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Preface

This proceeding is a combination of selected papers from the 2nd International Conference on Sustainable Development which was organized by the Institute of Development Studies and Sustainability-IDSS on February 16-18, 2018 at UIU Dhanmondi Campus, Dhaka, Bangladesh. The aim of the conference is to identify the ways to sustainability and share the empirical knowledge based on research, practice, and education. This theme emphasizes the strong foundation that is provided by using research to inform everyday practices, policies and research approaches. The conference will provide opportunities to interact with prominent leaders in the field and greatly expand on your global network of scholars and professionals. In total, we received 55 papers from this conference and published best 11 papers as a book from Scholars' Press. From rest of the papers, we have selected best 19 standard papers which we chose to publish as University proceeding.

We express our deep gratitude to all academics, scientists, economists, environmentalists, development practitioners, social activists, researchers, academics and policy analysts who contributed in the 2nd International Conference on Sustainable Development of United International University (UIU).

Our heartiest gratefulness to the Royal Netherland Embassy, Dhaka for their kind sponsorship towards this conference. And also we are very thankful to other sponsors for various supports to make this conference successful.

We gratefully acknowledge the cooperation of the reviewers, composers, designers and all others who sincerely extended help and cooperation for making it possible to publish this proceedings.



Hamidul Huq, PhD, WUR

Convener

2nd UIU-ICSD 2018

Deficiencies of Traffic Signal Control System at Airport Intersection in Dhaka City

Sultana Shajia¹, Dr. Shamsul Hoque²

¹ SMEC International Pty Ltd. Australia, House 374, Lane 6, DOHS Baridhara, Dhaka, Bangladesh

² Dept. of Civil Engg., Bangladesh University of Engineering & Technology, Dhaka, Bangladesh

Abstract

The widespread commercial, industrial, government, private and other activities have encouraged migration of people from outside resulting in abnormal growth of vehicular population in Dhaka city. The rapid growth of vehicular population is causing an enormous effect on traffic system. Hazrat Shahjalal International Airport intersection has been selected for this research study. In order to assess delay incurred at the junction as well as to make the junction operation by signal, in this study attempt has been made to design traffic sign in systematic way. Analysis has revealed that at Airport intersection maximum discharge is 8897 vehicles per hour. Analyzing the arrival traffic flow data and degree of saturation, it has been revealed that approximately 32% time is signal design enabled and for rest of the oversaturated traffic condition. There is a need for other non-signal treatments viz. elimination of the roundabout, introduction of U-loop, junction grade separation etc.

Keywords: Intersection; delay; saturation flow; traffic composition; arrival flow.

1. Introduction

Dhaka is the capital; administrative and commercial hub of Bangladesh has been phenomenal growth both in terms of population and motorization in the post-independence period of the country. In last five years, the population of the city has grown by about 50% to about 18.7 million, while for the same period the vehicle population has also grown by about 50% to more than 375,000 vehicles (Traffic Signal Synchronization Study, 2013).

Various factors such as road users and vehicle characteristics, faulty road design, unplanned or illegal roadside structures, unplanned intersections, irregularity and delay in maintaining traffic signals in signalized intersections, carelessness of traffic rule enforcing authority etc. cause traffic congestion. Traffic congestion has effect on traffic collision, environment, human health, productivity as well as economic loss, road user's characteristics especially on behavior of drivers and pedestrians, socioeconomic development, travel time, travel cost, accessibility etc. For example, driver aggression is caused by frustration because of traffic congestion and delay (D. Shiner 2000).

However, the traffic movement in Bangladesh and in other developing countries is rendered in more complexes due to the heterogeneous characteristics of the traffic stream using the same right of way. The stream includes slow push carts at one extreme and the fast-moving passenger cars at the other, with many intermediate types of vehicles depicting a wide variation in static and dynamic characteristics.

The research mainly attempts to study parameters that influence the design and performance of intersection and to suggest modification with respect to non-lane based traffic condition. The specific objectives are: to identify the existing situation at Hazrat Shahjalal International Airport (HSIA) intersection; to analyze junction operational delay of airport intersection at peak time; to propose delay minimizing signal timing plan and to propose recommendations

for improving operating condition of the junction.

The paper is structured as follows. Section 2 reviews the saturation flow, capacity, PCU which are directly related with degree of saturation and delay calculation. Section 3 acquaint with data collection and research methodology. Section 4 is the backbone of this paper: after a data description, we present the analysis of existing situation, delay calculation and proposed improved signal timing plan. Finally, other associated problems and conclusion are presented in Section 5 and Section 6 respectively.

2. Literature Review

In road traffic network 'at grade' junctions are very sensitive and important issue as this element of road produces maximum conflicts among the crossing, turning and merging vehicles. Intersections play a significant role especially for urban road network where vehicles face intersections frequently on their journey.

In a road traffic system, intersections are one of the prominent bottlenecks that interrupt smooth flow of traffic and thereby cause delays. Vehicle speed would have been much higher and journey time much lesser without these junctions. But where there is crossing, at grade intersections have to be provided as a natural solution. So, these junctions are becoming sensitive part with respect to the overall network. The overall performance and the capacity of the network will obviously be reduced due to faulty intersections in spite of having a very well-designed link. To avoid unnecessary delay or to get an efficient traffic flow movement, these intersections need to be designed properly and carefully.

2.1 Saturation flow rate

The saturation flow rate, s , is an important parameter for estimating the performance of a particular movement. Saturation flow rate is simply the headway in seconds between vehicles moving from a queued condition, divided into 3600 seconds per hour.

For calculation purposes, the saturated situation is simplified as an 'effective green period' through which flow is assumed to occur at the saturation rate, with 'lost' times at the start and end when no flow takes place. This concept was developed initially in the U.K. at the Road Research Laboratory (Webster and Cobbe 1966) (Road Note 34 1963) in the early 1960's and can be illustrated graphically in the figure (Fig. 1).

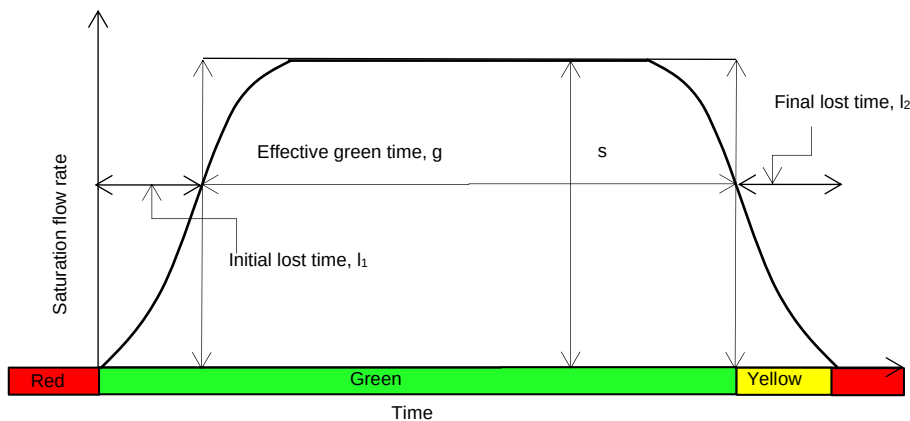


Fig. 1: Illustration of saturation flow and lost times at traffic signals

The curve in this figure is thus replaced by a rectangle of equal area, where the height is the saturation flow and the total lost time is equal to the combined green and amber periods minus the effective green time. An advantage of this concept is that capacity is then directly proportional to effective green time.

If G = combined green and amber periods (sec), g = effective green time (sec), c = cycle time (sec), l = lost time (sec) and s = saturation flow (vehicles/hour)

Then capacity = $g/s/c$ vehicles per hour

Where, $g = G - l$ sec

As per Road Note 34 Method (Road Note 34 1963), consists of taking classified counts of vehicles crossing the stop line, within the approach width, in six second intervals during the green and amber period of the cycle under saturated flow condition. An average number of 30 cycles is recommended to be used for each approach.

In this study for each movement five sets of data on every 6 seconds' interval have been taken. Then the data is converted into PCU. In this study saturation flow diagram has been drawn based on 5 cycle observation. These discharge flows in terms of PCU/6s values are then utilized to obtain saturation flow by using graphical method. The saturation flows (s) have been calculated taking the average height of the equivalent rectangle. The sample saturation flow calculation for one direction is shown in figure (Fig. 2).

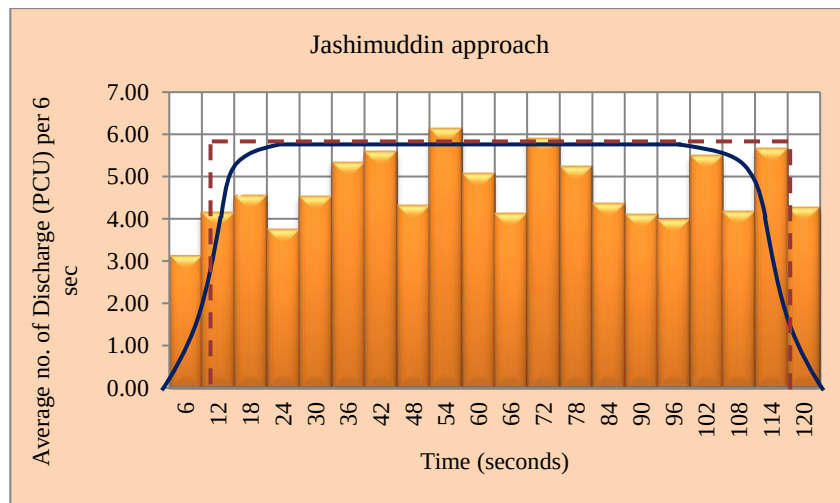


Fig. 2: Average saturation flow calculation at Jashimuddin approach

Average saturation flow calculation:

$\Sigma(\text{Height of rectangle} \times \text{green time excluding first and last interval}) = h \times (\text{Total green time excluding first and last interval})$ or

$$\Rightarrow h = 5.65 \text{ PCU/0.1 m}$$

The simple discharge curve is not appropriate in the case of right turning vehicles subjected to opposing flow, as vehicles may be forced to wait until a suitable gap appears in the opposing stream before they can cross. Often due to a, saturation 'plug' of opposing vehicles at the start of green period, right turners may not be able to depart initially, and sometimes a number of vehicles may be waiting to clear the junction at the start of the amber period.

For these situations, the saturation flow is affected by a number of factors in addition to the level and characteristics of the opposing flow. These factors will include the proportion of right turning vehicles in the stream and the number of right turning vehicles that can wait to turn right before straight-ahead vehicles are blocked i.e. the 'storage space' available (Hasan 1996).

2.2 Lost times

The traffic flow takes some time to reach the saturation level after the onset of green. Equally during the amber period, the rate of the flow falls away, in anticipation of the red signal.

The time lost due to start-up effects at the beginning of the green phase is defined as 'initial lost time' and the time lost by vehicles not making full use of amber period is termed as 'end lost time'. Then the 'total lost time' is the combination of these two lost times. This lost time controls how much green time is effectively lost to traffic due to driver reaction times, acceleration/deceleration effects at the start and end of each green phase. The resulting effective green time can therefore be defined as:

$$g = G + Y + R - (l_1 + l_2) \quad (1)$$

2.3 Capacity

At signalized intersections, capacity for a particular movement is defined by two elements: the maximum rate at which vehicles can pass through a given point in an hour under prevailing conditions (known as saturation flow rate), and the ratio of time during which vehicles may enter the intersection. These are shown as,

$$c = s \left(\frac{g}{C} \right) \quad (2)$$

Capacity is shown graphically in Fig. 3 as the area bounded by saturation flow rate and effective green time and volume is shown as the under the flow rate curve.

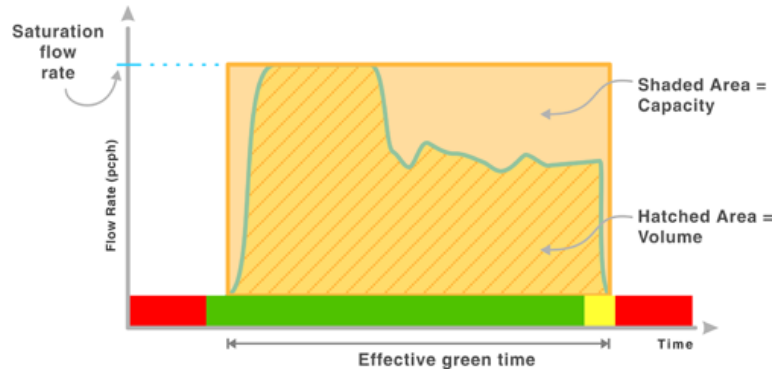


Fig. 3: Illustration of volume and capacity of a signalized movement

2.4 Volume-to-Capacity ratio

The volume-to-capacity ratio, also known as the v/c ratio or the degree of saturation, is calculated for each movement using the following equation:

$$\frac{v}{c} = \frac{v}{s \left(\frac{g}{C} \right)} = \frac{vC}{sg} \quad (3)$$

Movements or lane groups with volume-to-capacity ratios less than 0.85 are considered under saturated and typically have sufficient capacity and stable operations. For movements or lane groups with a volume-to-capacity ratio of 0.85 to 1.00, traffic flow becomes less stable due to natural cycle-to-cycle variations in traffic flow.

2.5 Delay

Vehicle delay is most important parameter used by transportation professionals to measure the performance of signalized intersections. This parameter is utilized in both the design and evaluation of traffic signalized intersections. As an example, delay minimization is frequently used as primary optimization criteria when determining the operating parameters of traffic signals at both isolated and coordinated signalized intersections. In another example, the HCM uses the average delay incurred by vehicles on approaches to signalized intersections as a criterion for determining level of service. Moreover, delay is criteria whose meaning is easily comprehended by both traffic professional and the general public. However, delay is also a parameter that is not easily determined.

The Miller (1968) formula for delay is based on an explicit use of the average overflow queue parameter, n_r , given by

$$D_r = \frac{1}{2} * \frac{q c(1-u)^2}{1-y} + \frac{n_r(1-u)}{(1-y)} \quad (4)$$

The Miller (1968) formula for average delay, which is obtained as $d = \frac{D_r}{q}$, is

$$d = \frac{1}{2} * \frac{c(1-u)^2}{1-y} + \frac{n_r(1-u)}{q(1-y)} \quad (5)$$

The average overflow queue n_r , will naturally depend on the degree of saturation x . At low x , the expected expression of the overflow queue obtained empirically is

$$n_r = \frac{1}{2} * \frac{e^{-1.33\phi}}{1-x} \quad (6)$$

Where,

$$\phi = \frac{(1-x)qc}{x^{3/2}} \quad (7)$$

Vehicle arrival patterns, however, are not uniform. They are more likely to be random. Number of stochastic models has been developed; the most used one is Webster Model. The assumption in these models are 1) the rates are constant for the analysis period, 2) the demand is less than capacity 3) the relation of delay to the pattern is deterministic, and 4) the arrival pattern of vehicles is generally Poisson distribution. Using deterministic queuing analysis, Webster (1958) developed model for estimating the delay incurred by motorists at under saturated signalized intersection that becomes the basis for all subsequent delay models. The model developed isAlso, the widely used Webster's formula:

$$d = \frac{c(1-u)^2}{2(1-y)} + \frac{x^2}{2q(1-x)} - 0.65\left(\frac{c}{q^2}\right)^{\frac{1}{3}}x^{2+5\left(\frac{g}{c}\right)} \quad (8)$$

The first term of Webster model represents the uniform delay per vehicle. The second term attempts to account for the fact that the vehicles arrive randomly. This term increases rapidly with the degree of saturation. The third term is an adjustment factor to provide better mathematical fit to the theoretical curve. Following Webster's work, numerous studies were conducted on the subject of how to estimate delays at signalized intersection. As a result of these studies, a number of delay models based on deterministic queuing theory were proposed to suite the different field conditions. Among these, the most noticeable are the models developed by Miller (1963) and Akcelik (1981), and the models developed for use in Highway Capacity Manual (TRB, 1985, 1994, 1998) and Canadian Capacity Guide for signalized intersections (ITE, 1984, 1995).

2.6 Passenger Car Unit (PCU)

The traffic operations at a signalized intersection would be very much easier and simplified if all vehicles in the traffic stream were of an identical size and travelled straight ahead only. In practice, however, the operations are complicated because the traffic stream normally consists of an inseparable mixture of different types of vehicles performing different maneuvers at the traffic junction. The time taken by a vehicle to depart from the stop line varies considerably from vehicle to vehicle, because of the variations in their length, weight, power and driver behavior. Also, the time used by a vehicle to perform a turning movement, at an intersection, depends on its type.

3. Data Collection and Research Methodology

“In 1981, there were only 15 signalized intersections and another 15 were proposed in the Integrated Urban Development Plan. Prior to 1977, RAJUK was responsible for signal installation and control. In the early 1980s, control of signal was transferred to Traffic Police Division with RHD engineers assigned to help. This experiment lasted only a year before signals were reassigned to DCC. Traffic signals have increased over recent years with 12 signals being installed in just the last two years.” (DITS, 1994). There are about 98 intersections in DNCC and DSCC area of which 77 intersections are signalized and the remaining 21 ones are not signalized. Although there are 77 locations installed by signalization, non-operated traffic signalized intersections are seen around 26 locations. This is due to no maintenance made since installed.

