IMPACT ASSESSMENT OF NATURAL GAS EXPANSION AND DISTRIBUTION NETWORK ON RURAL LIVELIHOODS IN BANGLADESH: A CASE STUDY

Md. Shaha Alam Patwary* and Md. Serazul Islam**

Abstract

The purpose of the study was to evaluate the effects of natural gas transmission and distribution network on the livelihoods of the Bangladeshi rural people. To this end, a sample comprising 400 respondent household and commercial gas users of a rural area was selected by using Snowball sampling technique. With a view to analyzing the collected data and information from Mymensingh district through interview schedule, the descriptive statistical tools-frequency and percentage distributions were used. Chi-square test was also used to assess the association in income distribution. The findings of the study reveal that the standard of living of the selected natural gas users was improved with the natural gas expansion and distribution network. The study also evidences some problems of the selected gas users which included the government's negligence in rural areas, initial high cost of gas connection, having no regional office, time consumption, having no emergency team, delay in preparation of gas bill and sending it to the customers, etc. The study concluded the major findings and recommended some measures which would help overcome the problems the users encountered.

Key words: Bangladesh, expansion and distribution, natural gas, rural livelihoods.

บทคัดย่อ

การวิจัยนี้มีวัตถุประสงค์เพื่อประเมินผลกระทบของการส่งแก๊สธรรมชาติและการกระจายเครือข่ายการส่งแก๊สธรรมชาติที่มีต่อการดำรงชีพของคนชนบทในสาธารณรัฐประชาชนบังกลาเทศ กลุ่มตัวอย่างประกอบด้วยครัวเรือน 400 ครัวเรือน และผู้ประกอบการค้าแก๊สในพื้นที่ชนบทซึ่งเลือกโดยใช้การอ้างอิงต่อเนื่องปากต่อปาก (Snowball Sampling Technique) ในการวิเคราะห์ข้อมูลที่เก็บ

*Mr. Md. Shaha Alam Patwary holds an M.S. degree in Statistics from University of Chittagong (Bangladesh). Currently he is working as a Lecturer in the Department of Statistics, University of Chittagong, Bangladesh.

**Dr. Md. Serazul Islam holds a Ph.D. in Business Administration from Islamic University, Kushtia (Bangladesh). Currently he is working as an Assistant Professor in School of Business, Bangladesh Open University.

รวบรวมจากเมืองมายเมนซิงค์โดยการสัมภาษณ์ มีการใช้สถิติเชิงพรรณนา คือค่าความถี่และค่าร้อยละ และมีการใช้การทดสอบความเป็นอิสระต่อกันของสองประชากร (Chi-square Test) เพื่อประเมินความสัมพันธ์ของการกระจายรายได้ ผลการศึกษาพบว่า มาตรฐานการครองชีพของผู้ใช้แก๊สธรรมชาติดีขึ้นจากการขยายตัวของการใช้แก๊สธรรมชาติและเครือข่ายการส่งแก๊สธรรมชาติ การศึกษาครั้งนี้ยังแสดงให้เห็นถึงปัญหาของผู้ใช้แก๊ส ซึ่งรวมไปถึงการเพิกเฉยของรัฐบาลในพื้นที่ชนบท ค่าใช้จ่ายที่สูงของการเชื่อมต่อแก๊ส การไม่มีสำนักงานภูมิภาค การสิ้นเปลืองเวลา การไม่มีทีมฉุกเฉิน ความล่าช้าในการเตรียมใบเรียกเก็บเงินและการส่งใบเรียกเก็บเงินให้ลูกค้า เป็นต้น การศึกษาได้สรุปผลการวิจัยที่สำคัญและเสนอแนะมาตรการซึ่งจะช่วยแก้ปัญหาที่ผู้ใช้แก๊สประสบ

INTRODUCTION

In an agrarian country like Bangladesh, where fossil fuel is scarce, natural gas is the most imperative natural resource. It has extended its diversified uses in power plants, raw material of fertilizer factories, different commercial, industrial, domestic and many other uses. The average daily production of gas as of 15 March 2011 is 2007 million cubic feet per day (Petrobangla, 2011). There are four separate distribution companies: Titas Gas Transmission and Distribution Company Limited (TGTDCL), Bakhrabad Gas Systems Limited (BGSL), Jalalabad Gas Transmission and Distribution System Limited (JGTDSL) and Pashchimanchal Gas Company Limited (PGCL) that are engaged in expansion and distribution of natural gas in different regions of Bangladesh. Amongst the companies TGTDCL, the oldest and largest gas company, is supplying 74.4 percent of the total gas consumed in the country. During the 2009-2010 fiscal year, TGTDCL sold 14, 962.94 million cubic meter gas to its customers and gain Tk[1].63,794.9 million. The company has been making remarkable contribution towards the economic progress of the country. During the 2009-2010, TGTDCL earned sales revenue of Tk. 63,050.0 million and net profit of Tk. 2,064.0 million, which is 38.04 percent higher than the pre-

Table 1: Company wise Natural Gas Distribution Areas in Bangladesh

Name of the Company	Year of Establishment	Controlling Areas
TGTDCL	1964	Dhaka Division including Brahmanbaria District
BGSL	1980	Chittagong Division excluding Brahmanbaria District
JGTDSL	1986	Greater Sylhet District
PGCL	1999	Northwest Region.

