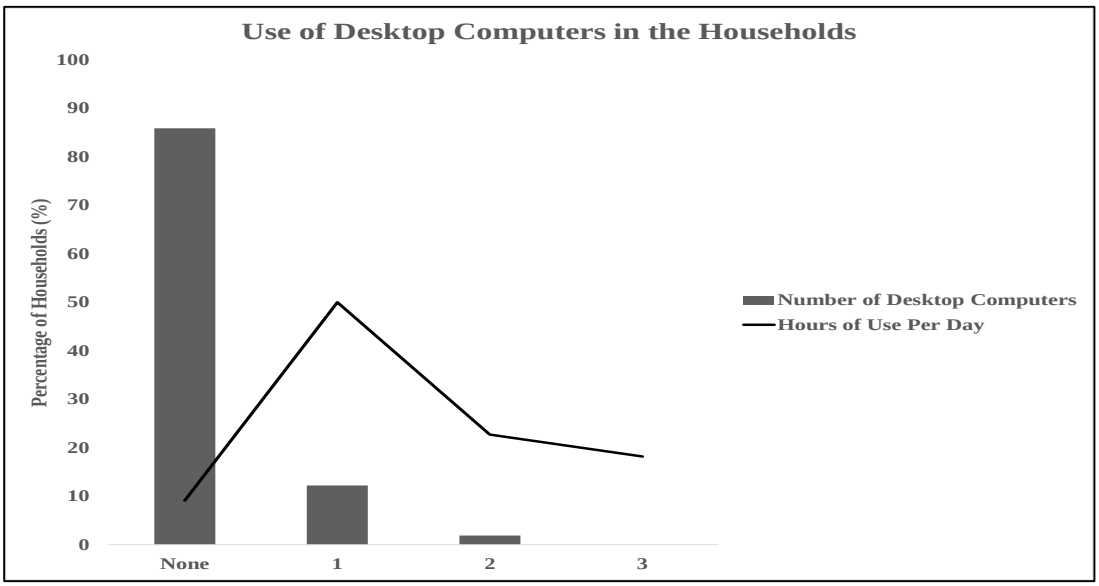

FIGURE 19: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF DESKTOP COMPUTER

4.8.2.11. Water Motors

Most of the households used hand pumps to fetch water from underground. However, during the survey, it was learned that 33 households had water motors in their homes.

The average use of each water motor was reported to be 1 to 2 hours per day. *(Figure 20)*

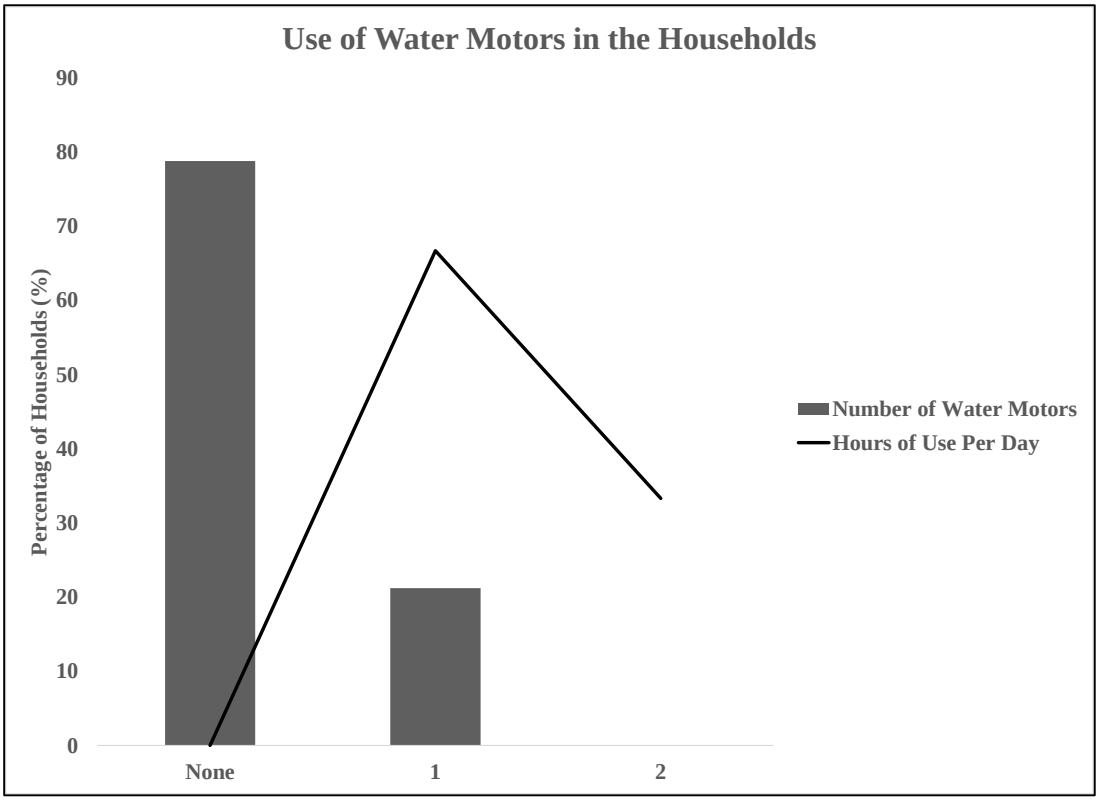

FIGURE 20: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF WATER MOTORS

4.8.2.12. Laundry Machines

Only 5 Households owned laundry machines while all others did not own that.

Most of them reported its average use of 1 hour every alternate day i.e. half an hour per day. *(Figure 21)*

4.8.2.13. Cloth Iron

Around 63% households stated that they own 1 cloth iron, which they usually use approximately half an hour per day. *(Table 50 and 51)*

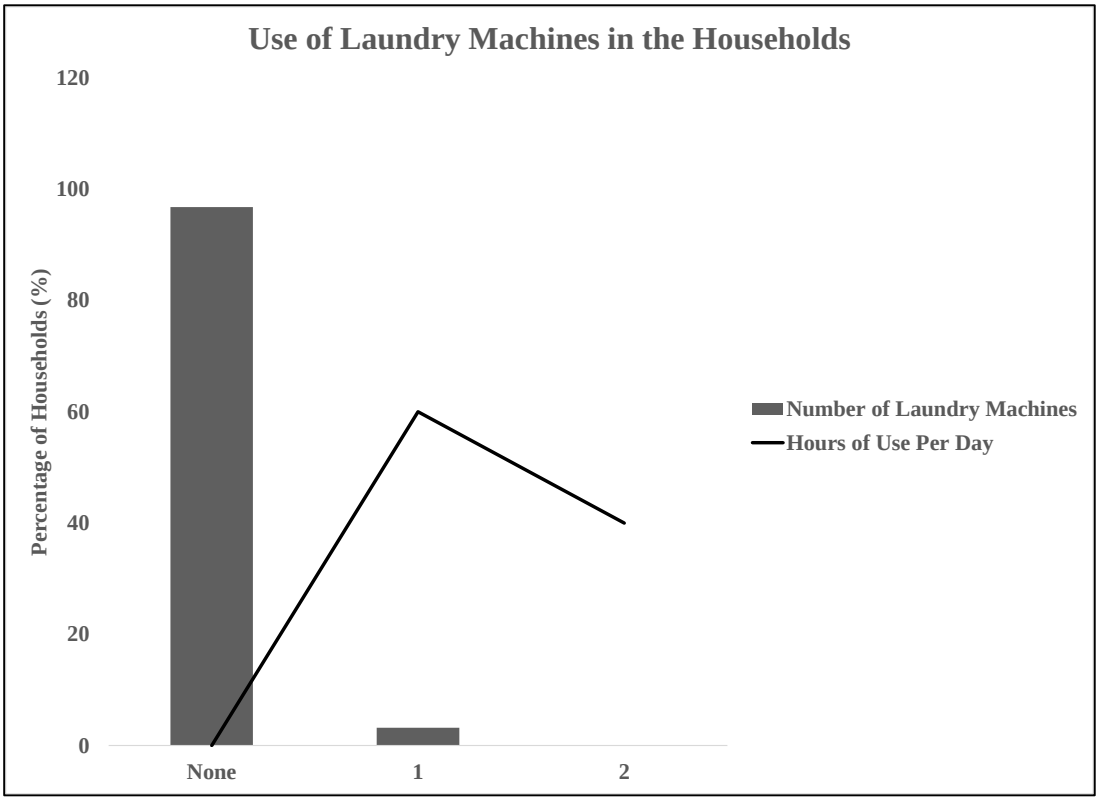

FIGURE 21: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER AND DAILY USE OF LAUNDRY MACHINES

TABLE 50: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE NUMBER OF CLOTH IRONS

Number of Cloth Irons	Number of Households	Percentage of Households
None	58	37.2
1	98	62.8
Total	156	100.0

TABLE 51: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO DAILY USE OF EACH CLOTH IRON

Number of Hours/Day	Number of Households	Percentage of Households
None	0	0.0
0.5	96	98.0
1	2	2.0
Total	98	100.0

4.8.3.Monthly Electricity Bill

The households were further asked about the average electricity bill. The results, summarized in *Figure 22*, show that 66% households had a monthly electricity bill of Rs. 1,000 to 3,000.

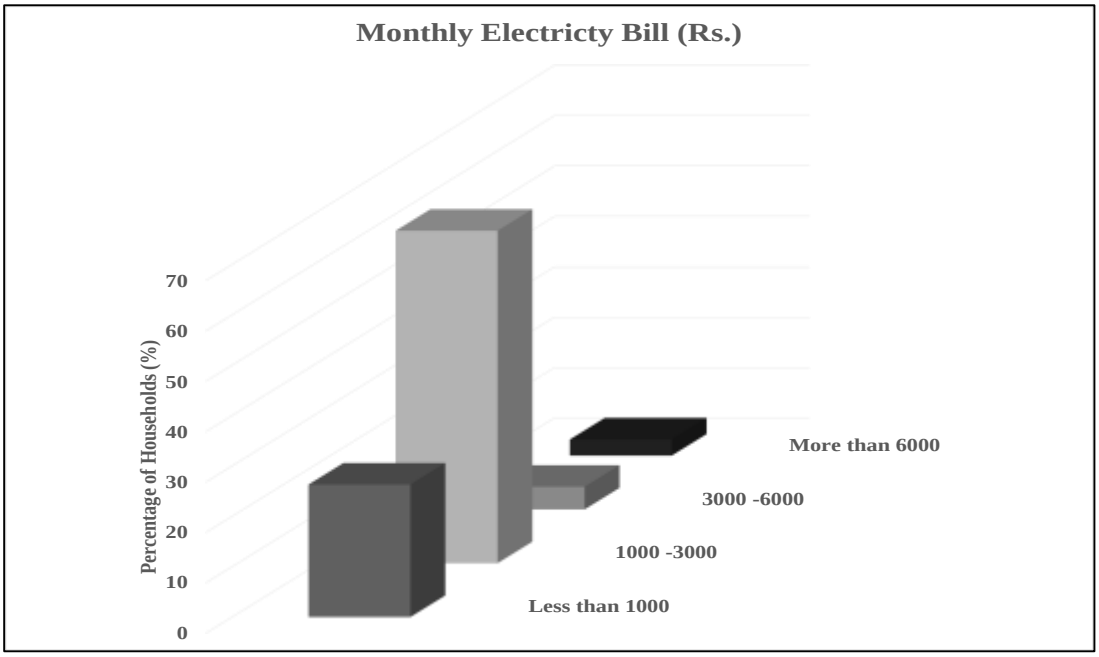

FIGURE 22: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE MONTHLY ELECTRICITY BILL

4.8.4. Preferred Source of Electricity

During the survey, the respondents were asked that if they had free choice, what would they prefer as source of electricity. The detailed breakdown of the results is shown in *Table 52.*

TABLE 52: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PREFERRED SOURCE OF ELECTRICITY

Sources of Electricity	Number of Households	Percentage of Households
Grid	25	16
Diesel Generator	0	0
Natural gas generator	0	0
storage battery	0	0
Solar home System	131	84
Total	156	100

4.9. Perceptions about Renewable Energy and Microfinancing

The last section of the survey questionnaire was focused on assessing the perceptions and preferences of the community regarding renewable energy technologies and micro financing. The following sub-sections were included in this section of the questionnaire:

4.9.1.Knowledge about Renewable Energy Sources

The results show that 136 households in the village knew about biomass energy as they were already using the firewood as a source of energy. Moreover 120 households in the village had a knowhow about solar energy. *(Table 53)*

TABLE 53: NUMBER OF HOUSEHOLDS WITH RESPECT TO THE KNOWLEDGE OF RENEWABLE ENERGY SOURCE(S) (MORE THAN ONE ANSWER POSSIBLE)

Renewable Energy Sources	Number of Households
None	35
Solar	120
Wind	5
Biomass	136
Hydro	3
Other	0

4.9.2.Positive Impacts of Renewable Energy Technologies

The respondents were further asked about their thoughts on whether the use of renewable energy technologies can bring any changes in life. The answers are summarized in *Table 54*

TABLE 54: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR PERCEPTIONS REGARDING IMPACTS OF RENEWABLE ENERGY TECHNOLOGIES

Change Which Could be Brought by Renewable Energy Technologies	Number of Households	Percentage of Households
Yes, it can reduce energy costs	127	81.4
Yes, (other reason)	2	1.3
No	4	2.6
Don't Know	23	14.7
Total	156	100.0

4.9.3.Adoption of Renewable Energy Technology

More than 90% households in the village stated that they had never tried to access any kind of renewable energy technology *(Table 55).* More than 35% of them reported that high cost of the renewable energy technologies kept them from trying to acquire them. *Table 56* provides a detailed breakdown of the reasons.

TABLE 55: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PREVIOUS EFFORTS FOR ACQUIRING RENEWABLE ENERGY TECHNOLOGIES

Previous Efforts to Acquire Renewable Energy Technologies	Number of Households	Percentage of Households
Yes	12	7.7
No	144	92.3
Total	156	100.0

TABLE 56: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE REASONS FOR NOT TRYING TO ACQUIRE RENEWABLE ENERGY TECHNOLOGIES

Reasons for Not Trying to Acquire Renewable Energy Technologies	Number of Households	Percentage of Households
High cost	51	35.4
Unawareness about its benefits	2	1.4
Unawareness about its existence	33	22.9
Unavailability	58	40.3
Total	144	100.0

4.9.4.Willingness to Buy Renewable Energy Technology on Micro-Loan

The households in the surveyed village were then directly asked about their willingness to buy renewable energy technologies on Micro-Loan. A clear majority of the respondents, i.e. 82.7% gave a positive response while 17.3% showed their un-willingness. *(Figure 23)*

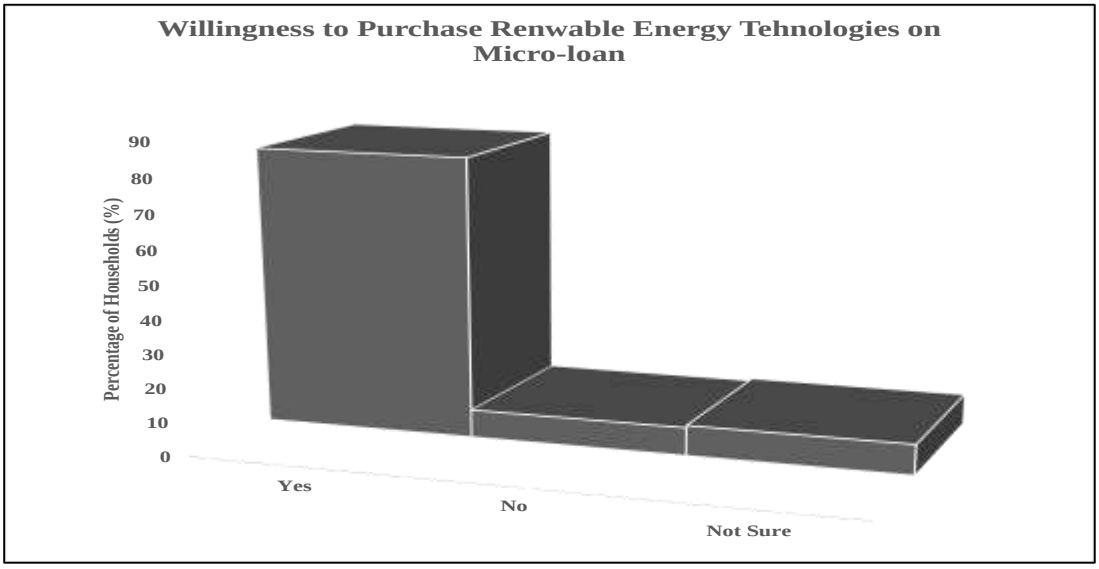

FIGURE 23: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR WILLINGNESS TO BUY RENEWABLE ENERGY TECHNOLOGIES ON LOAN

Among the 17.3% households who showed their un-willingness, 37% stated that their financial situation does not allow them to take loan. The detailed breakdown is provided in *Table 57.*

TABLE 57: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THEIR REASONS FOR UN-WILLINGNESS TO BUY RENEWABLE ENERGY TECHNOLOGIES ON LOAN

Reasons for Un-willingness	Number of Households	Percentage of Households
Financial problems	10	37
Not sure if it will benefit us	4	14.8
No need	13	48.1

4.9.5.Preferred Type of Renewable Energy Technology on Micro-Loan

When asked which renewable energy technology they would prefer to acquire through Micro-Loan, around 93% respondents opted for solar home system, while 7% stated they would prefer biogas plant. *(Table 58)*

TABLE 58: NUMBER AND PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PREFERRED TYPE OF RENEWABLE ENERGY TECHNOLOGY

Renewable Energy Technology	Number of Households	Percentage of Households
Solar Home System	145	92.9
Biogas	11	7.1
Total	156	100.0

4.9.6.Preferred Upfront Payment

More than half of the respondents stated that they could only afford an upfront payment of Rs. 6000 or less, for buying renewable energy technology on Micro-Loan. *(Figure 24)*

4.9.7.Preferred Monthly Installment

Around 74% households reported that a monthly installment of less than or equal to Rs. 2000 would suit them the most, while 21% said they could pay Rs. 2000 to 4000 per month as installment. *(Figure 25)*

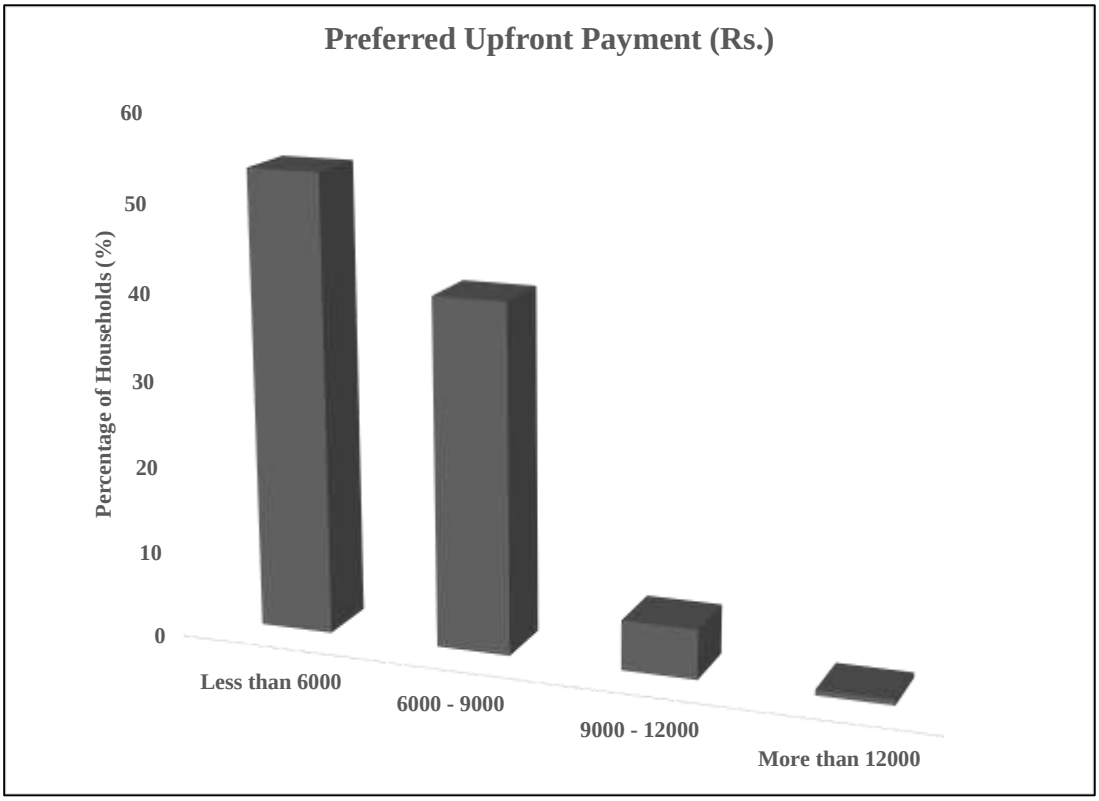

FIGURE 24: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PREFERRED UPFRONT PAYMENT (RS.)

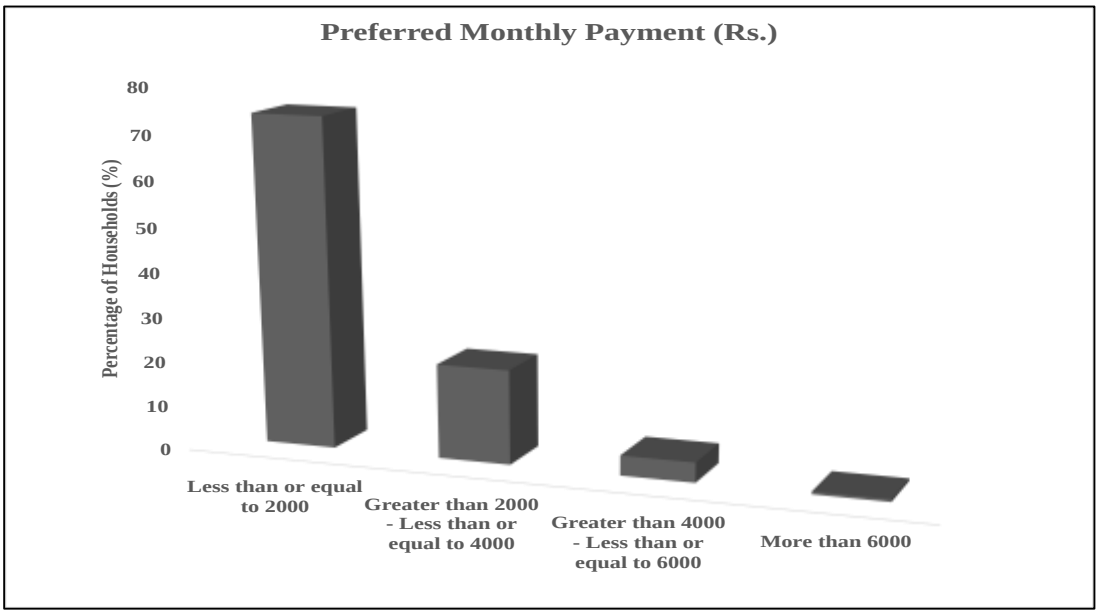

FIGURE 25: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PREFERRED MONTHLY PAYMENT (RS.)