Data from airport intersection was collected on Tuesday, 15 April 2014. Because traffic counts during a Sunday morning rush hour and a Thursday evening rush hour may show exceptionally high volumes and are not normally used in analysis; therefore, counts are usually conducted on a Monday, Tuesday or Wednesday. Digital video camera was used to collect data on the field for 24 hours. The video camera was mounted at the top of the sculpture located at the roundabout near the intersection and was focused covering two legs of the intersection. Care was taken to cover full queue on stop line only. The recording was done for 24 hours.

3.1 Study area selection

HSIA intersection of Dhaka city has been selected for the analysis. The following information explains the importance of airport intersection.



Fig. 4: Location of airport intersection

Based on RHD database, the busiest road is Dhaka (Banani) – Jaydebpur – Mymensingh

(N3) where the AADT are 29709 and 28903 for Link no N3-4R and N3-4L respectively (Source: Road Maintenance and Management System, Roads and highways Department, 2013).

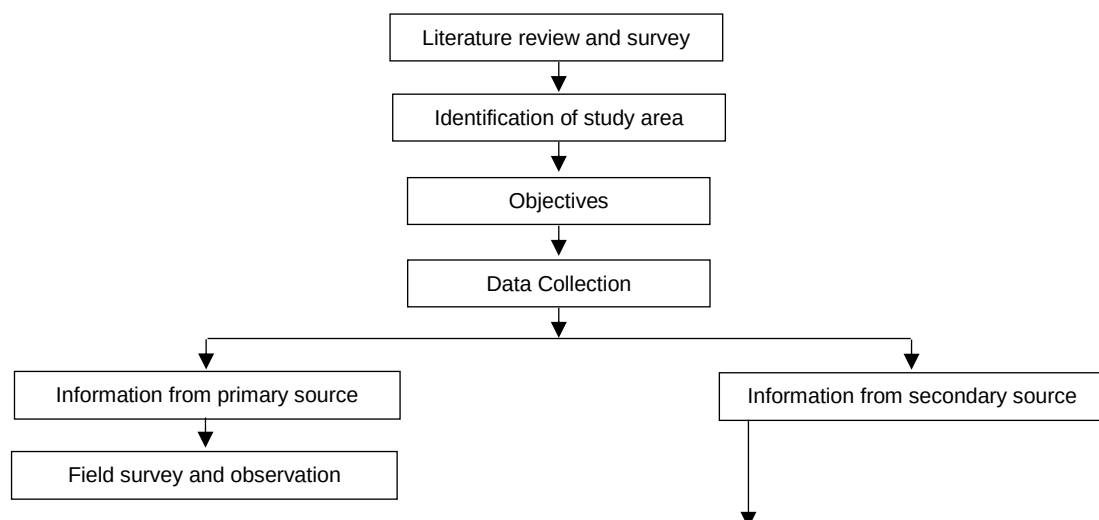
HSIA is the largest airport in Bangladesh. It is the hub of all Bangladeshi airlines. At present the capacity has 8.0 million passengers annually and in FY 2014-15, it handled 6.7 million passengers. The passenger growth rate is 9.5 percent a year. The airport is located in Kurmitola and North of the capital Dhaka and West of the intersection. On the other hand, Airport railway station or Biman Bondor railway station situated opposite to HSIA, it can also be accessed from the airport road.

Currently upgradation of HSIA is going on which include construction of the third terminal and improvement in apron and hanger facilities would help the airport double its passenger handling capacity. In the first phase, the third terminal, cargo village, VIP complex and domestic terminal will be constructed. The works are ongoing and supposed to be completed by 2019. The future demand of these developments will immensely affect the intersection if there is no treatment to meet the demand (Source: The Daily Star, 04 July, 2013 and The Financial Express, 08 August, 2015).

Greater Dhaka sustainable urban transport project (BRT: Gazipur – Airport) is ongoing and now in construction phase. According to Greater Dhaka Sustainable Urban Transport project design report, a BRT station will be constructed before the intersection at Jashimuddin approach and end point after the junction. This intersection is connecting the main North and South corridor. Also, this intersection is very prone to accidents because it is always crowded with pedestrian and passenger especially during Hajj time.

3.2 Outline of the research methodology

For study the existing signal system, the necessary survey involves regarding the system requirements, no of phases, types of signal, arrival traffic flow, types of signal controllers, no. of lanes, signal timing control, maximum green time, maximum cycle time, presence of non-motorized vehicle at signalized intersections etc. Information was also collected from the concerned organizations such as Roads and Highways Department (RHD), Dhaka City Corporation (DCC), Dhaka Metropolitan Traffic Police (DMP), Rajdhani Unnayan Kartipakha (RAJUK), Bangladesh Road Transport Authority (BRTA), Dhaka Transport Coordination Authority (DTCA) and Bangladesh Railway (BR).



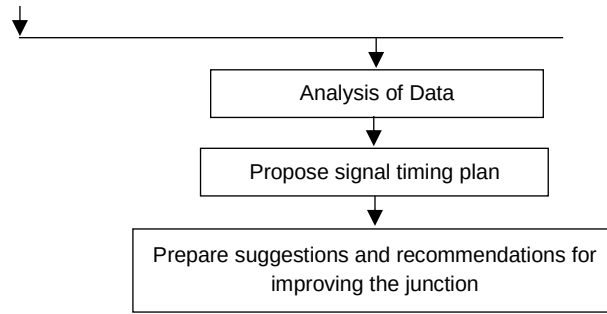


Fig. 5: Outline of the research methodology

3.3 Data analysis

The performance of the junction is to be evaluated based on the following factors:

- Degree of saturation of the junction
- Delay per vehicle

Before any analysis can be done to evaluate the performance of the junction, we will have to obtain the following parameters for the 4 approaches.

- (i) Saturation flow, s
- (ii) Delay per vehicle, d

To obtain these parameters, cars passing through the junction at each movement during the green time are counted. Different types of vehicles within the traffic stream make it difficult to express flow in terms of vehicle. To overcome this problem flow value is calculated by converting all the vehicles to a common type usually the passenger car (PCU). It is the method of expressing various types of vehicles having different characteristics in a common equivalent unit. It is needed to remove the effect of traffic composition from flow calculation. The converted factors for calculating PCU specification are given in table 1.

Table 1. PCU conversion

Vehicle type	PCU
Car, Taxi	1.0
Utility (Jeep, Pickup, Laguna, Human hauler)	1.0
CNG	0.75
Micro-bus, Ambulance	1.0
Mini-bus	3.0
Large Bus (single decker and double decker)	3.0
Motor cycles	0.75
Truck (small)	3.0
Truck (medium)	3.0
Heavy truck, Trailer container	3.0
Rickshaw, Rickshaw-van	2.0
Bicycle	0.5
Animal Push cart	4.0

Source: Bus Rapid Transit Line-3 Corridor Study in Dhaka

4. Analysis of Existing Situation

To analyze the existing situation of signal timing on the selected intersection, three major works have to be done. The first one is the counting of approach wise directional vehicular

flow of the existing design. The second one is to calculate the saturation flow by these counted vehicles, which will later be employed to obtain the degree of saturation for each movement, and the rest is to calculate the delay per vehicle. In the following section, the details description of these three steps of works are given along with relevant equations whenever necessary.

4.1 Traffic composition at airport intersection

In order to calculate saturation flow vehicles, need to be converted into common unit it is called PCU. In order to convert the total composition of traffic stream which was collected in the field and composition is shown in the following pie chart. Pie chart 6 gives graphical presentation of classified traffic volume at different approaches. Fig. 7 shows the vehicle composition comparison in different time period in 24 hours.

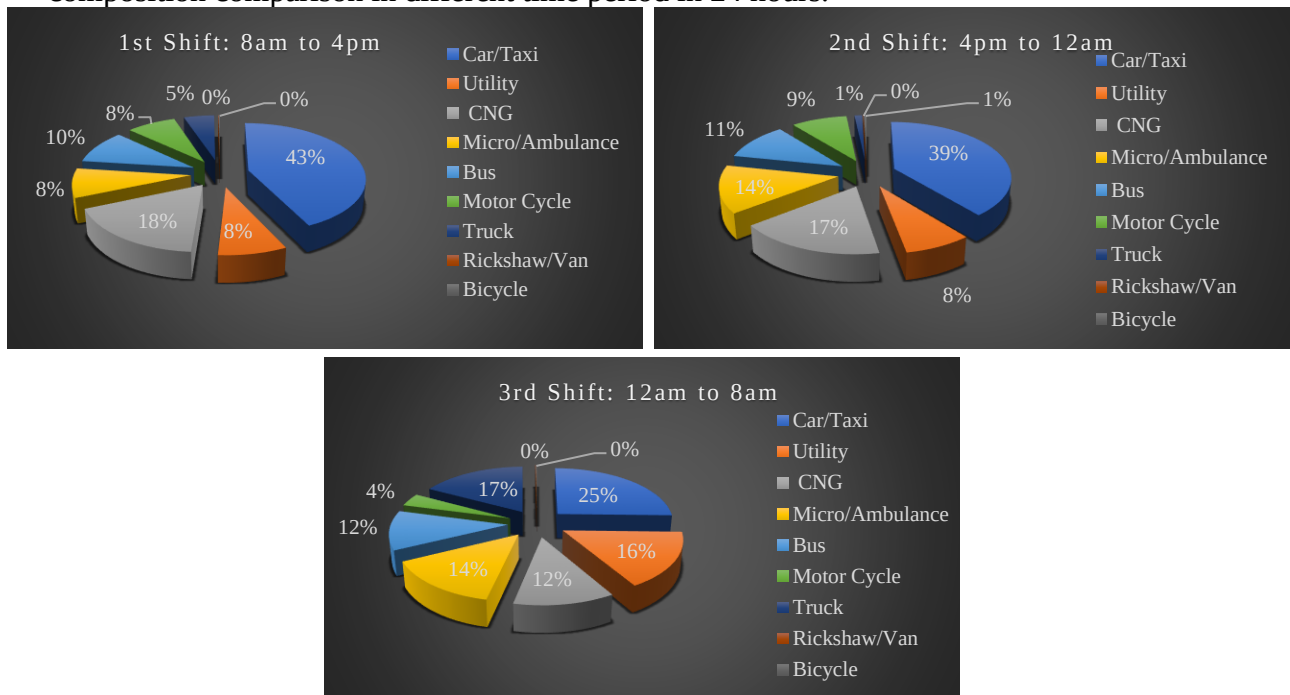


Fig. 6: Vehicle composition at airport intersection

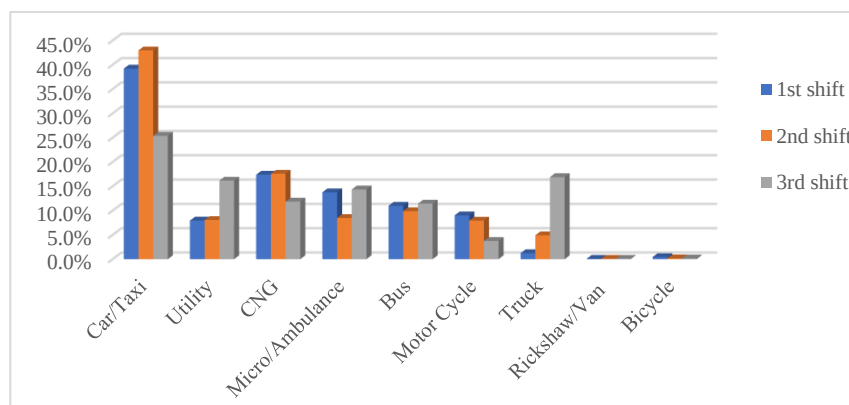


Fig. 7: Comparison of vehicle composition in different

According to the above Fig. 7 the 1st shift starts from 8:00 am to 4:00 pm, the 2nd shift is from 4:00 pm to 12:00 am and 3rd shift is from 12:00 am to 8:00 am. From the comparison graphical form, it shows that the most dominating vehicle is car /taxi and according to 2nd shift, it is 42.9% and on average 35.8% of total vehicles in 24 hours are passing through this intersection.

Along the corridor, it is found that the next dominating vehicle type is CNG. On a typical working day on average 15.6% of total vehicles are CNG. A close observation of graphical form of vehicle comparison revealed that smaller sized vehicles (Car/ Taxi, Utility, Microbus and Ambulance) comprise about 74.3% of the total traffic stream.

It also shows that during day time truck movement is very less about 3.1% of traffic. Dhaka Metropolitan Police has banned covered goods trucks on June 30 2009 with a capacity of more than one-and-a-half tonnes from operating in the capital during the day, between Sunday and Thursday in an attempt to reduce large vehicles clogging roads during peak hours. For this reason, at night time truck movement is much higher and about 16.9%. As this corridor is NMT (Non-motorized Transport) free. So, these types of vehicle are least and less than 0.3%.

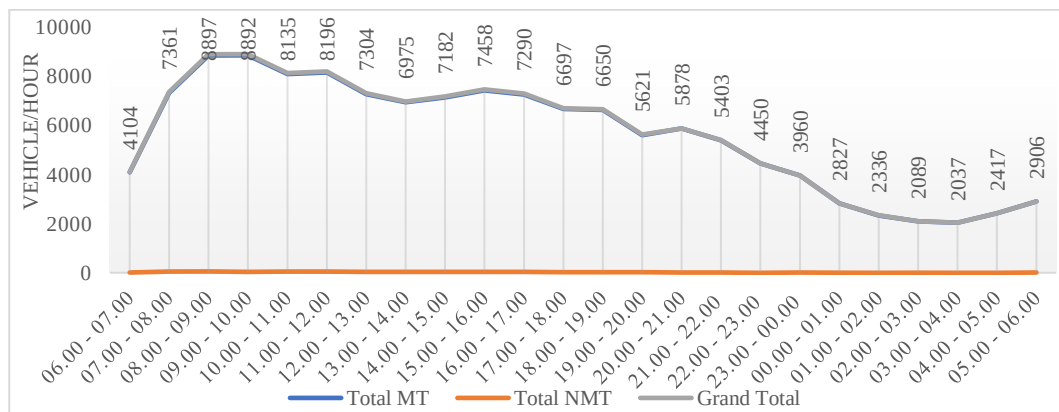


Fig. 8: Comparison of motorized and non-motorized traffic based on grand total

From Fig. 8, it can be seen that at Airport intersection maximum discharge is 8897 veh/hr, which occurs during 8:00 am to 9:00 am in a typical working day. Comparing 24 hours data, the highest discharge is occurred from 8:00 am to 12:00 pm and the average veh/hr is 8530.

4.2 Flow fluctuation

Using these PCU values, observed flows are converted in terms of PCU values. For comparison purpose a superimposed flow fluctuation diagram is presented in Fig. 9 for 24 hours for the whole junction.

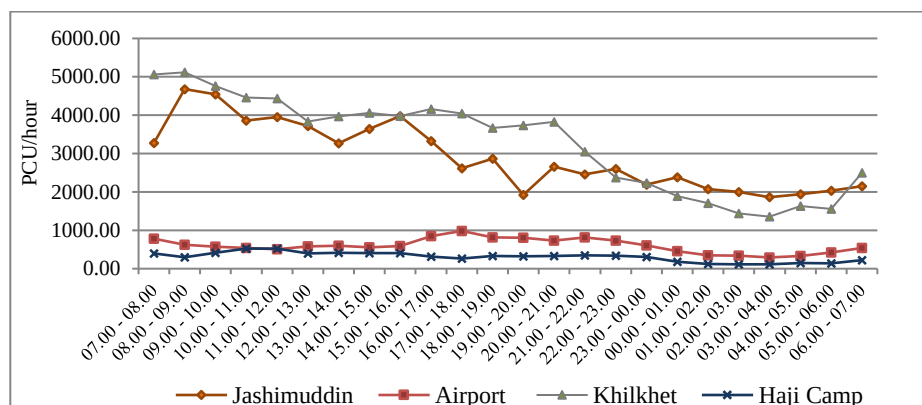


Fig. 9: Comparison of flow fluctuation at airport intersection

From comparison flow fluctuation at airport intersection, Fig. 9 shows that the major vehicular movement is occurred through North and South corridor and it is about 87% of total movement where 41% from North (Jashimuddin approach) and 46% from South

(Khilkhet approach).

More close analysis shows that at this studied intersection the most dominating approach in terms of flow is Khilkhet approach which is 5% higher than Jashimuddin approach. This imbalance between North and South flows might be due to the fact that for outbound traffic from Dhaka they are using either Dhaka-Mymensingh Highway (N3) or Dhaka-Ashulia Highway (N302). But while returning from outside to Dhaka city, for the Ashulia corridor they have two alternatives. At Dhaka they could split into two branches and the other one is Mirpur road (N501).

Approximately 8% vehicles are coming from HSIA. The least vehicles are from Hajicamp approach and it is only 4%.

4.3 Counting of vehicular flow

The counted flow is used to calculate the saturation flow. Another data has been taken for design arrival flow. After that the vehicle flow is converted into PCU and subsequently presented as design flow (vph). The design flow for all approaches is shown in Table 2. One set of data during the peak period from 8.00am to 9.00am in the morning and the other set of data during the peak period from 4.00 pm to 5.00 pm in the evening has taken for analysis.

Table 2: Directional design arrival flow calculation (morning and evening peak hour)

Approach	Arrival flow, q, PCU per hour	
	Morning peak hour	Evening peak hour
Jashimuddin	4679.50	3325.75
From airport	624.25	844.50
Khilkhet	5117.00	4156.50
Haji Camp	300.25	314.00

From Table 2, it is clearly evident that morning peak is the acute traffic leading condition, which is 11% higher than the evening peak. Also, the data shows that Jashimuddin and Khilkhet approach are the most dominating approach in the whole junction.