Source: Annual Report of Petrobangla (2009)

vious year (Titas, 2010). The company provided 68,443 new connections, which is 9.79 percent higher than the previous year. The system loss during the period was 6.47 percent, which was 0.59 percent less than the previous year indicating a saving of Tk. 170.0 million.

Natural gas is a gas consisting primarily of methane, typically with 0-20 percent higher hydrocarbons (Knight, 2010). Natural gas is often described as the cleanest fuel, producing less carbon dioxide (CO2) per joule delivered than either coal or oil. However, natural gas emits about 5.3 billion tons CO2, while coal and oil emits 10.6 and 10.2 billion tons correspondingly, which are about twice as compared to the natural gas (Wikipedia, 2010). Wakdikar (2002) observed that by imparting sufficient training to the users, Compressed Natural Gas (CNG) can become a cost-effective, efficient, and user-friendly solution to overcome environmental problems. If the choice lies between living in a cancerous environment and a cleaner environment, people are sensible enough to make their decision and would surely honor the Indian Supreme Court's decision for converting all the highly polluting public transport vehicles to CNG mode in an effort to clean environment. A livelihood becomes sustainable when a family or a community has sufficient assets and capability to use them to create a life free from hunger, disease, illiteracy and all other factors associated with poverty (Ashley, 2000). Natural gas (NG) is more uniformly disseminated and wide-reaching than crude oil. In about 90 countries around the world, it is found in reservoirs 3,000 to 15,000 feet below the earth's surface. At the end of 1999, world-proven reserves of NG were about 5172 trillion cubic feet (B.P. Amoco Statistical Review of World Energy-2000, 2001). Bernstein (1992) states that as the global economic aspirations increase rapidly, energy demand will also increase irrespective of the energy efficiency mechanism used. Given the necessary support, the renewable energy system can meet that growing demand with lower prices than conventional fuel (Howarth, 1997; Sims, 2001). Not being heavier than air, NG disperses easily into the atmosphere and does not form an adequately rich concoction for combustion to take place; consequently, CNG vehicles are more energy-efficient (Chaudhari, 2000), dipping carbon dioxide emissions. CNG permits the use of catalytic converter more significantly than diesel. CNG vehicles release 40% less of nitrous oxide (a toxic gas that creates smog), 90% less of hydrocarbons (which carry carcinogens), 80% less of carbon monoxide (a poisonous pollutant), and 25% less of carbon dioxide (a major greenhouse gas) as compared to diesel or petrol driven vehicles. In addition, noise level of CNG engine is much lower than that of petrol or diesel (Nataraj, 2000). Winebrake (2000) demonstrated that, though propane is a clean fuel, it is very expensive. In the US, although Liquefied petroleum gas dominates the alternative fuel vehicles (AFV), CNG has lately shown the highest growth rate among all AFV types, due mostly to the low cost of NG and extremely low emissions from CNG vehicles, which make them striking to fleet operators. The livelihoods approach is concerned first and foremost with people. So an accurate and realistic understanding of people's

strengths (here called "assets" or "capital") is crucial to analyze how they endeavor to convert their assets into positive livelihood outcomes (Bebbington, 1999). From the project 'Environmental Impact Assessment (EIA)' of TGTDCL (2010) for gas transmission line from Monohordi valve station to Narsingdi-12 valve station has been found to have positive impact on the national economy due to improvement of gas supply situation. It is expected that with improved gas supply, new gas based power plants and industries will be set up and existing industries will be able to run smoothly, which, in turn, will contribute to the national economy. Some beneficial impact at local level would come in the form of employment. This, in turn, would induce some positive impacts on some other parameters, including commercial activities in the project area. Similar findings have been observed in the report of Canadian petroleum association (CPA, 1991). Jahan (2008) found that farmers are benefited by homestead agro-forestry. It also provides opportunity of employment. International Natural Gas Supply Association (2010) reported that coal, oil and other fuel release remarkably higher levels of harmful carbon emissions, nitrogen oxides (NO2), and sulfur dioxide (SO2) than natural gas. Slowdown in agricultural growth and productivity, changing cropping patterns, increase in distress migration, changing consumption patterns, government policies favoring industrial houses, among others have seriously undermined the food and livelihoods security of the poorer households in India (Hiremath, 2007). Perryman Group, a Texas-based consulting group, which conducted an economic impact study of the activity in the Barnett Shale on Fort Worth and the surrounding area, estimated that Barnett Shale NG accounts for $ 8.2 billion in annual output (8.1 percent of total output in the regional economy), and 83, 823 jobs (8.9 percent of total jobs). There are also important employment and income effects on local businesses who supply the industry and effects that result from employees spending their wages locally surrounding Fort Worth (Kelsey, 2005).