4.9.8.Preferred Duration of Loan

In case of loan duration, more than half of the respondents said they would be most comfortable if the loan duration is 3 years or more. *(Figure 26)*

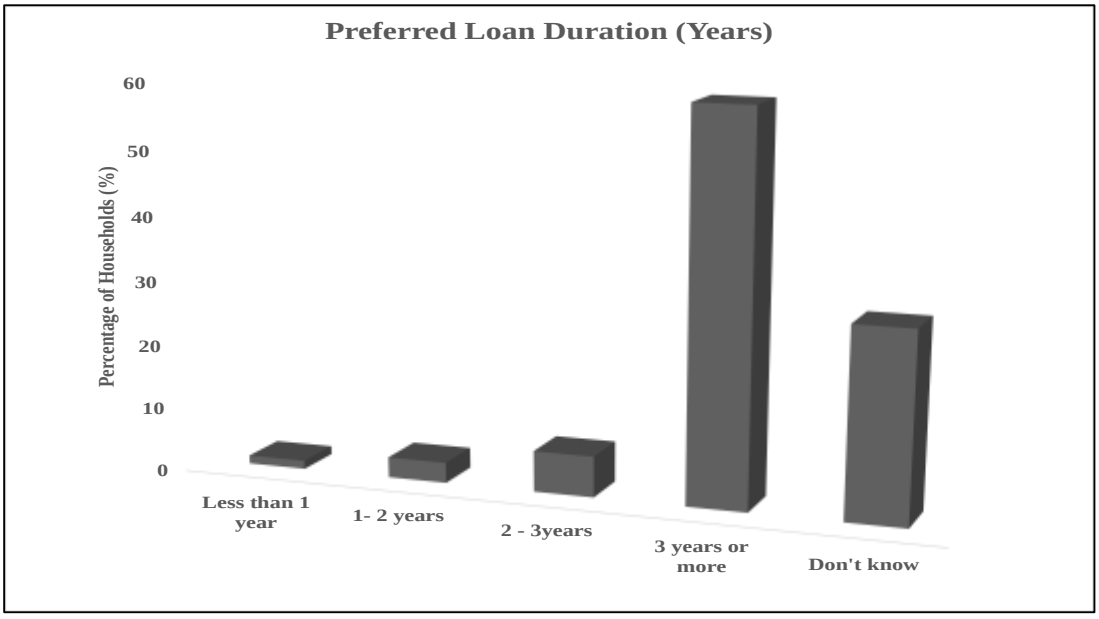

FIGURE 26: PERCENTAGE OF HOUSEHOLDS WITH RESPECT TO THE PREFERRED DURATION OF LOAN

4.10. Comments and Suggestions from the Respondents

At the end of the survey, each respondent was asked to express his opinion or any comments/suggestions about the proposed renewable energy microfinance intervention. The major points raised by the respondents are summarized below:

4.10.1. Interest Rate

Majority of the respondents expressed that the bank loans are provided with the compulsion of interest rates (‘Sood’ in Urdu) and being Muslims, they are forbidden to indulge in any interest-based activity Therefore, they suggested that the micro-loan should be designed without the element of interest rate in it.

4.10.2. Operation and Maintenance of Renewable Energy Technologies

Another concern of the local community was the complicated operation of renewable energy technologies. They expressed their concern that they might not be able to operate the system correctly and hence their money could go to waste. Moreover, they also feared that if the system stops working during or after the loan period, it will cost them more money and hassle. Some of the respondents suggested that the loan provider should take the responsibility of maintenance and that maintenance should not cost them extra money.

4.11. Conclusion

From the survey results, it can be concluded that most of the households in the case study village are both willing and able to adopt renewable energy technologies, through micro-loans.

The survey results further show that solar home system is the preferred type of technology for the respondents. It employs that solar home systems can be considered for micro-financing.

Summary

The results of the household survey revealed the following major points:

1. The majority of case study village households have 5-6 residents in the household, with most of the family members being either primary or secondary school qualified, and 1-2 family members responsible for bread earning for the whole family.
2. The major profession in the village is regular employment, with agriculture and livestock being a close second. Accordingly, most of the households get monthly income.
3. Eighty out of 156 surveyed households reported that their average monthly household income is between Rs. 20,000-30,000. Approximately the same number of households said that they spend on average Rs. 20,000-30,000 per month for household expenses.
4. Most common energy source used for lighting is electricity, while LPG is used for cooking, electric fans are used for space cooling in summers and firewood is used for space and water heating in winters by most of the households.
5. Lighting, space cooling with fans and air conditioners, watching TV, listening to radio, charging mobile phones, using laptop and desktop computers, using laundry machines and cloth irons are the electricity intensive activities conducted in the village.
6. More than half of the households have an average electricity bill of Rs. 1000 to 3000 per month.
7. When asked their willingness to buy renewable energy technologies on Micro-Loan, around 83% said yes. Among them, 93% said they would prefer solar home system for buying on micro loan.

8. Most of the respondents willing to buy renewable energy technology on micro loan said they could only afford an upfront payment of Rs. 6,000 or less and a monthly installment of Rs. Rs. 2000 or less. Also, most of them preferred a loan duration of 3 years or more.
9. The respondents expressed their concern about the element of Interest rate in bank loans and suggested that the proposed Micro-Loan should be designed to be interest-free. They also demanded that the maintenance service should also be provided by the loan provider, without extra fee.
10. Based on the survey results, solar home system should be further considered for micro financing in the case study village.

Chapter 5

Solar Home System Design

Just like any other technological system, a SHS performs only as well as its worst component. Therefore, on one hand, it is extremely important to ensure quality of each component as even one poor quality component can downgrade the whole system's performance. On the other hand, proper sizing also holds critical importance because both over and under sized components induce significant in-efficiencies in the system, resulting in high price per unit power and high risk of system failure.

The sizing of Solar Home Systems (SHS) depend mainly on the energy demand and appliance use, available solar resources and available system components.

Basic framework used of SHS sizing is shown in the *Figure 27*.

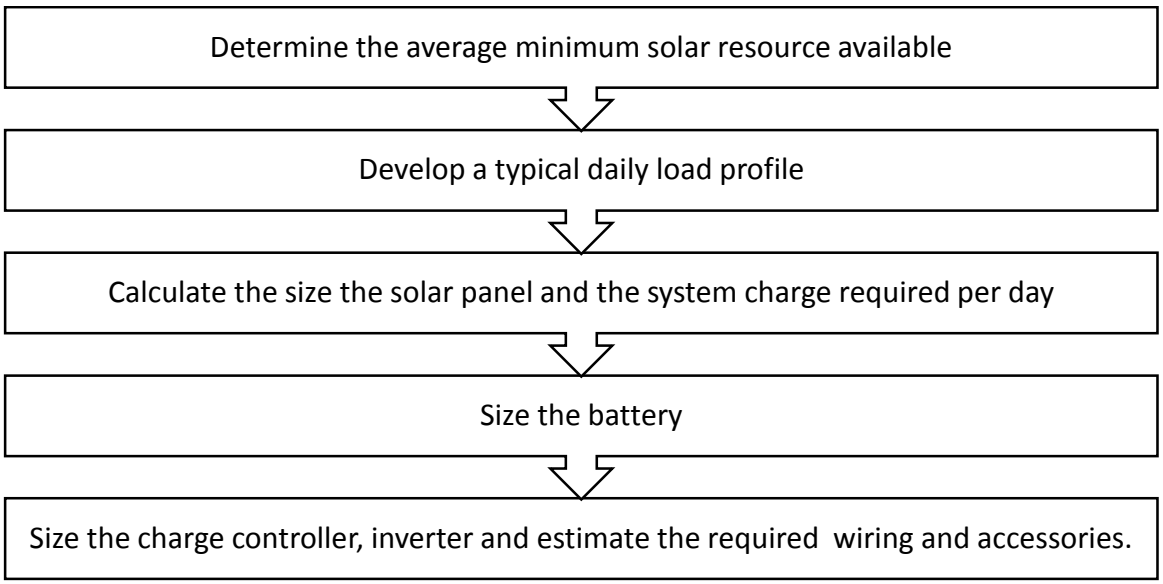

FIGURE 27: TYPICAL FRAMEWORK FOR SHS DESIGNING

In this study, the first two steps are performed manually while the other steps have been performed using ***RETScreen International*** simulation software.

5.1. Available Solar Resources

The case study village is located in the northern Barani area of Punjab province. The area receives and annual average rainfall of 1000 – 1200 mm, occurring mostly in July and August as monsoon rains. Winter season lasts from December to February and

remains mostly dry, spring season, from March to May, remains also remains dry, but hot and from June to September, the wet summer season prevails. The region also experiences a monsoon retreat season in October and November. *Table 59* shows a summary of regional climatic information of Rawalpindi [1, 2, 3].

TABLE 59: CLIMATE OF RAWALPINDI DISTRICT

Parameter	Rawalpindi
Longitude	33°36'00"N
Latitude	73°02'24"E
Elevation	~490m
Annual average precipitation	1000-1200 mm
Average June highs/lows	38/24 °C
Average January highs/lows	16/3 °C
Absolute Maximum	47 °C
Absolute Minimum	-3 °C

As shown by the solar radiation model developed by the National Renewable Energy Laboratory (NREL), USA [4] *(Figure 28),* Pakistan has got abundant solar resources.

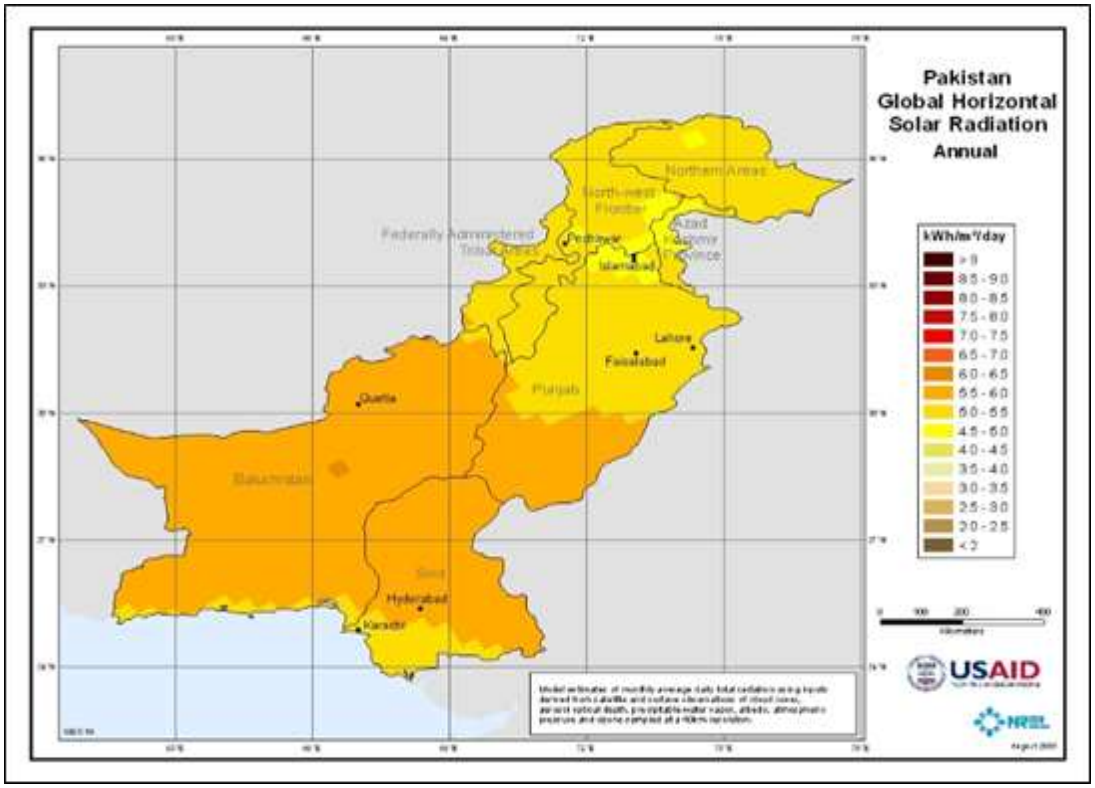

FIGURE 28: SOLAR RESOURCES OF PAKISTAN

The Global solar radiation is essentially the sum of direct and diffused solar radiations falling on a horizontal surface. As shown by the solar resource map, the project area

receives an annual global solar radiation average of around 5.0-5.5 kWh/m2/day. The case study village, Jajja, lies with the coordinates 33° 16' 12" N and 73° 8' 9.5994" E. The *Tables 60 and 61* show the detailed estimates of average daily solar radiation, as simulated by RETScreen.

TABLE 60: DAILY SOLAR RADIATION INCIDENT ON A HORIZONTAL SURFACE (KWH/M2/DAY)

Month	kWh/m2/day
Jan	2.13
Feb	3.22
Mar	3.77
Apr	4.56
May	5.26
Jun	5.67
Jul	4.79
Aug	4.63
Sep	4.36
Oct	4.33
Nov	3.13
Dec	2.32
Annual Average	**4.02**

TABLE 61: DAILY SOLAR RADIATION INCIDENT ON EQUATOR-POINTED 33 DEGREE TILTED SURFACE (KWH/M2/DAY)

Month	kWh/m2/day
Jan	2.86
Feb	4.07
Mar	4.16
Apr	4.55
May	4.86
Jun	5.05
Jul	4.36
Aug	4.47
Sep	4.65
Oct	5.47
Nov	4.49
Dec	3.41
Annual Average	4.36

5.2. Typical Load Profile

Since the village households varied with their income status, number of residents, number of rooms and hence the lifestyle, it was not possible to design a solar home system catering to the exact need of all the households.

Therefore, a typical load profile for the individual households in the case study area was developed keeping in mind that ***the proposed solar home system size and design should be able to bear the summer season load of the electricity intensive activities which are carried out in atleast 50% households in the village.***

Recalling the survey results, it was learned that the village households are involved in the following electricity intensive activities:

1. Lighting: 156 Households
2. Space Cooling (Fans): 154 Households
3. Space Cooling (Air-conditioning): 4 Households
4. Watching TV: 145 Households
5. Listening to Radio: 20 Households
6. Charging mobile phones: 139 Households
7. Using desktop computer: 22 Households
8. Charging laptop: 8 Households

The results clearly shows that only 4 activities i.e. Lighting, Space cooling with fans, watching TV and charging mobile phones, are carried out in more than 50% households. Therefore, the typical load profile will be developed considering only these 4 activities.

1. Lighting:

The village households are using two types of lighting fixtures i.e. tube lights and compact fluorescent lights, commonly known as energy savers.

In the previous chapter, the use of tube lights in the village has been discussed in detail. The survey results show that all the households use tube lights, except for the 41 households which reported using other lighting technologies. Moreover, among those who use tube lights in their homes, majority of the households said they have 4 tube lights installed in their house and each of them is used for an average 3 hours per day.

The use of compact fluorescent lights has also been analyzed in previous chapter. It can be seen from the survey results that most of the households have 2 of these lights installed in their house. Moreover, more than half of the households said that they use each of the energy savers for an average 5 hours each day.

Overall, a typical household in the case study village presents the following lighting profile:

- ✓ 4 Tube lights, each used for 3 hours per day.
- ✓ 2 Compact Fluorescent lights, each used for 5 hours per day.

2. Space Cooling with Fans:

In total, 154 out of 156 households surveyed reported using fans for space cooling in summers. As depicted by the survey results, more than 26% households have 3 fans installed in their house. As for the daily use of fans, around half of the households reported a use of more than 8 hours for each fan, per day. Since it can be well understood that due to local climate, space cooling is needed throughout day and night in summers, so an average of 10 hours each fan would be an appropriate conservative estimate of fan usage in the village.

Therefore, for the purpose of developing a typical load profile, we can conclude that an average household uses:

- ✓ 3 Fans, each used for 10 hours per day.

3. Watching TV:

It can also be seen in the survey results that 138 out of the 156 households own one or more color Televisions. Among them, more than 86% reported having only 1 television for the whole family. Also, around half of the households having color Television in their home said that they watch it for on average 4 hours each day.

Therefore, it can be concluded that in a typical household, there is:

- ✓ 1 colored TV, used for 4 hours per day

4. Charging Mobile Phones:

All except 17 households had atleast 1 mobile phone in their house. Moreover, around half of the participating households said they have only 1 mobile phone in the house. Also, more than 74% said that they have to charge the mobile phone for on average 1 hour each day.

So, it can be deduced that a typical household in the village uses:

- ✓ 1 Mobile phone, charged for 1 hour per day

In summary, the survey results present the following as a typical summer season electricity

- ✓ 4 Tube lights, each used for 3 hours per day.
- ✓ 2 Compact Fluorescent lights, each used for 3 hours per day.
- ✓ 3 Fans, each used for 10 hours per day.
- ✓ 1 colored TV, used for 4 hours per day
- ✓ 1 Mobile phone, charged for 1 hour per day

Generally, these appliances have the average wattage shown in *Table 62* [5, 6]

TABLE 62: AVERAGE WATTAGE OF VARIOUS ELECTRIC APPLIANCES

Appliance	**Wattage**
Tube Light	40
Compact Fluorescent light	22
Fan	80
TV	200
Mobile Phone Charger	5

The typical load profile was then calculated as shown below:

Tube Lights:	4 x 40 watts x 3 hours = 480 watt-hour/day
Compact Fluorescent Lights:	2 x 22 watts x 5 hours = 220 watt-hour/day
Fans:	3 x 80 watts x 10 hours = 2400 watt-hour/day
Television:	1 x 200 watts x 4 hours = 800 watt-hour/day
Mobile Phone Charger:	1 x 5 watts x 1 hour = 5 watt-hour/day
Total:	3905 watt-hour/day
	= 43.905 kWh/day
	= 117.15 kWh/month

5.3. RETScreen Simulations for PV System Design

RETScreen has been used to design the solar photovoltaic home systems for this study. The designing has been conducted with following standards:

General:

Grid Electricity Rate: 20 PKR/kWh

Fuel Cost Escalation Rate:	10%
Inflation Rate:	8%
Discount Rate:	10%
Project Life:	25 Years

Inverter:

Inverter Efficiency:	95%
Miscellaneous Losses:	1%

Battery:

Days of Autonomy:	1
Voltage:	12
Efficiency:	90%
Maximum Depth of Discharge:	80%
Charge Controller Efficiency:	95%
Temperature Control Method:	Ambient
Average Battery Temperature De- rating:	2.4%

Photovoltaic:

Solar tracking mode:	Fixed
Slope:	33.3 degrees
Azimuth:	0.0 degrees
Annual Titled Solar Radiation:	1.59 MWh/m²

System Price Estimates:

Solar Panels:	Yingli Solar - @ Rs. 100 per Watt
Battery:	Rs. 15 Per Watt
Charge Controller:	Rs. 25,000
Wiring:	2% of power system cost
Inverter:	1 kW – Rs. 14,000
Transportation and Installation:	Rs. 5,000

5.3.1.PV System for Typical Existing Load

This system has been designed as per the typical load profile established earlier. The RETScreen simulation results are shown below:

SYSTEM LOAD

Description	AC/DC	Base case load	Hours of use per day	Days of use per week
		W	h/d	d/w
Tube Light	AC	40.00	3.00	7
Tube Light	AC	40.00	3.00	7
Tube Light	AC	40.00	3.00	7
Tube Light	AC	40.00	3.00	7
Compact Fluorescent Light	AC	22.00	5.00	7
Compact Fluorescent Light	AC	22.00	5.00	7
Ceiling Fan	AC	80.00	10.00	7
Ceiling Fan	AC	80.00	10.00	7
Ceiling Fan	AC	80.00	10.00	7
Television	AC	200.00	4.00	7
Mobile Phone Charger	AC	5.00	1.00	7
Total Number of Watts			649.00	
Total Daily AC Load			3.91 kWh	
Peak Annual Load			0.65 kW	

SYSTEM DESIGN

Inverter	1 kW
Battery	470 Ah (6 kWh)
Power Capacity of Selected Solar Panels	1715 Watts (1.72 kW)
Efficiency of Selected Solar Panels	15 %
Electricity delivered to load by the selected solar panels	1.47 MWh (103%)

SYSTEM COST

Component	Cost (PKR)
Solar Panels	171,500
Charge Controller	25,000
Battery	84,580
Inverter	14,000
Wiring	5,622
Transportation/Installation	5,000
Total	305,702

FINANCIAL VIABILITY

Pre-tax IRR – equity	19.6%

Pre-tax IRR – assets	19.6%
After-tax IRR – equity	19.6%
After-tax IRR – assets	19.6%
Simple payback	10 years
Equity payback	6.8 years
Net Present Value (NPV) (PKR)	456,961
Annual life cycle savings (PKR/Year	50,342
Benefit-Cost (B-C) ratio	2.49
GHG reduction cost	(39,783)

5.3.2.Proposed Scenarios for Cutting Cost of the PV System

Considering the high cost of the PV system for the typical load profile, it can be well assumed that the majority of the potential SHS users in the case study village will not be able to afford this system. Moreover, since the village households are different in terms of their income and electricity consumption, a single design of PV system cannot be proposed for all the households in the community.

As mentioned earlier, the survey results indicated that the village population can be divided into 3 distinct groups with respect to their monthly income i.e.

1. Lower income group (10,000 to 2,000 Rs. Per month)
2. Medium income group (20,000 to 30,000 Rs. per month)
3. Higher income group (30,000 to 40,000 Rs. Per month)

When looked into further depth, it was also found that majority of lower income group households had 2 rooms in their house, most of those earning between 20,000 to 30,000 Rs. Per month had 3 rooms in their house while more than half of the households falling in the higher income group had 4 or more rooms in their house *(Table 63).*

TABLE 63: CROSS-TABULATION OF HOUSEHOLD INCOME AND NUMBER OF ROOMS IN THE HOUSE

		How many rooms are there in the house you currently reside in?				**Total**
		1	2	3	4 or more	
	Less than 10,000	0	0	3	5	8

How much is the total household monthly income (Rs.)?	10,000-20,000	2	19	7	2	30
	20,000-30,000	0	7	64	9	80
	30,000-40,000	0	0	10	20	30
	Above 40,000	0	1	0	7	8
Total		2	27	84	43	156

It is therefore suggested that instead of one typical solar PV system package, the households are offered 3 different packages fitting to the basic needs of 2-room house, 3-room house and 4-room house.

Moreover, it was also seen that the current electricity consumption practices are highly in-efficient. In this regard, it was proposed that the existing lighting fixtures, which consume a major chunk of electricity, should be replaced with high efficiency LED counterparts so as to reduce the total load of the PV system and hence its cost.

With these considerations, the following 3 system designs with reduced load and hence reduced cost are presented.

