ANALYSIS OF THE IDCOL SOLAR HOME SYSTEM PROGRAM IN BANGLADESH

A Project Paper

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by

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ABSTRACT

Energy is one of the most important ingredients required to alleviate poverty and realize rural development. With the growing concerns of climate change and carbon emissions, renewable energy is now considered as an essential element of any strategy for sustainable energy development. This project paper attempts to analyze the case of the IDCOL Solar Home System (SHS) Program in its creation of a "green" business model. The SHS business model showed that it is in principle a viable model. It has multidimensional benefits of social, economic, political and environmental. Also, a simple statistical analysis was done to determine how various factors affecting the SHS program affect those sales. The lessons learned from the SHS program in Bangladesh are also discussed in order to see what can be applied in other renewable energy programs in Bangladesh or any other part of the world.

BIOGRAPHICAL SKETCH

Ashraf is an MPS Candidate in Global Development with major in International Development under the International Programs-College of Agriculture and Life Sciences. Prior to his studies in Cornell, he worked for five years in a state-owned financial institution in Bangladesh, Infrastructure Development Company Limited (IDCOL). He worked in various positions in the credit administration unit of IDCOL and was tasked with overall financial management and evaluation of the company investment portfolios. He holds Bachelor's degree in Business Administration from North South University, Dhaka and Master's degree in Business Administration from University of Dhaka, Bangladesh.

ACKNOWLEDGMENTS

In preparation of this paper, I had to take the help and guidance of some respected persons, to whom I shall be forever in debt. As the completion of this paper gave me much pleasure, I would like to show my heartiest gratitude to Professors Steven Kyle and David Lee, for giving me guidance and direction through numerous consultations. I would also like to expand my gratitude to Professors Aija Leiponen and John Mathiason for guiding me both directly and directly in writing this paper.

In addition, special thanks to Mr. S.M. Monirul Islam, Mr. Farhan Reza, Mr. Mohammad Rashedul Islam and Mr. Zabir Ibne Raquib from IDCOL, for giving permission and to provide the necessary material to complete the analysis.

Many people, especially my cohorts have made valuable suggestions and recommendations on my paper which gave me the motivation to improve the quality.

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LIST OF ABBREVIATIONS

ADB: Asian Development Bank

GIZ: Deutsche Gesellschaft für Internationale Zusammenarbeit

GPOBA: Global Partnership on Output Based Aid

IDCOL: Infrastructure Development Company Limited

IsDB: Islamic Development Bank

JICA: Japan International Cooperation Agency

KfW: Kreditanstalt für Wiederaufbau ("Reconstruction Credit Institute")

OBA: Output based Aid

PO: Partner Organization

REREDP: Rural Electrification and Renewable Energy Development Project

SHS: Solar Home System

USAID: US Agency for International Aid

WBG: World Bank Group

Section 1: Background

I was standing under the scorching sun in front of a little tin-shed house in the Lalmonirhat district, a northern district of Bangladesh, listening to a woman who was describing in tears how she gave away the Solar Home System (SHS) that we installed, as part of the dowry when she was sending her daughter away. Her son-in-law and his parents demanded the SHS that was installed under the Government's Test Relief Project (TR/KABITA), along with other things. I was there as part of a periodic inspection from the office to check the overall implementation of the project. Not finding anything when I was thinking that it was a phony installation, the woman described the real reason. Listening to her I asked myself, "what am I doing here?" Am I making any contribution towards betterment of the lives of these people?

Inception of IDCOL SHS Program:

Infrastructure Development Company Limited (IDCOL) started its operation in 1997. The first project it undertook was a 450 MW Independent Power Plant built by Meghnaghat Power Limited (MPL). It launched its capstone project, IDCOL Solar Home System (SHS) Program, in 2003, facilitating credit sales in rural off-grid areas as part of a larger rural electrification program supported by the World Bank's (WB) Rural Electrification and Renewable Energy Development Project (REREDP). Later on, Asian Development Bank (ADB), Islamic Development Bank (IsDB), Japan International Cooperation Agency (JICA), KfW, GIZ and USAID expanded additional financing in the project.

Rationale for World Bank Involvement under the Project:

The World Bank initiated this project to support Bangladesh's effort to raise levels of social development and economic growth by increasing access to electricity in remote rural areas. As

part of the then Millennium Development Goals (MDGs), which later evolved into the Sustainable Development Goals (SDGs), Bangladesh wanted to reduce carbon emissions by overcoming market barriers for renewable energy development. The IDCOL SHS Program was one of the earliest renewable energy initiatives in Bangladesh that had the potential to grow on a large scale. Also, as a state-owned financial institution, the mission of the SHS program was to fulfill basic electricity requirements in the rural areas and supplementing government's vision of "Electricity for All" by 2021. The World Bank had considerable experience in financing renewable energy projects and also the project was consistent with the WB's country assistance strategy 2006-2009 for Bangladesh[1]. They also wanted to contribute to the sustainable development of Bangladesh with particular emphasis on rural population, in addition to reducing GHG emissions.

Task of IDCOL:

The tasks of IDCOL under the project were as follows:

a) Developing consumer awareness of SHS and their potential for rural lighting;
b) Selection of Partner Organizations (POs) who would implement the project on behalf of IDCOL;
c) Establishing standards to be met for equipment;
d) Providing refinancing loans to the POs which would ultimately be transferred to the customers (up to 80%); and
e) Supervising activities of POs and coordinating activities between participants (POs, suppliers and customers).

As on February 2018 IDCOL had installed 4.1 million SHSs in the off-grid rural areas of Bangladesh. It is currently generating a power equivalent of 80 MW and 8.25 million people are

[1] The World Bank's Project Information Document (PID), July 2007

being benefited by the project. It has created jobs for approximately 70,000 people and the fossil fuel saving is estimated to be 165,000 ton/year (IDCOL, 2018).

Section 2: Rationale of the Paper

It is widely accepted that electricity changes the way of life and enhances economic activity at the household level. The immediate benefit of electrification comes through improved lighting, which will extend the hours of work in a household, will allow the children to study at night and increase other economic activities. It will improve educational achievements and benefits other household activities like sewing by women, social gathering and many others. Introduction of electricity will also bring communication devices such as televisions and radios which improve access to information and provide entertainment to family members. Small businesses, especially that are operated from the household levels, can be operated longer hours in the evening and can bring production efficiency and growth. Given its substantial benefits, the World Bank supported the REREDP project in Bangladesh, similar to their contributions in many other countries. The rationale of this project paper is to analysis the IDCOL SHS Program and to see whether it has made any impact on its beneficiaries. In the paper the program modality will be described and by using an analytical framework its impact will be ascertained.

As part of the analysis of the SHS program, some statistical methods were used which are discussed in Section 6. The source of the sample data is the IDCOL database. A major issue for analysis is the limitation imposed by the availability of data. IDCOL only collects data that are relevant to SHS system inspection. They do not have sufficient in-depth data related to individual households. If the data regarding such things as individual household income, composition of beneficiary household, and number of appliances used were available, a more conclusive statistical analysis could have been done. Some of the categories of data were only available after 2013 in IDCOL database. Also, there are some typo and transcription errors in the database mostly made by human operators.

Section 3: Literature Review

Historically rural development has meant rapid agricultural growth and societal service for the poor, together with reduction of poverty. The United States Department of Agriculture (USDA) has defined rural development as improvement in overall rural community conditions, including economic, social, environmental, health, infrastructure and housing.

Biswas et al. (2004) have raised the question of whether rural development in Bangladesh can be achieved through photovoltaic technology. The study argued that marginal landless famers can be involved in the solar business as their income level is low for that part of the rural society. During the study period, the authors found that the largest solar plant at that time was operating unsatisfactorily due to an inadequate billing and maintenance system.

Household energy consumption in rural Bangladesh is substantial compared to national energy use and it is influenced by different locational or regional factors, along with family size, income, land ownership, education level etc. (Miah et al., 2010). The authors found that 78% of the households in rural areas use electricity and consume on average 48 KW-h of electricity.

Pode (2013) found that incomes for some businesses have doubled with installation of SHS. The study claimed that the SHS program in Bangladesh is one of the most successful rural electrification programs in the world. This study ranked the motivation of the rural population to improve their lifestyle as the main reason that is influencing the installation of SHS.

Bhattacharyya (2006) argued that SHS is not able to meet the most important energy demand, i.e., cooking for poor. Environmental benefits are also limited. The study concluded that SHS has a limited impact on poverty alleviation. In a different study, it has been revealed that household

income is a key determinant for choosing SHS installation. In addition, there are some non-income factors (Komatsu et al., 2001), which are: rechargeable batteries, high kerosene consumption, and the large number of mobile telephones.

The installation of SHS also created opportunities for additional income, promoted local entrepreneurs, created job for both skilled and unskilled labors, promotes industry and ultimately reduces carbon emissions (Sharif and Mithila, 2013). Wijayatunga and Attalage (2005) in their study in the context of Sri Lanka found that rural households were extremely satisfied with their improved quality of life due to the replacement of kerosene lamps with SHSs.

Mourshed et al. (2011) found that the technical issues of SHS as a standalone system to supply electricity in off-grid rural Bangladesh work well. The authors did not find any underperformance in the system.