It is also shows that at Khilkhet approach, the arrival flows both for morning and evening peak hour are almost same and it 48% of total flow. Similar scenario is for Haji Camp approach, 3% in morning peak hour and 4% in evening peak hour of total flow. Major difference appears in Jashimuddin approach, morning time is more demanding than evening which is 6% higher. On the other hand, the arrival flow in the evening time from HSIA is 4% higher than the morning time.

4.4 Calculation of saturation flow

The Road Note 34 method is applied to calculate the saturation flow for all other approaches. The saturation flow for all four approaches is shown in Table 3.

Table 3: Saturation flow (morning and evening peak hour)

Approach	s (veh per hr)	
	Morning peak hour	Evening peak hour
Jashimuddin	26487.20	19142.20
From airport	3877.12	5640.96
Khilkhet	32862.48	23826.60
Haji Camp	3206.56	2470.36

Note that: In the absence of getting oversaturated conditions for airport and Haji Camp approaches for both morning and evening peak hour actual saturation flow could not be calculated. For these approaches, saturation flows are estimated from the other over saturated approaches and considering the corresponding approach width.

4.5 Flow ratio

The flow ratio is expressed by the ratio of design flow and saturation flow, $y = q/s$ where q indicates design flow and s indicates saturation flow. After calculating u and y , they are used to calculate the degree of saturation, x by the equation $x = y/u$. Cycle time and green time are obtained from field. The value of cycle time in the morning is 490 sec. However, green time varies from phase to phase. In phase A, it is 165sec, in phase B it is 85, in phase C it is 170 sec and in phase D it is 70 sec.

Subsequently, using the cycle time and different green time for different phases, the flow ratio (y), green time ratio (u) and the degree of saturation (x) of 4 approaches are calculated. Results are summarized in Table 4 and 5.

Table 4: Calculation of degree of saturation (morning peak hour)

Approach	q (PCU/hr)	s	y (q/s)	g (sec)	c (sec)	u (g/c)	x = y/u
Jashimuddin	4679.50	26487.20	0.177	165	490	0.337	0.525
From airport	624.25	3877.12	0.161	85	490	0.173	0.928
Khilkhet	5117.00	32862.48	0.156	170	490	0.347	0.449
Haji Camp	300.25	3206.56	0.094	70	490	0.143	0.655

Table 5: Calculation of degree of saturation (evening peak hour)

Approach	q (PCU/hr)	s	y (q/s)	g (sec)	c (sec)	u (g/c)	x = y/u
Jashimuddin	3325.75	19142.20	0.174	140	415	0.337	0.515
From airport	844.50	5640.96	0.150	65	415	0.157	0.956
Khilkhet	4156.50	23826.60	0.174	155	415	0.373	0.467
Haji Camp	314.00	2470.36	0.127	55	415	0.133	0.959

4.6 Delay calculation

The values of x ranging from 0.462 to 0.977 and 0.529 to .878 are obtained from morning and evening respectively. According to practical consideration; the degree of saturation limit in between the values of 0.7 to 0.9 is well acceptable.

The Miller (1968) formula for delay is based on an explicit use of the average overflow queue parameter, n_r , given as $d = D/q$. The values of the average delay per vehicles d for each approach are summarized in Table 6 and 7.

Table 6: Calculation of average delay per vehicle (morning peak hour)

Approach	x	y (q/s)	$e^{-1.33x}$	g (sec)	c (sec)	Φ	n_r	u (g/c)	d
Jashimuddin	0.476	0.1604	0.2645	165	490	1013.81	256.087	0.337	284.022
From airport	0.977	0.1694	0.2645	85	490	2.04	11.638	0.173	268.313
Khilkhet	0.570	0.1977	0.2645	170	490	696.84	214.171	0.347	252.876
Haji Camp	0.834	0.1191	0.2645	70	490	8.92	7.098	0.143	287.154

$\Sigma = 1092.364$

Table 7: Calculation of average delay per vehicle (evening peak hour)

Approach	x	y (q/s)	$e^{-1.33x}$	g (sec)	c (sec)	Φ	n_r	u (g/c)	d
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Jashimuddin	0.567	0.191	0.2645	140	415	389.38	118.838	0.337	218.041
From airport	0.878	0.137	0.2645	65	415	14.47	15.655	0.157	236.368
Khilkhet	0.529	0.197	0.2645	155	415	587.39	164.818	0.373	212.927
Haji Camp	0.686	0.091	0.2645	55	415	19.95	8.415	0.133	263.846

$$\Sigma = 931.18$$

The first widely used approximate delay formula was developed by Webster (1961, reprint of 1958 work with minor amendments) from a combination of theoretical and numerical simulation approaches: The values of the average delay per vehicles d for each approach are summarized in Table 8 and 9.

Table 8: Calculation of average delay per vehicle (morning peak hour)

Approach	x	y (q/s)	g (sec)	c (sec)	u (g/c)	d
Jashimuddin	0.525	0.177	165	490	0.337	130.731
From airport	0.928	0.161	85	490	0.173	220.766
Khilkhet	0.449	0.156	170	490	0.347	123.686
Haji Camp	0.655	0.094	70	490	0.143	197.542

$$\Sigma = 672.725$$

Table 9: Calculation of average delay per vehicle (evening peak hour)

Approach	x	y (q/s)	g (sec)	c (sec)	u (g/c)	d
Jashimuddin	0.515	0.1737	140	415	0.337	110.127
From airport	0.956	0.1497	65	415	0.157	206.424
Khilkhet	0.467	0.1744	155	415	0.373	98.601
Haji Camp	0.959	0.1271	55	415	0.133	285.685

$$\Sigma = 700.837$$

4.7 Proposed signal timing

Timing plans are developed for specific sets of traffic conditions, it is important to define the times of day when those traffic conditions exist, and therefore, the times of the day when each plan should be used. It is also important to determine the number of unique sets of traffic conditions that will require signal timing plans. The process of selecting the number of timing plans and the times of the day when they operate may be determined through a combination of reviewing traffic data along the corridor, such as 24-hour directional traffic counts, intersection turning movement counts (TMCs), and traffic engineering judgement.

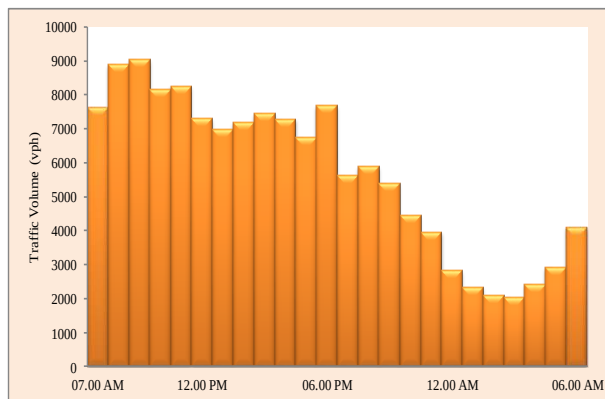


Fig. 10: Total traffic volumes summary used to determine signal day plans

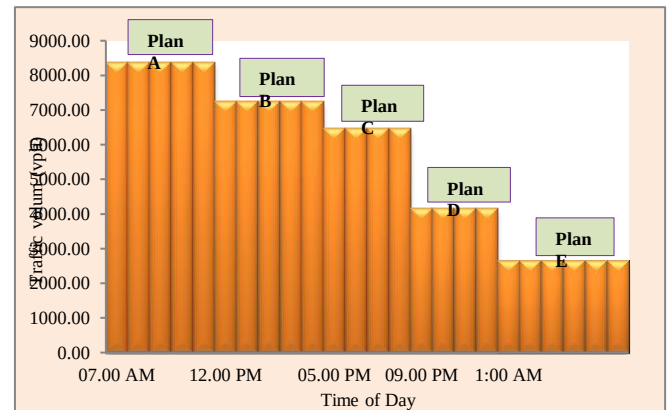


Fig. 11: Traffic volume summary with signal day plan

Based on 24-hour traffic volume data, Fig. 10 shows the hourly periods of arrival traffic

flow that are included three major periods (am, pm and off-peak). Frequently, the greatest benefits can be found in breaking the off-peak period from the peak periods. Scientifically 4 to 6 hours' flow fluctuation pattern reasonable average but significant, based on this five plans have been obtained and these are shown graphically in Fig. 11.

It has been mentioned that degree of saturation criteria should be 0.9. Accordingly, from the analysis it has been found that approximately 32% time is signal design worthy, otherwise other times of degree of saturation is beyond 0.9 for which signal design cannot be calculated as Webster's Model.

Approach	Amber, sec	Red-Amber, sec	Inter green, sec	Lost time, (<i>l</i>) sec
Jashimuddin	3	2	9	13
From airport	3	2	10	6
Khilkheth	3	2	9	10
Haji Camp	3	2	10	6

Note: This longer inter green is obtained as the studied junction is roundabout.

$$L = \text{all red} + \text{green} - \text{ends lost times} = 61 \text{ sec} \quad (10)$$

$$\text{Optimum cycle, } C_o = \frac{1.5L+5}{1.0-Y} = 196 \text{ sec} \quad (11)$$

$$\text{Total effective green time, } C_o - L = 196 - 61 = 135 \text{ sec} \quad (12)$$

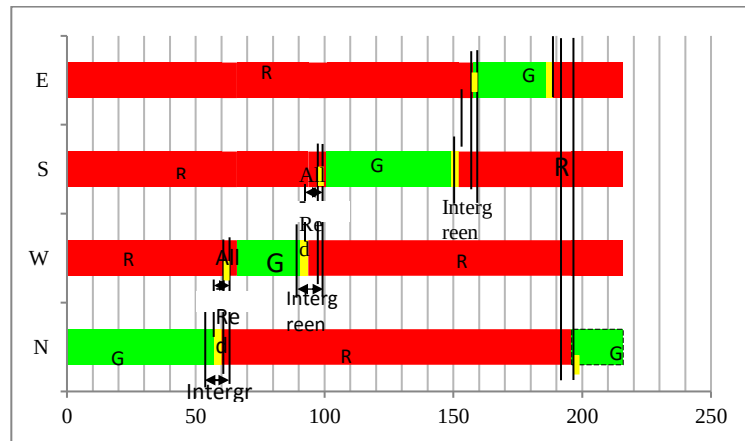


Fig. 12: Proposed signal timing for Plan A

The Fig. 12 shows the distributions of traffic volume and signal cycle of Plan A. Summary of other signal timings are given in Table 10.

Table 10: Summary of different signal plan

Approach	Green time, sec	Amber, sec	Red-amber, sec	Inter green, sec	Optimum cycle time, (C_o) sec	Plan
Jashimuddin	57	3	2	9	196	Plan A
From airport	25	3	2	10		
Khilkheth	48	3	2	9		
Haji Camp	28	3	2	10		
Jashimuddin	47	3	2	9	168	Plan B
From airport	24	3	2	8		
Khilkheth	39	3	2	9		
Haji Camp	24	3	2	8		
Jashimuddin	31	3	2	9	138	Plan C
From airport	19	3	2	8		
Khilkheth	35	3	2	9		

Haji Camp	19	3	2	8	113	Plan D
Jashimuddin	27	3	2	9		
From airport	13	3	2	8		
Khilkheth	26	3	2	9		
Haji Camp	14	3	2	8		
Jashimuddin	23	3	2	9	104	Plan E
From airport	13	3	2	8		
Khilkheth	22	3	2	9		
Haji Camp	12	3	2	8		

4.8 Delay calculation

To improve the junction performance and reduction of delay for various approaches can be done by re-designing signal timings. Five signal timing plans have been proposed for a typical working day. Based on these plans the average delay per vehicle has been calculated to compare the existing situation. Delay has measured based on both Miller (1968) and Webster (1958) formula.

The comparison of total delay per vehicle for all approaches between proposed design plan and existing design phasing and cycle time are by graphical representation in Fig. 13 and 14.

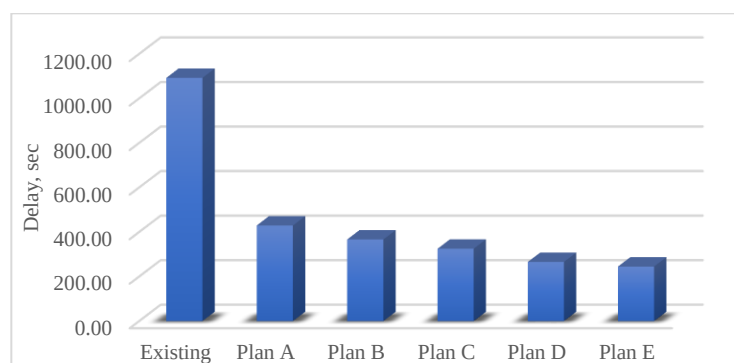


Fig. 13: Comparison of total delay per vehicle between proposed and existing design using Miller's formula

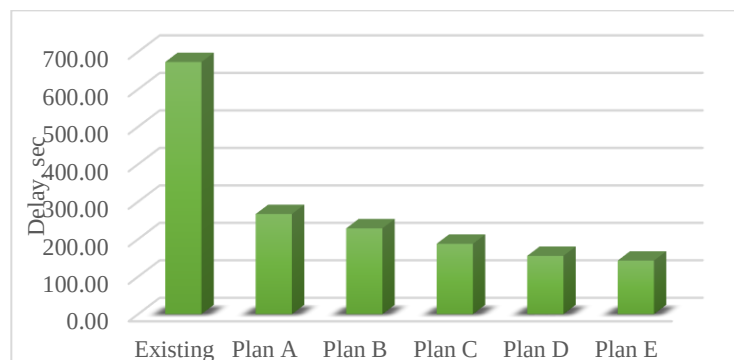


Fig. 14: Comparison of total delay per vehicle between proposed and existing design using Webster's formula

From this analysis, it is observed that the values of delay measured from Miller's and Webster's formula are very close. On average 60%, 66%, 71%, 76% and 78% time is saved for Plan A, Plan B, Plan C, Plan D and Plan E respectively in a typical day.

4.9 Pedestrian Movement

At airport intersection, one of the major considerations is pedestrian movement. Pedestrians are crossing the road at any time even in green time during the traffic movement. These have an effect on safety and also increase delay (Fig. 15).



Fig. 15: Jaywalking at airport intersection

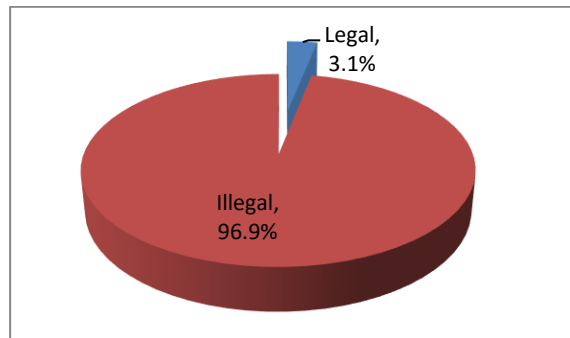


Fig. 16: Pedestrian crossing at airport intersection

The violation occurs for the deficiency of traffic control device and awareness of traffic rules and regulations. From video data, it has been found that in the morning peak hour (08:00 am to 09:00 am) approximately total 1936 pedestrians per hour are crossing the airport road. Among them 1878 or 96.9% are violated the traffic signal at airport intersection in peak hour.

At airport intersection pedestrians' volume is significant so it can be used the pedestrian travel time as follows:

$$\text{Ped time} = 5 \text{ sec} + \text{walk time} \quad (13)$$

From field data, it has found that approximately 12.82 minutes in peak hour is used for pedestrian movement.

4.10 Proposed three phase plans

Analyzing the data, it has been revealed that Airport intersection can be converted three phases junction instead of four phases by constructing a tunnel or underpass or overpass for through traffic (north to south and south to north) untouched. There will be two northbound lanes and two southbound lanes connecting Jashimuddin and Khilkheth road.

(a) This underpass or overpass will turn the junction from four phases in to three phases. As a result, the cycle length will reduce and the major traffic can flow without any disruption. Using the Webster's formula, the cycle length is 95 sec for Plan A.

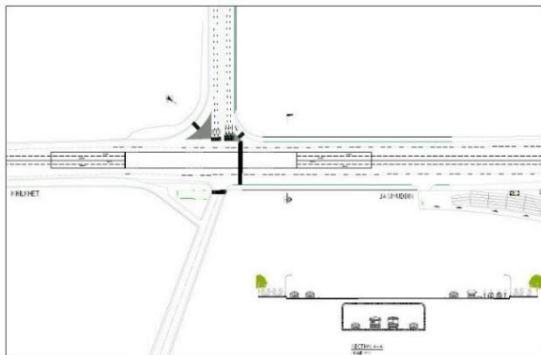


Fig. 17: Layout plan and profile of underpass



Fig. 18: Superimposed image of elevated section

(b) Alternative grade separation can be made at airport approach. It has been found from different case studies that the Airport bound traffic need smooth and uninterrupted service. But in HSIA the scene is different and is not at ease for the travelers. To make simpler travel, a trumpet interchange can be constructed to at Airport approach and will down at Khilkhet approach. A ramp can be connected at Haji Camp approach to connect BRT and railway station (Fig. 19). Using the same method, the cycle length is 100 sec for Plan A.