Though sufficient number of studies has not been done on natural gas issue, all the above studies are undoubtedly explicit in terms of natural gas. At home and abroad, many studies have been conducted in the rural areas of Bangladesh and few studies have been made on the natural gas. No specific studies entailing the necessity of the natural gas for mass development of rural areas in connection to livelihoods change have been carried out. In the present study, efforts have been made to extract the issues relating to rural livelihoods change due to natural gas connection.

OBJECTIVES OF THE STUDY

In general, the objective of the study was to assess the impact of gas distribution network on livelihoods of people in the rural areas of Mymensingh district. In specific, the objectives of the study were:

i) to portray the descriptive statistics regarding the biological and socio-economic characteristics of the respondents;

ii) to examine the trends of gas connection and the revenues derived from it;

iii) to evaluate the changes in the respondents' livelihoods made by the gas expansion and distribution network;

iv) to identify the problems the gas users encountered during and after gas connection; and

v) to put forward some recommendations in the light of the findings.

DATA AND METHODOLOGY

The data and methodology applied in the present descriptive study are outlined below:

1. Sample Design

Keeping view all the objectives of the study and considering the limitations of the research with respect to time, cost, manpower and other facilities, Muktagacha upazila of Mymensingh district from Dhaka division has been selected for this research. Thus, the people who were connected with the network of TGTDCL from 2006 to 2010 comprise the sampling frame. Population of the study area is 321,759. Amongst them 49.23 percent are female; 94.37 percent are Muslims, Hindu 5.33 percent, Christian 0.21 percent, and others 0.23 percent (BBS, 2001), which are little less than that are found in Banglapedia (2006). Here, the sampling frame was submerged into two categories (household users and commercial users) and then a sample of size 400 was selected equally (household users = 200, commercial users = 200). The owners of compressed natural gas (CNG) converted buses, CNG auto rickshaws, CNG converted maxis, hotels, sweetmeat shops, puff rice factories, bakeries, and confectionaries were treated as commercial respondents. In this stage perfect sample selection procedure could not be adopted as the complete sampling frame is not available.

2. Variables of the Study and their Management

It is assumed that the impact of gas distribution network on livelihoods is influenced by various characteristics of the respondents. Some characteristics of the respondents were selected to find out whether they had bearings on their livelihoods with gas distribution network. Due to unavailability of literatures relating to this study in regional aspect of Bangladesh, there are no rationales regarding the selection of study variables. In the light of the objectives of the study, variables were given final shape through a prior discussion with the prospective respondents and research experts. The selected characteristics covered sex, age, education, occupation, income, expenditure, gas connection period, and usage status of natural gas. The changes in human, social, natural, physical, and financial capital and in the rural livelihoods were also studied.

3. Types and Sources of Data

In most parts of the study, primary data were used. However, in trend analysis of the number of different gas connections and corresponding revenues, secondary data were used. The sources of primary data were the household and commercial users of natural gas. Secondary sources included

the annual reports of TGTDCL, websites, and other published documents.

4. Data Collection

In order to collect the desired data and information, a draft survey schedule was carefully prepared in conformity with the objectives of the study. The draft schedule was pre-tested with some respondents in the study area for best possible improvement, rearrangement, and modification. However, pre-tested respondents were not included in the final list of respondents. For the present study, data collection was started in January 2011 and completed within one and a half month commencing the survey with rigorous effort in all the aspects. Since no specific study was made earlier on the natural gas connection in the selected area, a sampling frame of the respondents was neither available nor very easy to form with time and resource constraints. Considering these limitations respondents were surveyed objectively on door to door basis following the Snowball sampling method.

5. Data Processing

The data and information supplied by the respondents were recorded directly in the interview schedules by the researchers. However, in processing of raw data, the quantitative variables were entered directly but in case of qualitative variables, different categories of attributes were entered with the number 1, 2, 3 etc. for valid statistical analysis.

6. Data Analysis

In this descriptive study, frequency and percentage distributions were used to make general discussion. Chi-square test was used to assess the association in income distribution. α – Reliability was used to observe the change in livelihood strategies, and problems regarding present gas distribution system. Trend analysis was performed with pooled data model and the significance of model parameters was tested by t-test. Statistical Packages for Social Sciences (SPSS for Windows version 12.0 Chicago: SPSS Inc, 2008) is used to analyze the data.