Section 4: Solar Home System Business Model

The project is based on credit sales of SHS by the Partner Organizations (POs) who received loans and grants from IDCOL to support their own credit facility provided to the customers. The POs can be any registered entity (private business, NGO, Micro Finance Institution or other type of community organization). The POs obtain the SHS equipment from the suppliers, in compliance with the technical standards set by an independent Technical Standards Committee (TSC) of IDCOL, which also reviews product credentials and approves/certifies eligible equipment. The four steps of are described as follows and shown in **Exhibit I**[2]:

1. Households are required to make a down payment equivalent to at least 10% of the system cost, net of subsidy. The remaining 90% is financed by a loan at market rates, which customers obtain through POs;
2. On the receipt of a down payment, the POs enter into a sale/lease agreement with a supplier. IDCOL must approve the provisions of the agreement and the systems must meet the quality specifications approved IDCOL's TSC. The POs receive three months credit from the supplier and install the systems;
3. After installation, the PO applies to IDCOL to refinance the loan and grant. IDCOL inspectors inspect the households to verify that the system has been installed properly. IDCOL provides a grant to the PO equal to the entire amount of the subsidy. IDCOL also refinances 70%-80% of the loan amount. Upon receiving the finds from IDCOL, the PO pays back the credit received from the supplier;

[2] OBA Approaches: Output based aid in Bangladesh: Solar Home System for Rural Households, April 2012, World Bank

4. IDCOL then claims the fund used for financing from the donors, loan from the World Bank, ADB, IsDB or JICA, and the grant from GPOBA, KfW or GTZ.

Financing Structure:

During a market study carried out during the preparatory stage of the project, it was found that the main barrier to SHS sales was the high initial cost and the inability of the majority of the rural households to meet the expenses in the short term (Ratnayeke, 2005). For this reason, a longer-term efficient pay-for-service arrangement was developed with low monthly payments. A sample SHS scheme is shown in the following table using 50Wp SHS for illustration:

SHS Cost	**$380**	**Financing Term of loans from PO to Household**	
System buy-down Grant A	$38.40	Loan	$290.36
Remaining cost	$341.60	Loan tenor	3 years
Household down payment (15%)	$51.24	Interest amount (12% p.a. flat rate)	$104.53
Credit to customer	**$290.36**	Total Household Payment	$394.89
IDCOL Refinance (80%)	$232.29	**Monthly Household Installment**	**$10.97**
PO contribution (20%)	$58.07		
Institutional Development Grant B	$10.24		

Source: IDCOL presentation at United Nations Practitioners Network, October 2013

Table: Financing Structure of a 50 Wp SHS (amount in US Dollars)

Targeting:

The SHS scheme targets poor people living in remote areas of Bangladesh where grid electricity is not expected to reach in the next five years. The POs offer a range of products sizes from 10 Watts to 135 Watts, so the customers can choose as per their demand and financial capacity. A sample of the most popular SHS packages with cost is shown in **Exhibit II**. The subsidy is small compared to the subsidies for grid extensions and the SHS programs in other countries (World

Bank, 2012). In order to encourage commercial oriented SHS market, the subsidies were gradually reduced.

Verification:

IDCOL must verify the claims of the POs and make payments within 21 days of the claim. IDCOL has 300+ technical inspectors. They check upon receiving instruction from the head office whether the household is in an off-grid area, verify that POs have used the equipment that meet the IDCOL TSC requirements, and that the system is fully operational. If any discrepancy is found, PO must fix the problems to get the subsidy and the refinancing. The POs along with IDCOL maintains a call center to receive customer complaints.

Promotion and Program Arrangements:

The SHS program has been administered by IDCOL. Its involvement is both in the areas of facilitating and development of the program. Rather than establishing operating guidelines and then taking a passive role by relying on the POs, IDCOL took an active role in developing the program, marketing and raising consumer awareness initiatives and building necessary skills for the POs for carrying out the program activities in a commercial scale. Some of the activities of IDCOL were as follows:

a) Assisting the POs by way of training their personnel in SHS activities (installation and maintenance) as well as capacity strengthening and organizational development, and
b) Launching a consumer awareness program to popularize the use of solar appliances in the rural areas. A number of radio and television advertisements, publicity billboards, celebration ceremonies of milestone SHS installations and demonstration of SHS installations in selected rural areas were arranged to enable rural people to gain a first-hand

knowledge of the potentials of SHS. Examples of promotional activities are included in **Exhibit III**.

While a part of the cost for training and promotional activities were borne by POs, the majority was funded by IDCOL through the assistance of donors. The World Bank had an allocation in its project component for customer and staff training as well as for promotional campaigns.

In addition to activities described above, IDCOL also provided support for a technical group which handled the certification of equipment that was used in the program. The group assisted when any equipment malfunction arose. The suppliers provided guarantees of 20 years for the solar panel, 5 years for the battery, 3 years for the controller and 1 year for the light appliances under the program. In addition, the battery suppliers arranged for the buyback of unserviceable batteries at a pre-arranged price and for their environmentally safe disposal.

Section 5: Multidimensional Benefits of SHS Program[3]

Political:

The Government of Bangladesh has the goal of ensuring access to electricity for all by 2021. Before and during the implementation of the program, the government has reiterated its commitment to the aforementioned goals and supported IDCOL via environment friendly policies, tax benefits, institutional support, financial support, etc. Along those lines, the government opened a new department, the Sustainable and Renewable Energy Development Authority (SREDA) under the Ministry of Power, Energy and Mineral Resources, in 2010. Since then, IDCOL and SREDA have been working side by side in developing policies, implementing projects and supporting sponsors in their investments in renewable energy initiatives.

Prior to the start of SHS program, IDCOL was and still is assisting the government in generating grid electricity via the financing of various gas fired and duel-fuel power plants. In addition to those projects, the government also prepared the markets for the SHS project by eliminating import duties on appliances in April 2000 (World Bank, 2007).

In addition to the goal of ensuring electricity for all by 2021, as part of the UN Sustainable Development Goals (SDGs), the Bangladesh government has also established the long-term vision of producing 10% in renewable energy by 2025. The IDCOL SHS program is playing a huge role in achieving that vision. Through IDCOL, the government is funding other projects, apart from

[3] This section of the report is written based on the following case studies and reports:

1. An evaluation report on IDCOL SHS Program submitted to the World Bank on May 2013. The report was prepared by Bangladesh Institute of Development Studies (BIDS).
2. Social Impacts of Solar Home System in Rural Areas: A Case study in Bangladesh, August 2017 by Kabir E., Kim KH., Szulejko JE.

SHS, to generate electricity and renewable energy on a much broader scale. In the words of Mr. Mahmood Malik, Executive Director and Chief Executive Officer of IDCOL (Reuters, 2015):

"IDCOL is also involved in the financing of renewable energy applications such as biomass installations, commercial and domestic biogas-based power plants, solar irrigation pumps, solar mini grids, wind energy, and small hydropower projects, which are developed by the private sector, NGOs, and various communities. We are very much in the process of creating a green Bangladesh."

Although the government removed the import duties on solar panels, local Bangladeshi solar panel manufacturers have flourished because of the IDCOL SHS program and also received additional support from the government. IDCOL has also financed two local solar panel assembling projects from its own funds. Improvements in the local market led to a dispute about the quality of cheaper imports that do not adhere to the program's strict technical standards. In response, government has introduced a 10% import duty on solar panels from the fiscal budget 2017-18 (Dhaka Tribune, 2017). The duty aims to protect local manufacturers as well as the consumers from sub-standard products.

Economic:

In the impact study by Bangladesh Institute of Development Studies (BIDS), SHS were considered economically beneficial by 71% of the households. After SHS installation, the maintenance cost is projected to be minimal for 25 years. SHS households who are now using solar LED lights, used kerosene lamps before. They had to buy kerosene every month and whenever the price of kerosene increased, they reduced consumption of kerosene to avoid the increase in monthly kerosene expenditures. In the process, they also gave up on economic activities that they would have done

under normal circumstances. Introduction of SHS now saves users time, money and energy for purchasing and transporting kerosene from markets. Moreover, due to efficient lighting, households now can pursue commercial activities like sewing and handicrafts. They can now earn extra money by sewing during evening hours using bright solar lights which were not possible before. Owners of tea stalls and local shops reported longer evening business hours and increased profit since the installation of an SHS. These profits were then invested for business expansion. Grocery shop owners who were using kerosene lamps before can now do business for extended hours as a result of the introduction of SHS systems.

The poverty rate based on the upper poverty line in Bangladesh has gone down significantly from 2000 to 2016[4]. In the rural areas it has gone down from 52.3% to 26.4% and in urban areas it has moved from 35.2% to 18.9%. This reduction is also reflected in the SHS mode of sales. While reviewing the financing mode of Dhaka division we can observe that the cash sale is highest in the districts of Dhaka and Narayanganj. These are the two metropolitan areas in the Dhaka division having more wealthy people than other districts. District-wide details on SHS financing modes for the Dhaka division are shown **Exhibit IV.**

Social:

SHS adoption has both direct and indirect social impacts on users. Access to SHS electricity enhances the general quality life of users. Activities of daily living like studying, working under lights, watching TV programs, and charging electronic appliances are frequently undertaken by people who have SHS in their households. In households, 10 to 75 Wp panels are the most widely

[4] State of the Bangladesh Economy FY 2017-18, Center for Policy Dialogue, Bangladesh, January 2018

used one. Panels of 80 to 135 Wp are the commercial panels which are commonly used for markets and small commercial households.

Lighting is the most common SHS application and most SHS packages include LED lights. LED lighting provides a step forward in quality and convenience. Solar lighting allows rural families to extend their workday into the evening hours. Due to extended study and household work hours, convenience, security and cleanliness, lighting is considered to be the most important benefit of the SHS program. Prior to use of SHS, households experienced air pollution, fires, and explosions due to use of kerosene lamps. Solar lights are free of toxic emissions and the use of solar lights frees households from refueling and maintaining kerosene lamps. Women in households are no longer dependent on sunlight only. Lighting also benefits other household activities such as sewing, social gatherings at night, studying, and so on. In the BIDS evaluation study, it was found that the households that are headed by women use solar systems more than the households headed by men. Also, women's roles in decision-making have increased due to their increased economic activities.