Package 1: 2-Room System

SYSTEM LOAD

Description	**AC/DC**	**Base case load**	**Hours of use per day**	**Days of use per week**
		W	**h/d**	**d/w**
LED Tube Light	AC	18.00	3.00	7
LED Tube Light	AC	18.00	3.00	7
LED Bulb	AC	9.00	5.00	7
LED Bulb	AC	9.00	5.00	7
Ceiling Fan	AC	80.00	10.00	7
Ceiling Fan	AC	80.00	10.00	7
Mobile Phone Charger	AC	5.00	1.00	7
Total Number of Watts			219.00	
Total Daily AC Load			1.80 kWh	
Peak Annual Load			0.22 kW	

SYSTEM DESIGN

Inverter	1 kW
Battery	217 Ah (3 kWh)
Power Capacity of Selected Solar Panels	735 Watts (0.74 kW)
Efficiency of Selected Solar Panels	15.0 %
Electricity delivered to load by the selected solar panels	0.67 MWh (101.5%)

SYSTEM COST

Component	**Cost (PKR)**
Solar Panels	73,500
Charge Controller	25,000
Battery	39,052
Inverter	14,000
Wiring	2,751
Transportation/Installation	5,000
Total	159,303

FINANCIAL VIABILITY

Pre-tax IRR – equity	*19.0%*
Pre-tax IRR – assets	*19.0%*
After-tax IRR - equity	*19.0%*
After-tax IRR - assets	*19.0%*
Simple payback	*10.5 years*
Equity payback	*7 years*
Net Present Value (NPV) (PKR)	*219,744*
Annual life cycle savings (PKR/Year	*24,209*
Benefit-Cost (B-C) ratio	*2.38*
GHG reduction cost	*(41,435)*

Package 2: 3-Room System

SYSTEM LOAD

Description	**AC/DC**	**Base case load**	**Hours of use per day**	**Days of use per week**
		W	**h/d**	**d/w**
LED Tube Light	AC	18.00	3.00	7
LED Tube Light	AC	18.00	3.00	7
LED Tube Light	AC	18.00	3.00	7
LED Bulb	AC	9.00	5.00	7

LED Bulb	AC	9.00	5.00	7
Ceiling Fan	AC	80.00	10.00	7
Ceiling Fan	AC	80.00	10.00	7
Ceiling Fan	AC	80.00	10.00	7
Mobile Phone Charger	AC	5.00	1.00	7
Total Number of Watts			317.00	
Total Daily AC Load			2.66 kWh	
Peak Annual Load			0.32 kW	

SYSTEM DESIGN

Inverter	1 kW
Battery	320 Ah (4 kWh)
Power Capacity of Selected Solar Panels	1040 Watts (1.04 kW)
Efficiency of Selected Solar Panels	16.2 %
Electricity delivered to load by the selected solar panels	0.97 MWh (100.4%)

SYSTEM COST

Component	**Cost (PKR)**
Solar Panels	104,000
Charge Controller	25,000
Battery	57,549
Inverter	14,000
Wiring	3,731
Transportation/Installation	5,000
Total	209,280

FINANCIAL VIABILITY

Pre-tax IRR – equity	20.0%
Pre-tax IRR – assets	20.0%
After-tax IRR - equity	20.0%
After-tax IRR - assets	20.0%
Simple payback	9.8 years
Equity payback	6.7 years
Net Present Value (NPV) (PKR)	325,622
Annual life cycle savings (PKR/Year	35,873
Benefit-Cost (B-C) ratio	2.56
GHG reduction cost	(41,664)

Package 3: 4-Room System

SYSTEM LOAD

Description	AC/DC	Base case load	Hours of use per day	Days of use per week
		W	h/d	d/w
LED Tube Light	AC	18.00	3.00	7
LED Tube Light	AC	18.00	3.00	7
LED Tube Light	AC	18.00	3.00	7
LED Tube Light	AC	18.00	3.00	7
LED Bulb	AC	9.00	5.00	7
LED Bulb	AC	9.00	5.00	7
Ceiling Fan	AC	80.00	12.00	7
Ceiling Fan	AC	80.00	12.00	7
Ceiling Fan	AC	80.00	12.00	7
Ceiling Fan	AC	80.00	12.00	7
Mobile Phone Charger	AC	5.00	1.00	7
Total Number of Watts			415.00	
Total Daily AC Load			3.51 kWh	
Peak Annual Load			0.42 kW	

SYSTEM DESIGN

Inverter	1 kW
Battery	422 Ah (5 kWh)
Power Capacity of Selected Solar Panels	1470 Watts (1.47 kW)
Efficiency of Selected Solar Panels	15.0 %
Electricity delivered to load by the selected solar panels	1.31 MWh (102.2%)

SYSTEM COST

Component	Cost (PKR)
Solar Panels	147,000
Charge Controller	25,000
Battery	76,046
Inverter	14,000
Wiring	4,961
Transportation/Installation	5,000
Total	272,007

FINANCIAL VIABILITY

Pre-tax IRR – equity	19.9%
Pre-tax IRR – assets	19.9%
After-tax IRR – equity	19.9%
After-tax IRR – assets	19.9%
Simple payback	9.8 years
Equity payback	6.7 years
Net Present Value (NPV) (PKR)	418,750
Annual life cycle savings (PKR/Year	46,133
Benefit-Cost (B-C) ratio	2.54
GHG reduction cost	(40,548)

Summary

The proposed packages for 2-room, 3-room and 4-room solar PV home system are summarized in the table below. These are targeted for their respective income group however, based on their needs and financial state, the households will be free to choose any one of the system proposed below:

SUMMARY OF PROPOSED SOLAR HOME SYSTEM DESIGNS

	Package 1	**Package 2**	**Package 3**
Income Range	10,000 to 20, 000 Rs.	20,000 to 30,000 Rs.	30, 000 to 40, 000 Rs.
Load	✓ 2 x18W LED Tube Lights (3 hours/ day each) ✓ 2 x 9W LED Bulbs (5 hours/day each) ✓ 2x 80W Ceiling Fans (10 hours/day each) ✓ 1 x 5W mobile phone charger (1 hour/day)	✓ 3 x18W LED Tube Lights (3 hours/ day each) ✓ 2 x 9W LED Bulbs (5 hours/day each) ✓ 3 x 80W Ceiling Fans (10 hours/day each) ✓ 1 x 5W mobile phone charger (1 hour/day)	✓ 4 x18W LED Tube Lights (3 hours/ day each) ✓ 2 x 9W LED Bulbs (5 hours/day each) ✓ 4 x 80W Ceiling Fans (10 hours/day each) ✓ 1 x 5W mobile phone charger (1 hour/day)
Price (Rs.)	159,303	209,280	272,007

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Chapter 6

Microfinance Model Design

This chapter discusses the viable design of SHS Microfinance model based on the household survey results and the designed SHS packages.

6.1.Proposed Microfinance Model

As established in the chapter on Literature review, One-Hand Implementation model for renewable energy microfinancing is simple, less expensive and is showing promising results in Bangladesh in the form of Grameen Shakti and IDCOL. Therefore, it is evident that One-Hand model is currently the most appropriate model for SHS microfinancing in Pakistan.

However, all the financial models currently being implemented under the One-hand Implementation model, including the Grameen Shakti model, are based on interest rate. On the other hand, during the demand assessment, the element of 'interest rate' in loans turned out to be a big concern among the household. Since almost all the target clients are Muslims and Islam prohibits getting involved in businesses having the element of interest rate in it, special care was taken design a loan which could be accepted by the clients. Therefore, there is a need to look towards Islamic finance instruments for designing a viable loan scheme for Pakistan.

The literature shows that Diminishing Musharakah has shown the most tremendous growth with respect to share in Islamic finance in Pakistan. Although, it has not been tested specifically for renewable energy micro financing, it has shown encouraging results for financing of various other physical assets for example house, machinery etc, Therefore, in this study, a Diminishing Musharkah model is being proposed for renewable energy micro financing in the rural areas of Pakistan.

Diminishing Musharakah is a relatively newly developed form of Musharakah, and is based on the concept of 'Sharikat ul Milk' i.e. joint ownership of an asset. According to this concept, the lender and the borrower enter into a partnership agreement either for ownership of a physical asset or a commercial enterprise. The share of the lender is divided into a number of units and the borrower promises to buy these units one by

one in a certain amount of time. In this way, the share of borrower is gradually increased and the share of lender is gradually decreased until the borrower acquires 100% share [1].

This detailed Shariah standards on Sharikat ul Milk and Diminishing Musharakah based on it, as per the State Bank of Pakistan's Islamic Banking Department have been consulted while designing the loan model [2].

6.2.Proposed Micro Loan Structure

This section details the designing and structure of the proposed micro loan for solar home system micro financing in Pakistan.

6.2.1.Target Payment Structure

Before designing the loan structure, it is necessary to develop a target payment structure based on the willingness and ability to pay of the local community. The *Table 64, 65 and 66* shown below show the income group wise distribution of households with their preference of upfront payment, monthly instalment for renewable energy Micro-Loan and monthly electricity bills.

TABLE 64: CROSS TABULATION OF MONTHLY HOUSEHOLD INCOME AND PREFERENCE OF UPFRONT PAYMENT

		How much money (Rs.) can you pay upfront?				Total
		Less than 6000	6000 - 9000	9000 - 12000	More than 12000	
How much is the total household monthly income (Rs.)?	Less than 10,000	5	3	0	0	8
	10,000-20,000	26	4	0	0	30
	20,000-30,000	46	33	1	0	80
	30,000-40,000	4	23	2	1	30
	Above 40,000	2	0	6	0	8
Total		83	63	9	1	156

TABLE 65: CROSS TABULATION OF MONTHLY HOUSEHOLD INCOME AND PREFERENCE OF MONTHLY PAYMENT

		What monthly payment (Rs.) can you afford?				Total
		Less than or equal to 2000	Greater than 2000 - Less than or equal to 4000	Greater than 4000 - Less than or equal to 6000	More than 6000	
How much is the total household monthly income (Rs.)?	Less than 10,000	7	1	0	0	8
	10,000-20,000	30	0	0	0	30
	20,000-30,000	65	15	0	0	80
	30,000-40,000	11	16	2	1	30
	Above 40,000	2	1	5	0	8
Total		115	33	7	1	156

TABLE 66: CROSS TABULATION OF MONTHLY HOUSEHOLD INCOME AND MONTHLY ELECTRICITY BILL

		How much is your electricity bill per month (Rs.)?				Total
		Less than or equal to 1000	Greater than 1000 -Less than or equal to 3000	Greater than 3000 -Less than or equal to 6000	More than 6000	
How much is the total household monthly income (Rs.)?	Less than 10,000	0	2	1	5	8
	10,000-20,000	23	7	0	0	30
	20,000-30,000	18	61	1	0	80
	30,000-40,000	0	28	2	0	30
	Above 40,000	0	5	3	0	8
Total		41	103	7	5	156

Considering these figures, the range of Target monthly instalment and upfront payment for respective income groups was inferred as:

a) Lower income group (10,000 to 2,000 Rs. Per month)
   - ✓ Target upfront payment: Rs. 6,000
   - ✓ Monthly bill: Rs. 1,000
   - ✓ Preferred monthly payment: Rs. 2,000
   - ✓ Target Monthly Installment: 3,000 Rs. Approx.

b) Medium income group (20,000 to 30,000 Rs. per month)
   - ✓ Target upfront payment: Rs. 6,000
   - ✓ Monthly bill: Rs. 3,000
   - ✓ Preferred monthly payment: Rs. 2,000
   - ✓ Target Installment: 5,000 Rs. Approx.

c) Higher income group (30,000 to 40,000 Rs. Per month)
   - ✓ Target upfront payment: Rs. 9,000
   - ✓ Monthly bill: Rs. 3,000
   - ✓ Preferred monthly payment: Rs. 4,000
   - ✓ Target Installment: 7,000 Rs. Approx.

6.2.2.Salient Features of Micro Loan Design

The micro loan was designed with the following specifications and features:

- ✓ The loan has been designed based on the estimated costs of the proposed solar home system designs elaborated in the previous chapter, i.e. Rs. 159,303 for package 1, Rs. 209,280 for package 2 and Rs. 272,007 for package 3.
- ✓ It is proposed that each client should be provided with installation and maintenance services for the duration of loan. This will not only ensure optimal performance of the solar home system, but will also help build a trustworthy relationship with the client, hence making the stable loan re-payment process smooth.
- ✓ The MFI will charge a rent of Rs. 1,550, 1,750 and 1,950 per month for package1, package 2 and package 3 respectively, for the whole duration of loan. This rent will include the MFIs profit as well as maintenance cost for the system estimated at 2% of the original system cost, per year.

- ✓ In this case study, a maximum 5 year loan period is suggested based on the following factors.
    1. Life of Solar Home System: The international case studies in solar home system micro financing suggest that the component of solar home system having the shortest life span should be viewed as a critical indicator for determine the term of loan. In this case, the component having shortest life is the battery (average 3 – 5 years), therefore, it is suggested that the loan repayment period should not extend beyond 5 years.
    2. Preference of Clients: Most of the surveyed households in the case study area stated that they would be most comfortable with a loan period of 3 years or more.
- ✓ In most cases, the solar home system itself serves as a collateral since in case of non-payment or other issues, the MFI can easily un-install it and cancel the agreement.
- ✓ Loan re- payment frequency depends on the frequency of household income. In this case, most of the target clients get monthly income, therefore the loan was designed with monthly instalments.
- ✓ Upfront payment will be kept as 15% since most of the microfinance banks and institutes in Pakistan and abroad currently charge atleast 15% as upfront payment.

6.2.3.Finalized Micro Loan Design

Since the target clients have different income levels and electricity needs, 3 different solar home system packages were proposed in the previous chapter. Based on the Diminishing Musharakah model, the loan schemes for each of the packages were calculated using the following formulas [3, 4]:

$$\text{Rental Rate} = x = \frac{R}{P}$$

$$\text{Monthly Installment (Rs.)} = \frac{x[P-(1+x)^n C]}{(1+x)^n - 1}$$

Where,

R = Monthly rent (Rs.)

P= Total price of solar home system (Rs.)

C= Borrower's contribution in the partnership (Rs.)

Package 1

Total Cost of PV System (Rs.):	159303
Down Payment (%):	15
Down Payment (Rs.):	23895
Remaining Balance (Rs.):	135408
Maintenance Cost (per year):	2% of the system cost per year
Monthly Rent (Rs.):	1550
Rental Rate:	0.0097299
Monthly Installment (Rs.):	1439.933793

LOAN STRUCTURE FOR PACKAGE 1

Month	**Rent (Rs.)**			**Monthly Installment (Rs.)**	**Total payment (Rs.)**	**Equity of A (Rs.)**	**Equity of B (Rs.)**	**Share of A (%)**	**Share of B (%)**
	Amount	Share of A	Share of B						
							159,303		
0						23,895	135,408	15.00	85.00
1	1,550	233	1,318	1,440	2,990	25,568	133,735	16.05	83.95
2	1,550	249	1,301	1,440	2,990	27,257	132,046	17.11	82.89
3	1,550	265	1,285	1,440	2,990	28,962	130,341	18.18	81.82
4	1,550	282	1,268	1,440	2,990	30,683	128,620	19.26	80.74
5	1,550	299	1,251	1,440	2,990	32,422	126,881	20.35	79.65
6	1,550	315	1,235	1,440	2,990	34,177	125,126	21.45	78.55
7	1,550	333	1,217	1,440	2,990	35,950	123,353	22.57	77.43
8	1,550	350	1,200	1,440	2,990	37,740	121,563	23.69	76.31
9	1,550	367	1,183	1,440	2,990	39,547	119,756	24.82	75.18
10	1,550	385	1,165	1,440	2,990	41,371	117,932	25.97	74.03
11	1,550	403	1,147	1,440	2,990	43,214	116,089	27.13	72.87
12	1,550	420	1,130	1,440	2,990	45,074	114,229	28.29	71.71
13	1,550	439	1,111	1,440	2,990	46,953	112,350	29.47	70.53
14	1,550	457	1,093	1,440	2,990	48,850	110,453	30.66	69.34
15	1,550	475	1,075	1,440	2,990	50,765	108,538	31.87	68.13
16	1,550	494	1,056	1,440	2,990	52,699	106,604	33.08	66.92
17	1,550	513	1,037	1,440	2,990	54,651	104,652	34.31	65.69
18	1,550	532	1,018	1,440	2,990	56,623	102,680	35.54	64.46
19	1,550	551	999	1,440	2,990	58,614	100,689	36.79	63.21
20	1,550	570	980	1,440	2,990	60,624	98,679	38.06	61.94
21	1,550	590	960	1,440	2,990	62,654	96,649	39.33	60.67

22	1,550	610	940	1,440	2,990	64,703	94,600	40.62	59.38
23	1,550	630	920	1,440	2,990	66,773	92,530	41.92	58.08
24	1,550	650	900	1,440	2,990	68,863	90,440	43.23	56.77
25	1,550	670	880	1,440	2,990	70,973	88,330	44.55	55.45
26	1,550	691	859	1,440	2,990	73,103	86,200	45.89	54.11
27	1,550	711	839	1,440	2,990	75,254	84,049	47.24	52.76
28	1,550	732	818	1,440	2,990	77,426	81,877	48.60	51.40
29	1,550	753	797	1,440	2,990	79,620	79,683	49.98	50.02
30	1,550	775	775	1,440	2,990	81,834	77,469	51.37	48.63
31	1,550	796	754	1,440	2,990	84,070	75,233	52.77	47.23
32	1,550	818	732	1,440	2,990	86,328	72,975	54.19	45.81
33	1,550	840	710	1,440	2,990	88,608	70,695	55.62	44.38
34	1,550	862	688	1,440	2,990	90,910	68,393	57.07	42.93
35	1,550	885	665	1,440	2,990	93,235	66,068	58.53	41.47
36	1,550	907	643	1,440	2,990	95,582	63,721	60.00	40.00
37	1,550	930	620	1,440	2,990	97,952	61,351	61.49	38.51
38	1,550	953	597	1,440	2,990	100,345	58,958	62.99	37.01
39	1,550	976	574	1,440	2,990	102,761	56,542	64.51	35.49
40	1,550	1,000	550	1,440	2,990	105,201	54,102	66.04	33.96
41	1,550	1,024	526	1,440	2,990	107,664	51,639	67.58	32.42
42	1,550	1,048	502	1,440	2,990	110,152	49,151	69.15	30.85
43	1,550	1,072	478	1,440	2,990	112,664	46,639	70.72	29.28
44	1,550	1,096	454	1,440	2,990	115,200	44,103	72.31	27.69
45	1,550	1,121	429	1,440	2,990	117,761	41,542	73.92	26.08
46	1,550	1,146	404	1,440	2,990	120,346	38,957	75.55	24.45
47	1,550	1,171	379	1,440	2,990	122,957	36,346	77.18	22.82
48	1,550	1,196	354	1,440	2,990	125,594	33,709	78.84	21.16
49	1,550	1,222	328	1,440	2,990	128,256	31,047	80.51	19.49
50	1,550	1,248	302	1,440	2,990	130,943	28,360	82.20	17.80
51	1,550	1,274	276	1,440	2,990	133,657	25,646	83.90	16.10
52	1,550	1,300	250	1,440	2,990	136,398	22,905	85.62	14.38
53	1,550	1,327	223	1,440	2,990	139,165	20,138	87.36	12.64
54	1,550	1,354	196	1,440	2,990	141,959	17,344	89.11	10.89
55	1,550	1,381	169	1,440	2,990	144,780	14,523	90.88	9.12
56	1,550	1,409	141	1,440	2,990	147,629	11,674	92.67	7.33
57	1,550	1,436	114	1,440	2,990	150,505	8,798	94.48	5.52
58	1,550	1,464	86	1,440	2,990	153,409	5,894	96.30	3.70
59	1,550	1,493	57	1,440	2,990	156,342	2,961	98.14	1.86
60	1,550	1,521	29	1,440	2,990	159,303	0	100.00	0.00

A= Borrower; B= MFI

Rental Division: A: (15/100) x 1,550= Rs. 233; B: (85/100) x 1,550= Rs. 1,318

Total Payment made to the MFI (Rs.) = 179,396

Maintenance cost @2% of the system cost (Rs.) = 15,930 for the whole loan duration

Profit to the MFI (Rs.) = 179,396-151,338-15,930= 28,058

Package 2

Total Cost of PV System (Rs.):	209,280
Down Payment (%):	15
Down Payment (Rs.):	31392
Remaining Balance (Rs.):	177888
Maintenance Cost (per year):	2% of the system cost per year
Monthly Rent (Rs.):	1750
Rental Rate:	0.0083620
Monthly Installment (Rs.):	2032.606283

LOAN STRUCTURE FOR PACKAGE 2

Month	**Rent (Rs.)**			**Monthly Installment (Rs.)**	**Total payment (Rs.)**	**Equity of A (Rs.)**	**Equity of B (Rs.)**	**Share of A (%)**	**Share of B (%)**
	Amount	Share of A	Share of B						
							209,280		
0						31,392	177,888	15.00	85.00
1	1,750	263	1,488	2,033	3,783	33,687	175,593	16.10	83.90
2	1,750	282	1,468	2,033	3,783	36,001	173,279	17.20	82.80
3	1,750	301	1,449	2,033	3,783	38,335	170,945	18.32	81.68
4	1,750	321	1,429	2,033	3,783	40,688	168,592	19.44	80.56
5	1,750	340	1,410	2,033	3,783	43,061	166,219	20.58	79.42
6	1,750	360	1,390	2,033	3,783	45,454	163,826	21.72	78.28
7	1,750	380	1,370	2,033	3,783	47,866	161,414	22.87	77.13
8	1,750	400	1,350	2,033	3,783	50,299	158,981	24.03	75.97
9	1,750	421	1,329	2,033	3,783	52,753	156,527	25.21	74.79
10	1,750	441	1,309	2,033	3,783	55,226	154,054	26.39	73.61
11	1,750	462	1,288	2,033	3,783	57,721	151,559	27.58	72.42
12	1,750	483	1,267	2,033	3,783	60,236	149,044	28.78	71.22
13	1,750	504	1,246	2,033	3,783	62,772	146,508	29.99	70.01
14	1,750	525	1,225	2,033	3,783	65,330	143,950	31.22	68.78
15	1,750	546	1,204	2,033	3,783	67,909	141,371	32.45	67.55
16	1,750	568	1,182	2,033	3,783	70,509	138,771	33.69	66.31