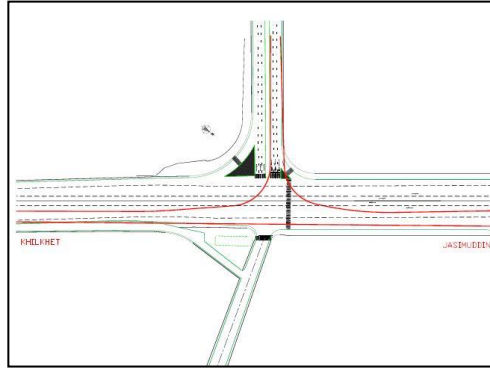


Fig. 19: Plan view of elevated section from airport to Khilkhet approach

5. Other Associated Problems

The efficiency of the intersection does not totally depend on the signal timing. There are also some other factors such as, road marking, median, parking, buses stoppage, footpath, and pedestrian facilities. There are some problems and solutions of those problems have been suggested along with some photo and figures as shown below:

5.1. Roundabout

A "modern roundabout" is a type of looping junction in which road traffic travels in one direction around a central island and priority is given to the circulating flow. Signs usually direct traffic entering the circle to slow and to give way to traffic already on it. Because low speeds are required for traffic entering roundabouts, they are physically designed to slow traffic entering the junction to improve safety, so that the roads typically approach the junction radially; whereas rotaries are frequently designed to try to increase speeds, and thus have roads that enter the traffic circle tangentially.



Fig. 21. Roundabout at airport intersection

Because of the requirement for low speeds, roundabouts usually are not used on controlled-access highways. Analyzing the arrival traffic flow data and degree of saturation, it has been revealed that approximately 32% time is signal design enabled and for rest of the oversaturated traffic condition. There is a need for other non-signal treatments viz.

elimination of the roundabout, introduction of U-loop, junction grade separation etc. Based on data analysis and field observation, it has been found that this roundabout increase delay by increasing travel time.

Channelization at airport junction is intended to: a) segregate traffic flows from each other and reduces the area of conflict between different intersecting traffic streams; b) provide junction angles to give good visibility; c) define driving patterns and indicate which road has priority at a junction.

5.2. Drainage

Drainage is an important consideration in the design of an intersection. The development of the drainage for the roadway affects (or is affected by) roadway grades, roadway cross section, curb ramp placement, and intersection location. Water logging during monsoon (May to October) as a common problem in Dhaka as well as airport junction. Main causes are excessive rainfall, inadequate drainage sections, conventional drainage system with low capacity and gravity, natural siltation, absence of inlets and outlets, indefinite drainage outlets, lack of proper maintenance of existing drainage system, and over and above disposal of solid waste into the drains and drainage paths.

The pictures are illustrating (Fig. 23) the water logging situation near airport intersection due to rainfall which creates unbearable traffic congestion. The oversaturated period become very acute when drainage water is stagnant which drastically reduce the effective width as the saturation flow is directly related with road width. About 7 to 8 ft which is nearly 10% to 12% reduce the effective road width. This needs to be addressed immediately.



Fig. 23. Pictures illustrates water logging situation near airport intersection

5.3. CNG / Fuel station

Two CNG / Fuel stations are situated near the intersection towards south (Fig.24). It is one of the major bottlenecks and creates huge traffic jam during morning and evening peak hour. To maintain this intersection in full operation it is urgent to shift those fuel stations immediately.



Fig. 24. Fuel station near the airport station

5.4. Traffic signal post

There is no traffic signal in airport intersection. This section is fully manually controlled by traffic police. Traffic signal posts are critical elements of the traffic signs because they communicate the rules, warnings, guidance, and other agency information that drivers as well as road users need to safely and efficiently navigate roads and streets. Well maintained signal posts are important as they help drivers make good decisions.

5.5. Pedestrian signal light operate (PSLO)

Pedestrian signal lights improve pedestrian safety at traffic lights crossing. For many years, traffic volumes were much lower, and pedestrians could take their cues from the same traffic lights as motorists. Things are more complicated today, so pedestrian signals were introduced to provide means to separate the pedestrian from the motorists at the intersection. Now-a-days traffic police are using rope to control the pedestrian. A warning sign should be placed which shows the prohibition of illegal road crossing. For this purpose, strictly followed traffic policy and enforcement is necessary to be imposed by the concern authority.

5.6. Road marking

There is no lane marking in this section. Bare roads are leading to total vehicular confusion. Road markings include all lines patters, words and colors applied on or attached to the road surface or kerb. These markings promote road safety and ensure smooth flow of traffic. Sometimes road markings are used to supplement the message of road signs and other devices.

5.7. Upgradation of international airport

Currently upgradation of Hazrat Shahjalal International Airport is going on, which include construction of the third terminal and improvement in apron and hanger facilities would help the airport double its passenger handling capacity (Fig. 26). In the first phase, the third terminal, a five-star and a three-star hotel with a shopping arcade, cargo village, VIP complex and domestic terminal will be constructed. The works are ongoing and supposed to be completed by 2019.

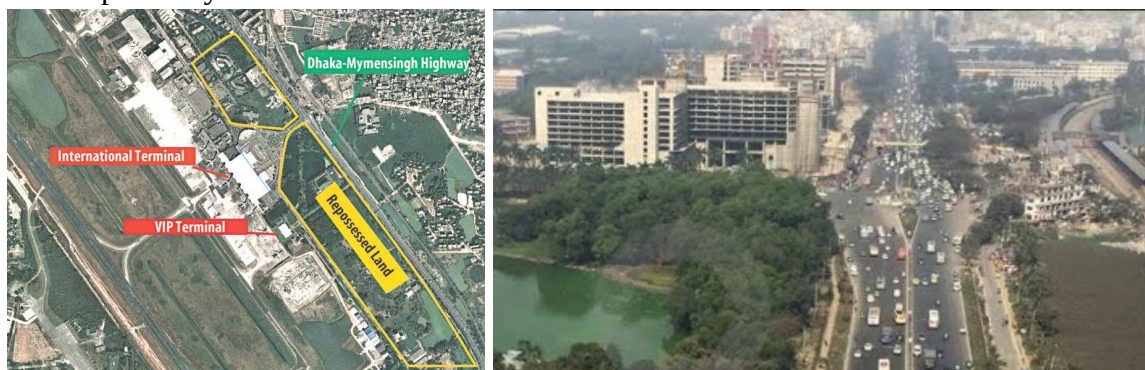


Fig. 26. Airport upgradation construction site near airport intersection

6. Conclusions

This paper presents the existing problem at airport intersection to derive the operational delay of traffic. Delay is frequently used as an optimization and evaluation criteria because it is measure of performance that a driver can directly relate to. Moreover, delay is criteria whose meaning is easily comprehended by both traffic professional and the general public. The objective is the minimization of delay time by proposing new signal timing plan and

improving operating condition of the junction by proposing three phase signal plans.

A tunnel of the underpass of approx. 200 m or elevated section can be constructed in such a way as to leave the through traffic (north to south and south to north) unscathed. There will be two northbound lanes and two southbound lanes connecting the Jashimuddin road with the Khilkhet road. This underpass or overpass will turn the junction from four phases in to three phases. As a result, the cycle length will reduce and the major traffic can flow without any disruption.

It has been found from different case studies that the Airport bound traffic need smooth and uninterrupted service. But in HSIA the scene is different and is not at ease for the travelers. To make simpler, an interchange can be constructed to at Airport approach and will down at Khilkhet approach. A ramp can be connected at Haji Camp approach to connect BRT and Railway station.

To ease the traffic gridlock, need proper channelization for left turning traffic to a) segregate traffic flows from each other and reduces the area of conflict; b) provide junction angles to give good visibility; c) define driving patterns and indicate which road has priority at a junction.

Despite all the traffic engineering measures there is a significant importance of the involvement of the traffic police for effective implementation of these measures. Qualitatively more discipline in the starting and stopping operations can be observed when there were sufficient number of traffic police at the junction. This implies that in the context of Bangladesh whatever engineering measures may be taken, its success will always depend on the performance and the involvement of traffic police. So, effective and sufficient number of traffic police should be deployed in all the important junctions.

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Determinants of Fertility Rate Decline in the South Asian Countries: A Panel Data Approach

Istihak Rayhan¹, Khaleda Akter² and Farjana Khanom²

¹ M. Sc. Student, Department of Economics, Jahangirnagar University, Savar, Dhaka-1342

² M. Sc. Student, Department of Economics, Jahangirnagar University, Savar, Dhaka-1342

Abstract

Over the last three decades fertility rate decline substantially all over the world. The aim of this study is to investigate the macroeconomic determinants of fertility rate decline in the South Asian countries. Data are taken from seven south Asian countries named Bangladesh, India, Sri-Lanka, Nepal, Pakistan, Bhutan and Maldives over the period of 1990-2015. Breusch-Pagan, Honda, King-Wu, Standardized Honda and Standardized King-Wu Lagrange Multiplier test confirm there exists cross-section effects. Hausman test confirm that fixed effect model is appropriate for empirical analysis for this study. But Breusch-Pagan LM test, Pesaran scaled LM test and Baltagi, Feng, and Kao bias-corrected scaled LM test confirm that there exists cross-sectional dependence in residuals. Therefore, Panel Corrected Standard Error (PCSE) model has been employed to get the unbiased estimators. Empirical results of PCSE model confirm that per capita GNI, Female labor force participation rate, Education, Infant mortality rate, and urbanization have statistical significant impact on fertility rate in the south Asian countries. Empirical results reveal that increase of per capita GNI, female labor force participation rate, education, and urbanization will cause to decline fertility rate, while decline of infant mortality rate will cause to decline it, which is in accordance with our theoretical expectation. Therefore, we expect that to control the population growth rate policy makers should take these factors under their consideration.

Keywords: *Fertility Rate, South Asian Countries, Fixed effect model, Cross-sectional dependence, Panel Corrected Standard Error (PCSE)*

1. Introduction

Over the last four decades it's a tremendous achievement for the developing countries that they can substantially bring population growth rate under their control. The highest population growth rate was 1.80 percent per year during 1955-1975 and between 1965 to 1970 it was the peak time when population had been grown at a rate of 2.06 percent ('World population' 2017). But in 2010 to 2015 it becomes 1.18 percent. Perhaps, population in the south Asian countries is a matter of concern because three among top ten populous countries around the world are in South Asia; India 2nd, Pakistan 5th and Bangladesh 7th ('World population' 2017). Almost 22.43% of world population live in this three south Asian countries. If we consider countries ranking both total population (more than 20 million people) and population density (more than 250 people per square kilometer) then the top three countries of the world are India, Pakistan and Bangladesh, respectively, and Sri-Lanka is in 10th position. It means that south Asian countries are overly populated. Average fertility rate in the south Asian countries were always higher than the world average. In 1961 the average fertility rate at the world level was 5.01, while in the south Asian countries it was 6.05, and in 2015 fertility rate at the world level becomes 2.45, while in the south Asian countries it was 2.492 percent. In the south Asian region, India and Sri-Lanka are considered as growing country respect to population, but Bangladesh and Pakistan are considered rapidly growing countries respect to population. The population size and fertility rate of south Asian countries are shown in Figure-1 and Figure-2 respectively by area plot.

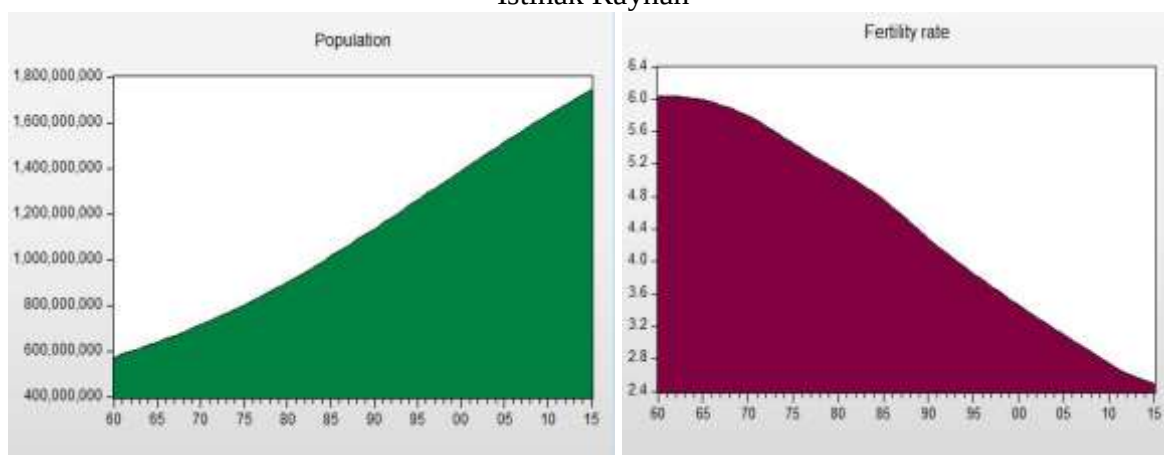


Figure 1: Population in South Asia

Figure 2: Total Fertility rate in South Asia

Day by day, population size in the south Asian countries is increasing. Such a huge population living in those countries may create a severe pressure on its agricultural lands, forests and other natural resources. As a result, it is a great challenge to allocate and distribute the basic needs such as food, shelter, education, medical facilities etc. to its entire population. In this context, it is obvious to control the population growth rate of those countries and establish a suitable policy to utilize existing population. The total fertility rate (TFR) is not only an indicator to indicate the future population size of a country but also it has a big impact on the socioeconomic condition of a country. For example, by understanding the level, pattern and the nature of fertility, the decision makers can take appropriate steps to prepare a suitable policy for a country. Low fertility rate can play a good role to accelerate economic growth in a populous country. That's why, in this study we try to identify core macroeconomic factors that can play a crucial role in controlling fertility rate. Some very important macroeconomic factors such as per capita GNI, proper education, infant mortality rate, female workers participation in the total labor force, and Urbanization can play a good role in controlling fertility rate, besides biological factors like use of modern contraceptive method.

Theoretically female education can play a good role in controlling fertility rate. Generally the opportunity cost of an educated female is higher than an uneducated female so that educated females try to engage themselves into various economic activities which influence them to take less children. At the same time son preference of an educated female is much smaller than an uneducated female. For this reason educated females feel happy with their small family whether they have male or female children. Moreover there exists a trade-off between number of children and the time available for children. An educated mother tries to give more time to their children and it becomes easier for her if family size remains small. Educated women may be more receptive to modern social norms and family planning campaigns and they are aware about planned family size. They are also aware about their health and the risk associated with taking more children. For these types of reasons, theoretically it is believed that female education has a significant impact on fertility control. It's also an important consideration which won't touch by most of the past empirical works that besides female education male education also has a great importance on fertility rate decline. Whether a girl is sent to school or not, whether a girl can get access to higher education or not, whether a wife takes part in the labor force or not, whether a woman takes more than two children or not, these types of decisions are greatly controlled by the male in a house in the south Asian region. And an educated father or husband should

be more liberal than an uneducated father or husband. That's why, not only female education but also male education are important factor in controlling fertility rate. In this context we use both male and female education that means overall education and try to identify its impact in the south Asian countries in determining fertility rate.

Theoretically it is believed that there exists a negative relationship between economic growth and fertility rate. When per capita income is very low then people cannot invest more on their children to enhance human capital or they cannot afford that. Rather they want more children, especially boys, because they believe that these boys will remove their suffering in the future by increasing family income. But as per capita income increases, people convert their focus on human capital, which gradually reduce the tendency of more child. As a result, with higher economic growth cause to decline fertility rate. Theoretically infant mortality rate is a very important determinant of fertility rate. When infant mortality rate was high, the uncertainty associated with a child becomes high too. To minimize this uncertainty people have a tendency to take more child which increase fertility rate. But when infant mortality rate was low or negligible then this uncertainty also tends towards zero and people feel happy with less child and for this reason fertility rate decline. Moreover theoretically it is believed that four possible mechanisms such as biological, replacement, insurance and societal response play influential role by which infant mortality can influence fertility rate.

It is believed that the process of urbanization can directly influence the fertility rate, because empirical studies suggest that urban fertility rate is lower than the rural fertility rate. The reason behind this is that urban women get some extra facilities like access to higher education, access to health care service, access to labor force etc. Moreover, Urban area free from many superstition and urban women can overcome some back dated social norms which remains at a strong position in the rural mind. For this reason expansion of urbanization process is helpful to control fertility rate.