SHSs also have significant health benefits in rural areas. Because SHSs have a minimal carbon footprint, they have more positive environmental impacts than fossil fuels. The SHSs replace kerosene, which releases carbon monoxide, nitric oxides, and sulphur dioxide, which are all harmful indoor air pollutants. These pollutants can cause impaired lung function and lead to infectious diseases. Because of SHS usage, burn injuries, fires and explosions have also been reduced in the rural areas.

Environmental:

One of the most import impacts of the SHS program is its contribution to low carbon emissions. The United Nations Framework Convention on Climate Change (UNFCC) in its COP 21 meeting

held on 12 December 2015 in Paris reached a landmark agreement to combat climate change and intensify actions and investments needed for a sustainable low carbon future (Paris Agreement, 2015). Bangladesh, then an LDC, is exempted by the rules of convention from any mitigation. However, Bangladesh has committed to keep its carbon emissions as low as possible because it is already experiencing some adverse effects of climate change. In the survey conducted by BIDS, it was observed that SHS households consume 3.67 liters less kerosene per month than the users of non-SHS households. Therefore, it was calculated that roughly 240 thousand MT of carbon dioxide is reduced due the implementation of the project. As followed by the SHS program, IDCOL is undertaking other renewable energy initiatives to promote and reduce carbon emission.

Technological:

Although lighting is the most popular application of the SHS system, access to information, and various entertainment and communication facilities also provide strong incentives for SHS usage. SHS has increased the opportunity for access to information by watching TV or listening to radio broadcast in places where people did not have the capacity to run those things. Due to a high level of illiteracy in rural Bangladesh, radio and television is the most convenient source of information. SHS also provided better communication opportunities via mobile phones and internet. The internet has now made it possible to obtain and share information on education and health issues from local and government sources as well NGOs. Government is already experimenting with new forms of agricultural applications and the increased access to information brought by SHS can be very influential at spreading information about new ideas and techniques in agriculture, as well as health, nutrition, family planning and other cultural issues. The usage of mobile money is on the rise in Bangladesh and the SHS appliances have enabled the charging of mobile phones and brought the internet to rural areas.

Access to such facilities is bringing changes in the lifestyles of rural people too. Rather than socializing with each other, some people are now spending more time in watching TV to be up to date on current national and global affairs. Rural people now gather in tea stalls after hard days of work and watch their favorite TV shows together.

Section 6: Business Model Innovation

A business model is a holistic description of the contexts in which a company operates and how it generates value for its customers and itself. Companies may change part of their business models so that they can create a competitive advantage over their competitors. A business model innovation is thus the creation of a new business model that better satisfies the needs of customers compared to the existing business model.

The SHS business model was one of the first where a financial institution went beyond its main purpose of profitability and focused more on user aspects and the behavior of "green utilization." When the project first started in 2003, the world was slowly beginning to understand the aspects of climate change and its impacts on our daily lives. The first project of IDCOL, a 450 MW Independent Power Plant by MPL, was made in the traditional project financing mode. However, the idea of renewable energy was still quite new to peoples' minds and was regarded as a very high-risk business sector in Bangladesh. In order to successfully promote the idea of renewable energy and to successfully implement the project on a large scale, a mechanism was required that could reduce the installation cost on the one hand and provide a platform to the investors to build a commercial business on the other.

Value Creation:

The refinancing scheme in the SHS program allowed the POs to focus more on the installation and provide low-priced electricity to off-grid rural households. It helped build an ecosystem that put the idea of renewable energy into people's mind, a concept that was initially foreign to many of them. The institutional grant components of the financing scheme improved the core resources and capabilities of the POs. In the beginning they were mostly small NGOs which just offered micro-

credit facilities to a certain region. Having become involved with such a large project enabled them to increase both their financial and human capital. The scheme enabled the POs to build a new partner network, with suppliers from whom they had bought the solar appliances and with other organizations that operate in the same field but in different regions. It allowed them to learn from others' practices and coordinate their efforts in an effective manner. In addition to providing financing to the POs, IDCOL also extended financing to local companies for setting up solar panel assembling plants in Bangladesh. The purpose of this financing was to develop a market locally which at one hand reduced the panel cost for the POs, which is the main component of the system, and on the other hand, to develop a local market by enabling local firms in doing panel assembling. Furthermore, the grant and the subsidies allowed the POs to determine the most cost-effective option among different alternatives of equipment to purchase and operate, on the condition that this equipment meets IDCOL's technical standards requirements. Lastly, the environmental impact and the reduction of carbon emission as a result of implementing this project is very significant. All of these issues combined created value for the households, POs and IDCOL.

Value Capture:

The SHS business model helped to satisfy basic energy needs, i.e., lighting, especially in the off-grid rural areas. It induced increased economic activities in those areas where before people had no means of lighting at night. It created economic channels for the rural people which were inaccessible to them before the project. Also, the cheaper SHS system and reduced down-payment options combined with more flexible microloans induced poor households to adopt more efficient consumption behavior. The amount that they were saving by using the solar appliances (in contrast to kerosene lamps) now can be spent in other income-generating activity. Due to the SHS project, the households can now use other electronic devices (like TV, fan, refrigerator) which were

inaccessible to them before. It also generated a green image and brand in the area. Households that adopted the SHS system feel proud that they now have a mean of electricity generation in their houses which adds to their social status in the area. Finally, the large-capacity SHS systems in the market area created job opportunities and business revenues for a lot of people and increased economic activity in the whole area. All these activities together captured value from the SHS business model from the standpoint of the households involved. Following is the framework for SHS value creation and value capture:[5]

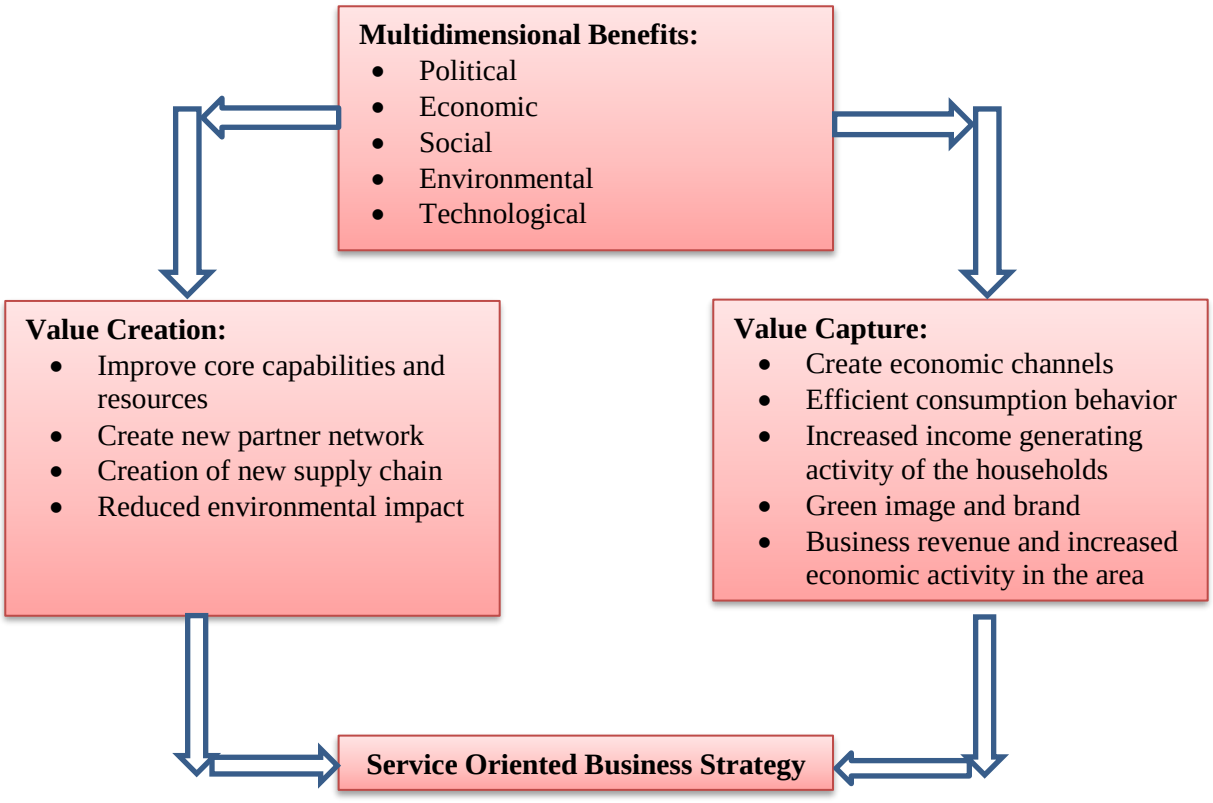


Figure: Framework for Value Creation and Value Capture in the context of IDCOL SHS Program

[5] Adapted from The Framework of Green Business Model for Eco-Innovation by Jing H, Jiang B.S., *Supply Chain Oper. Manag.* 2013.