FINDINGS AND ANALYSES

The major findings derived from the study are analyzed below:

Table 2 reveals that most of the respondents (61.25 percent) in the study area were female and the rest were male. As per BBS (2001), the percentage of female in Mymensingh district is 49.23 percent. It is also observed that the age of the respondents varies between 19 to 74 years with mean age 44 years and standard deviation of 27 years, where majority part of the respondents (66.75 percent) belongs to the middle age group. (Table 2)

It is also observed that almost all (90 percent) the respondents are educated irrespective of the level of education. Interestingly, most of the respondents (77.5 percent) are primary and secondary educated, which is a positive sign for the literacy status of a third world country like, Bangladesh. However, 90.0 percent of the

Table 2: Distribution of Respondents' Socio-economic Profiles

Factors and categories	Frequency	Mean ± SD	Max	Min
Age (in years)				
Young (<25)	35 (8.75)			
Middle (25 - 50)	267 (66.75)	44±27	74	19
Old (50+)	98 (24.5)			
Sexual Status				
Male	155 (38.75)			
Female	245 (61.25)	-	-	-
Education				
Illiterate	40 (10.0)			
Primary	180 (45.0)	-	-	-
Secondary	130 (32.5)			
Higher Secondary & above	50 (12.5)			
Occupation				
Business	78 (19.5)			
Transport Business	122 (30.5)	-	-	-
Public and Private Services	200 (50.0)			
Income Categories (Million Tk.)				
Low(<0.1)	70 (17.5)			
Medium (0.1 - 0.3)	300 (75.0)	0.24755±0.022585	0.42	0.086
High (>0.3)	30 (7.5)			
Expenditure (Million Tk.)				
Low (< 0.075)	100 (25.0)			
Medium (0.075 - 0.02)	285 (71.25)	0.0705±0.008654	0.25	0.067
High (>0.02)	15 (3.75)			

Source: Field Survey (2011); Figures within parentheses represents percentages

respondents were found literate or have at least signature knowledge required for communication, which indicates a good scenario for the study area as because the literacy rate in rural areas of Bangladesh is 51.81 percent (BLS, 2011). The results give evidence of the peoples' willingness towards education in the rural areas like Mymensingh.

Yearly income of respondents ranged from Tk. 0.086 million to Tk.0.42 million with an average of Tk. 0.24755 million and standard deviation Tk. 0.022585 million. On the basis of scores obtained, the respondents were classified into three categories as shown in table 2 indicating that the family income of majority (75.0 percent) of the respondents is medium because most of the family members are involved in different mediocre activities such as small business (transport and others), public services and private services (80.5 percent).

Yearly total family expenditure[2] as incurred by the respondents of the study area

varies from Tk. 0.067 million to Tk. 0.25 million with an average of Tk. 0.0705 million and standard deviation Tk. 0.008654 million. Computed figures indicate that the highest parts (71.25 percent) of the respondents incurred medium expenditure[2] while 25.0 percent made low and the rest did high expenditure. The income and expenditure distribution of the respondents indicates their propensity to savings as their earnings exceed their expenditures. If they save more, they can invest their savings in different potential money generating sectors, which would accelerate the positive trend of national economy of Bangladesh.

Table 3 shows that there was an increasing trend of yearly gas connection. Nowadays there is a shortfall of gas supply with respect to demand. Government has imposed embargo for new gas connection in recent years, henceforth, the gas connection rate sharply decreased in 2010, as apparent from both table 3 and Fig. 1.

All the respondents were not engaged

Table 3: Association between the Respondents' Income and Gas Connection Period

Number of Years Connected	Yearly Income (in Million Tk.)			Total
	Low Income (<0.1)	Moderate Income (0.1 - 0.3)	High Income (>0.3)	
5 (=2006)	20 (28.55)	30 (10.0)	0 (0.0)	50 (12.5)
4 (=2007)	20 (28.55)	80 (26.7)	10 (33.3)	110 (27.5)
3 (=2008)	10 (14.3)	80 (26.7)	10 (33.3)	100 (25.0)
2 (=2009)	10 (14.3)	100 (33.3)	10 (33.3)	120 (30.0)
1 (=2010)	10 (14.3)	10 (3.3)	0 (0.0)	20 (5.0)
Total	**70 (100)**	**300 (100)**	**30 (100)**	**400 (100)**
Value of Chi-square statistic = 73.69			p-value = 0.000	