17	1,750	590	1,160	2,033	3,783	73,131	136,149	34.94	65.06
18	1,750	612	1,138	2,033	3,783	75,775	133,505	36.21	63.79
19	1,750	634	1,116	2,033	3,783	78,442	130,838	37.48	62.52
20	1,750	656	1,094	2,033	3,783	81,130	128,150	38.77	61.23
21	1,750	678	1,072	2,033	3,783	83,841	125,439	40.06	59.94
22	1,750	701	1,049	2,033	3,783	86,575	122,705	41.37	58.63
23	1,750	724	1,026	2,033	3,783	89,331	119,949	42.69	57.31
24	1,750	747	1,003	2,033	3,783	92,111	117,169	44.01	55.99
25	1,750	770	980	2,033	3,783	94,914	114,366	45.35	54.65
26	1,750	794	956	2,033	3,783	97,740	111,540	46.70	53.30
27	1,750	817	933	2,033	3,783	100,590	108,690	48.06	51.94
28	1,750	841	909	2,033	3,783	103,464	105,816	49.44	50.56
29	1,750	865	885	2,033	3,783	106,362	102,918	50.82	49.18
30	1,750	889	861	2,033	3,783	109,284	99,996	52.22	47.78
31	1,750	914	836	2,033	3,783	112,230	97,050	53.63	46.37
32	1,750	938	812	2,033	3,783	115,201	94,079	55.05	44.95
33	1,750	963	787	2,033	3,783	118,197	91,083	56.48	43.52
34	1,750	988	762	2,033	3,783	121,218	88,062	57.92	42.08
35	1,750	1,014	736	2,033	3,783	124,264	85,016	59.38	40.62
36	1,750	1,039	711	2,033	3,783	127,336	81,944	60.84	39.16
37	1,750	1,065	685	2,033	3,783	130,433	78,847	62.32	37.68
38	1,750	1,091	659	2,033	3,783	133,557	75,723	63.82	36.18
39	1,750	1,117	633	2,033	3,783	136,706	72,574	65.32	34.68
40	1,750	1,143	607	2,033	3,783	139,882	69,398	66.84	33.16
41	1,750	1,170	580	2,033	3,783	143,084	66,196	68.37	31.63
42	1,750	1,196	554	2,033	3,783	146,313	62,967	69.91	30.09
43	1,750	1,223	527	2,033	3,783	149,569	59,711	71.47	28.53
44	1,750	1,251	499	2,033	3,783	152,852	56,428	73.04	26.96
45	1,750	1,278	472	2,033	3,783	156,163	53,117	74.62	25.38
46	1,750	1,306	444	2,033	3,783	159,502	49,778	76.21	23.79
47	1,750	1,334	416	2,033	3,783	162,868	46,412	77.82	22.18
48	1,750	1,362	388	2,033	3,783	166,263	43,017	79.45	20.55
49	1,750	1,390	360	2,033	3,783	169,685	39,595	81.08	18.92
50	1,750	1,419	331	2,033	3,783	173,137	36,143	82.73	17.27
51	1,750	1,448	302	2,033	3,783	176,617	32,663	84.39	15.61
52	1,750	1,477	273	2,033	3,783	180,127	29,153	86.07	13.93
53	1,750	1,506	244	2,033	3,783	183,666	25,614	87.76	12.24
54	1,750	1,536	214	2,033	3,783	187,234	22,046	89.47	10.53
55	1,750	1,566	184	2,033	3,783	190,832	18,448	91.19	8.81

56	1,750	1,596	154	2,033	3,783	194,461	14,819	92.92	7.08
57	1,750	1,626	124	2,033	3,783	198,119	11,161	94.67	5.33
58	1,750	1,657	93	2,033	3,783	201,809	7,471	96.43	3.57
59	1,750	1,688	62	2,033	3,783	205,529	3,751	98.21	1.79
60	1,750	1,719	31	2,033	3,783	209,280	0	100.00	0.00

A= Borrower; B= MFI

Rental Division: A: (15/100) x 1,750= Rs. 263; B: (85/100) x 1,750= Rs. 1,488

Total Payment made to the MFI (Rs.) = 226,956

Maintenance cost @2% of the system cost (Rs.) = 20,928 for the whole loan duration

Profit to the MFI (Rs.) = 226,956 - 198,816-20,928= 28,140

Package 3

Total Cost of PV System (Rs.):	272,007
Down Payment (%):	15
Down Payment (Rs.):	40801
Remaining Balance (Rs.):	231206
Maintenance Cost (per year):	2% of the system cost per year
Monthly Rent (Rs.):	1950
Rental Rate:	0.0071689
Monthly Installment (Rs.):	2804.998676

LOAN STRUCTURE FOR PACKAGE 3

Month	**Rent (Rs.)**			**Monthly Installment (Rs.)**	**Total payment (Rs.)**	**Equity of A (Rs.)**	**Equity of B (Rs.)**	**Share of A (%)**	**Share of B (%)**
	Amount	Share of A	Share of B						
							272,007		
0						40,801	231,206	15.00	85.00
1	1,950	293	1,658	2,805	4,755	43,899	228,108	16.14	83.86
2	1,950	315	1,635	2,805	4,755	47,018	224,989	17.29	82.71
3	1,950	337	1,613	2,805	4,755	50,160	221,847	18.44	81.56
4	1,950	360	1,590	2,805	4,755	53,325	218,682	19.60	80.40
5	1,950	382	1,568	2,805	4,755	56,512	215,495	20.78	79.22
6	1,950	405	1,545	2,805	4,755	59,722	212,285	21.96	78.04
7	1,950	428	1,522	2,805	4,755	62,955	209,052	23.14	76.86
8	1,950	451	1,499	2,805	4,755	66,212	205,795	24.34	75.66
9	1,950	475	1,475	2,805	4,755	69,491	202,516	25.55	74.45
10	1,950	498	1,452	2,805	4,755	72,795	199,212	26.76	73.24

11	1,950	522	1,428	2,805	4,755	76,121	195,886	27.99	72.01
12	1,950	546	1,404	2,805	4,755	79,472	192,535	29.22	70.78
13	1,950	570	1,380	2,805	4,755	82,847	189,160	30.46	69.54
14	1,950	594	1,356	2,805	4,755	86,246	185,761	31.71	68.29
15	1,950	618	1,332	2,805	4,755	89,669	182,338	32.97	67.03
16	1,950	643	1,307	2,805	4,755	93,117	178,890	34.23	65.77
17	1,950	668	1,282	2,805	4,755	96,590	175,417	35.51	64.49
18	1,950	692	1,258	2,805	4,755	100,087	171,920	36.80	63.20
19	1,950	718	1,232	2,805	4,755	103,609	168,398	38.09	61.91
20	1,950	743	1,207	2,805	4,755	107,157	164,850	39.40	60.60
21	1,950	768	1,182	2,805	4,755	110,730	161,277	40.71	59.29
22	1,950	794	1,156	2,805	4,755	114,329	157,678	42.03	57.97
23	1,950	820	1,130	2,805	4,755	117,954	154,053	43.36	56.64
24	1,950	846	1,104	2,805	4,755	121,604	150,403	44.71	55.29
25	1,950	872	1,078	2,805	4,755	125,281	146,726	46.06	53.94
26	1,950	898	1,052	2,805	4,755	128,984	143,023	47.42	52.58
27	1,950	925	1,025	2,805	4,755	132,714	139,293	48.79	51.21
28	1,950	951	999	2,805	4,755	136,470	135,537	50.17	49.83
29	1,950	978	972	2,805	4,755	140,254	131,753	51.56	48.44
30	1,950	1,005	945	2,805	4,755	144,064	127,943	52.96	47.04
31	1,950	1,033	917	2,805	4,755	147,902	124,105	54.37	45.63
32	1,950	1,060	890	2,805	4,755	151,767	120,240	55.80	44.20
33	1,950	1,088	862	2,805	4,755	155,660	116,347	57.23	42.77
34	1,950	1,116	834	2,805	4,755	159,581	112,426	58.67	41.33
35	1,950	1,144	806	2,805	4,755	163,530	108,477	60.12	39.88
36	1,950	1,172	778	2,805	4,755	167,508	104,499	61.58	38.42
37	1,950	1,201	749	2,805	4,755	171,514	100,493	63.05	36.95
38	1,950	1,230	720	2,805	4,755	175,548	96,459	64.54	35.46
39	1,950	1,258	692	2,805	4,755	179,612	92,395	66.03	33.97
40	1,950	1,288	662	2,805	4,755	183,704	88,303	67.54	32.46
41	1,950	1,317	633	2,805	4,755	187,826	84,181	69.05	30.95
42	1,950	1,347	603	2,805	4,755	191,978	80,029	70.58	29.42
43	1,950	1,376	574	2,805	4,755	196,159	75,848	72.12	27.88
44	1,950	1,406	544	2,805	4,755	200,370	71,637	73.66	26.34
45	1,950	1,436	514	2,805	4,755	204,612	67,395	75.22	24.78
46	1,950	1,467	483	2,805	4,755	208,884	63,123	76.79	23.21
47	1,950	1,497	453	2,805	4,755	213,186	58,821	78.38	21.62
48	1,950	1,528	422	2,805	4,755	217,519	54,488	79.97	20.03
49	1,950	1,559	391	2,805	4,755	221,884	50,123	81.57	18.43

50	1,950	1,591	359	2,805	4,755	226,279	45,728	83.19	16.81
51	1,950	1,622	328	2,805	4,755	230,707	41,300	84.82	15.18
52	1,950	1,654	296	2,805	4,755	235,165	36,842	86.46	13.54
53	1,950	1,686	264	2,805	4,755	239,656	32,351	88.11	11.89
54	1,950	1,718	232	2,805	4,755	244,179	27,828	89.77	10.23
55	1,950	1,751	199	2,805	4,755	248,735	23,272	91.44	8.56
56	1,950	1,783	167	2,805	4,755	253,323	18,684	93.13	6.87
57	1,950	1,816	134	2,805	4,755	257,944	14,063	94.83	5.17
58	1,950	1,849	101	2,805	4,755	262,598	9,409	96.54	3.46
59	1,950	1,883	67	2,805	4,755	267,286	4,721	98.26	1.74
60	1,950	1,916	34	2,805	4,755	272,007	(0)	100.00	0.00

A= Borrower; B= MFI

Rental Division: A: (15/100) x 1,950= Rs. 293; B: (85/100) x 1,950= Rs. 1,658

Total Payment made to the MFI (Rs.) = 285,300

Maintenance cost @2% of the system cost (Rs.) = 27,201 for the whole loan duration

Profit to the MFI (Rs.) = 285,300 - 258,407 - 27,201= 26,893

6.3. Replicability of the Proposed Model

Although, this model has been specifically proposed considering the needs and affordability of the households in case study village, it can be adapted for implementation in all on-grid rural and urban areas of Pakistan. In fact, it is expected that the 2-room, 3-room and 4-room PV systems and the associated microfinance packages will prove to be more affordable and attractive for urban population as their monthly income and electricity bill is significantly higher than the rural population. Moreover, the same model can also be used for other renewable energy technology products like solar stoves, biogas plants etc.

Summary

The proposed micro loan packages for the 2-room, 3-room and 4-room PV system designs, based on the concept of Diminishing Musharakah are summarized below:

SUMMARY OF PROPOSED MICROFINANCE MODELS

	Package 1	**Package 2**	**Package 3**
Income Range (Rs.)	10,000 to 20, 000	20,000 to 30,000	30, 000 to 40, 000
PV System Price (Rs.)	159,303	209,280	272,007
Total Payment Made to the Lender (Rs.)	179,396	226,956	285,300

Upfront Payment (Rs.)	23,895	31,392	40,801
Monthly Payment (Rs.)	2,990	3,783	4,755
Duration of Loan (months)	60	60	60

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[1] Usmani, M. Taqi, An Introduction to Islamic Finance, Volume 20 of Arab and Islamic laws series, Kluwer Law International, 2002.

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[3] Meera A. K. M., Abdul R. D., Home Financing through the Musharakah Mutanaqisah Contracts: Some Practical Issues, J.KAU: Islamic Econ. 22(1) (2009) 3-27

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Chapter 7

Conclusion and Recommendations

This chapter outlines the major conclusions of this study and recommends approaches for further work and improvement in the field of renewable energy micro financing in Pakistan.

7.1. Conclusion

Based on the results and analysis of the primary and secondary research conducted within the scope of this study, it can be concluded that:

- ✓ Majority of the households in the case study village are willing to take micro-loans for switching to renewable energy technologies.
- ✓ Most of households have reservations about the element of interest-rate in conventional microfinance and would prefer if the proposed micro-loan is based on Islamic principles.
- ✓ The locally available resources and the preferences of the survey respondents, indicate that solar home system is the most feasible renewable energy technology for the households.
- ✓ The village households have varied electricity requirements depending upon the number of residents, number of rooms and electricity consumption behaviors. Therefore one specific solar home system design cannot cater to the electricity needs of all the households.
- ✓ The village households vary in terms of their ability of pay and the majority of them fall into 3 distinct income groups; lower income households with Rs. 10,000 to 20,000 income per month, middle income households with Rs. 20,000 to 30,000 per month and higher income households with Rs, 30,000 to 40,000 per month. Therefore one specific micro-loan structure cannot cater of the needs of the whole population.
- ✓ Majority of the lower income households live in a 2-room house, most of the middle income households have 3-rooms in their house while almost all of the higher income households reported 4 or more rooms in their house.

- ✓ The best possible solution is therefore to offer 3 different solar home system packages for 2-room, 3-room and 4-room houses, targeted for lower, middle and higher income households respectively. The summary of the packages designed in this study is:

SUMMARY OF PROPOSED SOLAR HOME SYSTEM DESIGNS

	Package 1	**Package 2**	**Package 3**
Income Range	10,000 to 20, 000 Rs.	20,000 to 30,000 Rs.	30, 000 to 40, 000 Rs.
Load	✓ 2 x18W LED Tube Lights (3 hours/ day each) ✓ 2 x 9W LED Bulbs (5 hours/day each) ✓ 2x 80W Ceiling Fans (10 hours/day each) ✓ 1 x 5W mobile phone charger (1 hour/day)	✓ 3 x18W LED Tube Lights (3 hours/ day each) ✓ 2 x 9W LED Bulbs (5 hours/day each) ✓ 3 x 80W Ceiling Fans (10 hours/day each) ✓ 1 x 5W mobile phone charger (1 hour/day)	✓ 4 x18W LED Tube Lights (3 hours/ day each) ✓ 2 x 9W LED Bulbs (5 hours/day each) ✓ 4 x 80W Ceiling Fans (10 hours/day each) ✓ 1 x 5W mobile phone charger (1 hour/day)
Price (Rs.)	159,303	209,280	272,007

- ✓ Considering the simplicity and success rate of One-Hand Model, it can be inferred that One-Hand model is most appropriate implementation model for SHS microfinancing in Pakistan.
- ✓ Diminishing Musharakah currently holds the largest share in Islamic finance industry of Pakistan, therefore an interest-free renewable energy microfinance model established on the Islamic finance concept of Diminishing Musharakah would be the most viable financial model for implementation in Pakistan.
- ✓ The upfront cost remains a big issue in the micro-loan designing since the target customers do not have the means to pay high upfront costs while on the other hand, designing a loan with low upfront cost considerably enhances the risk for MFIs.
- ✓ A summary of proposed SHS micro-loan structure for each of the 3 solar home systems packages, based on Diminishing Musharakah Model with One-Hand Implementation, is shown:

SUMMARY OF PROPOSED MICROFINANCE MODEL DESIGNS

	Package 1	**Package 2**	**Package 3**
Income Range (Rs.)	10,000 to 20, 000	20,000 to 30,000	30, 000 to 40, 000
PV System Price (Rs.)	159,303	209,280	272,007
Total Payment Made to the Lender (Rs.)	179,396	226,956	285,300
Upfront Payment (Rs.)	23,895	31,392	40,801
Monthly Payment (Rs.)	2,990	3,783	4,755
Duration of Loan (months)	60	60	60

7.2. Recommendations

Considering the conclusions of this study, specially the issue of upfront cost, it is recommended that the Government of Pakistan (GoP) takes steps to encourage the promotion of renewable energy micro financing in Pakistan.

One of the possible approaches is to initiate a scheme on the lines of the ***'Prime Minister's Youth Business Loans'*** schemes, where the government incentivizes the borrowers by offering them access to bank loans with only 8% interest rates, while the government itself pays the remaining 7% interest rate and all other charges.

On the same lines, it is recommended that for SHS microfinancing, the upfront payment for borrows be reduced to 3% instead of 15% while the GoP launches a scheme where it offers to pay the remaining 12% upfront cost to the bank as subsidy. This will not only reduce the upfront payment for borrower to an affordable level, but will also enhance the commercial attractiveness of the scheme due to backing from the Government.

Moreover, in order to mitigate the high risks of MFIs due to risk of non-payment, it is suggested that the regional electricity distribution company (DISCO), which is IESCO in this case, be involved in the monthly payment process. The inclusion of monthly loan instalment in the electricity bills of the households will enhance the rate of recovery and hence the risk of default will be decreased. The DISCO will charge a fixed rate, i.e. Rs. 50 per month, from the MFI for providing the service of payment collection.

A pictorial representation of the recommended SHS micro financing model for Pakistan is shown in *Figure 29.*

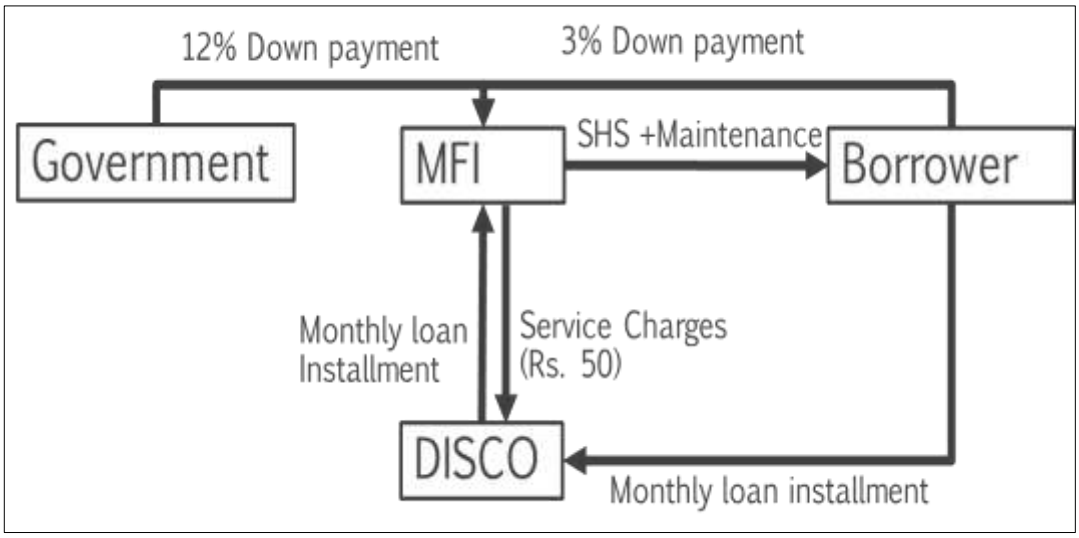

FIGURE 29: RECOMMENDED SHS MICRO FINANCING MODEL FOR PAKISTAN

A summary of the recommended micro loan payment structures with government subsidy for 3 solar home system packages proposed in this study are summarized below. The detailed calculations can be found in *Annex II.*

COMPARISON OF MICRO-LOAN STRUCTURE WITH AND WITHOUT SUBSIDY

	Package 1	**Package 2**	**Package 3**
Income Range (Rs.)	10,000 to 20, 000	20,000 to 30,000	30, 000 to 40, 000
PV System Price (Rs.)	159,303	209,280	272,007
Monthly Payment (Rs.)	2,990	3,783	4,755
Duration of Loan (months)	60	60	60
Without Subsidy			
Upfront Payment (Rs.)	23,895	31,392	40,801
With Subsidy			
Total Upfront Payment (Rs.)	23,895	31,392	40,801
Upfront Payment (Rs.) to be made by GoP	19,116	25,114	32,641
Upfront Payment (Rs.) to be made by Borrower	4,779	6,278	8,160

If presented in context with the potential greenhouse gas emissions savings, the government subsidy approach recommended in this study can also be eligible for funding through ***Clean Development Mechanism.***

Moreover, offering this kind of scheme for renewable energy micro financing will bring several positive impacts on Pakistan's economy:

- ✓ Firstly, the mass adoption of decentralized renewable energy technologies, especially solar home system, will reduce the load on Pakistan's national grid.
- ✓ It will enhance Pakistan's energy self-dependency by reducing the need of importing fossil fuels for power generation.
- ✓ It will significantly increase the share of renewable energy in Pakistan's energy mix and will decrease the country's greenhouse gas emissions.

Annexes

Annex I: Household Survey Questionnaire

Household Survey Questionnaire

Location: Village Jajja, U/C Manghot, Tehsil Gujjar Khan, District Rawalpindi **Questionnaire Number:**____

Good morning/afternoon. My name is Warda Ajaz. I am coming on behalf of National University of Sciences and Technology (NUST). I am currently conducting a survey to assess the feasibility of micro financing of renewable energy projects in rural areas, in order to recommend the possibilities and necessity of lending mechanisms. The information will be used for preparing a demand assessment report only and the particulars of the respondents will not be made public.