Section 7: Statistical Analysis of SHS Program

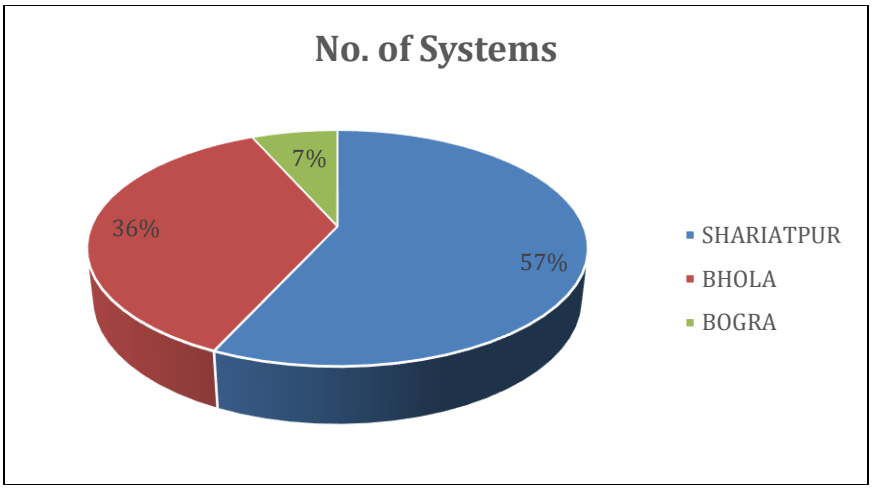
Description of Sample Data:

For the statistical analysis of the SHS program, three administrative districts were chosen for the sample – Shariatpur, Bogra and Bhola. These three districts were chosen based on their geographical locations. Bogra is one of the northern districts located in Rajshahi division. Shariatpur is almost in the middle located in Dhaka division. Bhola is the largest island of Bangladesh located in the south, a part of Barishal division. A map of administrative districts of Bangladesh highlighting the sample districts is attached in **Exhibit V.**

From the sample of three districts, the following variables were used for the statistical analysis of the SHS program: number of SHS systems in each district, capacity of solar PV modules in each households and their corresponding price, type of sales (loan or cash sale) of each SHS systems and number of beneficiaries in each households. The following tables and figures illustrate the summary of the information.

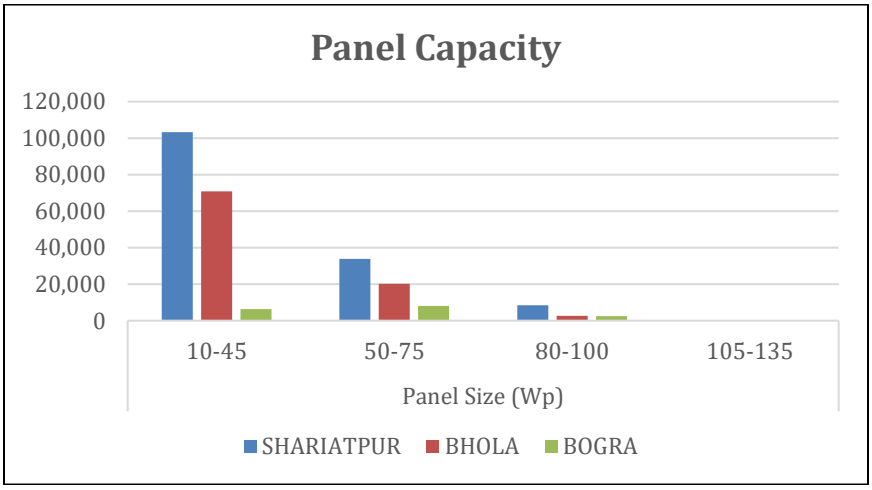
Number of Systems:

Districts	No. of Systems
Shariatpur	145,836
Bhola	93,706
Bogra	17,021
Total	**256,563**



Panel Size:

Districts	Number of Systems by Panel Size (Wp)			
	10-45	**50-75**	**80-100**	**105-135**
Shariatpur	103,247	33,912	8,506	171
Bhola	70,863	20,164	2,636	43
Bogra	6,385	8,082	2,537	17
Total	**180,495**	**62,158**	**13,679**	**231**

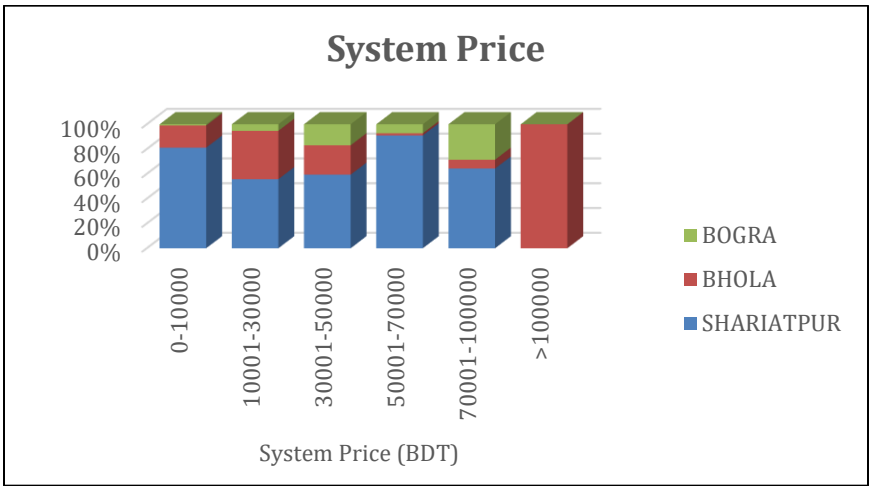


System Price:

Districts	Number of Systems by System Price (BDT)					
	0-10000	**10001-30000**	**30001-50000**	**50001-70000**	**70001-100000**	**>100000**
Shariatpur	5,341	121,262	19,123	101	9	0
Bhola	1,178	84,889	7,635	2	1	1

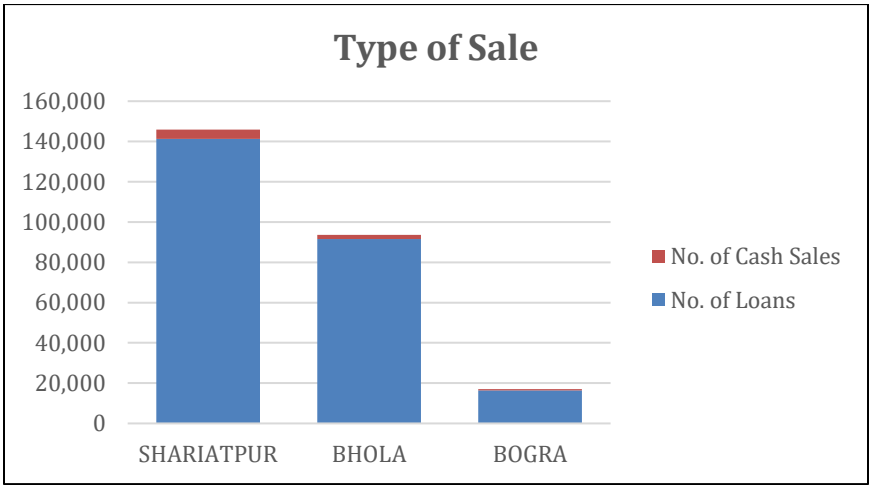
Districts	Number of Systems by System Price (BDT)					
	0-10000	10001-30000	30001-50000	50001-70000	70001-100000	>100000
Bogra	63	11,489	5,457	8	4	0
Total	**6,582**	**217,640**	**32,215**	**111**	**14**	**1**

USD 1 = BDT 84



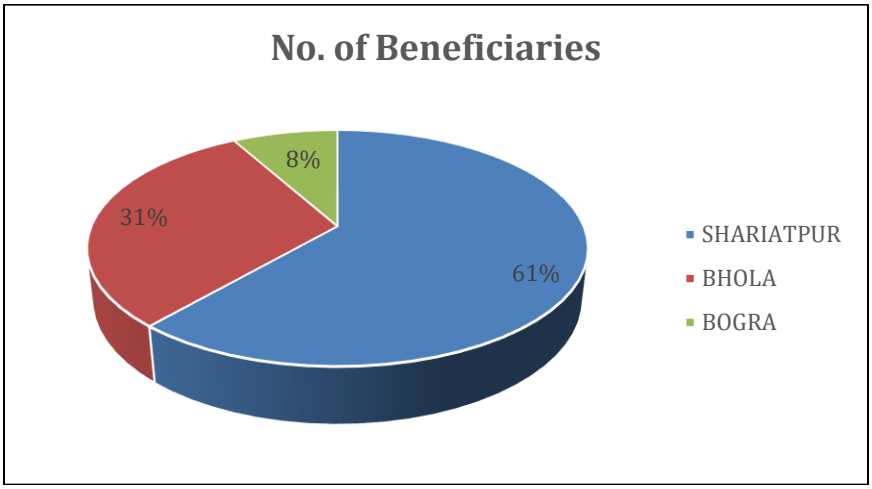
Type of Sale:

Districts	No. of Loans	No. of Cash Sales
Shariatpur	141,351	4,485
Bhola	91,486	2,220
Bogra	16,476	545
Total	**249,313**	**7,250**



Number of Beneficiaries:

Districts	No. of Beneficiaries
Shariatpur	568,554
Bhola	282,386
Bogra	75,105
Total	**926,045**



Correlation between Variables:

Core Hypothesis:

The purpose of the analysis is to develop an appropriate multiple linear regression model to relate the two type of sales, loan and cash, to the system price, down-payment amount, panel size and number of beneficiaries. It is expected to examine if the independent variables (system price, down-payment, panel size, nember of beneficiaries) are successful in explaining the outcome variable, which is the sales. Before building up the model we need to check whether a correlation exists between the independent variables where one is closely related to the other in some way. If multicollinearity exists between independent variables in a regression model, it can cause problems because independent variables are no longer independent. The core hypothesis is that there is no

relationship between system price, down-payment, panel size, number of beneficiaries and type of sales.