Source: Field Survey (2011); Figures within parentheses represents percentages

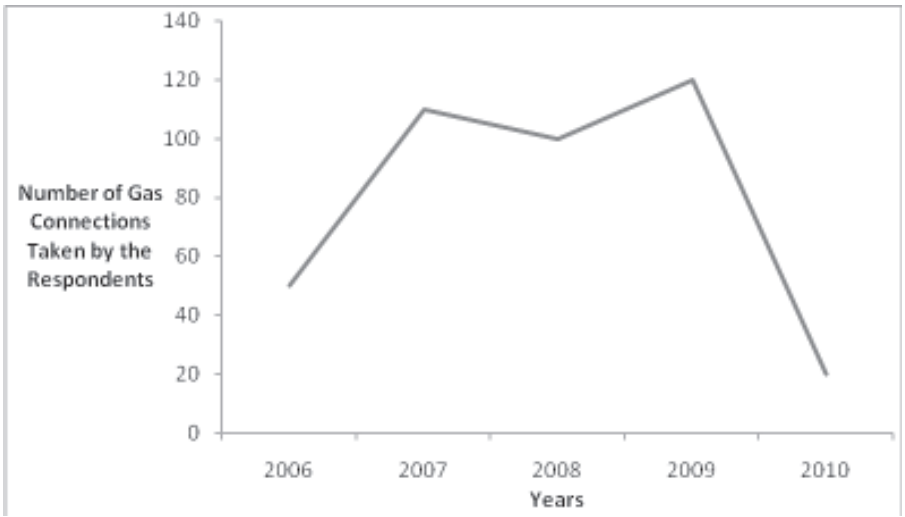

Figure 1: Year-wise Gas Connections Taken by the Respondents

with gas generated income sources. By inserting income distribution, an exertion was made to exhibit the real scenario of socio-economic status of the respondents. Table 3 exhibits that the number of people having low income is decreased in the recent years (2008-2010). It is also observed from table 3 that the people of high income group who had already been connected with gas distribution network did not enrich their cohort but could contribute in the potential growth of national economy. Moderate income group had fallen down from the accelerating trend. However, the real situation is quiet alarming. From the bivariate analysis, it is found that there was a highly significant ($p<0.01$) association between number of connected years and income distribution.

On the basis of yearly gas connection, respondents are categorized into 5 year groups as shown in table 3 indicating that the highest proportion (30 percent) of the respondents had connected themselves in gas distribution network in 2009, while 5.0 percent (lowest) of the respondents connected in the process in 2010. If it continues years to years, the livelihoods of rural people will likely be deteriorated. Though the livelihoods will be changed in time, this change will not be very effective for acceleration of socio-economic status to a greater extent.

At present, as there are no exports or imports of natural gas, the growth of domestic consumption tracks the growth of domestic production. Initial demand was very low, but nowadays, the demand has increased dramatically. The provisions of providing connections, however, has decreased rapidly.

The livelihoods of a large number of people are associated with natural gas in the rural and economically disadvantageous area of Mymensingh district. Livelihoods of an area are ascertained by the 5 types of capitals such as human capital, social capital, natural capital, physical capital, and financial capital. Table 4 discloses the changes made in the livelihood status due to natural gas connection in the study area. From the value of – Reliability factor (0.77) it can be stated that 77 percent of livelihood strategies can be changed by these five capitals.

Table 4 reveals that the distribution of studious children and working children[4] changes remarkably after connecting to the gas network. It is obvious that the percentage of working children is increased. This inherent problem for a least developed country like Bangladesh cannot be changed in a year. But the rate of increment is lower than the rate of increment of studious children, which is very positive. Their health[5] and ability of working[6] have improved substantially. Henceforth, human capital in the study area has changed dramatically.

Social capital shows the connectedness to different network[7], membership of different organization, which is the reflection of the social status of livelihoods. Table 4 illustrates that network and connectedness of the study area has improved after gas network expansion. There is remarkable positive change of membership in formalized group after construction of gas distribution network.

Natural capital represents the environmental condition such as land, water, air, forest etc. which is very crucial for human being. Table 4 depicts the change in natu-

Table 4: Effects of Natural Gas Expansion and Distributio Network on Capitals

Types of Capital	Before Taking Connection		After Taking Connection	
Human Capital	Total	Studious/skilled	Total	Studious/skilled
Studious Children	700	410 (58.57)	870	700 (80.46)
Working Children	320	50 (15.63)	960	350 (36.46)
Health Status	Not good (75.8%)		Good (92.4%)	
Ability to Labor	Not good (78.3%)		Good (93.1%)	
Social Capital				
Network and Connectedness	Not good (87.0%)		Good (93.5%)	
Membership in Formalized Group	20 % of the respondents were members		65 % of the respondents are members	
Natural Capital				
Land (Tk. per Decimal)	0.04 million		0.3 million	
Quality Water Supply	Not Good (78.0%)		Good (86.5%)	
Air Quality	Not Good (84.0%)		Good (96.0%)	
Forestation[3]	Deforesting (81.7%)		Deforesting decreases (91.5%)	
Physical Capital				
Transportation	Not Good (76.8%)		Good (95.7%)	
Secure Shelter	Not Good (81.9%)		Good (93.4%)	
Infrastructures	Not Good (79.3%)		Good (92.6%)	
Sanitation	Not good (82.1%)		Good (94.2%)	
Financial Capital per Annum (in Million Tk.)				
Income	0.1556		0.29055	
Cash and Deposit	0.305		0.5557	
Liquid Assets	5.57235		41.025	
Liabilities	0.06255		0.14365	
α - Reliability = 0.77				

Source: Field Survey (2011), Figures within parentheses represents percentages, Human capital represents the skills, knowledge, ability to labour and good health that together enable people to pursue different livelihood strategies and achieve their livelihood objectives.

ral capital of the study area as price of land increases dramatically after constructing gas distribution network. Because of natural gas, the life style of people has improved.

Quality of water supply and air quality[8] have changed in great extent and deforestation is also decreased, which represents the positive commitment to the environment.