STREET ADDRESS: گھر کا پتا

NAME OF THE RESPONDENT: جواب دہندہ کا نام

PHONE NUMBER: فون نمبر

POSITION OF RESPONDENT IN HOUSEHOLD: جواب دہندہ کی گھر میں حیثیت

i. Head ☐
ii. Spouse ☐
iii. Other (Please specify relation to the household head and age): _____

NUMBER & AGE OF RESIDENTS گھر کے افراد کی تعداد اور عمر

1. Number: تعداد ____
2. Male: مرد ____
3. Female: خواتین ____

4. Age: عمر
i. Less than 18 years ☐
ii. 19-25 years ☐
iii. 26-50 years ☐
iv. More than 50 years ☐

EDUCATION OF RESIDENTS گھر کے افراد کی تعلیم

5. Classify number of residents according to education level تعلیمی درجہ بندی کے لحاظ سے گھر کے افراد کی تعداد بتائیے
i. Illiterate: ____
ii. Primary School: ____
iii. Secondary School: ____
iv. Higher Secondary School: ____
v. University: ____
vi. Other(Please specify): _____

EMPLOYMENT STATUS ملازمت کی حیثیت

6. Classify number of residents according to employment status ملازمت کی حیثیت کے لحاظ سے گھر کے افراد کی تعداد بتائیے
i. Employed: ____
ii. Un employed: ____
iii. Self employed: ____

HOUSEHOLD INCOME گھریلو آمدنی

7. What is the main source of Income? گھر میں آمدنی کا بڑا ذریعہ کیا ہے؟
i. Regular employment (steady income) ☐
ii. Trade ☐
iii. Agriculture and/or livestock ☐
iv. Services ☐
v. Industry ☐
vi. Others (Please specify):_____

8. Do you do any income generating activity at home? کیا آپ گھر میں کوئی کاروبار کرتے ہیں؟
i. Yes:_____ ☐
ii. No:_____ ☐

9. What is the frequency of income? آمدنی کتنے عرصے بعد آتی ہے؟
i. Daily ☐
ii. Weekly ☐
iii. Monthly ☐
iv. Seasonal ☐
Other(Please specify):_____

10. How much is the total household monthly income (Rs.): گھر کی اوسط ماہانہ آمدنی کتنی ہے؟
i. Less than 10,000/- ☐
ii. 10,000 - 20,000 /- ☐
iii. 20,000 - 30,000/- ☐
iv. 30,000 – 40,000/- ☐
v. Above 40,000/- ☐

11. How much money (Rs.) is spent for your routine monthly expenses? گھر کے ماہانہ خرچے کے لیے ہر ماہ کتنی رقم خرچ ہوتی ہے؟
i. Less 10,000/- ☐
ii. 10,000 - 20,000 /- ☐
iii. 20,000 - 30,000/- ☐
iv. 30,000 – 40,000/- ☐
v. Above 40,000/- ☐

BASIC LIVING CONDITIONS رہائشی حالت

12. Do you get enough food for family? کیا آپ کو گھر کے افراد کے لیے کافی غذا میسر ہے؟
i. Yes ☐
ii. No ☐

13. What is the ownership status of the house you currently reside in: جس گھر میں آپ رہتے ہیں، اس کی ملکیت کی نوعیت کیا ہے؟
i. Owned property ☐
ii. Family property ☐
iii. Rental property ☐
iv. Other(Please specify): _____

14. How many rooms are there in the house you currently reside in: جس گھر میں آپ رہتے ہیں، اس میں کتنے کمرے ہیں؟
i. 1 ☐
ii. 2 ☐
iii. 3 ☐
iv. 4 or more ☐

HOUSEHOLD FINANCIAL SITUATION گھر کی مالی حالت

15. What among the following is present in the house? ان میں سے کونسی اشیاء گھر میں موجود ہیں؟

i.	Land/own business premises	☐	ix.	TV	☐
ii.	House	☐	x.	Refrigerator	☐
iii.	Cattle	☐	xi.	Landline telephone	☐
iv.	Car/truck/tractor	☐	xii.	Mobile phone	☐
v.	Motorbike	☐	xiii.	Savings at home	☐
vi.	Cycle	☐	xiv.	Savings at bank	☐
vii.	Production tools and equipment	☐	xv.	Other (Please specify):	
viii.	Radio	☐		_____	

16. During the last 12 months, what has been the status of your family income? پچھلے ۱۲ مہینے میں آپ کی آمدنی کی حالت کیسی رہی؟

i.	Increased	☐
ii.	Stayed constant	☐
iii.	Decreased	☐
iv.	Changed in other ways (Please specify): _____	

17. If your income decreased or got affected negatively, what did you do to overcome the situation? اگر آپ کی گھریلو آمدنی میں کمی ہوئی یا اس پر برا اثر پڑا تو آپ نے صورتحال سے قابو پانے کے لیے کیا اقدام کیے؟

i.	Borrowed money at no cost	☐	v.	Migration of a family member for employment	☐
ii.	Borrowed money with interest	☐	vi.	Sold productive business equipment	☐
iii.	Borrowed edible items	☐	vii.	a family member got new employment	☐
iv.	Sold real estate	☐	viii.	Other(Please specify):	
				_____	

18. Have you ever sought loan? کیا آپ نے کبھی قرض لیا ہے؟

i.	Yes	☐
ii.	No	☐

LOAN INFORMATION (Applies only if the answer to Question # 18 was 'Yes') قرض کی معلومات

19. Where did you get the loan from? آپ نے قرض کہاں سے لیا؟

i.	Immediate Relative (Relation: _____)	☐
ii.	Distant Relative (Relation: _____)	☐
iii.	Institution/Bank (Name: _____)	☐
iv.	Friend	☐
v.	Other (Please specify): _____	

20. What was the purpose of seeking loan? قرض لینے کا مقصد کیا تھا؟

i.	Consumption (appliances, food, etc.)	☐
ii.	Business	☐
iii.	Education	☐
iv.	Heath reasons	☐
v.	Unexpected events	☐
vi.	Other(Please specify): _____	

21. Upto which amount (Rs.) was/is you total loan? قرض کی رقم کتنی تھی؟

i.	Less than 25,000	☐
ii.	25,000 – 50,000	☐
iii.	51,000- 100,000	☐
iv.	Above 100,000	☐

22. Do you have a loan at the moment? کیا فی الوقت آپ نے کوئی قرض لیا ہوا ہے؟

i.	Yes	☐
ii.	No	☐

23. If yes, how much (Rs.)? اگر ہاں، تو قرض کی رقم کتنی ہے؟

i.	Less than 25,000	☐
ii.	25,000 – 50,000	☐
iii.	51,000- 100,000	☐
iv.	Above 100,000	☐

24. Being a male/ Female, is it solely your responsibility to pay back the loan? کیا مرد / خاتون ہونے کے ناطے قرض کی ادائیگی آپ کی ذمہ داری ہے؟

i.	Yes	☐
ii.	No	☐

25. If no, then who is responsible for paying back the loan? اگر نہیں، تو قرض کی ادائیگی کس کے ذمہ ہے؟

i.	Male Members	☐
ii.	Female Members	☐
iii.	Shared Responsibility	☐

26. Are you facing problems to pay it back? کیا آپ کو قرض کی ادائیگی میں مشکلات درپیش ہیں؟

i. Yes ☐ If yes, please specify_____
ii. No ☐ _____

AGRICULTURE (Applies only if the household is involved in agricultural activities) زراعت

27. What is the ownership status of your agricultural land? آپ کی زرعی زمین کی ملکیت کی نوعیت کیا ہے؟

i. Owner ☐
ii. Tenant ☐
iii. Lessee ☐
iv. Family property ☐
v. Government land ☐
vi. Other(Please specify):
_____

28. What is the area of your agricultural land? آپ کی زرعی زمین کا رقبہ کتنا ہے؟

i. Less than 1 acre ☐
ii. 1 acres – 5 acres ☐
iii. 5 acres – 10 acres ☐
iv. Above 10 acres ☐

29. What is the total area under cultivation? زیر کاشت رقبہ کتنا ہے؟

i. Less than 1 acre ☐
ii. 1 acres – 5 acres ☐
iii. 5 acres – 10 acres ☐
iv. Above 10 acres ☐

30. Which crops do you cultivate? آپ کون سی فصلیں کاشت کرتے ہیں؟

i. Wheat ☐
ii. Barley ☐
iii. Maize ☐
iv. Millets ☐
v. Pulses ☐
vi. Vegetables and fruits ☐
vii. Other(Please specify):_____

31. What is the approximate quantity of crops residue from your crops? آپ کی فصلوں سے حاصل ہونے والے فضلے کی اوسط مقدار کتنی ہوتی ہے؟

_____

32. What do you do to crops residue? آپ فصلوں سے حاصل ہونے والے فضلے کا کیا کرتے ہیں؟

i. Burn it ☐
ii. Use it for _____ ☐
iii. Sell it ☐
iv. Others (Please specify):_____
_____

33. From where do you get water for agriculture? آپ زراعت کے لیے پانی کہاں سے حاصل کرتے ہیں؟

i. Private well ☐
ii. Community well ☐
iii. Hand pump ☐
iv. Tube well ☐
v. Other(Please specify):
_____

34. Did the market price change during the last two years? کیا پچھلے ۲ سالوں میں فصلوں کی قیمت فروخت میں تبدیلی ہوئی ہے؟

i. Yes, it increased ☐
ii. Yes, it decreased ☐
iii. No ☐
iv. Don't know ☐

35. Have you had any change in production compared to last season? کیا آپ کی فصلوں کی پیداوار میں پچھلے سال کی نسبت تبدیلی آئی ہے؟

i. Yes, it increased ☐
ii. Yes, it decreased ☐
iii. No ☐
iv. Don't know ☐

LIVESTOCK (Applies only if the household is involved in livestock activities) مویشی

36. What animals do you have? Please specify the number of each. آپ کے پاس کون سے مویشی ہیں؟براہ میربانی ان کی تعداد بتائیے۔

i. Cows (_____) ☐
ii. Goats (_____) ☐
iii. Chicken (_____) ☐
iv. Other(Please specify):_____

37. Do you get additional income from livestock? کیا آپ کو مویشیوں سے اضافی آمدنی حاصل ہوتی ہے؟

i. Yes ☐
ii. No ☐

38. If you get additional income from livestock, please specify how?
اگر آپ کو مویشیوں سے اضافی آمدنی حاصل ہوتی ہے، تو کیسے؟
i. Selling animals ☐
ii. Selling animal products (e.g. eggs, milk etc.) ☐
iii. Other(Please specify): _____

39. How much do you earn (Rs.) per month from livestock?
آپ کو مویشیوں سے ماہانہ کتنی آمدنی حاصل ہوتی ہے؟
i. Less than 2,000 ☐
ii. 2,000 – 4,000 ☐
iii. 4,000 – 6,000 ☐
iv. Above 6,000 ☐

40. What is the approximate quantity of livestock waste from your animals?
آپ کے مویشیوں سے روزانہ کتنا گوبر پیدا ہوتا ہے؟
_____

41. What do you do to livestock waste?
آپ مویشیوں سے پیدا ہونے والے گوبر کا کیا کرتے ہیں؟
i. Use it for _____ ☐
ii. Sell it ☐
iii. Others (Please specify): _____ ☐
_____

ENERGY CONSUMPTION — توانائی کا استعمال

42. Which energy sources do you know of?
آپ توانائی کے کن ذرائع سے واقف ہیں؟
i. Electricity ☐
ii. Natural gas ☐
iii. Kerosene oil ☐
iv. Liquefied Petroleum Gas (LPG) ☐
v. Fire wood ☐
vi. Dung ☐
vii. Coal ☐
viii. Solar ☐
ix. Hydro ☐
x. Biomass ☐
xi. Other(Please specify): _____

43. Which type(s) of energy do you need the most?
آپ کس قسم کی توانائی کی ضرورت سب سے زیادہ محسوس کرتے ہیں؟
i. Electricity ☐
ii. Natural gas ☐
iii. Kerosene oil ☐
iv. Liquefied Petroleum Gas (LPG) ☐
v. Fire wood ☐
vi. Dung ☐
vii. Coal ☐
viii. Solar ☐
ix. Hydro ☐
x. Biomass ☐
xi. Other(Please specify): _____

44. What type of energy do you use for lighting? Please specify its estimated cost per month.
روشنی کے لئے آپ توانائی کے کون سے ذرائع استعمال کرتے ہیں اور ان پر ماہانہ خرچ کتنا آتا ہے؟
i. Electricity: _____
ii. Kerosene: _____
iii. Battery: _____
iv. Candles: _____
v. Uninterrupted power supply (UPS): _____
vi. Fuel Generator (Please specify the fuel: _____
vii. Other(Please specify): _____

45. What type of energy do you use for Cooking? Please specify its estimated cost per month.
کھانا پکانے کے لئے آپ توانائی کے کون سے ذرائع استعمال کرتے ہیں اور ان پر ماہانہ خرچ کتنا آتا ہے؟
i. Natural gas: _____
ii. Dung cake: _____
iii. Liquefied Petroleum Gas (LPG): _____
iv. Firewood: _____
v. Coal: _____
vi. Other(Please specify): _____

46. What type of energy do you use for space cooling? Please specify its estimated cost per month.
گھر کو ٹھنڈا رکھنے کے لئے آپ توانائی کے کون سے ذرائع استعمال کرتے ہیں اور ان پر ماہانہ خرچ کتنا آتا ہے؟
i. Electricity: _____
ii. Battery: _____
iii. Uninterrupted power supply (UPS): _____
iv. Fuel Generator (Please specify the fuel: _____
v. Other(Please specify): _____

47. What type of energy do you use for space heating?
گھر کو گرم رکھنے کے لئے آپ توانائی کے کون سے ذرائع استعمال کرتے ہیں اور ان پر ماہانہ خرچ کتنا آتا ہے؟
i. Natural gas: _____
ii. Dung: _____
iii. Liquefied Petroleum Gas (LPG): _____
iv. Firewood: _____
v. Coal: _____
vi. Other(Please specify): _____

48. What type of energy do you use for water heating? Please specify its estimated cost per month.
پانی گرم کرنے کے لئے آپ توانائی کے کون سے ذرائع استعمال کرتے ہیں اور ان پر ماہانہ خرچ کتنا آتا ہے؟
i. Natural gas: _____
ii. Dung: _____
iii. (Liquefied Petroleum Gas) LPG: _____
iv. Firewood: _____
v. Coal: _____
vi. Other(Please specify): _____

49. In case of using Firewood or dung, who is responsible for collecting them?
اگر آپ لکڑی یا گوبر کا استعمال کرتے ہیں تو اس کو اکٹھا کرنے کی ذمہ داری کس پر ہے؟
i. Men ☐
ii. Women ☐
iii. Children ☐
iv. Others (Please specify): _____

GENERAL USE OF ELECTRICITY بجلی کا روزمرہ استعمال

50. Which of the following electricity consuming activities are conducted in your household?
ان بجلی استعمال کرنے والی سرگرمیوں میں سے کونسی سرگرمیاں آپ کے گھر میں کی جاتی ہیں؟

i. Lighting ☐
ii. Space cooling (fans) ☐
iii. Space cooling (Air conditioning) ☐
iv. Watch TV ☐
v. Listening to radio ☐
vi. Charging mobile phones ☐
vii. Using desktop computer ☐
viii. Charging of Laptops ☐
ix. Other (Please specify)_____

51. Please provide the following information about the number of electric devices and hours of use per day.
براہ مہربانی ان برقی اشیاء کی تعداد اور روزانہ استعمال کے بارے میں معلومات فراہم کیجیئے۔

Device	*Number*	*Hours/Day*	*Device*	*Number*	*Hours/Day*
Tube Lights			*Fan*		
Energy Savers (Compact Fluorescent lights)			*Ac*		
LED lights			*Mobile phone charger*		
TV (Black and White)			*Laptop charger*		
TV (Coloured)			*Desktop computer*		
Radio/Tape recorder			*Water motor*		
Other			*Other*		

52. How much is your electricity bill per month (Rs.)?
آپ کے گھر بجلی کا ماہانہ بل کتنا آتا ہے؟

i. Below 1,000/- ☐
ii. 1,000/- 3000/- ☐
iii. 3,000 - 6,000/- ☐
iv. Above 6,000/- ☐

53. If you had free choice, what would you prefer as a source of electricity?
اگر آپ کے پاس انتخاب کرنے کا اختیار ہو، تو آپ بجلی کے کس ذریعے کو ترجیح دیں گے؟

i. Grid ☐
ii. Diesel Generator ☐
iii. Natural Gas generator ☐
iv. Storage Battery ☐
v. Solar Home System (SHS) ☐
vi. Other (Please specify):_____

54. Do you use electricity for income generating activities at home?
کیا آپ گھر پر کاروباری سرگرمیوں کے لیے بجلی استعمال کرتے ہیں؟

i. Yes ☐
ii. No ☐

55. If yes, which types of electrical appliances are involved in income generation at home?
اگر ہاں تو ان میں سے کونسی برقی اشیاء گھر پر کاروباری سرگرمیوں کے لیے استعمال ہوتی ہیں؟

i. Lights ☐
ii. Fans ☐
iii. Machinery(Please specify):_____ ☐
iv. Other (Please specify):_____ ☐

PERCEPTIONS ABOUT RENEWABLE ENERGY AND MICRO FINANCING SCHEMES
قابل تجدید توانائی اور مائکروفائنانسنگ کے بارے میں نقطہ نظر

56. Which renewable energy sources do you know about?
آپ قابل تجدید توانائی کے کن ذرائع سے واقف ہیں؟

i. None ☐
ii. Solar ☐
iii. Wind ☐
iv. Biomass ☐
v. Micro hydro ☐
vi. Others(Please specify):
_____

57. Do you think renewable energy can benefit you in any way?
کیا آپ سمجھتے ہیں کہ قابل تجدید توانائی آپ کو کسی قسم کا فائدہ دے سکتی ہے؟

i. Yes, it can reduce energy cost ☐
ii. Yes,_____ ☐
iii. No ☐
iv. Don't know ☐

58. Which type of renewable energy sources do you think are suitable for your household?
آپ کے خیال میں قابل تجدید توانائی کے کون سے ذرائع آپ کے گھر کے لیے موزوں ہیں؟

i. Solar ☐
ii. Wind ☐
iii. Biomass ☐
iv. Micro hydro ☐
v. Others(Please specify):
_____

59. Have you ever tried to get access to any kind of renewable energy?
کیا آپ نے کبھی کسی قسم کی قابل تجدید توانائی حاصل کرنے کی کوشش کی ہے؟

i. Yes ☐
ii. No ☐

60. If you did not try to access any kind of renewable energy, what are the reasons/constraints?
اگر آپ نے کبھی کسی قسم کی قابل تجدید توانائی حاصل کرنے کی کوشش نہیں کی اس کی وجوہات کیا ہیں؟

i. High cost ☐
ii. Unawareness about its benefits ☐
iii. Unawareness about its existence ☐
iv. Unavailability ☐
v. Other(Please specify):
_____

61. If you are offered loan for buying some kind of renewable energy, would you go for it?
اگر آپ کو قابل تجدید توانائی حاصل کرنے کے لیے قرضہ دیا جائے، تو کیا آپ کو قبول ہوگا؟

i. Yes ☐
ii. No ☐
iii. Don't know ☐

62. If you would not go for loan to get renewable energy, what are the reservations which are holding you back?
اگر آپ کو قابل تجدید توانائی حاصل کرنے کے لئے قرضہ لینا منظور نہیں، تو اس کے پیچھے کون سے تحفظات ہیں؟

i. Financial problems ☐
ii. Unawareness about the benefits ☐
vi. Unawareness about its existence ☐
iii. No need ☐
iv. Other(Please specify):
_____

63. If your reservations are taken care of, and you are offered loan for the purpose, which type of renewable energy would you prefer to buy?
اگر آپ کے تحفظات دور کر دیے جائیں اور آپ کو قرضے کی پیشکش کی جائے، تو کیا آپ کس قسم کی قابل تجدید توانائی حاصل کرنا پسند کریں گے؟

i. Solar ☐
ii. Wind ☐
iii. Biomass ☐
iv. Micro hydro ☐
v. Others(Please specify):
_____

64. How much money (Rs.) can you pay upfront?
آپ قرضے کے لیے ابتدائی طور پر کتنی رقم جمع کرا سکتے ہیں؟

i. Less than 6,000/- ☐
ii. 6,000 - 9,000/- ☐
iii. 9,000 - 12,000/- ☐
iv. Above 12,000/- ☐

65. What monthly payment (Rs.) can you afford?
آپ ماہانہ قسط کے طور پر کتنی رقم ادا کر سکتے ہیں؟

i. Less than 2,000/- ☐
ii. 2,000 - 4,000/- ☐
iii. 4,000 - 6,000/- ☐
iv. Above 6,000/- ☐

66. How long could you continue the payment?
آپ کتنے عرصے تک قرض کی ادائیگی جاری رکھ سکتے ہیں؟

i. Less than 1 year ☐
ii. 1 – 2 years ☐
iii. 2 – 3 years ☐
iv. 3 years or more ☐
v. Don't know ☐

67. How do you think this renewable energy system will impact your life?
آپ کے خیال میں یہ قابل تجدید توانائی آپ کی زندگی پر کس طرح اثر انداز ہو گی؟
_____
_____

68. What suggestions would you give for developing the best possible micro finance scheme offering you access to renewable energy systems?
آپ قابل تجدید توانائی فراہم کرنے کے لیے ایک بہترین مائکروفائنانس اسکیم تشکیل دینے کے سلسلے میں کیا رائے دے سکتے ہیں؟
_____
_____
_____

Thank you very much for your answers. These are very relevant for our study. As mentioned, we will keep your data confidential. We will only use the information for research purposes and do not intend to make it available to other persons. Have a nice day!

Annex II: Micro Loan Payment Calculations with Government Subsidy

Package 1

Total Cost of PV System (Rs.):	159,303
Down Payment (%):	15
Total Down Payment (Rs.):	23,895
Down Payment Made by Borrower (Rs.) @3%	4,779
Down Payment Made by Government (Rs.)@ 12%	19,116
Remaining Balance (Rs.):	135408
Maintenance Cost (per year):	2% of the system cost
Monthly Rent (Rs.):	1,550
Rental Rate:	0.0097299
Monthly Installment (Rs.):	1439.933793

LOAN STRUCTURE FOR PACKAGE 1

Month	**Rent (Rs.)**			**Monthly Installment (Rs.)**	**Total payment (Rs.)**	**Equity of A (Rs.)**	**Equity of B (Rs.)**	**Share of A (%)**	**Share of B (%)**
	Amount	Share of A	Share of B						
							159,303		
0						23,895	135,408	15.00	85.00
1	1,550	233	1,318	1,440	2,990	25,568	133,735	16.05	83.95
2	1,550	249	1,301	1,440	2,990	27,257	132,046	17.11	82.89
3	1,550	265	1,285	1,440	2,990	28,962	130,341	18.18	81.82
4	1,550	282	1,268	1,440	2,990	30,683	128,620	19.26	80.74
5	1,550	299	1,251	1,440	2,990	32,422	126,881	20.35	79.65
6	1,550	315	1,235	1,440	2,990	34,177	125,126	21.45	78.55
7	1,550	333	1,217	1,440	2,990	35,950	123,353	22.57	77.43
8	1,550	350	1,200	1,440	2,990	37,740	121,563	23.69	76.31
9	1,550	367	1,183	1,440	2,990	39,547	119,756	24.82	75.18
10	1,550	385	1,165	1,440	2,990	41,371	117,932	25.97	74.03
11	1,550	403	1,147	1,440	2,990	43,214	116,089	27.13	72.87
12	1,550	420	1,130	1,440	2,990	45,074	114,229	28.29	71.71
13	1,550	439	1,111	1,440	2,990	46,953	112,350	29.47	70.53
14	1,550	457	1,093	1,440	2,990	48,850	110,453	30.66	69.34
15	1,550	475	1,075	1,440	2,990	50,765	108,538	31.87	68.13