Supporting Hypotheses-I:

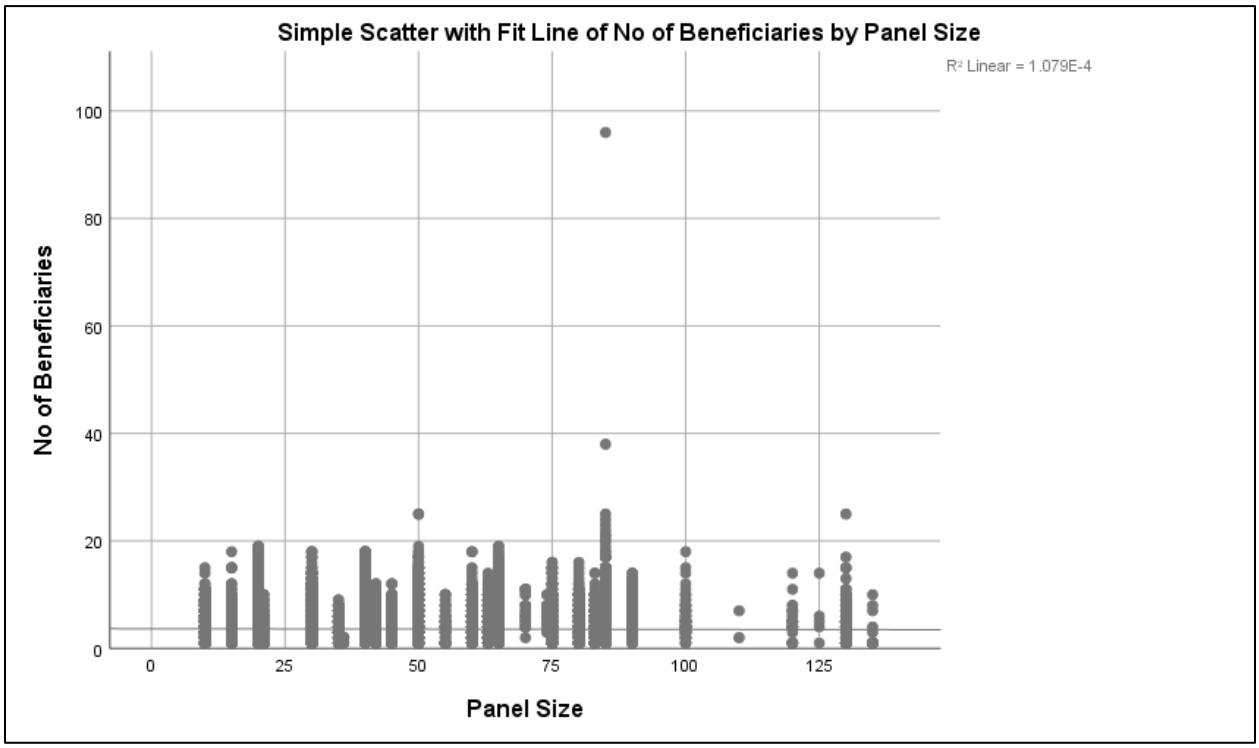
H_0: No linear relationship between panel size and number of beneficiaries
H_a: There is linear relationship between panel size and number of beneficiaries

Correlation between panel size and number of beneficiaries is as follows:

Correlations

		Panel Size	No of Beneficiaries
Panel Size	Pearson Correlation	1	-.010**
	Sig. (2-tailed)		.000
	N	256563	256563
No of Beneficiaries	Pearson Correlation	-.010**	1
	Sig. (2-tailed)	.000	
	N	256563	256563

**. Correlation is significant at the 0.01 level (2-tailed).



Interpretation:

Here, the level of significance, the α value, is assumed to be 0.05. (α=0.05).

The above table shows that the Pearson Correlation value between panel size and number of beneficiaries is -0.010, which means there is not a strong relation between these two variables. Therefore, at this significance level, we cannot reject null hypotheses and conclude that there is weak relationship between the two variables.

Although there is a weak relationship between the two variables, the negative value in the Pearson Coefficient explains that if the number of beneficiaries in the households increases, size of the PV modules decreases. It indicates that as the number beneficiaries increases in the households, they have to spend a huge portion of income on meeting their basic needs and then they can afford only a little for accessing electricity.

Supporting Hypotheses-II:

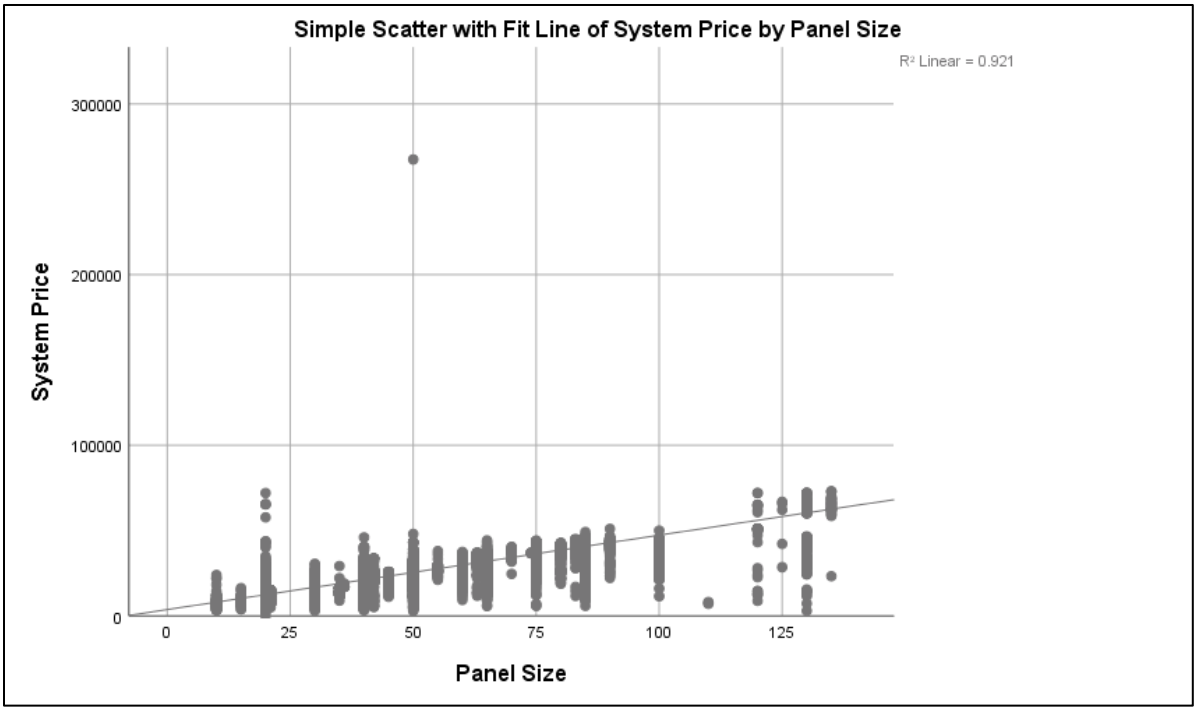
H_0: No linear relationship between panel size and system price
H_a: There is linear relationship between panel size and system price

The correlation between panel size and system price is as follows:

Correlations

		Panel Size	System Price
Panel Size	Pearson Correlation	1	.960**
	Sig. (2-tailed)		.000
	N	256563	256563
System Price	Pearson Correlation	.960**	1
	Sig. (2-tailed)	.000	
	N	256563	256563

**. Correlation is significant at the 0.01 level (2-tailed).



Interpretation:

Here, the level of significance, the α value is assumed to be 0.05. (α=0.05)

The above table shows that the Pearson Correlation value between panel size and system price is 0.960, which means there is a strong positive relation between these two variables. Therefore, at this significance level, we reject null hypotheses and conclude that there is strong linear relationship between the two variables.

The Pearson Correlation value explains that as the size of the PV modules increase, their corresponding prices also increase. It holds true since higher capacity of PV modules can support more appliances and can give backup longer hours at night. However, existence of a strong correlation does not imply a causal link between the variables. There can be also some hidden or intervening variables like installation cost, purchasing power of the households or demand of the

higher capacity solar PV modules. Any one of these variables can drive down the price of the SHS systems.