Physical capital of a society represents the various facilities such as transportation[9], secure shelter[10], infrastructures[11], sanitation[12] etc. Table 4 describes that almost all (above 93 percent) the respondents agreed that physical capital of their livelihoods has increased tremendously. It is inevitable that gas distribution line has played a pivotal role to improve the condition.

Financial capital is the most important factor for the change of livelihoods. Because of improvement in financial capital, other things can be improved. Average yearly income of respondents increased more than 80 percent (Tk.0.1556 million to Tk.0.29055 million) after taking gas connection. As a result, their buying capacity is increased and henceforth they can expend locally to avail many facilities. Average cash and deposit of the people under study raised more than 82 percent after gas network expansion. Liquid assets have increased more than 7 times than earlier to the respondents. Nevertheless, the change in liabilities is fairly less than the change in liquid assets.

Most of the respondents do not feel comfortable or agree to disclose their income, cash and deposit, assets and liabilities, so the data that were taken from their conversation may not be exact. Nonetheless, there was no doubt that a huge change of financial capital has occurred after gas connection. But, it is true that this change is not only for natural gas but also some other factors may be liable for this. This paradox can be resolved by furthering the research.

Each of the livelihood capitals has some different parameters. But, a few parameters play an important role to change the livelihoods quickly. Table 4 visualizes that land values have increased more than 7 times. Income of the respondents has increased 1.9 times more than before. Cash and deposit as well as liquid assets have risen dramatically. Because of gas distribution network, many new commercial institutions have been established. As a result, greater job opportunities have become available, henceforth, and earning money has become easy. Nonetheless, livelihoods of the people in the study area have changed remarkably.

For trend analysis, types of gas connection by TGTDCL were submerged purposively into two categories, namely, domestic and commercial connections. Here, since the study consists of domestic and commercial gas network with the gain of corresponding revenue collection from the year 2006 to 2010, henceforth, pooled data analysis is performed for these data.

In the present study, there are 2 cross-section points for either the number of connections or for the amount of revenue collected from those connections and 5 time points (single year). Thus, the pooled model for number of different gas connection can be expressed as:

$$Y_{ij} = a_j + b_j X_{ij}; \; i=1\ (1)\ 5,\ j=1\ (1)\ 2.$$

The estimators for parameters are -

$$\hat{b}_1 = \frac{\sum_i (\sum_j Y_{ij} - Y_{i2})(\Delta X_{ij})}{\sum_i \sum_j (\Delta X_{ij})^2}; \quad \text{and} \quad \hat{b}_2 = \frac{\sum_i (\sum_j Y_{ij} - Y_{i1})(\Delta X_{ij})}{\sum_i \sum_j (\Delta X_{ij})^2}$$

Estimators of intercepts are -

$$\hat{a}_1 = \left(\sum_i \sum_j Y_{ij} - \sum_i Y_{i2} \right) / 5; \text{ and}$$

$$\hat{a}_2 = \left(\sum_i \sum_j Y_{ij} - \sum_i Y_{i1} \right) / 5$$

Where Δx_{ij} is the deviation between time for i^{th} time point in the j^{th} cross-section and median time point.

Similar estimators can be derived for the amount of revenue collected from those connections.

From table 5, it can be demonstrated that for one year advancement, number of domestic connections and commercial connections may be increased by 299 and 4 in numbers respectively. Apart from this, the revenues collected from those connections may be swelled by Tk. 1.7 million and Tk.0.5 million per annum correspondingly. Parallel comparison expresses that there are positive hazards in all observed lines, which leave really good signs in many aspects relating to gas expansion and distribution network. Nevertheless, the test of significance of parameters (by t - test) indicates that there is a significant change in the number of domestic connections and corresponding revenues but the change is highly significant in the number of commercial connections and revenues collected from those connections with the change of time points.

Table 5: Trend Lines for Different Types of Gas Connections and Collected Revenues

Categories	Parameters		Trend lines
	Intercept	Slope	
Number of Domestic Connections	1217.33	298.86*	$1217.33 + 298.86 X_{ij}$
Revenue from Domestic Connections	50.09	16.62*	$50.09 + 16.62 X_{ij}$
Number of Commercial Connections	16.17	3.91**	$16.17 + 3.91 X_{ij}$
Revenue from Commercial Connections	12.77	5.29**	$12.77 + 5.29 X_{ij}$

Source: Researchers' Compilation; ** = $p<0.01$; * = $p<0.05$

PROBLEMS ENCOUNTERED BY THE RESPONDENT USERS

In the study area, gas distribution network has expanded in recent years and the users have been facing varying major problems which were exhausted in the interview schedule by a pilot survey and trial & error basis due to lack of related literatures in the context of Bangladesh. The respondents were asked to indicate any four major problems which they have encountered. Table 6 enumerates the major problems as mentioned by the respondents in this aspect. Here, multiple responses were collected. α - Reliability value 0.92 indicates that extracted problems cover 92 percent of the total problems. There might be other problems which were not yet identified.