2. Literature Review

This section para-phase some relevant literature related to fertility rate decline. Caldwell (1980) proposed mechanisms through which mass education produces declines in fertility. He argued that the primary determinant of the timing of the onset of the fertility transition is the effect of mass education on the family economy. Dreze and Murthi (1995) demonstrated the interaction among Fertility, Education and Development by analyzing the data of India. They examined the determinants of fertility levels and fertility decline using panel data. They found that women's education is the most important factor explaining fertility differences. Low levels of child mortality and son preference also contribute to lower fertility. They also find that general indicators of modernization and development such as urbanization, poverty reduction and literacy bear no significant association with fertility. Martin (1995) by analyzing data from the Demographic and Health Surveys for 26 countries found that higher education is consistently associated with lower fertility rate. Galored and Zang (1997) showed that the combined effect of fertility and income distribution is substantial in explaining per worker (per-capita) output and growth performance accross countries. Ahn and Mira (2001) by analyzing a panel of OECD aggregate fertility and labor market data between 1970-1995 found significant negative correlation between fertility rate and female labor force participation rate during 1970's and up to early 1980's, but found significant positive correlation by the late 1980's. Syamala (2001) analyzed the relationship between infant and child mortality and fertility. They demonstrated the influence of child mortality on fertility behavior of women. They

found that the net effect of child mortality could be substantial. Women with personal experience of child loss and having pessimistic opinion about the level of mortality produced on an average about two children more than similar women who never experience a child loss and were optimistic about the level. The tendency to replace a dead child was found to cut across the level of literacy and religious background of women. McNown (2003) investigated a cointegration model of age – specific fertility and female labor supply. They also included women's wages, unemployment rates and education attainment and male relative income. Their estimated long run relationships and short run dynamics are consistent with economic models of fertility and female labor market behavior. Engelhardt et al. (2004) analyzed the relationship between fertility and women's employment status by taking macro-level the time series data of France, West Germany, Italy, Sweden, the UK, and the USA over the period of 1960 -2000. They find a negative and significant correlation between them until about the mid 1980's and an insignificant or weaker negative correlation afterwards. Kimura and Yasui (2007) developed an overlapping generations model that incorporates occupational (educational) choices and fertility decisions and explained the fertility decline as the result of the popularization of higher education with capital accumulation. Li and Zhang (2007) found negative impact of fertility rate on economic growth using a panel data set of 28 provinces in China over twenty years. Hasan et al. (2009) examined the determinants of fertility decline by analyzing the Asian countries over the period 1975-2008. They explore the association of socioeconomic factors with fertility outcome in Asia. They found that family planning use in a community and female education are associated with a lower likelihood of giving birth. Family planning in a community is the main contributor in explaining fertility decline particularly in Bangladesh. Hondroyannis (2009) examined the relationship between fertility determinants and economic uncertainty based on panel data for 27 European countries. They used two measures of economic uncertainty associated with labor market decisions; one is production volatility and another is unemployment rate. Their results reveal that both measures of economic uncertainty have a significant negative impact on fertility rate. Ashraf et al. (2013) examined the interaction between the effects of Fertility reduction on economic growth. They assessed quantitatively the effect of exogenous reduction in fertility on output per capita. They examined the effect of a change in fertility from the UN medium –variant to the UN low – variant projection in Nigeria. They found that such a change would raise output per capita. Cygan-Rehm and Maeder (2013) investigated the effect of education on fertility under inflexible labor market conditions. They exploited exogenous variation from a German compulsory schooling reform to deal with the endogeneity of education. By using the data from two complementary datasets they examine different fertility outcomes over the life cycle. They found that increased education causally reduces completed fertility.

3. Methodology of this study

In this study we try to investigate the relationship among fertility rate, per capita GNI, female labor force participation rate, education, infant mortality rate, and urbanization. We treated fertility rate as dependent variable and rest of them as independent variables. The data are collected from the World Development Indicator 2017. A balanced panel data set of seven south Asian countries named Bangladesh, India, Sri-Lanka, Nepal, Pakistan, Bhutan and Maldives over the period of 1990-2015 are used for empirical works. Variables, their definitions and expected sign are presented in table-1.

Variable name	Definition	Expected Sign
Fertility rate (FR)	Fertility rate, total (births per woman)	
Per capita GNI (PGNI)	GNI per capita (current US dollar)	(-)
Education (EDU)	Enrollment in secondary school, general	(-)
Infant mortality rate (IMR)	Mortality rate, infant (per 1,000 live births)	(+)
Urbanization (UR)	Urban population percentage of total population	(-)
Female Labor Force Participation (FLF)	female labor participation percentage of total female labor force	(-)

Logarithmic transformation of the variables have been used to get the elasticities. The estimable model of this study is:

$$\ln FR = \alpha + \beta_1 \ln PGNI_{it} + \beta_2 \ln FLF_{it} + \beta_3 \ln EDU_{it} + \beta_4 \ln IMR_{it} + \beta_5 \ln UR_{it} + \varepsilon_{it} \dots (1)$$

Where $i = 1, 2, 3, \dots, N$

$t = 1, 2, 3, \dots, T$

And ε_{it} = the error or the disturbance term.

3.1 Fixed effect model

To analyze the impact of the variables those are time invariant fixed effect model is used. A fixed effect model allows the intercept in the regression model to vary across cross sections but does not allow the intercept to vary across time. The relationship between independent and dependent variables is explored by this model within an entity (here country). Independent variables may or may not be influenced by the individual characteristics of each entity. The functional form of fixed model is:

$$\ln FR = (\alpha + \mu_i) + \beta_1 \ln PGNI_{it} + \beta_2 \ln FLF_{it} + \beta_3 \ln EDU_{it} + \beta_4 \ln IMR_{it} + \beta_5 \ln UR_{it} + v_{it} \dots (2)$$

Where $i = 1, 2, 3 \dots N$

3.2 Random effect model

Random effect model is used to examine the differences in error variance components across time period or individual. In this model the variation across individuals (countries) is supposed to be random and uncorrelated with the explanatory variables included in the model. The functional form of random effect model is:

$$LnFR = \alpha + \beta_1 LnPGNI_{it} + \beta_2 LnFLF_{it} + \beta_3 LnEDU_{it} + \beta_4 LnIMR_{it} + \beta_5 LNUR_{it} + (\mu_i + v_{it})$$

.....(3)

Where $i = 1, 2, 3 \dots N$

It has been assumed in a random effect model that there is no correlation between individual effect (heterogeneity) and any predictor variable. Based on this assumption the model estimates error variance specific to groups (or times). The intercept and slopes of predictor variables are finite across entity. The difference among entities (or time periods) is not reflected in their intercepts, rather it is reflected in their individual specific errors. Random effect model is often termed as error component model as is treated as a part of the composite error term.

3.3 Lagrange Multiplier Tests for Random Effects

To select the best model between simple pooled OLS and random effect model Lagrange Multiplier tests are used. In this study Breusch-Pagan, Honda, King-Wu, Standardized Honda and Standardized King-Wu LM test have been employed.

3.4 Hausman Test

Hausman (1978) suggests a test that can be applied to the hypothesis testing problems with two different estimators. This test is called Hausman test. To select between fixed effect and random effect Model Hausman test is applied in this study.

3.5 Methods to Deal with Contemporaneous Correlation in the Model

When cross-sectional dependence or contemporaneous correlation exists in a panel data model, basic fixed effect or random effect model provides biased estimate. Therefore, in the presence of cross-sectional dependence Panel Corrected Standard Error (PCSE) model has been employed to get the unbiased results. Breusch-Pagan (1980) LM test, Pesaran (2004) scaled LM test and Baltagi, Feng, and Kao (2012) bias-corrected scaled LM test are used to check the cross-sectional dependence in this study.

4. Results and Discussion

The descriptive statistics of the variables used in this study in terms of their mean, standard deviation, minimum and maximum values are listed in following table. N, n and T represent number of total observation, number of panel ids (countries) and number of time periods respectively.

As panel data consists of repeated observations on the same individuals, we can find two sources of variance within the sample. It is due to the fact that each individual is systematically different from other individuals (between- individual variations) and individual's characteristics vary among observations over time (within – individual variation).

Table-2 shows the results of descriptive statistics of all the variables under consideration.

Table 2: Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max	Observations
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Id	Overall	4	1.419684	1	7	N= 182
	Between		1.581139	1	7	n= 7
	Within		0	4	4	T= 26
Year	Overall	2002.5	7.529014	1990	2015	N=182
	Between		0	2002.5	2002.5	n =7
	Within		7.529014	1990	2015	T=26
Infr	Overall	1.157251	.297836	.7241612	1.795752	N=182
	Between		.2502592	.8127498	1.497429	n =7
	Within		.1954843	.6693976	1.574334	T=26
Inpgni	Overall	6.410511	.6733581	5.247024	8.229511	N=182
	Between		.481176	5.757361	7.084599	n=7
	Within		.5164794	5.478644	7.555423	T=26
Inflf	Overall	3.651891	.5177217	2.526049	4.415848	N=182
	Between		.5574119	2.878975	4.389036	n=7
	Within		.1324482	3.298965	3.963927	T=26
Inedu	Overall	15.73807	1.469392	12.98963	18.66754	N=182
	Between		1.578859	14.15189	18.21403	n =7
	Within		.386544	14.57581	16.55001	T=26
Inimr	Overall	3.818435	.7122418	2.116256	4.665324	N=182
	Between		.7233409	2.564172	4.433438	n =7
	Within		.2923458	3.182051	4.420067	T= 26
Inur	Overall	3.130929	.3545957	2.180869	3.657337	N=182
	Between		.3657723	2.614852	3.529699	n =7
	Within		.1337047	2.696946	3.440045	T=26

4.1 Results of Lagrange Multiplier Tests for Random Effects

Table 3: Results of Lagrange Multiplier Tests for Random Effects

Lagrange Multiplier Tests for Random Effects			
Null hypothesis: No effects			
Alternative hypothesis: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives			
Test Hypothesis			
Test	Cross-section	Time	Both
Breusch-Pagan	95.8930 (0.0000)	0.62088 (0.4307)	96.5139 (0.0000)
Honda	9.79250 (0.0000)	0.78796 (0.2154)	7.48151 (0.0000)
King-Wu	9.79250 (0.0000)	0.78796 (0.2154)	9.14058 (0.0000)
Standardized Honda	16.4788 (0.0000)	0.91902 (0.1790)	5.05698 (0.0000)
Standardized King-Wu	16.4788 (0.0000)	0.91902 (0.1790)	9.26331 (0.0000)

To identify whether Pooled OLS model is the best model or there exists random effects we run Breusch-Pagan LM test, Honda LM test, King-Wu LM test, Standardized LM test and Standardized King-Wu LM test. All these tests reject the null hypothesis of no effects. Therefore, Pooled OLS is not suitable for this study.

4.2 Results of Hausman Test

Hausman test is run to determine whether fixed effect model or random effect model provides best estimates of the variables. Table-4 shows the results of Hausman test.

Table 4: Results of Hausman test

Hausman Test	Chi-Sq Statistic	Chi-Sq d.f.	Probability
Cross-section random	75.990764	5	0.0000

The probability value of the test statistic for Hausman test is lower than 0.001 in this study. So, we can reject the null hypothesis easily. As we can rejected the null hypothesis of random effect, alternative hypothesis of fixed effect is accepted. So fixed effect model is preferred over Random effect model according to Hausman test.

4.3 Results of cross-sectional dependence test

We use Breusch-Pagan (1980) LM test, Pesaran (2004) scaled LM test and Baltagi, Feng, and Kao (2012) bias-corrected scaled LM test are used to check the cross-sectional dependence in this study. The results of the cross-section dependence test are presented in table-5.

Table 5: Results of cross-section dependence test

Residual Cross-section Dependence Test Null hypothesis: No cross-section dependence (correlation) in residuals			
Test	Statistic	Degrees of freedom	Probability value
Breusch-Pagan LM	179.1480	21	0.0000
Pesaran scaled LM	24.40277		0.0000
Bias-corrected scaled LM	24.2677		0.0000

The null hypothesis of this three tests is that there is no cross-section dependence (correlation) in residuals. From table-5 we see that the respective p-value of these three test are zero. So we can reject the null hypothesis at 0.001 percent level of significance. As we can reject the null hypothesis, so we can say that there exist cross-sectional dependence (correlation) in residuals.

4.4 Results of Estimated models

Panel Corrected Standard Error (PCSE) model provides unbiased results in case cross-sectional dependence. It also gives results by correcting auto-correlation and heteroscedasticity. The estimated results of pooled regression, fixed effect model, random effect model and PCSE model are presented at table-6.

From the estimated results of the PCSE we find that the impact of per capita GNI is statistically significant and negative and one percent increase in per capita GNI, on average, will cause to decline fertility rate by 0.0472177 percent. This result is consistent with many other empirical findings and also consistent with our theoretical expectantion. Economic growth plays a significant role to decline fertlity rate.

It is found that the impact of female labor force participation rate on fertility rate is statistically significant and negative, which is in accordance with theoretical expectations and also consistent with many others empirical works. One percent increase in female

labor force participation rate, on average, will cause to decline fertility rate by 0.10 percent.

Impact of education on fertility rate is found statistically significant and negative, which is consistent with many other empirical works and in accordance with our theoretical expectations. Empirical results reveal that one percent increase in education, on average, decline fertility rate by 0.12 percent.

Empirical results also reveal that impact of urbanization on fertility rate is statistically significant and negative too, which is in accordance with our expectations. One percent increase in rate of urbanization process, on average will cause to decline fertility rate by 0.433292 percent.

Finally, the impact of infant mortality rate on fertility rate is found statistically significant and positive, which is in accordance with our theoretical expectation and also consistent with many other empirical works. Results reveal that if infant mortality rate can be reduced by one percent then, on average, fertility rate will decline by 0.2083 percent.

Table 6: Results of estimated models

Variables	Pooled Regression	Fixed Effect Model	Random Effect Model	PCSE Model
lnpgni	.0160065*** (0.0000)	-.046268** (0.0334)	-.066800*** (0.0000)	-.0472177*** (0.0000)
lnflf	-.122312*** (0.0000)	-.117757*** (0.0014)	-.244969*** (0.0001)	-.100210*** (0.0000)
lnedu	-.013410*** (0.0001)	-.136453*** (0.0000)	-.049734*** (0.0000)	-.120010*** (0.0000)
lnimr	.506850*** (0.0000)	.225478*** (0.0000)	.296354*** (0.000)	.208300*** (0.0000)
lnur	-.369613*** (0.0000)	-.342854*** (0.0064)	-.282549*** (0.0000)	-.433292*** (0.0000)
constant		4.08*** (0.0000)	3.0089*** (0.000)	4.123690*** (0.0000)
R ²	0.8412	0.9538	0.900	0.9986
Adj R ²	0.8376	0.9508	0.897	0.9985

*** Significant at 1% level

** significant at 5% level

* significant at 10% level

The R-square of the PCSE model is 0.9986 and the adjusted R-square is 0.9985 which is almost same as R-square. Therefore, after adjusted with degree of freedom almost 99.85 percent of the total variation of the total fertility rate can be explained by per capita GNI, female labor force participation rate, education, infant mortality rate and urbanization process in the south Asian countries.

PCSE model gives the unbiased estimators by correcting cross-sectional dependence. We also check the cross-sectional dependence of PCSE model, which are tabulated in table-7. From table-7 we see that all the three tests can not reject the null hypothesis of no cross-sectional dependence (correlation) in residuals. Therefore, there are no cross-sectional dependence in PCSE model.

Table 7: Results of cross-sectional dependence for PCSE model

Residual Cross-section Dependence Test Null hypothesis: No cross-section dependence (correlation) in residuals			
Test	Statistic	Degrees of freedom	Probability value
Breusch-Pagan LM	10.64013	21	0.9693
Pesaran scaled LM	-1.598563		0.1099
Bias-corrected scaled LM	-1.7353		0.0821

We also check whether data are normally distributed or not. The results of normality test are presented in table-8.

Table 8: Normality test result

Jarque-Bera = 0.2080
Probability = 0.9025

The null hypothesis of normality test is data are normally distributed and we can not reject the null-hypothesis at 10 percent level of significance. That means our data, which is used in this study, are normally distributed.

6. Conclusion and Policy Recommendation

In our study we attempt to identify the macroeconomic determinants of female fertility rate decline by analyzing seven South Asian countries using panel data regression analysis over the period of 1990- 2015. From the estimated PCSE results we find that the impact urbanization on fertility rate is higher than rest of the variables. One percent increase in urbanization process will cause to decline fertility rate by 0.433292 percent on average. The second influential variable to control fertility rate is the infant mortality rate. One percent decline of infant mortality, on average, will cause to decline fertility rate by 0.21 percent. The third important factor is education. If total secondary enrollment can be increased by one percent then, on average, fertility rate will decline by 0.12 percent. The fourth important variable is the female labor force participation rate. If female labor force participation can be increased by one percent then, on average, female labor force participation rate will decline by 0.10 percent. Finally the impact of per capita GNI on fertility rate is relatively small. One percent increase in per capita GNI, on average, will cause to decline fertility rate by 0.047 percent. So policy makers can give special focus on urbanization process, infant mortality rate, education and female labor force participation rate to control fertility rate in the south Asian countries.

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Identification of Drought in Barind Tracts using long term rainfall data and SPI

Md. Shafiqui Islam¹

¹Assistant Professor, Center for Sustainable Development, University of Liberal Arts Bangladesh and Doctoral Researcher, Institute of Disaster Management and Vulnerability Studies, University of Dhaka.

¹Corresponding author: Center for Sustainable Development, University of Liberal Arts Bangladesh, email: shafiqui.islam@ulab.edu.bd

Abstract

Drought identification is an important factor in managing drought risks. This study focuses on identification of drought at different locations using time series data of precipitation. Standardized Precipitation Index (SPI) was used in this study. 39 years rainfall data from six stations were used for the calculation of SPI. In getting in-depth information six focus group discussions were conducted in six locations. Most severe and extreme droughts were identified using 12 month precipitation data set. In case of 3 month data set, it was observed that the highest frequency of droughts was recorded in the study area. According to analysis it was observed that Tanore is the drought prone among other study locations. The drought scale and frequency depends on several factors including, month, distribution & duration of rain and amount of precipitation. Interestingly it was recorded that the maximum and minimum rainfall occurs at Tanore and eventually frequent drought occurs at Tanore. Mild dryness is very much common in winter among locations during the period but severe and extreme droughts were identified during pre monsoon and monsoon. Respondents from Focus Group Discussions reported that seasonal and rainfall variability is very much common in the study areas over time. They believed that it is happening due to climate change and changing of weather pattern. Some time erratic rainfall observed in the study areas and they believed that this is happening due to climate change. These droughts caused huge damage to the crops and people's livelihoods. Monsoon droughts are more severe than pre monsoon droughts. They entirely relied on rain-fed agriculture during monsoon. People opined that there is difference of rainfall among the locations. According to study findings it could be said that rainfall varied significantly among locations over time. SPI could be a helpful tool in identifying drought scale and frequency. This measurement can make the people aware about future crop planning and drought management. Identification of drought using SPI can contribute lots towards drought risk reductions.