Supporting Hypotheses-III:

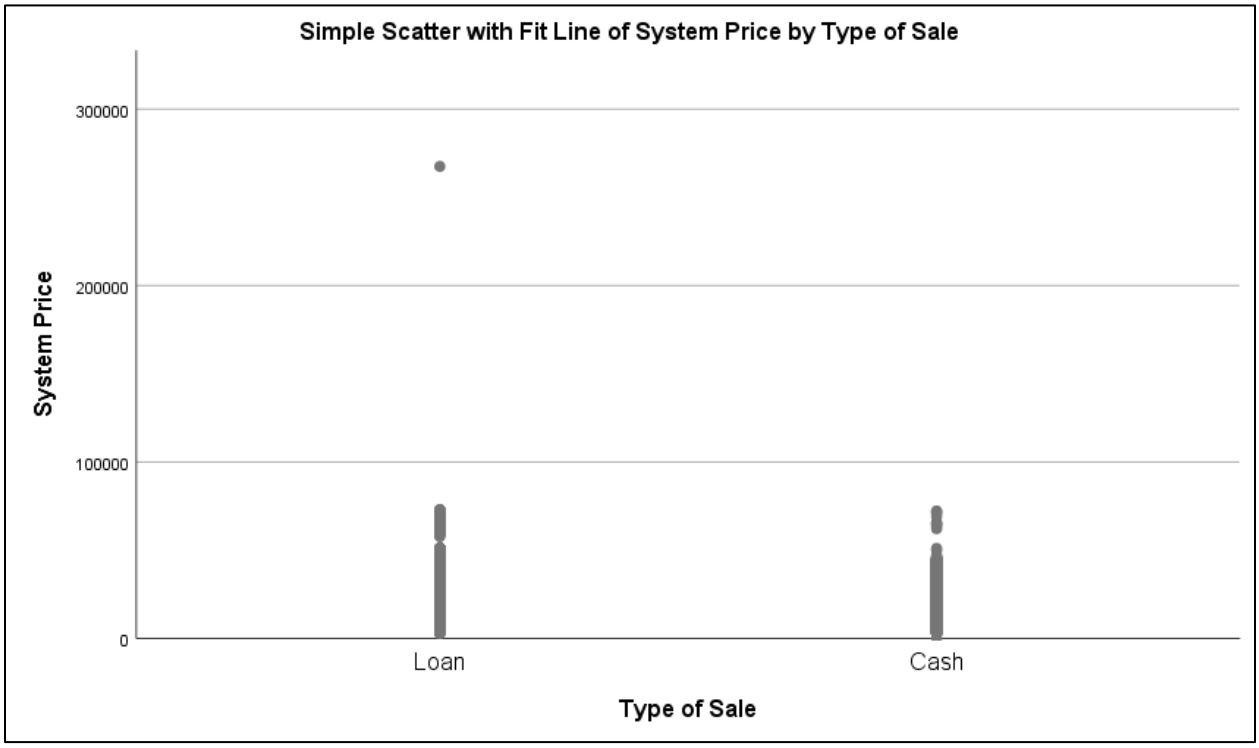
H_0: No linear relationship between type of sale and system price
H_a: There is linear relationship between type of sale and system price

Correlation between type of sale and system price is as follows:

Correlations

		Type of Sale	System Price
Type of Sale	Pearson Correlation	1	-.054**
	Sig. (2-tailed)		.000
	N	256563	256563
System Price	Pearson Correlation	-.054**	1
	Sig. (2-tailed)	.000	
	N	256563	256563

**. Correlation is significant at the 0.01 level (2-tailed).



Interpretation:

Here, the level of significance, the α value is assumed to be 0.05. (α=0.05)

The above table shows that the Pearson Correlation value between type of sale and system price is -0.054, which means there is a weak relation between these two variables. Therefore, at this significance level, we cannot reject null hypotheses and conclude that there is a weak linear relationship between the two variables.

IDCOL provides grant facilities to drive down the cost on the customers side and also does campaigns to promote the solar energy. Also, customers get on average three years' time to payback the installment amount as opposed to six months, the time that they get to pay back the microfinance loans. Therefore, they would be more interested to get a solar system installed in their house regardless of price. The negative value in the Pearson Coefficient explains that if the system price increases, the households would be more prone to pay back in installments rather than paying it in upfront.

Supporting Hypotheses-IV:

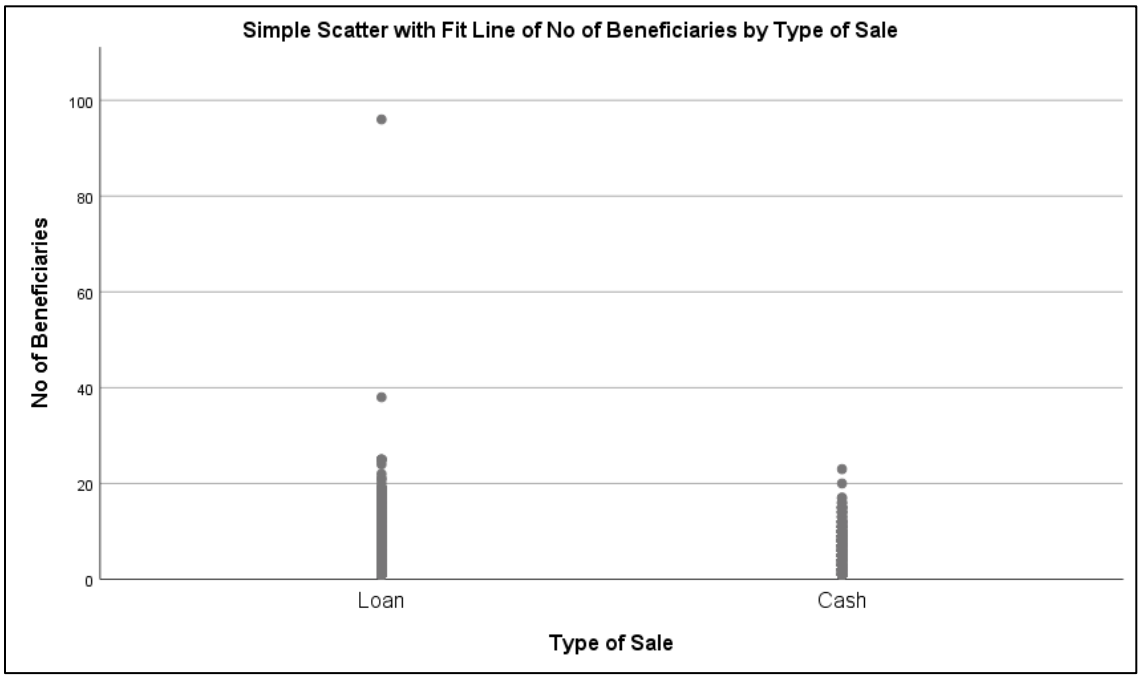
H_0: No linear relationship between type of sale and number of beneficiaries
H_a: There is linear relationship between type of sale and number of beneficiaries

Correlation between type of sale and number of beneficiaries is as follows:

Correlations

		Type of Sale	No of Beneficiaries
Type of Sale	Pearson Correlation	1	.040**
	Sig. (2-tailed)		.000
	N	256563	256563
No of Beneficiaries	Pearson Correlation	.040**	1
	Sig. (2-tailed)	.000	
	N	256563	256563

**. Correlation is significant at the 0.01 level (2-tailed).



Interpretation:

Here, the level of significance, the α value is assumed to be 0.05. (α=0.05)

The above table shows that the Pearson Correlation value between type of sale and number of beneficiaries is 0.040, which means there is a weak relation between these two variables. Therefore, at this significance level, we cannot reject null hypotheses and conclude that there is a weak linear relationship between the two variables.

Electricity is an important element both economically and socially as explained in previous sections. Therefore, regardless of the number of household members and based on the incentives that IDCOL provides, people shall get the SHS system. In addition, the places where IDCOL install the SHS systems are mostly off-grid areas. Since this is the only means of electricity, people are more willing to install the SHS systems regardless of number of households and type of sale since it is the only means of getting electricity.

Regression Analysis:

The "type of sale" was used as the dependent variable in a linear regression analysis on panel size, system price, down payment and number of beneficiaries were used as independent variables. Based on the reasoning previously explained, every single independent variable is statistically significant except for the number of beneficiaries and are related to some degree of change in the dependent variable. The magnitude of that change is derived from regressions run in SPSS.

For the regression analysis, a Multiple Linear Regression model was used:

Type of Sale $= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon_I$

X_1 = Panel size
X_2 = System price
X_3 = Down payment
X_4 = Number of beneficiaries
β_0 = Constant
$\beta_1, \beta_2, \beta_3, \beta_4$ are the Coefficient of X_1, X_2, X_3 and X_4
ε_I = Error term.

Now as we run the regression,

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.782[a]	.612	.612	.103	.612	101271.158	4	256558	.000

a. Predictors: (Constant), No of Beneficiaries, Panel Size, Downpayment, System Price

From the result it can be seen that both the Adjusted R Square and R Square is 61.2%. That is 61.2% variation in Type of Sale can be explained by variation in panel size, system price, down payment and number of beneficiaries.

Testing the validity of the Multiple Regression Model:

Global Test:

H_0: There is no association between the variables
H_a: There is association. (Only then the model will be proved right)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4313.315	4	1078.329	101271.158	.000[b]
	Residual	2731.813	256558	.011		
	Total	7045.128	256562			

a. Dependent Variable: Type of Sale

b. Predictors: (Constant), No of Beneficiaries, Panel Size, Downpayment, System Price

Form the outcomes of the ANOVA table, the significance level is 0.000, which means we can reject the null hypothesis and it passes the global test. So there is correlation between the response variable Y and the predictor variables X. The model also provides both the magnitude and the statistical significance of relationships between variables.

Local Test:

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.087	.001		1661.982	.000
	Panel Size	.004	.000	.427	95.116	.000
	System Price	-1.748E-5	.000	-.911	-208.011	.000
	Downpayment	4.528E-5	.000	.869	589.957	.000
	No of Beneficiaries	7.115E-5	.000	.001	.751	.453

a. Dependent Variable: Type of Sale

From the outcomes, the significance value of number of beneficiaries is (0.453) > α = 0.05. Therefore, this predictor variable, the "number of beneficiaries" do not contribute significant

information for the regression model of "Type of Sale", Y. So, we have to again run the regression but this time excluding this variable.

Re-running the regression:

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	1.087	.001		2005.306	.000
	Panel Size	.004	.000	.427	95.273	.000
	System Price	-1.748E-5	.000	-.911	-208.459	.000
	Downpayment	4.528E-5	.000	.869	590.221	.000

a. Dependent Variable: Type of Sale

After redoing the regression significance level of all the variables are less than 0.05.