It is evident from table 6 that almost all complained that the government had given priority to the urban areas as compared to pastoral area regarding gas expansion and distribution network. Moreover, it leaves an indication to the government that the grass-root people are now comparing their privileges with the privileged urban people in the context of industrialization and hence for improved livelihoods. Around three-fourth of the selected respondents indicated the initial high cost of gas line connection as the main problem as most of the rural people cannot afford such high amount. There is no regional office in the study area from which they can avail support or can get up-to-date information. This acute problem relating to gas connection is mentioned by 69.75 percent of the respondents. Usually, the time required for a domestic gas connection is at least 2 months. For other categories of customers, it requires more time as is disclosed by 65.25 percent of the respondents. Amongst the respondents, 64.25 percent experienced dependency on contractor as an intrinsic problem to take gas connection. All types of dependencies, as they mentioned, may lengthen the processing time to get gas connection. Natural gas is inflammable. In case of accident, it may cause unimaginable detrimental to assets and human. But, there is no emergency team for the study area as per the knowledge of respondents; as a result people do not get emergency service from the vendor. This severe problem is identi-

Table 6: Major Problems Encountered by the Respondent Gas Users

Types of Problems	Respondents (Multiple Responses)
Govt.'s negligence in rural areas	392 (98.0)
Initial cost is high	296 (74.0)
No regional office	279 (69.75)
Time consuming	261 (65.25)
Dependency on contractor	257 (64.25)
No emergency team	223 (55.75)
Delay in sending gas bill	73 (18.25)

α - Reliability = 0.92

Source: Field Survey (2011)

Figures within parentheses represent percentages

fied by 55.75 percent respondents. Very few customers (18.25 percent) do not get bill in time. So, they do not pay their bill in time which causes paying interest for late payment.

CONCLUSIONS

Natural gas distribution and expansion network in rural area has a significant impact on socio-economic condition of the users. Potentiality for income generation and financial capability was raised due to gas expansion network. The number of skilled manpower and studious children increased due to stronger financial capability. Health and labor condition of the people of the study area were improved remarkably. Positive changes were observed in network connection and the membership of the formal group after gas distribution network expansion. Quality water supply was ensured, deforestation decreased and fresh air became available in the study area. As a result, human capital, social capital, natural capital, physical capital, and financial capital position of the respondents were improved significantly.

The findings of the study confirmed that there was a very positive change in the livelihoods the people of the study area after gas distribution network expansion. Natural gas provides huge opportunities to increase income, jobs, assets, skilled manpower, etc. Because of natural gas, the environmental condition was improved remarkably. The trend in the number of domestic and commercial connections and corresponding revenues for the vendor is increasing, but it is not observed in the rural areas. Rural people are deserted through government's emphasize on urban area, which resembles the negligence towards the mass people. Government can remove this slur by paying more concentration on rural areas. However, decentralization of industrial and commercial area is expecting mandatory for improve livelihoods of the residents of rural areas in Bangladesh. Finally, it can be concluded that the inhabitants of the study area have been improving their livelihoods significantly by using natural gas.

RECOMMENDATIONS

Important guidelines comprise the policy recommendations for the gas distribution and expansion network in the pastoral area. Depending on the findings, the following recommendations are being made so that government's organizations as well as the private organizations make recognition about strength, weakness, opportunities, and threats on gas distribution and expansion network and they can take necessary, justified and straight-way action for improved livelihoods of the grass-root people: Natural gas distribution and expansion has a positive impact on the livelihoods of the rural people in terms of their employment and income generation, but the extent of the network in the rural areas is limited. The government should, therefore, put more emphasis on the gas distribution and expansion network to cover more rural areas so that their plan of rural women empowerment can be implemented. Due to the high initial cost of gas connection, a large portion of the rural people remains

outside the purview of the gas distribution and expansion network. So, the initial real cost should be low so that people in rural areas can get easy access to natural gas. Since the existing gas connection system is old and requires long time, the system should be changed with experienced technicians, modern equipments and new technology. Because of no or low supply of gas, the government with an official order has stopped new gas connection in the country. The government of Bangladesh should, therefore, give top priority on the optimal supply of power, gas, and water to the rural areas. In this connection, more emphasis can be placed on the successful implementation of Public-Private Partnership (PPP) Program. Due to non-availability of regional gas connection and distribution office, the new and existing users suffer from different problems including payment of bill and lodging of complaints. The government is, therefore, recommended to establish at least one regional office in the rural areas so that the users of these areas can get necessary services in time. To reduce harassment of the customers, the electronic services (such as e-mail, mobile SMS) system can be introduced so that they can get their bills and pay them back quickly. Last but not least, it is a proper time to rethink about the industrialization and commercialization in the rural areas with a view to bring the pastoral people to the process of national economic growth.

Acknowledgement: We, the authors are highly indebted to the respondents of the study, the research potentials and all the concerns regarding this study for their boundless help, without which we couldn't complete this type of baseline study.