Keywords: Drought; extreme drought; severe drought; livelihoods; society

1. Introduction

Drought exists in the world like as chronic disease. This is interlinked with abnormal consequences of weather and climate. Meteorological drought is lacking from uniform definition and this question has been raised several times (Agnew and Anderson, 1992; Whilhite, 1993). According to Palmer (1965) many agreed that drought is a meteorological event. The drought is originated from abnormality including less and erratic rainfall, water shortfall, extreme temperature and unavailability of underground water table. Meteorological drought is very much associated with weather parameter. Rainfall is one of the imperative drivers of meteorological drought. Erratic and less rainfall is the common feature in the Barind Tracts. The mean annual rainfall of Rajshahi, Chapainawabganj and Naogaon districts is lesser than other districts of Bangladesh (BBS, 2014). According to Morid et al., (2006), many rainfall based indicators are being used for identification and monitoring of drought. Long term mean rainfall which is deviated from normal is the most commonly used pointer for drought monitoring. The occurrence of rainfall less than seventy percent of normal precipitation in South Africa is called as drought and if it continues for consecutive two years indicate severe drought (Bruwer, 1990). The extreme weather parameters including precipitation and temperature may extend to severe drought and generated heat spell that can measure through statistical analysis of a localized rainfall data (Afnagideh et al., 2010). Standardized Precipitation Index (SPI) is the measure of actual rainfall and standardized departure with respect to rainfall frequency distribution function and hence the index has get popularities at present as the potential drought recognizer allowing relationship over locations and time. It requires long term rainfall data for specific locations to measure mean, standard deviation and SPI. The plus value of SPI indicates normal and wet year and minus value indicates from mild dryness to extreme drought for given locations. It means that values of SPI are expressed in standard deviations, positive SPI indicating greater than median precipitation and negative SPI indicating less than median precipitation (Edward, 1997 and McKee, 1995). It is being used widely for identification of drought intensity and scale in many countries in the world (Vicente-Serrano et al., 2004). The study was undertaken with the view to following objectives, research question and hypothesis: The main objective of this research was to identify drought in Barind Tracts using SPI. The following specific objectives were to:

- 1) analysis of long term rainfall data and identify drought year;
- 2) identify different scale of drought in the Barind Tracts;
- 3) know the variation of rainfall among the locations over time

The following research hypothesis are formulated a prior for testing at 99% level of confidence.

H_0 : There is no significant difference of rainfall among locations over time

H_1 : The mean annual rainfall have varied significantly among the locations over time

2. Methodology

Total six villages from six different locations (one village from each union, one union from each Upazilas and two upazilas from each district and three districts from Barind Tracts) were selected for this study. 39 years rainfall data were used for this study. Rainfall data were collected from Bangladesh Water Development Board (BWDB). Six stations rainfall data were collected for the period of 1976-2014. The rainfall data of Manda station was used for Niamatpur Upazila, The Manda station is very much close to Niamatpur. Daily rainfall data were recorded by the station and provided for this study from their record (computer and register record). Actual monthly rainfalls and corresponding normal from June to October for

39 years (1976 to 2014) were collected from BWDB. This rainfall data was used as the raw input for the calculation of SPI and descriptive statistics. The rainfall pattern of six locations was shown in Table 1. Six Focused Group Discussions (FGDs) were conducted addressing seasonal changes, rainfall pattern, time and frequency of drought months. Impacts of drought on livelihoods and crops were asked during discussion. The SPI was calculated using 3monthSPI for four times for the year and 6 month SPI for two times, 9month SPI for one time and 12 month SPI for one time, The SPI was calculated using the formula which was developed by Komuscu (1999). This study showed the functional relationship among drought duration, frequency and drought time scale using the Standardized Precipitation Index (SPI). The SPI calculation is very simple and requires only simple long range rainfall data and being self-determining of the scale of mean rainfall and thus analogous over range of climatic regions. As suggested by Komuscu (1999) and McKee (1995) drought classes with SPI value and probability was used for this study. Various statistical analysis and descriptive statistics including the mean, standard deviation, range etc were used for descriptions and comparisons. The chi-square tests of relationship wherever there are sets of variables for comparison are use for determines homogeneity of baseline indices. The test of contingency, k – sample chi-square test of homogeneity is used. The study was to elicit there is significant variation in the indices having similar milieu. The problem can be solved as a 5 x 4 contingency problem utilizing the rather normal chi-square test formula. The use of the conventional χ^2 formula involves the calculation of the expected frequencies using the formula.

$$Fe = FrFc/N$$

Where:

Fe = Expected frequency

Fr = Total row frequency

Fc = Total column frequency

N = Total frequency

The complete elements of the usual chi-square test are given below as;

$$\chi^2 = \sum (O-E)^2/E$$

Where

O = Observed frequency

E = Expected frequency

n = Number of categories

$$SPI = \frac{X - \bar{X}}{\sigma}$$

Here,

X = Actual Rainfall

$\bar{X}$ = Mean Rainfall

σ = Standard Deviation

3. Results and discussion

Drought is a generic statement and it is caused by the gap between requirement and availability of water. There are several definitions of hydrological drought, agricultural, ecological, and economic drought that reveal this. The analysis and occurrence of meteorological drought is elementary and fundamental. Basically drought is an abnormal occurrence. According to Mc Kee (1995) and Kumoscu (1999) drought classes and SPI have been assumed in this research. The study also emphasized on relationship between actual rainfall or /rainfall deviation and the behavior SPI and normal years. Several countries including Mexico (Giddings, 2005), Greece (Loukas et al., 2004) Iran (Morid et al., 2006), European Alps (Bartolini et al., 2009), Portugal (Paulo et al., 2005), Europe (Llyod et al., 2002), Eastern China (Bordi et al., 2004). Twelve months, 9 months, 6 months and 3 months SPI were used to identify drought classes and intensities in the study areas. It was reported that the highest and lowest rainfall occurs in Tanore Upazila. The highest rainfall (2624.5mm) rainfall recorded in 2014 and the lowest (582.7mm) in the year of 1977 (Table 1).

3.1 Identification of drought scale and frequency using twelve month SPI

Analyzing long term rainfall data for 39 years during 1976-2014, the results showed using 12 month SPI from January to December, 21 times drought occurred in Tanore and Shibganj, followed by Nachole and Porsha (20 times) and 19 times in Niamatpur and Godagari (Table 2). Severe drought occurred in the year 2009 and 2014 in Porsha Upazila. Shibganj reported severe drought in the year 1993 and extreme drought in 1999. It was observed that severe drought occurred in Tanore in the year of 1994 and 2008. One extreme drought occurred in 2007 at Tanore during the period of 1976-2014. In Godagari Upazila two severe drought years were observed in the year of 2010 and 2012. Only one severe drought occurred in Nachole Upazila and Niamatpur Upazila in 1982. The mild dryness was the regular phenomenon in every location of the study areas. Tanore and Shibganj Upazila represented highest frequency of mild dryness followed by Nachole, Porsha, Godagari and Niamatpur Upazila. On the other hand Niamatpur experienced 9 times moderate dryness followed by Nachole, Godagari, Porsha, Shibganj and Tanore Upazila. Two times severe drought were reported in Porsha, Tanore and Godagari Upazila during the period of 1976-2014. Only one time extreme drought was recorded in Tanore and Shibganj Upazila. Table 1 shows SPI values for all location with total rainfall of the year (Table 1). SPI provides both positive and negative values. -1.82 SPI value was estimated at Godagari in the year of 2012.

Table 1: Total rainfall and twelve month SPI for the period of 1976-2014

Year	Niamatput		Porsha		Nachole		Shibganj		Godagari		Tanore	
	Rainfall	SPI	Rainfall	SPI	Rainfall	SPI	Rainfall	SPI	Rainfall	SPI	Rainfall	SPI
1976	1116	-1.15	1245.5	-0.6	1336.1	-0.3	1123.8	-0.73	997	-1.23	1310.2	-0.43
1977	1977.7	1.13	782.9	0.44	796.2	1.69	148.1	1.04	834.5	1.05	582.7	-0.05
1978	1863.5	-0.45	852.6	-0.2	886.4	-0.5	718	-0.25	906.5	-0.28	749.5	-0.18
1979	1847.9	-0.64	902.5	0.62	905.7	-0.3	921.2	-0.01	956.8	-0.25	815.1	-0.18
1980	1809.3	0.65	935.4	0.5	945.2	0	979	0.1	973.3	0.35	1011.1	0.2
1981	1804	-0.95	955.3	0.42	979.9	2.48	988	1.54	986	0.75	1049.5	0.82
1982	1774	-1.49	1005.6	-1.4	986.7	-1.6	1006	-1.2	988	-1.38	1111.2	-1.06
1983	1759.2	0.62	1055.2	-0.6	992.6	-0.3	1009	-1.05	1047.2	-0.26	1182.5	-0.54
1984	1734.6	0.9	1120.8	-0.2	1023.4	-0.3	1070	0.49	1132	0.02	1183	-0.35
1985	1728	-1.3	1154.6	-0.3	1115	-0.2	1098.7	-0.25	1144.8	0.15	1203	-0.37
1986	1711.9	-0.11	1167.8	0.41	1158.2	0.73	1287	-0.04	1152.6	1.18	1233	0.24
1987	1706.7	1.84	1200.6	1.7	1212.3	0.3	1304	0.04	1164	1.31	1249	0.54
1988	1681.5	1	1204	0.55	1254.5	0.89	1322	1.32	1214.8	3.05	1263.5	1.02
1989	1633.6	-0.23	1271.8	-0.9	1279.3	-0.4	1328	0.34	1259.5	0.57	1269.6	0.71
1990	1632.2	1.25	1285.9	0.16	1322.6	0.29	1331.5	0.05	1265.2	-0.22	1335.5	-0.05
1991	1627.2	1.39	1336.5	1.29	1329.9	0.35	1333	1.92	1267.3	0.69	1344.3	0.48
1992	1605	-0.4	1371.4	-0.7	1329.9	-0.2	1388	-1	1277	-1.32	1415.4	-0.74
1993	1590	-0.89	1406.2	-0.2	1342.3	0.14	1416	-1.67	1284.7	0.72	1415.8	-0.53
1994	1504.1	-1.29	1420.1	-0.9	1343.6	-1.1	1419	-0.86	1291.8	0.7	1431	-1.77
1995	1490	0.2	1430	1.65	1379.7	0.19	1424.1	1.55	1343.7	0.4	1470.2	0.72
1996	1475.1	-1.12	1551	-0.5	1438.5	-1.1	1437	0.09	1377	-1.27	1472.5	-0.69
1997	1416.8	-1.03	1623.7	-1.1	1443.7	-0.8	1459.2	0.32	1379	-0.19	1507	0.43
1998	1382.5	0.49	1653.1	0.85	1480	1.01	1463	1.53	1395.2	0.21	1530.1	1.08
1999	1331.7	0.1	1655.6	-1.5	1495.1	2.94	1481	-2.98	1413.33	1.07	1576.7	2.7
2000	1318.4	0.92	1664.8	0.94	1514.4	0.97	1483.5	1.47	1435.4	1.29	1592.7	2.14
2001	1263	0.97	1688	-0.7	1536.6	0.33	1570	0.29	1449.2	0.48	1626.6	0.53
2002	1261	1.44	1708	1.01	1553.2	0.25	1583	-0.06	1469	-0.67	1670	1.46
2003	1222.8	0.81	1733.6	1.38	1559.1	0.02	1588.8	-0.79	1496	-1.26	1692.6	1.34
2004	1208.8	1.08	1826.7	1.55	1569.3	1.09	1649	-0.32	1528.5	0.14	1714.3	0.32
2005	1191.5	1.24	1860.4	1.05	1576.2	-0.1	1656	0.48	1530.7	0.27	1717.4	0.09
2006	1172.8	-0.83	1862.6	1.08	1729.7	-1.2	1755	-1	1536.4	-0.44	1789.4	-0.14
2007	1151.7	0.55	1890.9	0.34	1732.5	0.74	1895.3	1.05	1543.9	-0.16	1792.7	-2.17
2008	1125.6	-1.39	1905.5	-1.2	1796.2	-1.1	1897	-0.28	1620.9	-0.74	1836.3	-1.61
2009	1074.1	-0.78	1917.1	-1.8	1827.8	-0.6	2015.7	0.72	1627.9	-1.05	1917.3	-0.91
2010	1074	-0.65	1998.8	0.94	1844.3	-1.3	2078.9	-1.07	1632.7	-1.56	1943.5	-1.15
2011	1073.5	0.64	2038	-0.8	1875.8	0.11	2107	-0.12	1662.3	1.03	2052.7	-0.58
2012	1047	-1.39	2103.4	-1.4	2116.2	-1.4	2110.9	-0.36	1692.9	-1.82	2102	-0.62
2013	1046	-1.29	2144.7	-0.4	2432.8	-0.7	2116	-0.05	1700.4	-0.63	2387.5	-0.74
2014	1017.4	0.15	2162.3	-1.6	2615.4	-1	2276	-0.26	2180	-0.7	2624.5	0.04

Source: BWDB, 2015

Table 2: drought scale and frequency using 12m SPI

Scale	Location wise drought frequency (12m)						Drought type
	Niamatpur	Nachole	Godagari	Tanore	Shibganj	Porsha	
0 to -0.99	10	12	11	16	14	13	Mild
-1 to-1.49	9	7	6	2	5	5	Moderate
-1.5 to -1.99	x	1	2	2	1	2	Severe
Less -2	x	x	x	1	1	x	Extreme

3.2 Identification of drought scale and frequency using nine month SPI

The nine month analyses represented the drought situation in the study locations. The precipitation data were used from January to December over the period of 1996 to 2014. The highest drought frequencies were observed in Tanore Upazila (25 times) followed by Godagari, Porsha, Nachole, Niamatpur and Shibganj Upazila (Table 3). Only one severe drought was recorded in Tanore and Shibganj Upazila. In case of severe drought, Porsha and Godagari Upazila affected 3 times during the period of 19976-2014. The lowest severe drought was recorded in Tanore and Shibganj Upazila. The highest numbers of moderate drought were indentified in Niamatpur Upazila and mild drought in Tanore Upazila.

Table 3: drought scale and frequency using 9m SPI

Scale	Location wise drought frequency (9m)						Drought type
	Niamatpur	Nachole	Godagari	Tanore	Shibganj	Porsha	
0 to -0.99	12	16	16	21	13	15	Mild
-1 to-1.49	5	3	3	2	3	3	Moderate
-1.5 to -1.99	2	2	3	1	1	3	Severe
Less -2	x	x	x	1	1	x	Extreme

3.3 Identification of drought scale and frequency using six month SPI

Two time six month SPI were used in this analysis, one with the time period of January to June and another from July to December. It was identified that 23 times drought occurred in Niamatpur, Tanore and Porsha Upazila followed by Godagari, Nachole and Shibganj Upazila (Table 4) in the first half of the year. Only one extreme drought and two severe drought were indentified in Shibganj Upazila. One severe drought in Tanore and Porsha Upazila was identified. On the other hand, the highest drought frequencies were identified in Nachole, Shibganj and Porsha Upazila followed by Godagari, Niamatpur and Tanore Upazila in second half of the year (Table 5). Only one extreme drought was occurred in Tanore and Shibganj Upazila. Three times severe drought were identified in Godagari and Tanore Upazila.

Table 4: drought scale and frequency using 6m SPI

Scale	Location wise drought frequency (6m)						Drought type
	Niamatpur	Nachole	Godagari	Tanore	Shibganj	Porsha	
0 to -0.99	12	14	13	13	14	14	Mild
-1 to -1.49	5	6	4	2	6	7	Moderate
-1.5 to -1.99	2	1	3	3	x	x	Severe
Less -2	x	x	x	1	1	x	Extreme

Table 5: drought scale and frequency using 6m SPI

Scale	Location wise drought frequency (6m)						Drought type
	Niamatpur	Nachole	Godagari	Tanore	Shibganj	Porsha	
0 to -0.99	18	14	16	17	14	18	Mild
-1 to -1.49	5	7	6	5	3	4	Moderate
-1.5 to -1.99	x	x	x	1	2	1	Severe
Less -2	x	x	x	x	1	x	Extreme

3.4 Identification of drought scale and frequency using three month SPI

Four times three months SPI were used to identify drought frequencies in the study area. The first quarter for the month of January to March, second quarter for the month of April to June, third quarter for the month of July to September and forth quarter for the month of October to December. The highest drought frequencies (23 times) were identified at Niamatpur, Godagari and Porsha during the month of April to June (Table 6) followed by Tanore, Shibganj and Nachole. It was identified that the highest frequency of drought occurs at Tanore followed by Niamatpur, Nachole, Godagari, Shibganj and Porsha. Two extreme droughts were identified at Tanore during the month of April to June and July to September. Four times severe droughts were identified at Tanore in the month of April to June. On the other hand, 3 times severe drought were identified at Godagari in the month of July to September. No severe drought was identified at Niamatpur and Porsha during the period of 1976-2014 using 3 month SPI. Eventually no extreme drought was identified in the study locations except Shibganj.