16	1,550	494	1,056	1,440	2,990	52,699	106,604	33.08	66.92
17	1,550	513	1,037	1,440	2,990	54,651	104,652	34.31	65.69
18	1,550	532	1,018	1,440	2,990	56,623	102,680	35.54	64.46
19	1,550	551	999	1,440	2,990	58,614	100,689	36.79	63.21
20	1,550	570	980	1,440	2,990	60,624	98,679	38.06	61.94
21	1,550	590	960	1,440	2,990	62,654	96,649	39.33	60.67
22	1,550	610	940	1,440	2,990	64,703	94,600	40.62	59.38
23	1,550	630	920	1,440	2,990	66,773	92,530	41.92	58.08
24	1,550	650	900	1,440	2,990	68,863	90,440	43.23	56.77
25	1,550	670	880	1,440	2,990	70,973	88,330	44.55	55.45
26	1,550	691	859	1,440	2,990	73,103	86,200	45.89	54.11
27	1,550	711	839	1,440	2,990	75,254	84,049	47.24	52.76
28	1,550	732	818	1,440	2,990	77,426	81,877	48.60	51.40
29	1,550	753	797	1,440	2,990	79,620	79,683	49.98	50.02
30	1,550	775	775	1,440	2,990	81,834	77,469	51.37	48.63
31	1,550	796	754	1,440	2,990	84,070	75,233	52.77	47.23
32	1,550	818	732	1,440	2,990	86,328	72,975	54.19	45.81
33	1,550	840	710	1,440	2,990	88,608	70,695	55.62	44.38
34	1,550	862	688	1,440	2,990	90,910	68,393	57.07	42.93
35	1,550	885	665	1,440	2,990	93,235	66,068	58.53	41.47
36	1,550	907	643	1,440	2,990	95,582	63,721	60.00	40.00
37	1,550	930	620	1,440	2,990	97,952	61,351	61.49	38.51
38	1,550	953	597	1,440	2,990	100,345	58,958	62.99	37.01
39	1,550	976	574	1,440	2,990	102,761	56,542	64.51	35.49
40	1,550	1,000	550	1,440	2,990	105,201	54,102	66.04	33.96
41	1,550	1,024	526	1,440	2,990	107,664	51,639	67.58	32.42
42	1,550	1,048	502	1,440	2,990	110,152	49,151	69.15	30.85
43	1,550	1,072	478	1,440	2,990	112,664	46,639	70.72	29.28
44	1,550	1,096	454	1,440	2,990	115,200	44,103	72.31	27.69
45	1,550	1,121	429	1,440	2,990	117,761	41,542	73.92	26.08
46	1,550	1,146	404	1,440	2,990	120,346	38,957	75.55	24.45
47	1,550	1,171	379	1,440	2,990	122,957	36,346	77.18	22.82
48	1,550	1,196	354	1,440	2,990	125,594	33,709	78.84	21.16
49	1,550	1,222	328	1,440	2,990	128,256	31,047	80.51	19.49
50	1,550	1,248	302	1,440	2,990	130,943	28,360	82.20	17.80
51	1,550	1,274	276	1,440	2,990	133,657	25,646	83.90	16.10
52	1,550	1,300	250	1,440	2,990	136,398	22,905	85.62	14.38
53	1,550	1,327	223	1,440	2,990	139,165	20,138	87.36	12.64
54	1,550	1,354	196	1,440	2,990	141,959	17,344	89.11	10.89

55	1,550	1,381	169	1,440	2,990	144,780	14,523	90.88	9.12
56	1,550	1,409	141	1,440	2,990	147,629	11,674	92.67	7.33
57	1,550	1,436	114	1,440	2,990	150,505	8,798	94.48	5.52
58	1,550	1,464	86	1,440	2,990	153,409	5,894	96.30	3.70
59	1,550	1,493	57	1,440	2,990	156,342	2,961	98.14	1.86
60	1,550	1,521	29	1,440	2,990	159,303	0	100.00	0.00

A= Borrower; B= MFI

Rental Division: A: (15/100) x 1,550= Rs. 233; B: (85/100) x 1,550= Rs. 1,318

Total Payment made to the MFI (Rs.) = 179,396

Maintenance cost @2% of the system cost (Rs.) = 15,930 for the whole loan duration

Profit to the MFI (Rs.) = 179,396-151,338-15,930= 28,058

Package 2

Total Cost of PV System (Rs.):	209,280
Down Payment (%):	15
Total Down Payment (Rs.):	31,392
Down Payment Made by Borrower (Rs.) @3%	6,278
Down Payment Made by Government (Rs.)@ 12%	25,114
Remaining Balance (Rs.):	177,888
Maintenance Cost (per year):	2% of the system cost
Monthly Rent (Rs.):	1,750
Rental Rate:	0.0083620
Monthly Installment (Rs.):	2032.606283

LOAN STRUCTURE FOR PACKAGE 2

Month	**Rent (Rs.)**			**Monthly Installment (Rs.)**	**Total payment (Rs.)**	**Equity of A (Rs.)**	**Equity of B (Rs.)**	**Share of A (%)**	**Share of B (%)**
	Amount	Share of A	Share of B						
							209,280		
0						31,392	177,888	15.00	85.00
1	1,750	263	1,488	2,033	3,783	33,687	175,593	16.10	83.90
2	1,750	282	1,468	2,033	3,783	36,001	173,279	17.20	82.80
3	1,750	301	1,449	2,033	3,783	38,335	170,945	18.32	81.68
4	1,750	321	1,429	2,033	3,783	40,688	168,592	19.44	80.56
5	1,750	340	1,410	2,033	3,783	43,061	166,219	20.58	79.42

6	1,750	360	1,390	2,033	3,783	45,454	163,826	21.72	78.28
7	1,750	380	1,370	2,033	3,783	47,866	161,414	22.87	77.13
8	1,750	400	1,350	2,033	3,783	50,299	158,981	24.03	75.97
9	1,750	421	1,329	2,033	3,783	52,753	156,527	25.21	74.79
10	1,750	441	1,309	2,033	3,783	55,226	154,054	26.39	73.61
11	1,750	462	1,288	2,033	3,783	57,721	151,559	27.58	72.42
12	1,750	483	1,267	2,033	3,783	60,236	149,044	28.78	71.22
13	1,750	504	1,246	2,033	3,783	62,772	146,508	29.99	70.01
14	1,750	525	1,225	2,033	3,783	65,330	143,950	31.22	68.78
15	1,750	546	1,204	2,033	3,783	67,909	141,371	32.45	67.55
16	1,750	568	1,182	2,033	3,783	70,509	138,771	33.69	66.31
17	1,750	590	1,160	2,033	3,783	73,131	136,149	34.94	65.06
18	1,750	612	1,138	2,033	3,783	75,775	133,505	36.21	63.79
19	1,750	634	1,116	2,033	3,783	78,442	130,838	37.48	62.52
20	1,750	656	1,094	2,033	3,783	81,130	128,150	38.77	61.23
21	1,750	678	1,072	2,033	3,783	83,841	125,439	40.06	59.94
22	1,750	701	1,049	2,033	3,783	86,575	122,705	41.37	58.63
23	1,750	724	1,026	2,033	3,783	89,331	119,949	42.69	57.31
24	1,750	747	1,003	2,033	3,783	92,111	117,169	44.01	55.99
25	1,750	770	980	2,033	3,783	94,914	114,366	45.35	54.65
26	1,750	794	956	2,033	3,783	97,740	111,540	46.70	53.30
27	1,750	817	933	2,033	3,783	100,590	108,690	48.06	51.94
28	1,750	841	909	2,033	3,783	103,464	105,816	49.44	50.56
29	1,750	865	885	2,033	3,783	106,362	102,918	50.82	49.18
30	1,750	889	861	2,033	3,783	109,284	99,996	52.22	47.78
31	1,750	914	836	2,033	3,783	112,230	97,050	53.63	46.37
32	1,750	938	812	2,033	3,783	115,201	94,079	55.05	44.95
33	1,750	963	787	2,033	3,783	118,197	91,083	56.48	43.52
34	1,750	988	762	2,033	3,783	121,218	88,062	57.92	42.08
35	1,750	1,014	736	2,033	3,783	124,264	85,016	59.38	40.62
36	1,750	1,039	711	2,033	3,783	127,336	81,944	60.84	39.16
37	1,750	1,065	685	2,033	3,783	130,433	78,847	62.32	37.68
38	1,750	1,091	659	2,033	3,783	133,557	75,723	63.82	36.18
39	1,750	1,117	633	2,033	3,783	136,706	72,574	65.32	34.68
40	1,750	1,143	607	2,033	3,783	139,882	69,398	66.84	33.16
41	1,750	1,170	580	2,033	3,783	143,084	66,196	68.37	31.63
42	1,750	1,196	554	2,033	3,783	146,313	62,967	69.91	30.09
43	1,750	1,223	527	2,033	3,783	149,569	59,711	71.47	28.53
44	1,750	1,251	499	2,033	3,783	152,852	56,428	73.04	26.96

45	1,750	1,278	472	2,033	3,783	156,163	53,117	74.62	25.38
46	1,750	1,306	444	2,033	3,783	159,502	49,778	76.21	23.79
47	1,750	1,334	416	2,033	3,783	162,868	46,412	77.82	22.18
48	1,750	1,362	388	2,033	3,783	166,263	43,017	79.45	20.55
49	1,750	1,390	360	2,033	3,783	169,685	39,595	81.08	18.92
50	1,750	1,419	331	2,033	3,783	173,137	36,143	82.73	17.27
51	1,750	1,448	302	2,033	3,783	176,617	32,663	84.39	15.61
52	1,750	1,477	273	2,033	3,783	180,127	29,153	86.07	13.93
53	1,750	1,506	244	2,033	3,783	183,666	25,614	87.76	12.24
54	1,750	1,536	214	2,033	3,783	187,234	22,046	89.47	10.53
55	1,750	1,566	184	2,033	3,783	190,832	18,448	91.19	8.81
56	1,750	1,596	154	2,033	3,783	194,461	14,819	92.92	7.08
57	1,750	1,626	124	2,033	3,783	198,119	11,161	94.67	5.33
58	1,750	1,657	93	2,033	3,783	201,809	7,471	96.43	3.57
59	1,750	1,688	62	2,033	3,783	205,529	3,751	98.21	1.79
60	1,750	1,719	31	2,033	3,783	209,280	0	100.00	0.00

A= Borrower; B= MFI

Rental Division: A: (15/100) x 1,750= Rs. 263; B: (85/100) x 1,750= Rs. 1,488

Total Payment made to the MFI (Rs.) = 226,956

Maintenance cost @2% of the system cost (Rs.) = 20,928 for the whole loan duration

Profit to the MFI (Rs.) = 226,956 - 198,816-20,928= 28,140

Package 3

Total Cost of PV System (Rs.):	272,007
Down Payment (%):	15
Total Down Payment (Rs.):	40,801
Down Payment Made by Borrower (Rs.) @3%	8,160
Down Payment Made by Government (Rs.)@ 12%	32,641
Remaining Balance (Rs.):	23,1206
Maintenance Cost (per year):	2% of the system cost
Monthly Rent (Rs.):	1950
Rental Rate:	0.0071689
Monthly Installment (Rs.):	2804.998676

LOAN STRUCTURE FOR PACKAGE 3

Month	Rent (Rs.)			Monthly Installment (Rs.)	Total payment (Rs.)	Equity of A (Rs.)	Equity of B (Rs.)	Share of A (%)	Share of B (%)
	Amount	Share of A	Share of B						
							272,007		
0						40,801	231,206	15.00	85.00
1	1,950	293	1,658	2,805	4,755	43,899	228,108	16.14	83.86
2	1,950	315	1,635	2,805	4,755	47,018	224,989	17.29	82.71
3	1,950	337	1,613	2,805	4,755	50,160	221,847	18.44	81.56
4	1,950	360	1,590	2,805	4,755	53,325	218,682	19.60	80.40
5	1,950	382	1,568	2,805	4,755	56,512	215,495	20.78	79.22
6	1,950	405	1,545	2,805	4,755	59,722	212,285	21.96	78.04
7	1,950	428	1,522	2,805	4,755	62,955	209,052	23.14	76.86
8	1,950	451	1,499	2,805	4,755	66,212	205,795	24.34	75.66
9	1,950	475	1,475	2,805	4,755	69,491	202,516	25.55	74.45
10	1,950	498	1,452	2,805	4,755	72,795	199,212	26.76	73.24
11	1,950	522	1,428	2,805	4,755	76,121	195,886	27.99	72.01
12	1,950	546	1,404	2,805	4,755	79,472	192,535	29.22	70.78
13	1,950	570	1,380	2,805	4,755	82,847	189,160	30.46	69.54
14	1,950	594	1,356	2,805	4,755	86,246	185,761	31.71	68.29
15	1,950	618	1,332	2,805	4,755	89,669	182,338	32.97	67.03
16	1,950	643	1,307	2,805	4,755	93,117	178,890	34.23	65.77
17	1,950	668	1,282	2,805	4,755	96,590	175,417	35.51	64.49
18	1,950	692	1,258	2,805	4,755	100,087	171,920	36.80	63.20
19	1,950	718	1,232	2,805	4,755	103,609	168,398	38.09	61.91
20	1,950	743	1,207	2,805	4,755	107,157	164,850	39.40	60.60
21	1,950	768	1,182	2,805	4,755	110,730	161,277	40.71	59.29
22	1,950	794	1,156	2,805	4,755	114,329	157,678	42.03	57.97
23	1,950	820	1,130	2,805	4,755	117,954	154,053	43.36	56.64
24	1,950	846	1,104	2,805	4,755	121,604	150,403	44.71	55.29
25	1,950	872	1,078	2,805	4,755	125,281	146,726	46.06	53.94
26	1,950	898	1,052	2,805	4,755	128,984	143,023	47.42	52.58
27	1,950	925	1,025	2,805	4,755	132,714	139,293	48.79	51.21
28	1,950	951	999	2,805	4,755	136,470	135,537	50.17	49.83
29	1,950	978	972	2,805	4,755	140,254	131,753	51.56	48.44
30	1,950	1,005	945	2,805	4,755	144,064	127,943	52.96	47.04
31	1,950	1,033	917	2,805	4,755	147,902	124,105	54.37	45.63
32	1,950	1,060	890	2,805	4,755	151,767	120,240	55.80	44.20

33	1,950	1,088	862	2,805	4,755	155,660	116,347	57.23	42.77
34	1,950	1,116	834	2,805	4,755	159,581	112,426	58.67	41.33
35	1,950	1,144	806	2,805	4,755	163,530	108,477	60.12	39.88
36	1,950	1,172	778	2,805	4,755	167,508	104,499	61.58	38.42
37	1,950	1,201	749	2,805	4,755	171,514	100,493	63.05	36.95
38	1,950	1,230	720	2,805	4,755	175,548	96,459	64.54	35.46
39	1,950	1,258	692	2,805	4,755	179,612	92,395	66.03	33.97
40	1,950	1,288	662	2,805	4,755	183,704	88,303	67.54	32.46
41	1,950	1,317	633	2,805	4,755	187,826	84,181	69.05	30.95
42	1,950	1,347	603	2,805	4,755	191,978	80,029	70.58	29.42
43	1,950	1,376	574	2,805	4,755	196,159	75,848	72.12	27.88
44	1,950	1,406	544	2,805	4,755	200,370	71,637	73.66	26.34
45	1,950	1,436	514	2,805	4,755	204,612	67,395	75.22	24.78
46	1,950	1,467	483	2,805	4,755	208,884	63,123	76.79	23.21
47	1,950	1,497	453	2,805	4,755	213,186	58,821	78.38	21.62
48	1,950	1,528	422	2,805	4,755	217,519	54,488	79.97	20.03
49	1,950	1,559	391	2,805	4,755	221,884	50,123	81.57	18.43
50	1,950	1,591	359	2,805	4,755	226,279	45,728	83.19	16.81
51	1,950	1,622	328	2,805	4,755	230,707	41,300	84.82	15.18
52	1,950	1,654	296	2,805	4,755	235,165	36,842	86.46	13.54
53	1,950	1,686	264	2,805	4,755	239,656	32,351	88.11	11.89
54	1,950	1,718	232	2,805	4,755	244,179	27,828	89.77	10.23
55	1,950	1,751	199	2,805	4,755	248,735	23,272	91.44	8.56
56	1,950	1,783	167	2,805	4,755	253,323	18,684	93.13	6.87
57	1,950	1,816	134	2,805	4,755	257,944	14,063	94.83	5.17
58	1,950	1,849	101	2,805	4,755	262,598	9,409	96.54	3.46
59	1,950	1,883	67	2,805	4,755	267,286	4,721	98.26	1.74
60	1,950	1,916	34	2,805	4,755	272,007	(0)	100.00	0.00

A= Borrower; B= MFI

Rental Division: A: (15/100) x 1,950= Rs. 293; B: (85/100) x 1,950= Rs. 1,658

Total Payment made to the MFI (Rs.) = 285,300

Maintenance cost @2% of the system cost (Rs.) = 27,201 for the whole loan duration

Profit to the MFI (Rs.) = 285,300 - 258,407 - 27,201= 26,893

Annex III: Journal Paper

SHS Micro financing in On-Grid Rural Areas of Pakistan – What, Why, How!

Warda Ajaz, Parvez Akhter

Centre for Energy Systems, National University of Sciences and Technology, Islamabad, Pakistan

Abstract

Pakistan is facing ever worsening electricity crisis. Most urban areas experience 10 to 12 hours load shedding each day while in rural areas, the situation is much worse with on average 16 to 18 hours power outage per day. With end user energy micro-financing turning up as a light at the end of the tunnel for enhancing energy access in most developing countries like Bangladesh and Sri Lanka, employing this mechanism for encouraging the use of de-centralized solar power systems in on-grid areas of Pakistan, can significantly lessen the load on national grid. Especially for on-grid rural areas where the electricity load per household is much less than the urban households, introducing low cost solar home systems on micro-loans are likely to be more financially viable. In this context, this paper aims to investigate the feasibility of solar home system micro financing in on-grid rural areas of Pakistan. After conducting household surveys and collecting baseline information collection in a selected case study village, the study concludes that most of households are both willing and able to take micro-loans for switching to solar home systems for power generation.

Keywords: Solar Home System, Microfinance, Energy Access, Pakistan, National Grid

Background

In the twenty-first century, one of the utmost requirements for development and poverty reduction is access to energy(UNEP 2007; Rao et al. 2009; Ilskog 2008; Ilskog and Kjellström 2008).Various studies and historical evidence suggests that access to energy holds a pivotal role in the development of any country and no country has ever achieved significant poverty alleviation without improving energy access for the inhabitants(Rao et al. 2009).

Yet, more than 1.6 billion people around the world do not enjoy access to modern energy services(IEA 2011) and the majority of those lying on the lowest rung of the

energy ladder lives in rural areas(World Bank 2008; WHO 2009). On one hand, this employs impeded "opportunities for economic development,(Munasinghe 2009)" while on the other hand, presents a serious hurdle in achieving the most important Millennium Development Goals (MDGs) of reducing energy poverty, improving access to clean water and sanitation facilities and enhancing education and health services(UNDP 2012).

However, providing energy access to the whole population requires huge amount of capital and resources, which in case of most developing countries is almost impossible to mobilize(Sovacool 2013). According to the statistics from the International Energy Agency (IEA), around USD 9.1billion were invested worldwide in 2009 for expanding energy access and this investment must increase to USD 48 billion a year in order to achieve universal access to modern energy services by the year 2030(IEA 2011). If seen in comparison to the global energy expenditures, this amount equals to only 3% of what the world spends on energy services per year. Nevertheless, especially in case of developing countries, mobilizing such huge amount of financial resources should not be under-estimated.

Considering the inadequate availability of public monetary resources for improving energy access, catalyzing private finance for serving the purpose seems to be the only viable option(Glemarec 2012). One of the most promising avenue in this regard is micro financing, which has shown great potential for enhancing access to modern energy services in many developing countries including Bangladesh, India, Nepal, and Sri Lanka.

Introduction

Pakistan is facing an electricity crisis which is not only affecting the lives of the people but also hindering the country's economic development. Most of the urban areas are experiencing up to 10 to 12 hours of load shedding while the situation is even worse in the rural areas where the electricity remains unavailable for an average 16 to 18 hours per day(Mirza et al. 2007; Farooq and Shakoor 2013). As of 2011, the total shortfall in the system was more than 5000 Megawatts with the demand of 14,475 Megawatts and supply of only 9,465 Megawatts. After just 1 year i.e. in summer of 2012, this gap between demand and supply widened to 6,000 Megawatts as the demand increased to 15,000 Megawatts and the supply being only 9,000 Megawatts

(NEPRA 2012; Ebrahim 2012; Kessides 2013). According to latest figures for August 2014, the electricity demand was recorded at 19,600 megawatt with the supply of only 14,800 megawatts and the country experiencing a shortfall of 4,800 megawatts (Duniya News 2014).

As per the statistics from the National Electric Power Regulatory Authority (NEPRA), domestic sector consumes the major chunk of electricity as compared to the other sectors(Khalil and Zaidi 2014). Province wise distribution of electricity consumption by agriculture, bulk supply, domestic and industrial sectors is outlines in *Table 1*.

Table 1. Energy Consumption in Various Sectors (GWh)

Sector	Punjab	Sindh	KPK	AJK	Baluchistan	Total
Agriculture	6.8	1.2	0.5	0.0	4.1	13.0
Bulk supply	3.5	1.7	0.7	0.0	0.1	5.9
Domestic	28.0	9.3	7.3	0.8	0.6	46.1
Industry	18.3	6.1	1.9	0.1	0.2	26.7
Commercial	4.7	2.0	0.7	0.1	0.1	7.5
Other	0.3	0.3	0.0	0.1	0.0	0.7
Total	61.7	20.6	11.1	1.1	5.5	74,349

On the other hand, Pakistan is blessed with the richest natural energy resources. Especially in terms of solar resources, Pakistan lies in one of the most favourable geographic areas for generating energy from solar as it receives high solar insolation in the long summer season(Mirza, Mercedes Maroto-Valer, and Ahmad 2003). A study by NERL estimates that Pakistan has potential for generating 2.9 million megawatt of electricity through solar energy. Moreover, the Government of Pakistan also encourages the use of solar photovoltaic energy and has set ambitious goals for increasing the share of renewable energy in the national energy mix by 2030. According to NEPRA, the Government of Pakistan aims to have atleast 5% power generation through renewable energy technologies, including solar photovoltaic, by 2030(GIZ 2012).

In this situation, one way of reducing load on the national grid can be encouraging mass use of decentralized SHS, especially in on-grid rural areas where the household load is already very low as compared to urban households. However, a major hurdle in this regard is the high cost of SHS and uunfortunately, inspite of having the success stories of renewable energy micro financing in neighboring countries like Bangladesh,

India and Nepal, there is no prominent renewable energy micro-finance scheme, offered by the government, NGOs, MFIs or banks.

In this context, this research study has been designed with the aim of assessing the consumer's feedback and baseline situation to determine feasibility of introducing Solar Home System (SHS) micro financing schemes in on-grid rural communities of Pakistan. The scope of study was defined with the following points in mind:

1. The scope of this research is limited to a remote, on-grid village 'Jajja', located in the union council Manghot, Tehsil Gujjar Khan, District Rawalpindi.The village is located at the Mandrah-Chakwal road, at a distance of 20 kilometers from Mandrah.
2. The feasibility of renewable SHS micro-financing has been assessed in terms of:
    a. Demographic factors
    b. Energy usage and consumption behaviors
    c. Ability to pay
    d. Willingness to pay
3. It is expected that the results of this study will be applicable on the average on-grid rural communities of Pakistan, as the living conditions and the perceptions of the people are similar.

Methodology

The study relied on household surveys for finding the opinions and reservations of the potential consumers of SHS microfinance schemes. For this purpose, a case study village 'Jajja', located in Union Council Manghot of Rawalpindi District, Punjab, Pakistan, was selected for conducting household surveys. Although the village is connected to national grid, on average 12 -16 hours load shedding is frequent throughout the year due to ongoing power crisis in the country. The village comprises of 146 households, while 16 other households also reside along its boundary.

After selecting the case study village, basic demographic information and statistics were obtained from the Manghot Union Council Office. Based on this information, as well as after conducting a through literature search, a specially designed questionnaire

was prepared for obtaining the data required for assessing the current electricity consumption trends and consumer perceptions of solar home system micro financing in the selected case study village.