Endnotes

[1]Tk. is the abbreviated form of Bangladeshi Currency, the Taka. The exchange rate (January 2011) is US$1 = Tk. 71

[2]Respondents were asked to report their approximated monthly expenditures including all expenses and then researchers made a computation to get yearly expenditure.

[3]The variable forestation is measured by asking the respondents whether they are cutting more trees (garden/non-garden) than before for meeting the demand of fuel.

[4]To measure this variable, respondents were asked whether their children are going to school or working to earn money.

[5]Health status has been measured by asking about whether environmental pollution and any health complexity. If the respondent answer 'yes' then it is considered as 'Not good', otherwise it is reported as 'Good'.

[6]Ability of working has been measured by asking about their physical strength before and after taking gas connection.

[7]To measure this variable, respondents were asked whether they were more frequently interacting with different social organizations than before. If answer was 'yes', it was recorded as 'Good', else it was recorded as 'Not good'.

[8]For measuring this qualitative variable, respondents were asked whether the air was lighter and less toxic at present or not. Similar question is followed for assessing the variable 'Water quality.

[9]To get information on transportation, respondents were asked whether 'they were getting more transports to travel.

[10]Secure shelter was assessed by whether respondents observed fire burning at home or not.

[11]Infrastructure was determined by asking whether they were observing social development or not.

[12]To get response on Sanitation, we asked the respondents about the cleanliness or hygiene of their surroundings.

[13]For all these variables, if respondent's answer was 'Yes' it was recorded as 'Good', otherwise, it was treated as 'Not Good'.

REFERENCES

Ashley, C., (2000). "Applying livelihood approaches to natural resource management initiatives: Experiences in Namibia and Kenya". *ODI Working Paper*, London. 134.

BLS, (2011). Bangladesh Literacy Survey 2010. Final report, Industry and labour wing, Bangladesh bureau of statistics, Statistics division, Ministry of Planning. 2.

BBS, (2001). Bangladesh population census 2001. Preliminary report, Bangladesh bureau of statistics, Ministry of Planning, Government of Peoples' Republic of Bangladesh, Bangladesh.

Banglapedia, (2006). National encyclopedia of Bangladesh. Dhaka: Asiatic society of Bangladesh. I, II and III.

Bernstein, H., Crow, B., Johnson, H., (1992). *Rural livelihoods, crises and responses*. Oxford University Press. 107.

Bebbington, A., (1999). Capitals and capabilities: Framework for analyzing peasant viability: Rural livelihoods and poverty. *World Development* 27(12), 2021-2044.

B.P. Amoco Statistical Review of World Energy - 2000, 2001. In Indian petroleum and natural gas statistics 1999-2000. Economics and Statistics Division, Ministry of Petroleum and Natural Gas, New Delhi.

Chaudhari, M. K., (2000). Clearing the air: Better vehicles, better fuels. Tata Energy Research Institute. 277-284.

CPA, (1991). "Guidelines for pipe line, Canadian petroleum association". *Construction Journal of Gas and Oi*l 6, 6-9.

Hiremath, B. N., (2007). The changing faces of rural livelihoods. A Theme Paper, Institute of rural management, Anand.

Howarth and Richard, B. (1997). Energy efficiency and economic growth. Contemporary economic policy, xv.

INGSA, (2010). A report on natural gas and environment. A Policy Paper by International Natural Gas Supply Association.

Jahan, N. , (2008). Impact of homestead agro-forestry on livelihoods of rural households in Mymensingh district. Published M.S. Thesis, 86-114, Department of Agriculture Economics, Bangladesh Agricultural University.

Kelsey, T. W., (2005). Potential economic impacts on Marcellus shale in Pennsylvania: Reflections on the ferryman group analysis from Texas Publication Paper.

Knight, H., (2010). "Wonder fuel: Welcome to the age of unconventional gas". *Journal of Natural Gas* 7, 44-49.

Nataraj, M., (2000). Clearing the air: Better vehicles, better fuels. Tata Energy Research Institute. 261-266.

Petrobangla, (2009). Annual report of Petrobangla. Petrobangla. Dhaka, Bangladesh.

Petrobangla, (2011). Daily gas production statement of Bangladesh oil, gas and mineral resources corporation. Petrobangla. Dhaka, Bangladesh.

TGTDCL, (2010). Environmental impact assessment (EIA) on the project construction of 20" DN x 1000 psig parallel/loop gas transmission line from

Monohordi to Narsingdi valve station 12, Titas gas transmission and distribution company ltd. Dhaka, Bangladesh.

Titas, (2010). Annual Report 2009-10 of Titas gas transmission and distribution company ltd. Dhaka, Bangladesh.

Wakdikar, S., (2002). "Compressed natural gas: A problem or a solution?". *Current Science* 82 (1), 25 - 29.

Wikipedia , (2010). Natural gas supply association. Available at http://en.wikipedia.org

Winebrake, J. J., (2000). Strategic Planning for Energy and the Environment 19(4), 43-62.