Table 6: Drought scale and frequency using 3m SPI (April to June and July to September)

Scale	Location wise drought frequency and scale (3m)												Drought type
	Niamatpur		Nachole		Godagari		Tanore		Shibganj		Porsha		
	3m	3m	3m	3m	3m	3m	3m	3m	3m	3m	3m	3m	
0 to -0.99	18	15	15	15	19	14	13	17	13	15	19	14	Mild
-1 to-1,49	5	6	4	6	4	4	6	1	5	5	4	6	Moderate
-1.5 to -1.99	X	X	1	X	X	3	2	4	1	X	X	X	Severe
Less -2	x	x	x	x	x	x	x	x	1	1	x	x	Extreme

3.5 Testing of hypothesis

Along a comparative description of the baseline indices and hypothesis testing the distributional pattern of the annual rainfall, monthly temperature and static ground water level can as well be understood (Table 7). Variations in space of aspects of the rainfall climatology for the study area are presented in the above Table 7. Being locations within the Tropical monsoon climatic type, the mean value, range and the 39 year maximum values are expectedly very high, Table 7. The annual minimum is equally high with a low coefficient of variability values indicative of a high incidence of the summer rains throughout the period of study.

Table 7: Rainfall descriptive indices for six study locations in Barind Tracts (1976-2014)

	Niamarpur	Nachole	Godagari	Tanore	Shibganj	Porsha
Mean	1447.4385	1437.341	1337.37	1491.5615	1441.9667	1489.5615
Max	1978	2615.4	2180	2624.5	2276	2162.3
Mini	1017	796.2	834.5	582.7	148.1	782.9
SD	288	401	276	419	434	396
cv	19.897	27.899	20.638	28.091	30.098	26.585

The K-sample Chi-square test was used for this study. The determination of the expected frequencies for each entry in Table 7, the test statistic is appended below:

$\chi^2 = \sum (O-E)^2/E$ is utilized for rainfall data series

$$(1447.4 - 1415.6)^2/1415.6 + (1437.3 - 1572.8)^2/1572.8 + (1337.37 - 1385.29)^2/1385.29 + (1491.56 - 1533.50)^2/1533.50 + (1441.96 - 1290.42)^2/1290.42 + (1489.56 - 1606.79)^2/1606.79 + (1978 - 2265.64)^2/2265.64 + (2615.4 - 2517.23)^2/2517.23 + (2180 - 2217.08)^2/2217.08 + (2624.5 - 2454.28)^2/2454.28 + (2276 - 2065.25)^2/2065.25 + (2162.3 - 2316.68)^2/2316.68 + (1017 - 681.42)^2/681.42 + (796.2 - 757.08)^2/757.08 + (834.5 - 666.81)^2/666.81 + (582.7 - 738.15)^2/738.15 + (148.1 - 621.14)^2/621.14 + (782.9 - 696.77)^2/696.77 + (288 - 362.53)^2/362.53 + (401 - 402.79)^2/402.79 + (276 - 354.76)^2/354.76 + (419 - 392.72)^2/392.72 + (434 - 330.47)^2/330.47 + (396 - 411.49)^2/411.49 + (19.89 - 25.08)^2/25.08 + (27.89 - 27.87)^2/27.87 + (20.63 - 24.55)^2/24.55 + (28.09 - 21.17)^2/21.17 + (30.09 - 22.86)^2/22.86 + (26.58 - 28.47)^2/28.47$$

$$= (218.89 + 17.52 + 62.55 + 47.48 + 434.28 + 4857.34) \\ = 5638.09 \text{ df } 20 \text{ tvalue is } 37.5662$$

At 99% confidence level and (number of rows-1) (number of columns-1) = (5-1) (6-1) = 20 degrees of freedom, the calculated chi-square value i.e. calculated value is greater than critical value (5638.09 > 37.5662). According to assumed hypothesis the null hypothesis is rejected and alternative hypothesis is accepted. So rainfall is significantly varied among the locations over time.

4. Conclusion

Rainfalls data were analyzed for 39 years over the periods of 1976-2014. The analysis of rainfalls for six locations was studied for spatial pattern and descriptive statistics. The hypothesis on rainfall was formulated and tested. The interpretation was drawn based on test results. The variations of rainfall over the time was occurred due to several factors including the changes of cropping pattern, lack of trees, vegetation covers and water recycling and natural flow of rivers. There was a significant difference of rainfall among the locations over time. Results showed the dimension of annual rainfall spatial pattern and SPI value for the study locations. It was covered mean value, range value with the maximum and minimum, variance and standard deviation. The indices all of measured are considered as high particularly standard deviations, range and coefficient of variability matching with the tropical monsoon climate types. Statistical analysis and testing of homogeneity of data with the K-sample chi-square module is positive as the null hypothesis is rejected. Alternative hypothesis is accepted that support baseline indices are similar or homogeneous. The trend of annual rainfall showed declining among all locations.

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Effectiveness of Adaptive Measures against Storm Surge Hazard based on Field Experience from a Real Time Cyclone in Bangladesh Coast

Kazi Samsunnahar Mita^{1*}, A.S.M. Alauddin Al Azad¹, Md. Wasif Zaman¹, Mohiuddin Sakib¹,
Gazi Md. Riasat Amin¹, Tansir Zaman Asik¹, Anisul Haque¹, Md. Munsur Rahman¹

¹Institute of Water and Flood Management, Bangladesh University of Engineering and Technology (BUET), Dhaka-1000, Bangladesh. Kazi.mita@gmail.com

Abstract

Cyclone ROANU struck the eastern coast of Bangladesh at 1000 UTC on 21 May 2016 with the maximum wind speed of 110 km/h. A field visit was made in Banshkhali Upazila of Chittagong district in Bangladesh coast to assess immediate impact of the cyclone on protective infrastructures and local livelihood. During field visit, primary data related to damage occurred from ROANU including polder breaching, type of failure, surface water salinity etc. were collected. From collected information, it is evident that polders, which are the first line of defense against storm surge, performed poorly during ROANU. On the top of that poor drainage condition exacerbated water logging condition. Satellite image analysis also depicts the extent of inundation. Although cyclone shelters were not structurally damaged, in terms of location, accessibility and capacity of cyclone shelters were not adequate to evacuate people during the cyclone. Besides, many local residents claimed not to have enough time to prepare and go to nearby cyclone shelter after being informed about the warning. Collected water samples from local surface water sources exhibit salinity far more than acceptable standard for agriculture, drinking and fish farming. In this paper, we assessed the performance of protective measures (structural and non-structural) taken against cyclone and resulting storm surge. To improve disaster preparedness, a more reliable warning system, sufficient cyclone shelters and immediate action against waterlogging is desired by local people.

Keywords: *Cyclone ROANU, Polder Breaching, PRA tools, Protective measures, Disaster preparedness.*

1. Introduction

The coastal zone of Bangladesh is particularly vulnerable to climate-related impacts, especially cyclones, as severe cyclones strike Bangladesh's coast every three years (GoB, 2008). It is estimated that Bangladesh receives about two-fifths of the total impacts of global storm surges (Dasgupta, 2010). Almost one-sixth of tropical cyclones that develop in the Bay of Bengal make landfall on the Bangladesh coast (Sakib et al., 2016). Coast of Bangladesh is also vulnerable to storm surge. It is estimated that Bangladesh receives about two-fifths of the total impacts of global storm surges (Dasgupta, 2010).

Tropical cyclones, also called typhoons and hurricanes, are powerful storms generated over tropical and subtropical waters. Their extremely strong winds damage buildings, infrastructure and other assets; the torrential rains often cause floods and landslides; and high waves and storm surge often leads to extensive coastal flooding and erosion – all of which have major impacts on people (IPCC, 2012). Previous cyclonic events were catastrophic and their damage scenario is needed to analyze for further socio-economic

impact assessment. Historically, Chittagong coast is vulnerable to cyclones and storm surge impacts which have caused casualties, damage of local resources and infrastructure. In 1983 a cyclonic storm along Chittagong coast caused death to 1350 persons including fishermen, 2000 houses damaged and 20% Amon crops were destroyed. A powerful tropical cyclone struck the Chittagong district of southeastern Bangladesh on April 29, 1991. At least 139,000 people were killed by that cyclone (Haque and Blair, 1992). It caused a damage of around \$1.5 billion. Also 70,000 live stocks and many crops were washed away due to this severe cyclonic storm which made landfall at the north of Chittagong. Cyclone Mahasen made landfall near Chittagong on 16 May 2013, affecting almost 1.5 million people and killing 17 immediately. Approximately 49,000 houses have been completely destroyed and 45,000 houses partially destroyed due to this catastrophic phenomena.

Several studies have been conducted so far to evaluate the response of adaptive measures and damage of eco-system, household, livelihood and vulnerability assessment due to real time cyclones. Specially after cyclone SIDR many studies has been conducted in South-West coastal region of Bangladesh to evaluate performance of taken measures (JSCE, 2008). Even without cyclonic event, most earthen embankments of Bangladesh face light to moderate breaching arising out of rainfall splash, wave action, erosion, animal action and nature of human uses (Hossain M. Z., 2013). During SIDR about 2,290 km of embankment were affected, where, 362 km of embankment were fully destroyed while the rest were partially damaged (GoB, 2008). Accordingly, it was observed that 76% respondent could not reach in safer place due to rush of surge and also because of the inundation of road-network (Mallick et al. 2011). Cyclone shelters which are important protective measure, were inadequate for the population of the affected area (Islam et al. 2010). Kulatunga et al. (2014) claimed that according to the local respondents, location of the cyclone shelters are hugely influenced by politicians without giving adequate consideration to the needs of the general public and the critical areas that are subject to cyclones.

Since 2000 till 2017, among 9 tropical cyclones making landfall in Bangladesh coast, 5 out of them made landfall in Chittagong coast. The tropical cyclone ROANU struck the eastern coast of Bangladesh on 21 May, 2016. Before reaching Bangladesh coast, cyclone ROANU travelled all along the east coast of Sri Lanka, east coast of India including West Bengal. This type of track is quite unusual compared to the previous cyclone tracks that hit Bangladesh Coast (Fig. 1). In terms of wind speed (around 100 km/hr), cyclone ROANU was a moderate strength cyclone. But the damage it made along its landfall path was significant. Eighteen coastal districts were affected and among them, seven were severely affected. These seven districts were: Chittagong, Cox's Bazar, Bhola, Barguna, Laxmipur, Noakhali and Patuakhali. About 40,000 households were reported to be damaged. The cyclone hit the coast during high tide causing severe damage to the infrastructures, agricultural lands, fisheries and livestock. However, there is no literature available on damage caused by ROANU and underlying cause behind the destruction. This study aims to fill this gap by analyzing primary data collected from affected area.

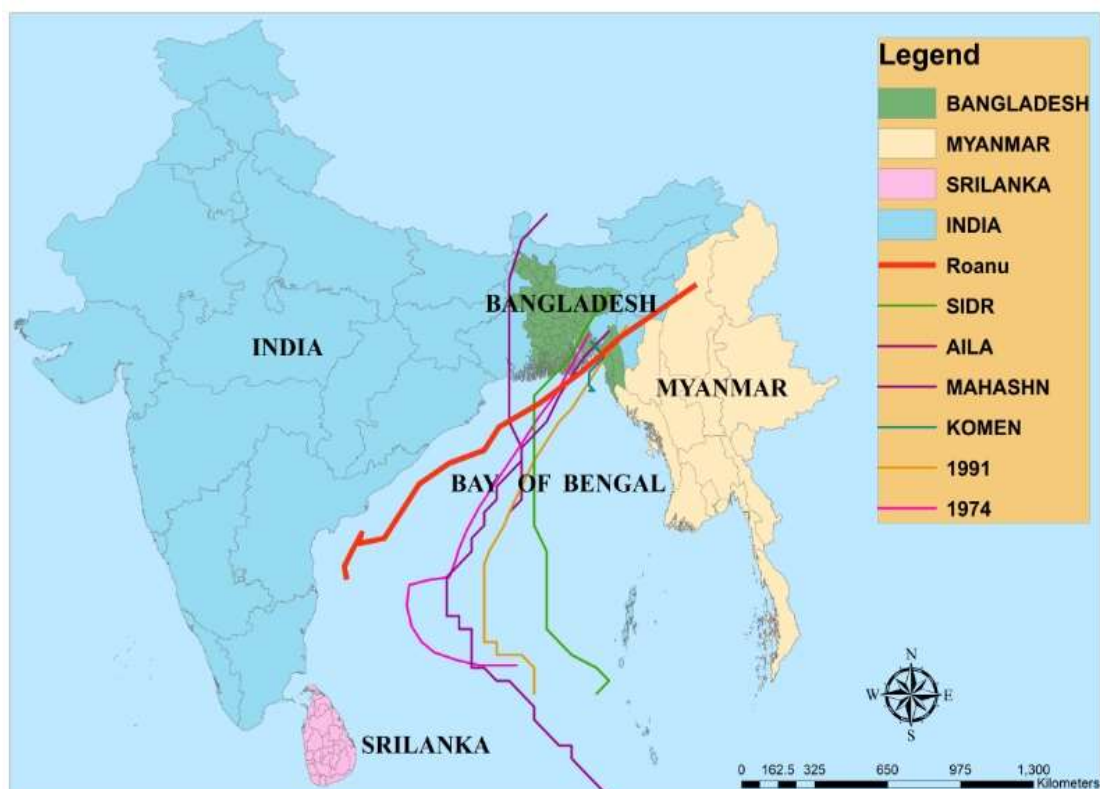


Fig. 1: Tracks of previous notable cyclones.

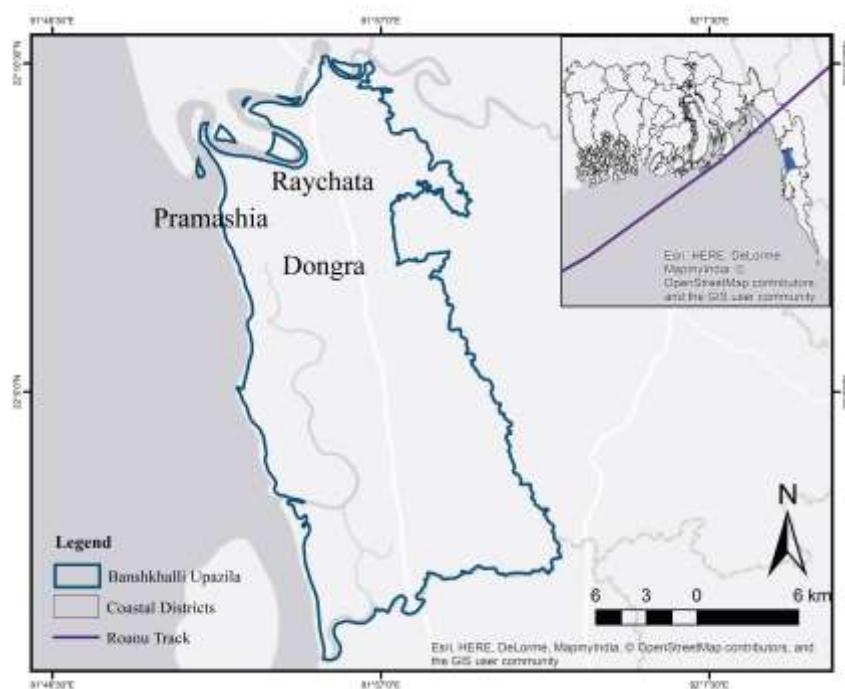


Fig. 2: Study area map including ROANU track.

2. Methodology

The major emphasis of the field visit was to assess performance of coastal structures (cyclone shelters, polders, road network) and existing warning system along with impact on ecosystem and livelihood. The study area was Banshkhali upazila of Chittagong district (Fig. 2) where the cyclone caused major damage. This study was conducted to record immediate response of local people. Several Participatory tools such as Focus Group

Discussions (FGD), Key Informant Interview (KII) were used to collect data. During discussions, peoples' perception was documented on the following points: (1) accessibility of cyclone shelters (2) location and capacity of the shelter (3) dissemination of cyclone warning (4) water supply and sanitation (5) power supply (6) surge height (7) occupations of local people (8) damage to livelihood and environment (9) pattern of local household (10) damage of vegetation (11) location of neighbouring cyclone shelter (12) existing cyclone warning system (13) food availability (14) livestock and (15) post disaster activities. On the basis of information collected from locals, data such as polder breaching point, type of breaching, extent of inundated area etc. were collected. Water samples were collected from nine locations of Banshkhali and tested in the laboratory to find the magnitude of salinity in the affected region. Sentinel 1A microwave images and Sentinel 2A satellite images of study area were analyzed to depict inundation extent. As ROANU hit Chittagong coast on 21st May, to get immediate inundation scenario Sentinel 1A Microwave images of 23rd May, 2016 has been used. SNAP-A common architecture for all Sentinel toolboxes have been used for analysis the micro wave images. Also, Sentinel 2A satellite image of 5 January 2016 has been analysed for calculation of NDVI (Normalized Difference Vegetation Index) to visualize the extent of vegetated / agricultural area before ROANU.

3. Effectiveness of Structural Adaptation (Polders, Cyclone Shelters and others)

Polder, as the first defensive coastal structure against storm surge has undergone through much deformation due to thrust force exerted by surge (Fig. 3). According to local government authorities 30 km of polder damaged severely, 2 km of embankment destroyed completely and 10 km of road damaged partially in Raychata village. All these claims were observed during field visit (figure 4). A sea facing polder of around 1.5m height located in Pramashia Bazar was totally collapsed and inundated around 5 km area of Raychata village (Fig. 5).



Fig. 3: Breached sea-facing polder at different locations of Banshkhali Upazila.



Fig. 4: Damaged road at Raychata of Banshkhali.



Fig. 5: Local resident showing height of demolished polder.