The designed questionnaire covered 4 broad themes, i.e. Demographic factors, Energy usage and consumption behaviors, Ability to pay, Willingness to pay. Quite naturally, the demographic factors affect an individual's way of living and preferences. Similarly, knowledge of energy usage and consumption behaviors are crucial for developing a baseline energy load profile for appropriate SHS designing. The other two parameters, i.e. Ability to pay and Willingness to pay also play an important part while designing microfinance schemes because if the end-user does not, for any reason, pay back the loan, the scheme will not sustain. While the former two parameters are relatively easier to assess, the latter two are quite complicated. Therefore, ability to pay was assessed through factors like monthly income and expenses of the households, reliability and frequency of income, savings, wealth and current loans. While an entire section of the questionnaire was exclusively designed for conducting a *Willingness-to-Pay (WTP) analysis.*

The questionnaire was then pre-tested in the field to check its appropriateness and then accordingly, the changes were made in the final version. After finalizing the revised questionnaire, all 156 households located in and around the village were surveyed. All the respondents were first briefed about the purpose of the survey.

A database for the statistical analysis was prepared in SPSS. After the household surveys were conducted, the data was cleaned, coded and entered into the SPSS database. Descriptive and Frequency distribution analysis was then conducted for detailed analysis of the data.

Results

This section outlines the results of the household surveys conducted within the scope of this study.

1. Number of Residents

The survey results depict that majority of households in the village i.e. 22.4%, have 6 residents in their house. This was followed by a percentage of 21.8% for those having 5 residents and 16% for the households having 4 residents. Overall, it can be

concluded that around half of the households have 5-6 residents in the house (*Table 2).*

Table 2: Number and Percentage of Households with respect to Number of Residents

Number of Residents	Number of Households	Percentage of Households
1	5	3.2
2	18	11.5
3	20	12.8
4	25	16.0
5	34	21.8
6	35	22.4
7	10	6.4
8	7	4.5
9	1	0.6
10	1	0.6
Total	156	100

2. Number of Residents with respect to Gender

Around 37% of the surveyed households had 3 male members in their family, while 27% had 2 male members. On an overall basis, more than 60% households reported 2-3 male members in the family. The survey results also showed that there are 2 female residents in around 42% of the surveyed households. This was followed by a figure of 23.7% for the households having 3 female members in the house (*Figure 1).*

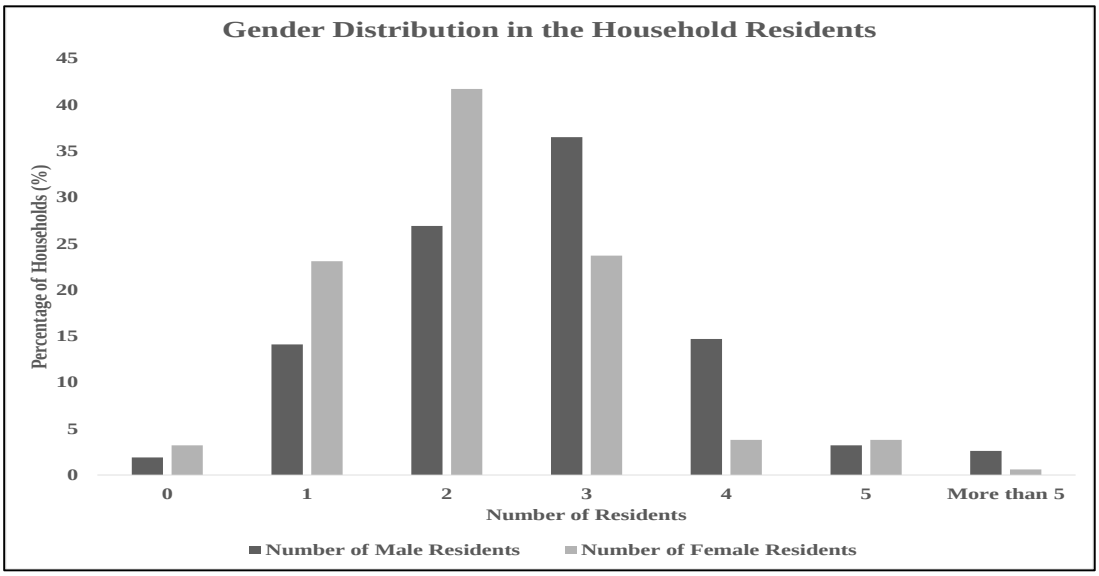

Figure 1: Percentage of Households with respect to Gender Distribution of Residents

3. Ownership Status of the House

99.4% respondents in the village were living in the house owned by themselves or their families. Only 1 household reported living in a rental house *(Table 3).*

Table 3: Number and Percentage of Households with respect to the Ownership Status of the House they live in

Ownership Status	Number of Households	Percentage of Households
Owned/Family Owned property	155	99.4
Rental property	1	0.6
Total	156	100.0

4. Number of Rooms in the House

Around 54% households lived in a 3-room house. This was followed by 28% who lived in a houses having 4 or more rooms (*Table 4).*

Table 4: Number and Percentage of Households with respect to the Number of Rooms in the House

Number of Rooms	Number of Households	Percentage of Households
1	2	1.3
2	27	17.3
3	84	53.8
4 or more	43	27.6
Total	156	100.0

5. Education Qualification of Residents

The results showed that in around 49% households, no family member was illiterate, while in 32% households, only 1 illiterate family member was reported. In 47.5% households, 1 to 2 family members had education upto the primary school level, 64% had 1 to 2 secondary school educated residents while the percentage of households reporting higher secondary school and university educated family members was very low. This trend shows that in the surveyed village, most of people are either primary or secondary school qualified (*Figure 2).*

6. Employment Status of Residents

Around 81% households in the surveyed village had 1 to 2 bread earners while more than half had 3 to 4 un-employed family members (*Figure 3).*

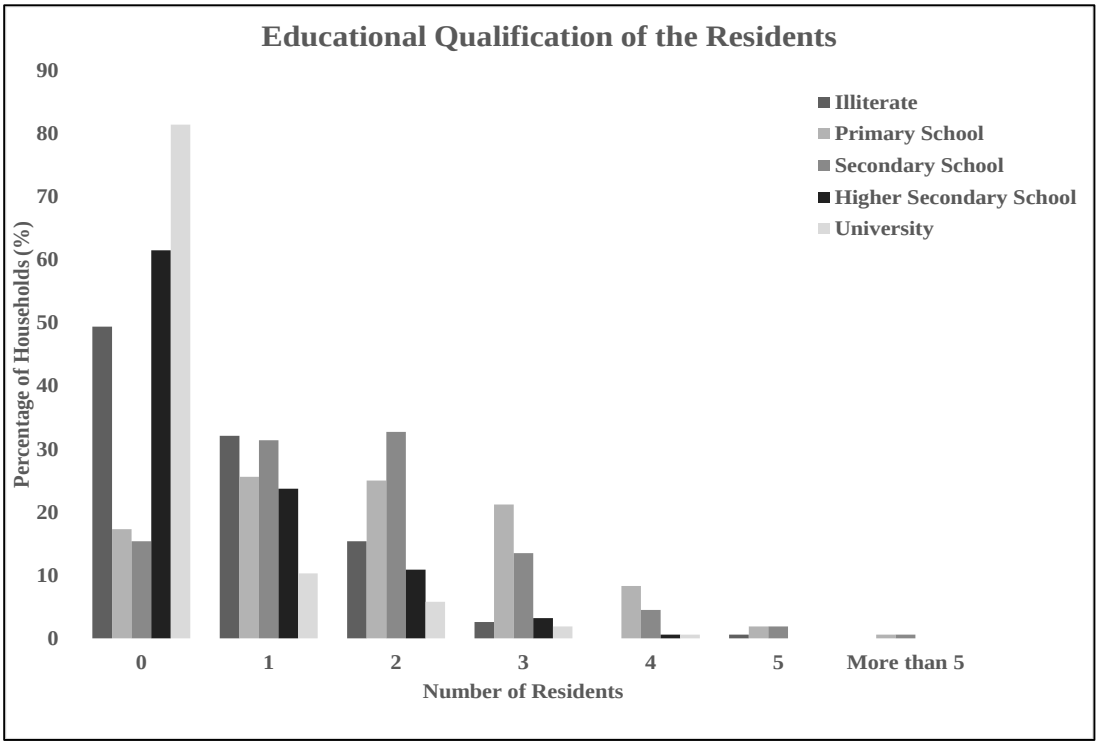

Figure 2: Percentage of Households with respect to their Educational Qualification

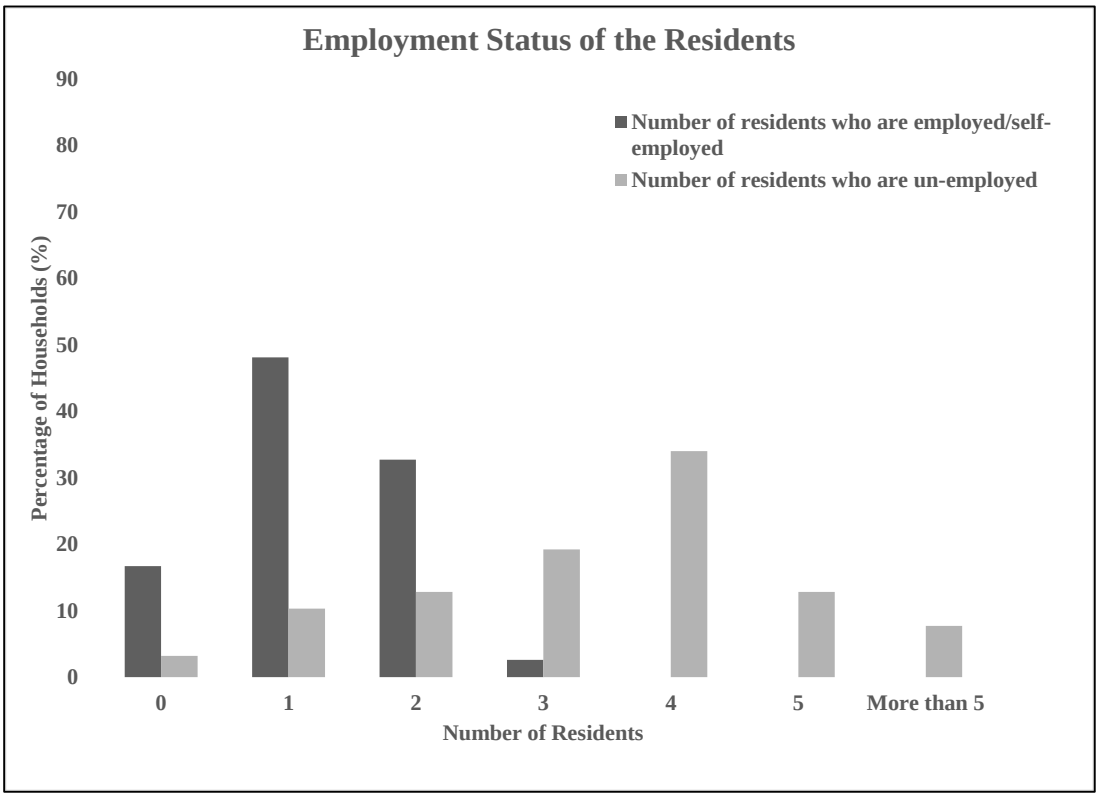

Figure 3: Percentage of Households with respect to Employment Status of the Residents

7. Source of Income

The respondents were also asked about the major sources of their family income. 122 households listed regular employment as their major source of income. This was followed by agriculture with 96 households earning a major part of their income through it (*Table 5).*

Table 5: Number of Households with respect to their Major source(s) of Income (more than one answer possible)

Major Sources of Income	Number of Households
Regular employment	122
Trade	8
Agriculture and/or Livestock	96
Other	22

8. Frequency of Income

According to the survey results, majority of households in the village received their income monthly or seasonally (*Table 6).*

Table 6: Number of Households with respect to their Frequency of Income (more than one answer possible)

Frequency of Income	Number of Households
Daily	13
Weekly	9
Monthly	127
Seasonal	88

9. Total Monthly Income

Out of 156 households, 80 reported that their average household monthly income is between Rs. 20,000-30,000. Only 8 surveyed households had the monthly income above Rs. 40,000 (*Figure 4).*

10. Monthly Expenses

After the monthly household income, the respondents were asked about the monthly household expenses. 53% households reported that their monthly expenses match their monthly income i.e. they spend Rs. 20,000 to 30,000 per month (*Figure 5).*

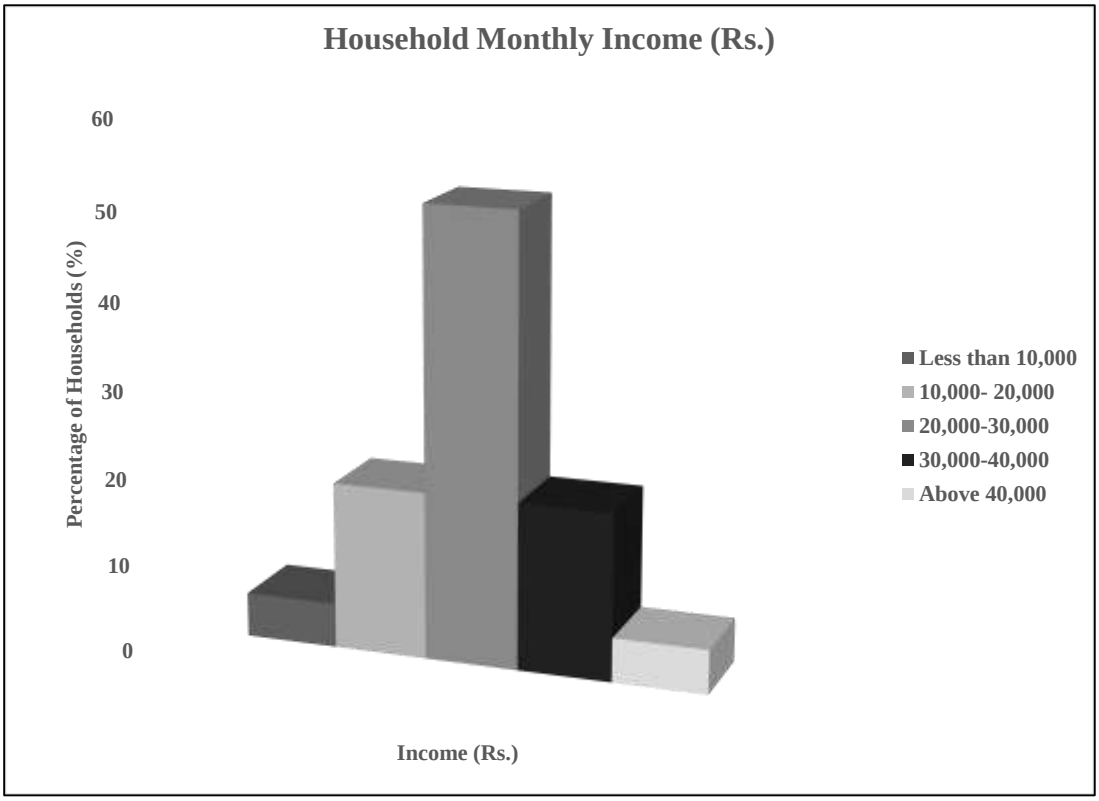

Figure 4: Percentage of Households with respect to their Average Monthly Household Income

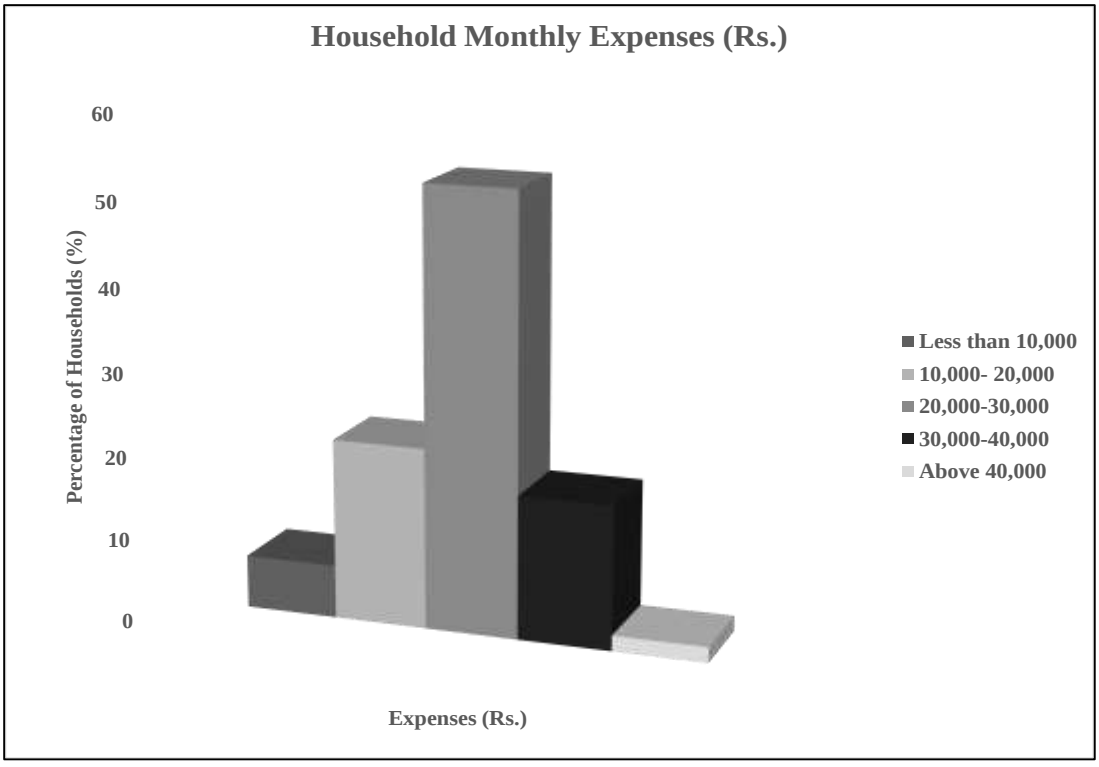

Figure 5: Percentage of Households with respect to their Average Monthly Household Expenses

11. General Use of Electricity

The next section focused on the electricity consumption in particular. The section comprised of the following sub-sections:

a. Electricity Intensive Activities at Home:

In order to get an idea of the electricity consumption trends in the surveyed village, the respondents were asked about the electricity intensive activities which are carried out in their household. As can be seen from *Table 7,* almost all the households used electricity for lighting and space cooling. The other major electricity consuming activities included watching TV and charging mobile phones.

Table 7: Number of Households with respect to their Electricity Intensive Activities (more than one answer possible)

Activities	Number of Households
Lighting	156
Space Cooling (Fans)	154
Space Cooling (Air-conditioning)	4
Watching TV	145
Listening to Radio	20
Charging mobile phones	139
Using desktop computer	22
Charging laptop	8

b. Use of Electric Appliances:

The electricity consumption behavior was further assessed by the questions directly targeted at the number and daily consumption of specific electric appliances in the household.

Considering the fact that the village is connected to the grid and the occasionally used appliances like laundry machines and cloth irons can be powered through the grid electricity, it only seems logical that the SHS be designed for catering to only the most commonly used activities outlined above.

Therefore, for SHS designing, only the activities conducted in atleast 50% of the households were further considered. These activities are Lighting, Space cooling with fans, Watching TV and Charging mobile phone and the use of appliances covering these activities are discussed below.

Tube lights:

Around 21% households reported that they have 4 tube lights installed in their homes, while 26% said they do not have any tube light in the house. Moreover, more than 34% said that the average use of each tube light in their home is 3 hours per day *(Figure 6).*

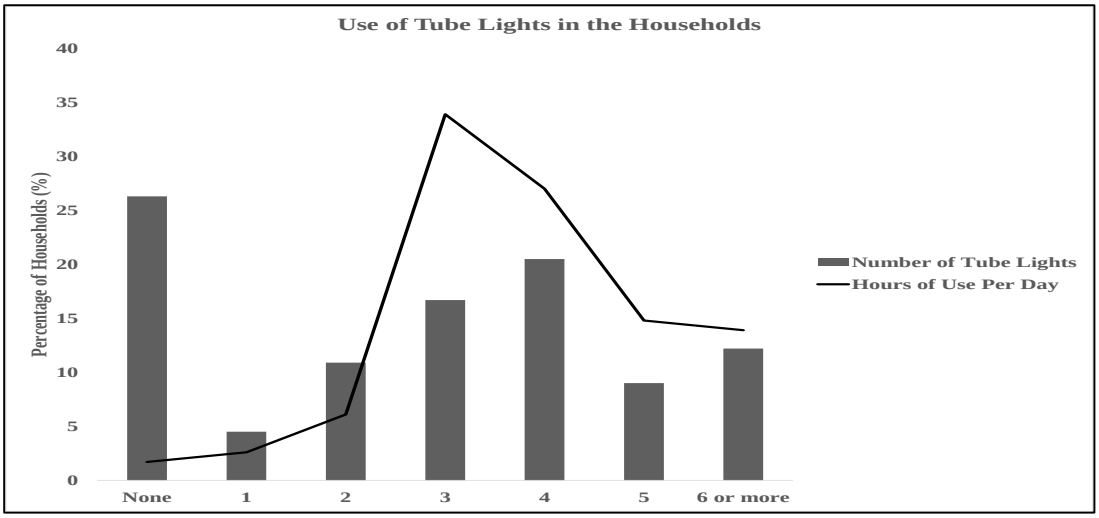

Figure 6: Percentage of Households with respect to the Use of Tube Lights

Energy Saver Lights (Compact Fluorescent lights):

When asked about the energy saving compact fluorescent lights, 18.6% said they have 2 energy savers installed in their home. *Figure 7* depicts a detailed breakdown of the answers. Also, as shown, 53% households stated that they use the energy saver light for around 5 hours per day.