A valid model for the Type of Sale of the SHS Program is given above and summarized below:

Type of Sale = 1.087 + 0.004 Panel Size – 0.00001748 System Price + 0.00004528 Down Payment

Now, the above regression equation states that positive change in "Panel Size", negative change in "System Price" and positive change in "Down Payment" will positively influence Type of Sale. That means if there is decrease in panel size, increase in system price and decrease in down payment, customers will choose loan as type of sale. On the other hand, if there is increase in panel size, decrease in system price and increase in down payment, customers will choose cash as type of sale.

From the above-mentioned analysis, it appears that the multiple regression model for explaining the "Type of Sale", Y is useful and adequate. Since IDCOL is implementing other renewable projects in similar models, from the historical data of SHS program it can be deducted that the panel size of solar systems, the system price and the down-payment amount affects significantly

the purchase behavior of the individual households. If these variables are properly handled, it can significantly impact the outcomes of the project as well as the overall success of the overall program itself.

Section 8: Lessons Learned from the IDCOL SHS Program[6]

1. **Presence of a Committed Implementing Agency:** The role of IDCOL as the implementing agency played a significant role in bridging the financing gap for developing the platform and institutional capacity of the partner organizations while implementing renewable energy projects in Bangladesh. Initially the other banks and financial institutions were unwilling to finance 'non-productive' loans. As governed by a qualified and independent Board of Directors comprising both public and private sector, IDCOL was from the beginning an enthusiastic promoter of off-grid solutions. One of the important key aspects of implementing such a program was to have the implementing agency passionate and committed to make the program successful.

2. **A Vibrant Existing Microfinance Environment:** A pre-existing network of competitive microfinance institutions and their well-established relationship with the clients in the rural areas helped the program to expand ten-fold. The historical presence of these organizations allowed for cost-effective and efficient outreach, whereas familiarity of the rural consumers led the program to grow trustworthiness among the beneficiaries and increased customer readiness. Also, it was found that when the POs would visit the households the collect payment, they would also perform maintenance of the systems. This increased the satisfaction among the customers.

[6] This section is based on the following two reports:
1. Output-Based Aid in Bangladesh: Solar Home System for Rural Households, Geeta Kumar and Zubair Sadeque, April 2012
2. Bangladesh Rural Electrification and Renewable Energy Development-SHS Project, GPOBA Case Study, June 2015

3. **Technical and Commercial Sustainability Support:** Successful off-grid electrification projects require significant technical assistance, both for the transaction and supervision. Technical assistance resources included in the project by IDCOL through various sources provided by the donors aided the POs to establish a market for SHS and managed growing of the program. IDCOL's Technical Standard Committee approves the standards for solar appliances and IDCOL inspectors ensured constant enforcement of the technical and performance standards. IDCOL also had a call center that provided recourse if customers experienced problems, and also quickly ensured that any problems were quickly addressed. In addition, IDCOL had the aim to make the SHS program fully commercial, with POs borrowing funds at the market rate. Both the refinancing rate and the capital subsidy were gradually reduced as the market reacts to program's success.

4. **Fostering a Sense of Ownership:** The program helped to adopt a sense of ownership with the consumers. This ensured proper maintenance and upkeep of the SHS systems. Before the SHS program, other approaches were tried like renting or leasing of SHS but they failed. IDCOL also provided grants to the POs for free customer training so they could carry out routine maintenance and repairs.

5. **Long-term Access to Finance for POs and Households:** The refinancing facility allowed the POs to refinance most of their loans to households while repaying IDCOL at a 6 percent interest rate with a ten-year payment period, including a grace period of two years (terms became tougher as the exposure increased). This refinancing mechanism allowed the POs with long-term access to finance and liquidity. This financing mechanism also allowed the POs to extend credit facility to the customers with repayment terms up to three years in contrast to

microfinance loans for which the usual tenure is six to twelve months. This reduced the consumers' monthly payment of installments and increased affordability.

6. **Shift of Performance Risk:** The program is designed in a way that shifts most of the project risks to the suppliers and the POs. It increases the sustainability of the project and mitigates some of the governance and corruption risks. If a SHS system does not function properly, a customer can stop paying the installments until the problem is resolved. The IDCOL Technical Standard Committee requires the POs to use products from a supplier that provides warranty. Only then they would provide certifications. The suppliers are required to provide a warranty to the POs, which is then extended in similar fashion to the customers (20 years for the solar PV module, five years for the battery, three years for the charge controller and lamp circuit). During the warranty period, POs and suppliers are responsible for replacing the defective equipment.

7. **Making SHS Affordable:** The SHS program structure made the SHSs affordable through a combination of credit, subsidies and various product choices customized for beneficiaries. However, even with affordable financing, actions to foster new technologies were needed. As discussed in the previous sections, the project shows that the households will pay for a SHS system if the monthly costs match with their overall expenditures. However, they need to have confidence if they want to buy the system. That is where the technical quality ensured by IDCOL and the after-sales service provided by the POs comes in. Increased customer awareness efforts by IDCOL also helped foster a sense of ownership among the beneficiaries.

Section 9: Conclusion

The IDCOL SHS program is a collaborative effort of IDCOL, its partner organizations and different ministries within the government where the strengths of each participant have been harnessed to the fullest extent. It has been observed through this program that electricity is highly desired by the rural communities, it provides development benefits and its expansion is a political priority. The subsidy component within the program has helped to improve the infrastructure and reduce the cost component for the beneficiaries. Subsidies were used to build up the initial market volume, PO expertise, customer awareness and quality standards. In effect, the subsidies used in the program helped to create conditions where they are no longer needed.

IDCOL and the POs are facing some challenges while recovering the loans from the field. Total loans disbursed to the POs as on December 2018 were $540.98 million and the outstanding loans amount to $212.57 million (IDCOL, 2018). In order to improve the collection efficiency of the POs, a collaborative effort of IDCOL, POs and the local government of Bangladesh was launched in 2016 called the Collection Efficiency Improvement Program (CEIP). The purpose of the CEIP is to encourage the customers to pay their dues and helping them through the recovery. In FY 2016-17, after much deliberation and negotiation, the SHS program was merged with the government's Test Relief and Food for Work (TR/KABITA) program under the Ministry of Disaster and Relief Management. The POs now install SHS systems under that program and receive payment directly from the government. IDCOL ensures technical supervision, 100% monitoring and overall administration. After receipt of payment from the government, the POs are now repaying their dues gradually.

IDCOL is now focusing on creating a more sustainable commercial renewable energy market through the lessons learned from the SHS program. The renewable energy programs of IDCOL include solar mini-grids, solar irrigation pumps, solar rooftop projects, an integrated cook stove program, as well as biogas and bio-fertilizer programs. IDCOL is also investing a lot of their resources in inspiring the usage of energy efficient equipment at the industrial level.

There is room for further research on the beneficiaries regarding influence of the program on income generation, child education, health conditions, leisure time, and other outcomes in order to further validate the impact of SHS on rural Bangladesh. Research can also focus on the service providers and POs of IDCOL regarding their perceptions and experiences in explaining the contribution of SHS to rural development in the country. Both the studies can then be compared to confirm the gaps in understanding, perception and reality and the needs for further action from the policy level for future programs.

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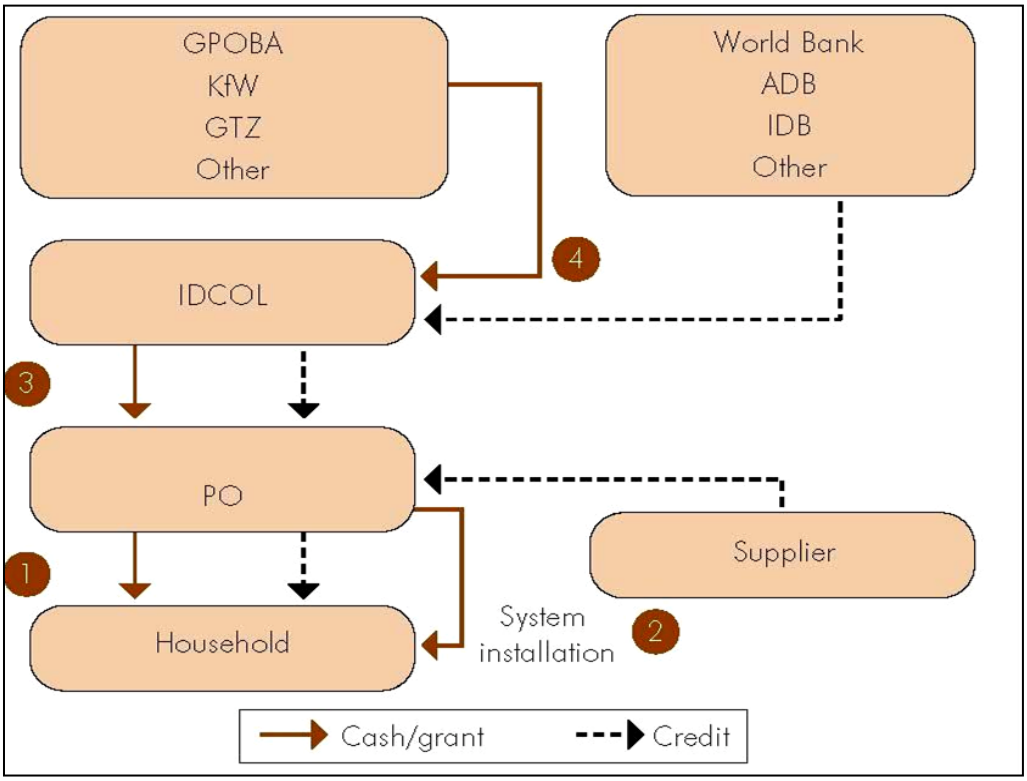
Exhibit I



The Output based SHS Scheme

Source: OBA Approaches: Output based aid in Bangladesh: Solar Home System for Rural Households, April 2012, World Bank