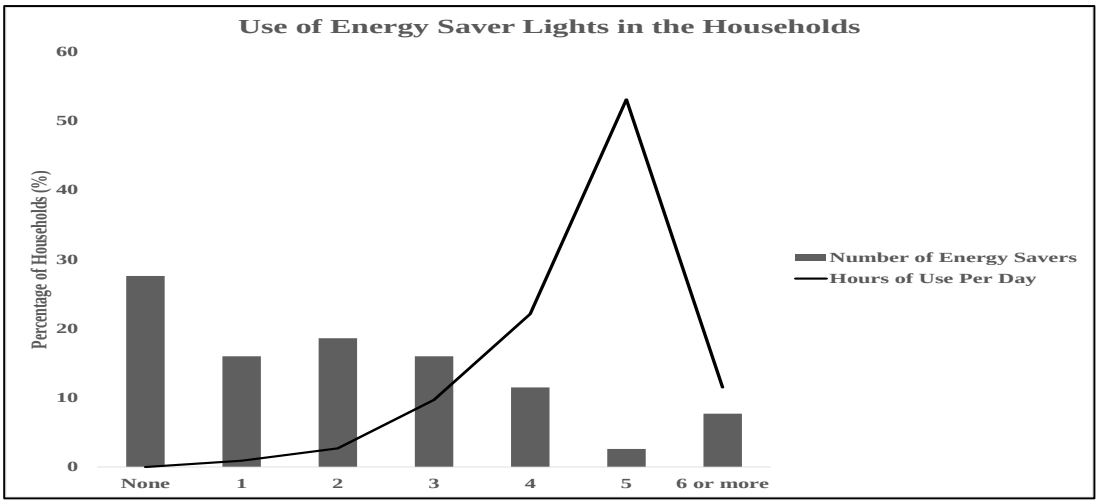

Figure 7: Percentage of Households with respect to the Use of Energy Saver Lights

LED Lights:

The survey results show that none of the households in the surveyed village was using LED lights, or was even aware of their benefit *(Table 8).*

Table 8: Number and Percentage of Households with respect to the Number of LED Lights

Number of LED Lights	Number of Households	Percentage of Households
None	156	100.0

Television:

Only 7 households in the village owned a black and white television, which was being used for 1 to 2 hours per day *(Figure 8).* However, 138 households reported owning colored TV and around half of them reported its use about 3 to 4 hours in a day *(Figure 9).*

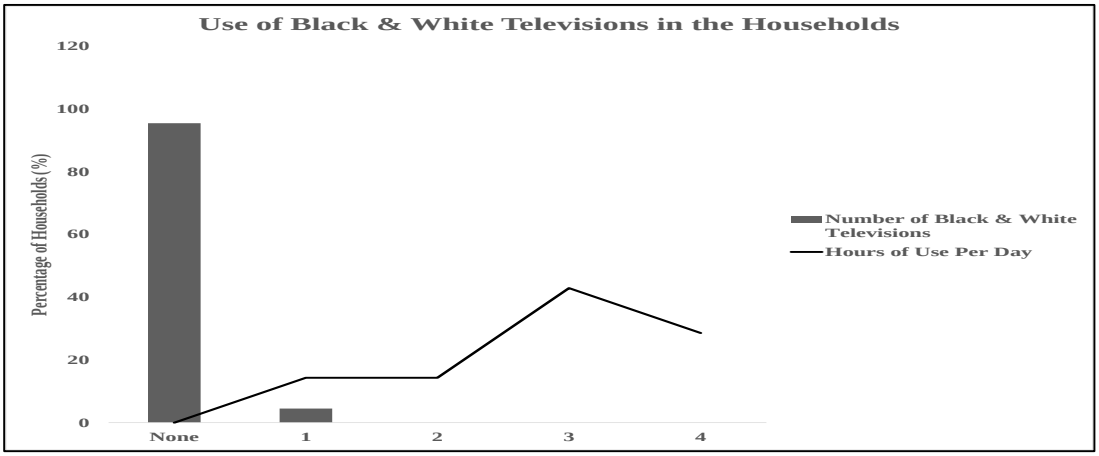

Figure 8: Percentage of Households with respect to the Use of Black and White TVs

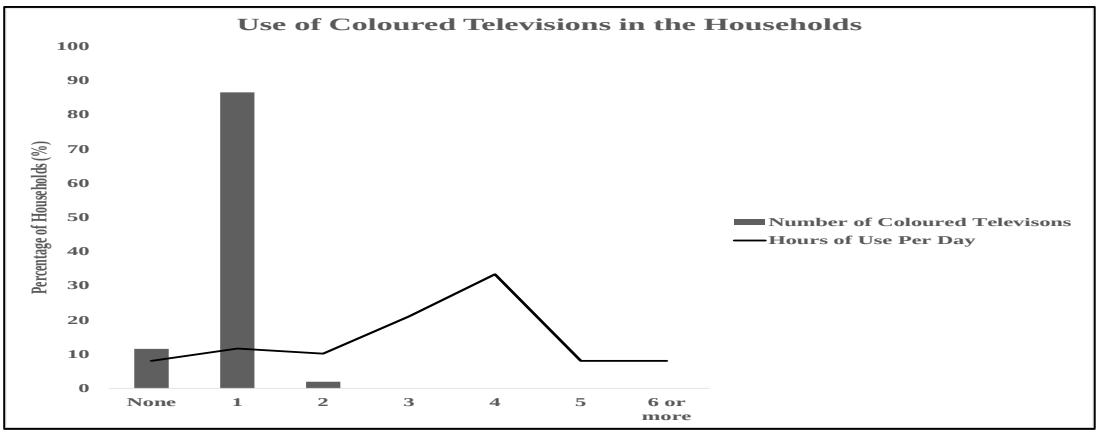

Figure 9: Percentage of Households with respect to the Number of Colored TVs

Fans:

Due to the geographical and climatic conditions in the area, space cooling is needed in every house in the village. This is why 154 households, out of 156, reported using fans during summer season. Around half of the village households have 2 to 3 fans installed in their house. Moreover, the average use of each fan was reported by almost all of households to be more than 6 hours *(Figure 10).*

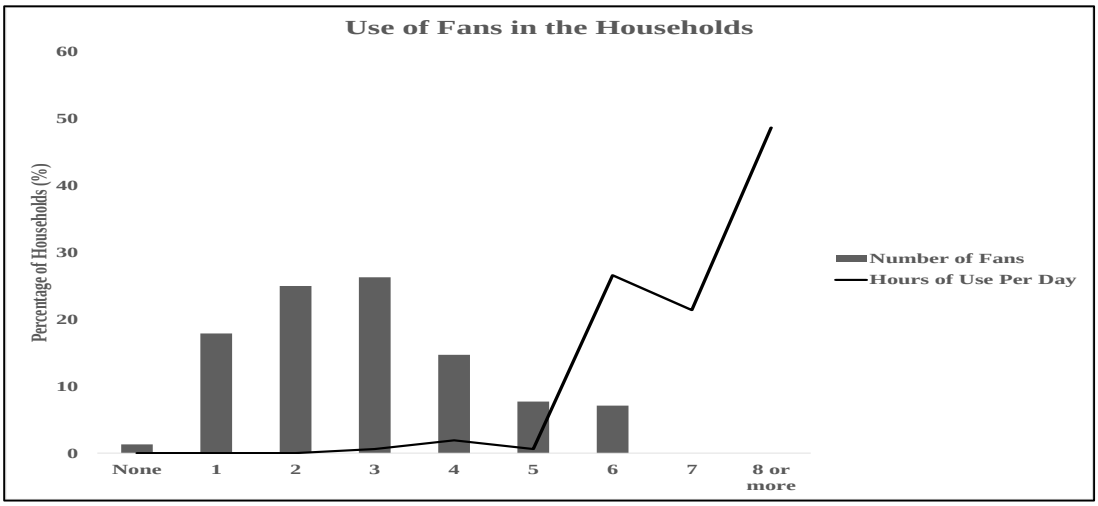

Figure 10: Percentage of Households with respect to the Use of Fans

Mobile Phones:

All except 17 households had atleast 1 mobile phone in their house. Around 47% reported 1 mobile phone, 22% reported 2 phones while 16% said they have 3 mobile phones in the house. The average use of a mobile phone charger was estimated to be 1 hour in a day *(Figure 11).*

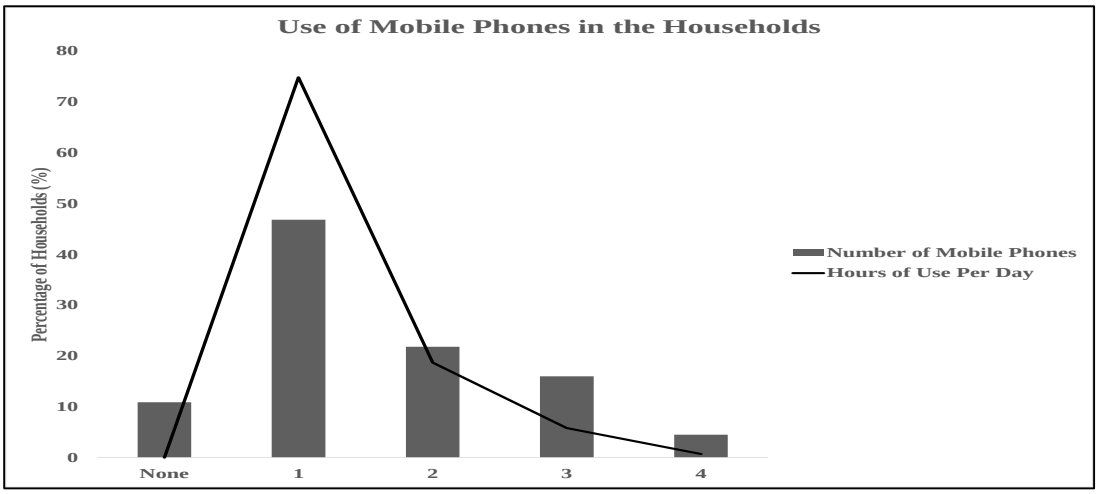

Figure 11: Percentage of Households with respect to the Use of Mobile Phones

12. Monthly Electricity Bill

The households were further asked about the average electricity bill. The results, summarized in *Figure 12*, show that 66% households had a monthly electricity bill of Rs. 1000 to 3000.

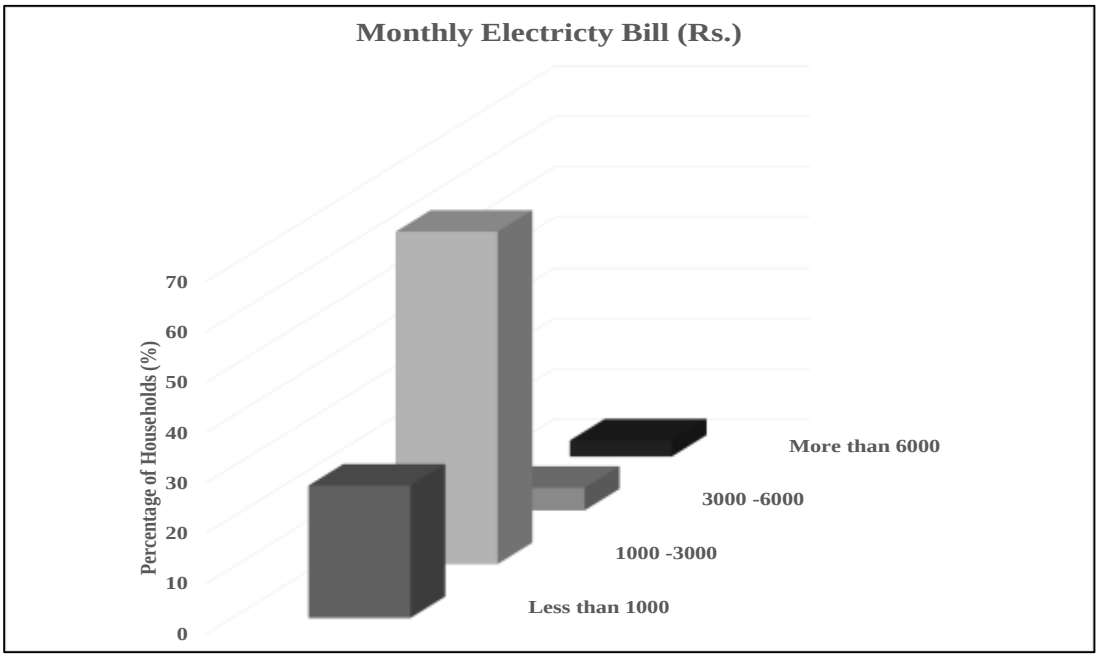

Figure 12: Percentage of Households with respect to the Monthly Electricity Bill

13. Perceptions about Renewable Energy and Micro financing

The last section of the survey questionnaire, was focused on assessing the perceptions and preferences of the community regarding renewable energy technologies and micro financing. The following sub-sections were included in this section of the questionnaire:

a. Willingness to Buy Renewable Energy Technology on MicroLoan:

The households in the surveyed village were then directly asked about their willingness to buy renewable energy technologies on microloan. A clear majority of the respondents, i.e. 82.7% gave a positive response while 17.3% showed their un-willingness *(Figure 13).*

Among the 17.3% households who showed their un-willingness, 37% stated that their financial situation does not allow them to take loan. The detailed breakdown is provided in *Table 9.*

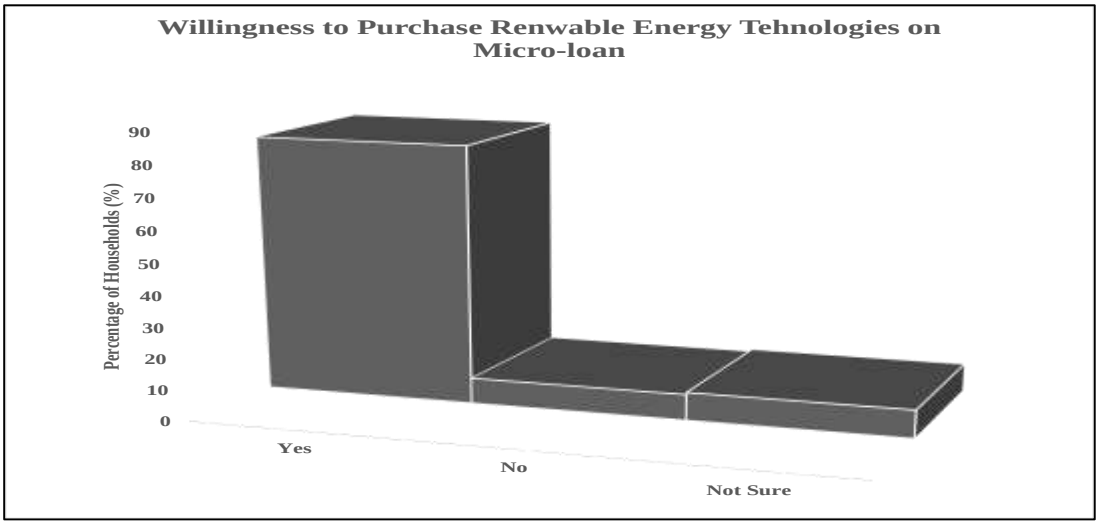

Figure 13: Percentage of Households with respect to their Willingness to Buy Renewable Energy Technologies on Loan

Table 9: Number and Percentage of Households with respect to their Reasons for Un-Willingness to Buy Renewable Energy Technologies on Loan

Reasons for Un-willingness	Number of Households	Percentage of Households
Financial problems	10	37
Not sure if it will benefit us	4	14.8
No need	13	48.1

b. Preferred Upfront Payment:

More than half of the respondents stated that they could only afford an upfront payment of Rs. 6,000 or less, for buying renewable energy technology on microloan *(Figure 14).*

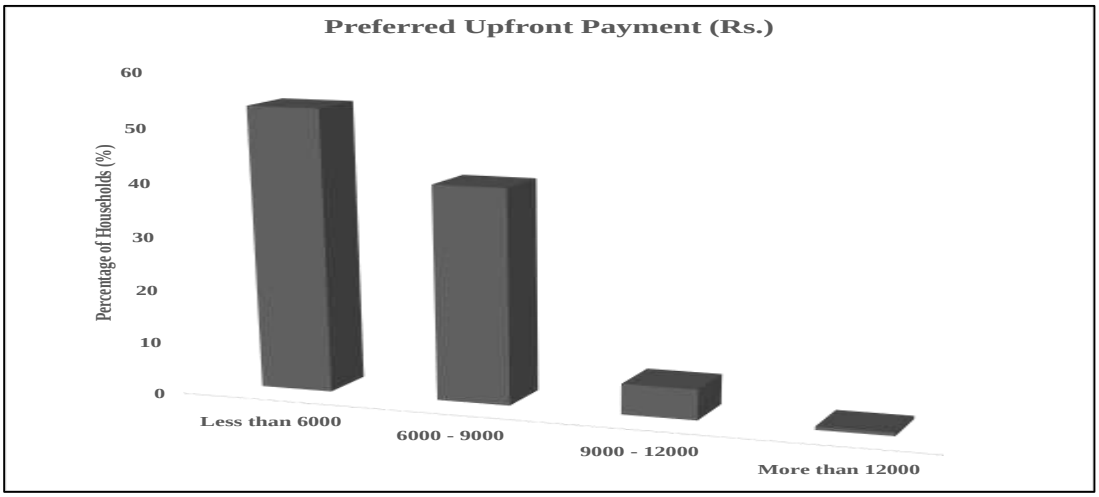

Figure 14: Percentage of Households with respect to the Preferred Upfront Payment (Rs.)

c. Preferred Monthly Installment:

Around 74% households reported that a monthly installment of less than Rs. 2000 would suit them the most, while 21% said they could pay Rs. 2000 to 4000 per month as installment *(Figure 15).*

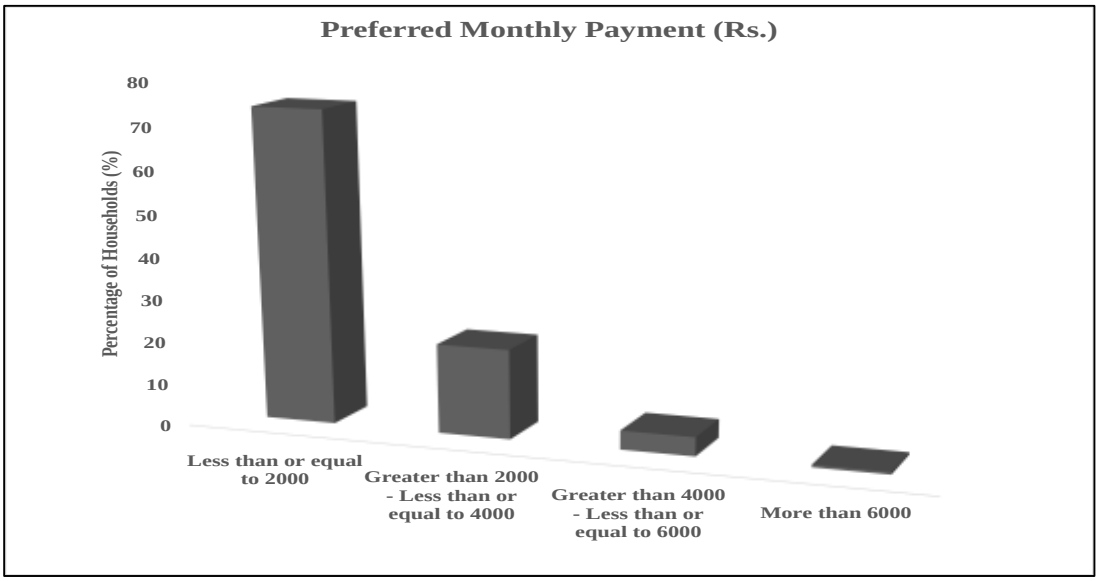

Figure 15: Percentage of Households with respect to the Preferred Monthly Payment (Rs.)

d. Preferred Duration of Loan:

In case of loan duration, more than half of the respondents said they would be most comfortable if the loan duration is 3 years or more *(Figure 16).*

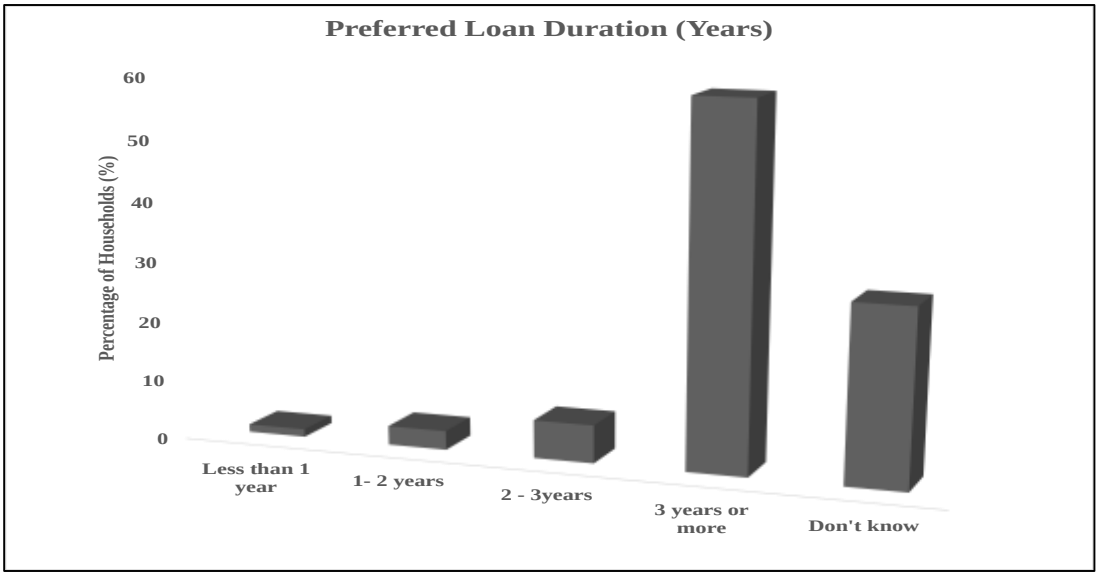

Figure 16: Percentage of Households with respect to the Preferred Duration of Loan

14. Comments of the Survey Respondents

In the end, the respondents were asked if they wanted to give any opinion or comments regarding the potential SHS microfinance schemes. Most of the respondents said that being Muslims, they have reservations about the element of interest rate in the micro loans offered by banks. Some others also pointed out the issue of maintenance of SHS, saying that the micro finance institute should also take care of the maintenance atleast for the duration of the loan.

SHS Design

From the survey results, it can be clearly deduced that majority of the households in the case study village are both willing and able to take micro-loans for switching to SHS, provided that the scheme offers interest free loan. Therefore, an appropriate interest-free SHS microfinance scheme can prove be highly feasible.

Based on the appliances involved in the electricity intensive activities conducted in atleast 50% households, and their most common hours of use as shown by the survey results, the following can be presented as a typical summer season electricity load of an average household in the case study village:

- ✓ 4 Tube lights, each used for 3 hours per day.
- ✓ 2 Compact Fluorescent lights, each used for 3 hours per day.
- ✓ 3 Fans, each used for 10 hours per day.
- ✓ 1 colored TV, used for 4 hours per day
- ✓ 1 Mobile phone, charged for 1 hour per day

Using the most common wattages of these appliances (PEPCO 2014; Standby Power 2014), It is therefore recommended that the SHS be designed with the following typical load profile:

Tube Lights:	4 x 40 watts x 3 hours = 480 watt-hour/day
Compact Fluorescent Lights:	2 x 22 watts x 5 hours = 220 watt-hour/day
Fans:	3 x 80 watts x 10 hours = 2400 watt-hour/day
Television:	1 x 200 watts x 4 hours = 800 watt-hour/day
Mobile Phone Charger:	1 x 5 watts x 1 hour = 5 watt-hour/day

Total:	3905 watt-hour/day = 43.905 kWh/day = 117.15 kWh/month

Micro-Loan Design

The survey results also revealed the most of the target customers prefer the following financial scheme for the micro loan.

Upfront Payment:	Rs. 6,000
Monthly Installment:	Rs. 2,000
Loan Duration:	3 or more years

Therefore, it is recommended that an interest-free microfinance scheme matching the above summarized specifications be offered to the on-grid rural households for micro financing.

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