Exhibit II

Popular SHS Packages

Capacity	Total Load	Operating Hour	Cost in USD
20Wp	Lamp:2 Mobile Charger: 1	4-5 hours	140
50Wp	Lamp:4 Black & White TV: 1 Mobile Charger: 1	4-5 hours	380
85Wp	Lamp:9 Black & White TV: 1 Mobile Charger: 1	4-5 hours	580
130Wp	Lamp: 11 Black & White TV: 1 Mobile Charger: 1	4-5 hours	940

Source: IDCOL presentation at United Nations Practitioners Network, October 2013

Exhibit III

Promotional Activities

Billboard

Celebration ceremony for the installation of 3 million SHSs inaugurated by the Hon'ble Prime Minister of Peoples Republic of Bangladesh Sheikh Hasina on November 5, 2014

Exhibit IV

SHS Financing Mode for Dhaka Division

Districts	No. of Loans	No. of Cash Sales	Loan in %	Cash in %
GAZIPUR	36,936	1,620	95.80%	4.20%
DHAKA	4,834	1,033	82.39%	17.61%
GOPALGANJ	56,033	1,457	97.47%	2.53%
KISHOREGANJ	87,381	3,046	96.63%	3.37%
MADARIPUR	78,222	2,649	96.72%	3.28%
TANGAIL	77,150	4,503	94.49%	5.51%
FARIDPUR	98,209	4,715	95.42%	4.58%
MUNSHIGANJ	13,584	887	93.87%	6.13%
MANIKGANJ	52,506	1,883	96.54%	3.46%
NARAYANGANJ	1,418	196	87.86%	12.14%
RAJBARI	24,246	1,039	95.89%	4.11%
NARSINGDI	37,316	2,027	94.85%	5.15%
SHARIATPUR	141,351	4,485	96.92%	3.08%

Source: IDCOL, 2018

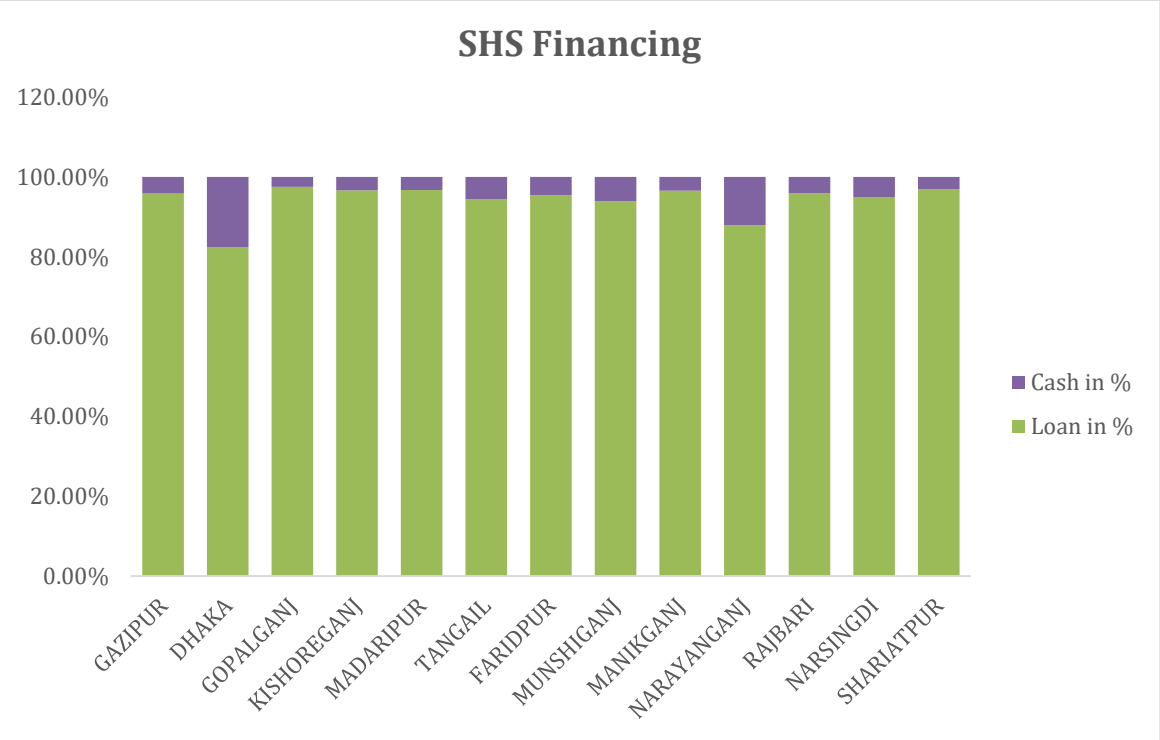
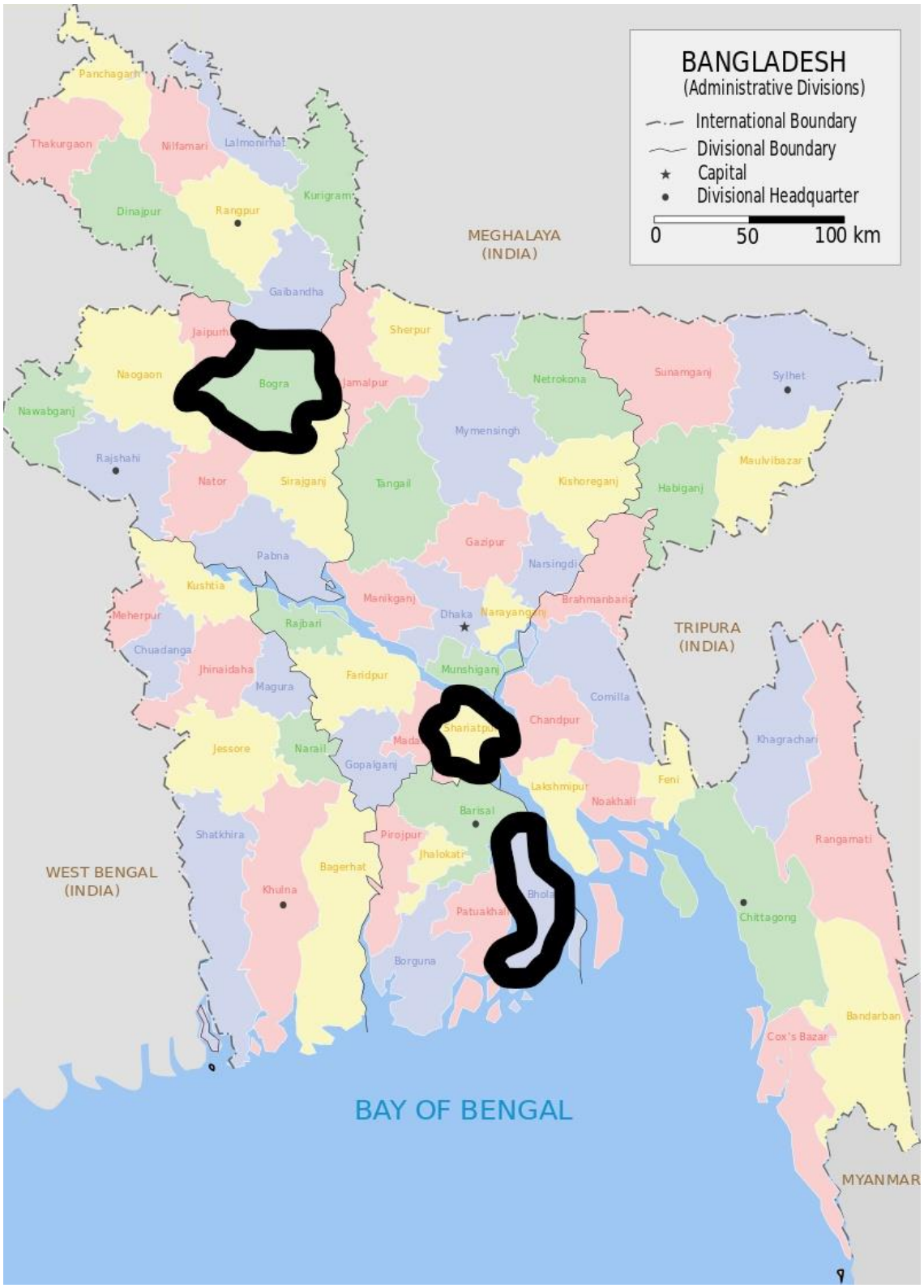


Exhibit V


BANGLADESH
(Administrative Divisions)
International Boundary
Divisional Boundary
Capital
Divisional Headquarter
0
50
100 km
MEGHALAYA
(INDIA)
TRIPURA
(INDIA)
WEST BENGAL
(INDIA)
MYANMAR
BAY OF BENGAL
Panchagarh
Thakurgaon
Nilfamari
Lalmonirhat
Kurigram
Dinajpur
Rangpur
Gaibandha
Jaipurhat
Sherpur
Naogaon
Bogra
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Tangail
Kishoreganj
Habiganj
Moulvibazar
Pabna
Gazipur
Narsingdi
Kushtia
Manikganj
Brahmanbaria
Meherpur
Rajbari
Dhaka
Narayanganj
Chuadanga
Jhinaidaha
Magura
Faridpur
Munshiganj
Comilla
Shariatpur
Chandpur
Khagrachari
Jessore
Narail
Gopalganj
Lakshmipur
Feni
Noakhali
Barisal
Shatkhira
Pirojpur
Jhalokati
Rangamati
Bagerhat
Khulna
Bhola
Patuakhali
Chittagong
Borguna
Bandarban
Cox's Bazar