Approximately 2000 houses were damaged in this union during the surge of ROANU. During FGD, local people reportedly witnessed depth of ROANU was around 3m. High tidal surge pressure and continuous sea water intrusion through breached portion of polder has made the condition even worsen leaving no scope for immediate repairing of polders and other infrastructures.

Cyclone shelters, on the other hand, were not structurally damaged by the thrust of cyclone ROANU in Banshkhali. Even though cyclone shelters are performing well, number of cyclone shelters is inadequate according to local people. As a result, existing cyclone shelters were overcrowded and people living in vicinity found it troublesome to go to cyclone shelter in adverse weather. Addition to this, uneven distribution of cyclone shelters hindered people from seeking refuge (Fig. 6). Lack of facilities to shelter domestic animals is one of the reasons behind unwillingness of people about moving to cyclone shelters. Local power dynamics also played a significant role in accommodating people during disaster. Lack of drainage caused a cyclone shelter of Pramashia bazar inaccessible, which indicates lack of maintenance. As it was constructed in lower elevation from the existing road level, torrential rain caused water logging in front of the building. Ground floor of the shelter was inundated and therefore, people could not go to the cyclone shelter in right time. Other Infrastructures like the hospitals, clinics, power relay centers etc. haven't been much affected by ROANU except being waterlogged in some areas. Both electricity and telecommunication distribution infrastructures were widely disrupted during ROANU. Electricity was disrupted for about 20 days in many remote and worst affected areas due to critical damages to the poles.

Death toll during ROANU is 26 people which is significantly low compared to past cyclones. But economic loss is noteworthy because of inundation of agricultural land, washing away of fish farms, damage of households, and contamination of drinking water sources.



Fig. 6: Location of cyclone shelters along travelled path.

3.1 Salinity Intrusion

Magnitude of salinity in coastal area plays a vital role in livelihood, life of human and ecosystem of the environment of brackish water (Kamal and Khan, 2009). As observed from field visit, vast area of Banshkhali upazila remained inundated by seawater following cyclone ROANU due to breaching and overtopping of several polders (Fig. 7).



Fig.7: Saline water intruded in (a) water body and (b) agricultural land.

Collected saline water samples from different surface water sources of Banshkhali Upazila were tested to assess the storm surge induced salinity level of inundated area (Fig. 8). Maximum salinity (16.20 ppt) was found in a pond adjacent to sea and minimum salinity was 8.51 ppt which was around 15 km away from sea. The magnitude of salinity was decreasing with distance (Table 1).

Water cannot be used for domestic purposes if salinity is higher than 1 ppt though it is still favourable for crops and livestock unless salinity exceeds 2 ppt (Palash *et al.*, 2014). According to Palash *et al.*, (2014), some freshwater aquaculture is possible when the salinity is below 4 ppt. Agriculture is affected vigorously if salinity value is more than 7 ppt (BARC, 2013). Forestry and fisheries are affected if salinity value exceeds 8 ppt and 10 ppt respectively. In case of more than 10 ppt, specifically when exceeds 15 ppt, only specialized brackish ecosystem can survive in such saline environment (Hossain *et al.*, 2014). From Table 1, it is clear that salinity levels of different surface water sources at Banskhali Upazila were far more than acceptable limit for domestic use, agriculture, forestry and fresh water fisheries after ROANU. Field observations also resonate with the findings of laboratory tests. Agricultural land, numerous water bodies were threatened by saline water from the Bay of Bengal posing a serious threat to the food security and biodiversity. According to local people of Raychata and Pramashia village, right after ROANU, water of 170 out of 200 ponds had turned saline and fish of these water-bodies had already died due to the high salinity. Congested water in the field was gradually making the soil unproductive. Additionally, surface water salinity had increased health risks, causes a scarcity of pure drinking water.



Fig. 8: Water sample collection locations.

Table 1: Salinity level at different locations of Banshkhali.

Identification Number	Location	Salinity concentration (ppt)
1	Pond (Pramasia)	16.20
2	Pond (West Raychata)	14.60
3	Fish lake (middle Raychata)	13.97
4	Pond (Middle Raychata)	13.50
5	Agricultural Land (East Raychata)	13.38
6	Pond (East Raychata)	12.96
7	Agricultural land (Dongra)	12.62
8	Agricultural land (Dongra)	11.59
9	Pond (Dongra)	8.51

3.2 Loss of agriculture and livelihoods

Traditionally people of Banshkhali are dependent on agriculture and fisheries. ROANU caused severe damage of agricultural land and fresh water fisheries (Fig. 9). Because of its' close proximity to sea, Raychata and Pramashia village received the thrust force of cyclone which caused severe damage to crops. This village was completely inundated and poor drainage facilities caused water logging. Stagnant saline water in agricultural land caused to degrade soil fertility slowly. So, economic loss is not only limited to one cropping season. As the waterlogged conditions continued and salinity is anticipated to rise in the soils and might restrict Aman crop cultivation, this would further whip the marginally poor people who lost their Robi crops already in the tidal surge of ROANU and there is nothing left for them. Aquaculture will also not be possible in long time because of saline water in ponds.



Fig. 9: Waterlogged agricultural land after ROANU.

3.3 Damage of Eco-system and live stocks

From field assessment, it was visible that whole ecosystem of Banshkhali upazila was severely affected due to the salinity intrusion by cyclonic storm surge ROANU (Fig. 10). As discussed earlier, Water of adjacent river and canals had become saline and thus fresh water fisheries had been suffering greatly. Many cattle, hens, ducks were washed away during cyclone. Remaining domestic animals of that region were passing through a critical situation as the whole area was contaminated by saline water.



Fig. 10: Damage of ecosystem and agricultural land at Raychata of Banshkhali Upazila.

4. Effectiveness of Non-Structural Adaptation (Cyclone Warning system)

4.1 Dissemination of cyclone warning

Cyclone warning was disseminated in the locality through announcement from radio and television and through hand-microphones. Generally, most of the time people get informed by radio and television about the warnings related to tropical cyclones. But during ROANU, due to disruption or disturbance of power supply, many people didn't get enough information about the exact location and time of landfall. That's why they depended mostly on local announcement made by using hand-microphones. Government employees, NGO workers and volunteers also actively took part in warning people and guided them to cyclone shelter prior to the cyclone. Even though local administration arranged warning by using hand microphones, in remote areas, there were very few volunteers active. As well as high wind velocity and torrential rain prevented warning given by hand microphones from reaching many people. Thus, people living in these areas were not fully aware of the imminent risk.

4.2 Cyclone warning system

Current cyclone warning system is mainly port oriented. The language used in the warning is also not understandable to the local people. Many people fail to correlate the warning for port with risk of being affected by cyclone. So, people got confused and delayed to take initiative. Besides, many people are reluctant to go to cyclone shelter leaving their house and other livelihood resources behind. Because of their ignorance, they risked their lives and stayed at home despite being warned.

Some people did not go to the cyclone shelter even if they got warning from television, radio and local held microphone. The reasons behind neglecting the warning are found as follows:

- a. Last devastating cyclone in eastern coastal area occurred in 1991, which was about 25 years from now. That made people a bit neglecting to take precautions.
- b. Some people were afraid of burglary. They remained at home to avoid chances of losing their resources and live stocks.
- c. Average capacity of cyclone shelters of this area is 1000, which is insufficient considering the total population. The cyclone shelter was over-crowded during ROANU and some people were not able to accommodate in the shelter.
- d. During ROANU, signal number 7 (port will experience severe weather from a light to moderate intensity cyclone having wind speed of 62-88 km/hr that is expected to cross over or near the port) was announced. But the actual wind speed of cyclone ROANU was more than 100 km/hr according to BMD. It is possible that actual wind speed in this location was more than 100 km/hr, but present warning system is not able to mention this. Since many people were not fully aware of imminent hazard, there unawareness played crucial role in their decision making.
- e. Local people got the wrong information about the landfall time of Cyclone ROANU. Instead of in the afternoon or evening of 21 May, Cyclone hit the land 6 hours earlier making people unprepared because of the common tendency of people living in coast to go to cyclone shelter right before cyclone makes landfall.

5. Satellite Image Analysis

Satellite images are used to analyse the extent of inundation. Remote sensing is a cost effective, accurate, and potential tool for mapping the aerial extent of inundation caused by tropical cyclones using high-to-moderate spatial resolution (5–30 m) satellite imagery.

Sentinel 1A Microwave data has been used for analysis of inundation during ROANU. Satellite radar images are most valued for flood detection purposes because- in contrast to optical imagery - their recording is independent of the availability of sunlight and the microwaves emitted by the system are able to penetrate haze and clouds. In contrast Sentinel 1A images are cloud independent with a high revisit time and almost 95% accurate. For this reason, Sentinel 1A microwave radar image has been used and processed in ArcGIS. The image with VV polarization of 23 May 2016 (Fig. 11) has been acquired from the official website of Sentinel. SNAP-A common architecture for all Sentinel toolboxes have been used for analysis the micro wave images. Finally, inundation mapping has been done using on-screen digitization of flooded area in ArcGIS.

Also, Sentinel 2A satellite image of 5 January 2016 (Fig. 11), has been analysed for calculation of NDVI (Normalized Difference Vegetation Index) to visualize the extent of vegetated/agricultural area before ROANU. The Normalized Difference Vegetation Index (NDVI) is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyse remote sensing measurements and assess whether the target being observed contains live green vegetation or not.

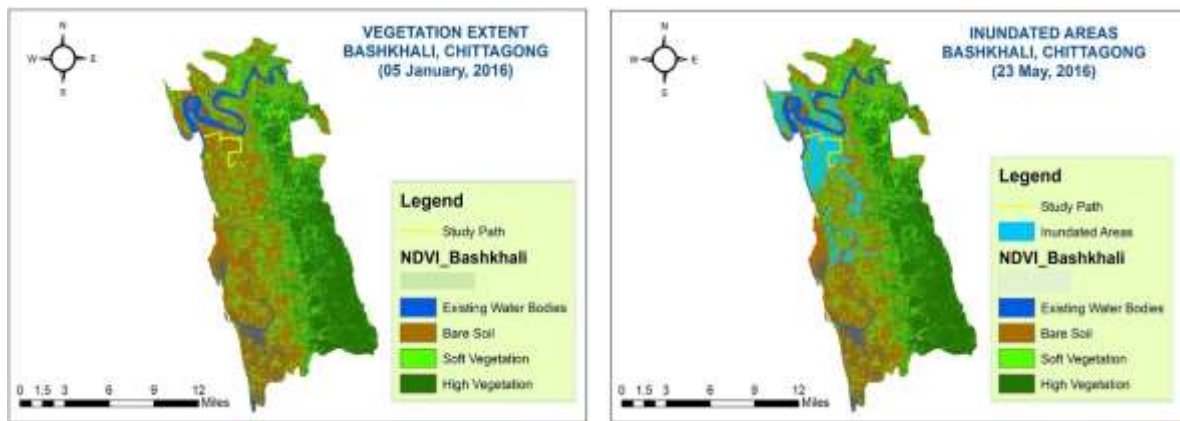


Fig. 11: Satellite image analysis before (left) & after (right) ROANU.

From Fig. 11, It is clear that surge water remained in Raychata and Dongra village on 23rd May, 2017- two days after ROANU. This satellite image analysis matches with the observations from field survey that local people were captured by the clogged water for the several days after landfall of ROANU.

6. Suggestions from local residents

People of Banshkhali provided many useful suggestions during interviews. Some of those suggestions can be implemented immediately to improve effectiveness of adaptive measures (both structural and non-structural) against storm surge disaster. Following recommendations are made based on our field visits to the study area.

- The present cyclone warning system is designed primarily for port. Surge height, wind speed and damage possibility are vital components of the impacts of cyclone. So it should be incorporated in the existing signal system in such a way which will be easily understandable for the local people.
- Polders are required to rehabilitate in order to protect coastal population from flooding after cyclone.
- Cyclone shelters need to be uniformly distributed in the exposed coast. Sometimes due to poor site selection, cyclone shelters constructed in lower elevation from the existing road level become inaccessible.
- Water supply and sanitation system need to be upgraded in present shelter premises.
- Saline contaminated ponds should be purified after cyclonic events using lime, chlorine and other water-purifying agents to prevent waterborne diseases.

7. Conclusions

The area inside the polder in Banshkhali are severely inundated by the storm surge flooding with highly concentrated saline water from the sea due to polder breach. From sea shore, around 15 km of Bashkhali upazila was inundated resulting widespread destruction. Microwave data (Sentinel-1A) along with Satellite Images (Sentinel-2A) analyses showed that a large area of Bashkhali was inundated. Present cyclone warning system was found difficult to understand by the local people. Available cyclone shelters in the affected area were inadequate and sometimes inaccessible in terms of location and capacity. Another reason to avoid cyclone shelters is that last devastating cyclone in eastern coastal area was occurred in 1991, which was about 25 years from now. That made people a bit neglectant

to take precautions. Salinity intrusion due to surge water inundation was found to be detrimental and caused damage to agriculture crops, livestock and eco-system. Failure in information transferring about upcoming cyclone among local community by respected government and non-government authority can not be ignored. Compiling every key points about precautionary measurements from the local community, it can be concluded that people still believe an improved warning system, strong polder and effective cyclone shelter could ensure their safety against storm surge. In that case they opted to live in the same place and were not interested to migrate.

Acknowledgements

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Empirical Modeling on Sanitation System, Hygiene Practice and Health at Rural Bangladesh

Md. Easin Ali¹, Shehab Uddin¹ and Dr. Md. Mizanur Rahman²

¹ Post graduate Researcher Student, Department of Geography & Environment, Jahangirnagar University, Savar, Dhaka-1342 (Bangladesh).

² Professor, Department of Geography & Environment, Jahangirnagar University, Savar, Dhaka-1342 (Bangladesh).

Abstract

Sanitation is the function of excreta management, wastewater management, solid waste management and drainage systems where health means a state of complete physical, mental, and social well-being. To know the relationship between health and sanitation system some phenomena of sanitation systems have selected and found its relation with different disease. This study was conducted a questionnaire survey on 60 respondents of Garuitupi Mauza. Therefore informal interview, field observation are also conducted. Both qualitative and quantitative data are collected and analysis in the study. For progressing the model, collected data has been classified into three category such as existing sanitation system, Knowledge & hygiene practice method and health status. In the study, in sanitation system includes toilet system, hand wash practice, shoe use practice and waste management system. In knowledge and hygiene practice method includes, educational status, hand washing process, knowledge about disease and symptoms and in health status includes different diseases. In the study area 31.67% latrines are made of Ring slab, 55 % respondent use shoes while using latrine, 71.67% people use tub well water for bathing, 20% peoples use soap for washing their hands before taking food and 45% people used soap after defecation. It focused that 60% are suffered by Diarrhoea, 25% by typhoid and 30% are suffered by Dysentery. Quack doctors is the main anchorage for treatment. This research also conducted cross table analysis calculated Karle Pearson correlation for observing the relationship among sanitation system hygiene practice and health. There is low and moderate correlation existing among the phenomena. For eliminating sanitation related disease, developing sanitation system and awareness people about health and hygiene practice is indispensable.

Key Words: Sanitation, Hygiene, Health, Disease, Correlation.

1. Introduction

Every year many people in Bangladesh are died by different types of diseases. But the diseases are causes for death are closely related with sanitation system. . The disease that spread more in rural are of Bangladesh Are Diarrhoea, Dysentery , Jaundice, Cholera, Hook Warm, , Chicken Pneumonia, Typhoid, Fever, Headache, Cancer and so on. Among the disease most of the diseases are related with sanitation system. Sanitation system is a one of the major component of environmental health. Water and Sanitation is one of the primary drivers of public health (Jong-wook L. 2004). To keep the environment healthy for human habitation and health purpose sanitation is needed because sanitation system is related to whole way of life. In study Jong-wook L. (2004) focused that by ensuring the availability of clean water and to adequate sanitation facilities for all people, irrespective of the difference in their living conditions, a huge battle against all kinds of diseases will be won. According to National Sample Survey Office (NSSO) (2012), only 32% of rural households have their own toilets and that less than half of Indian households have a toilet at home. There were more

households with a mobile phone than with a toilet. In Bangladesh, about 73.5% of the people have hygienic latrines (Bangladesh Economic Survey, 2017). Every eight seconds a child dies of water related disease (Online research, 2011). Mara, *et al.* (2010) focused that 2.6 billion people in the world lack adequate sanitation the safe disposal of human excreta. National Hygiene Promotion Strategy for Water Supply and Sanitation Sector in Bangladesh (2012) focused that Water and excreta related diseases such as diarrhoea, worm infestation and other respiratory diseases still remain a major health concern in Bangladesh. Estimates that a package of comprehensive sanitation and hygiene interventions can result in preventing 61 percent of the economic loss due to health impacts linked with sanitation and all the adverse impacts of inadequate sanitation related to water and welfare losses (Water and Sanitation Program, 2013). Bleich (2011) focused that Like many low income countries around the world, Bangladesh is in the midst of an epidemiologic transition where the burden of disease is shifting from a disease profile dominated by infectious diseases, under-nutrition and conditions of childbirth to one increasingly characterized by Non-communicable Chronic Diseases (NCDs).

As Bangladesh is a developing country the household pattern is change easily. With the development of socio-economic status it is very need to develop sanitation system. Though the progresses in sanitation and hygiene practices have been made substantially, the coverage is not satisfactory. In the remote areas the progress is significantly low. This study focused the condition of sanitation system and hygiene practice Garuitupi Mauza as a representative of remote rural in Bangladesh.

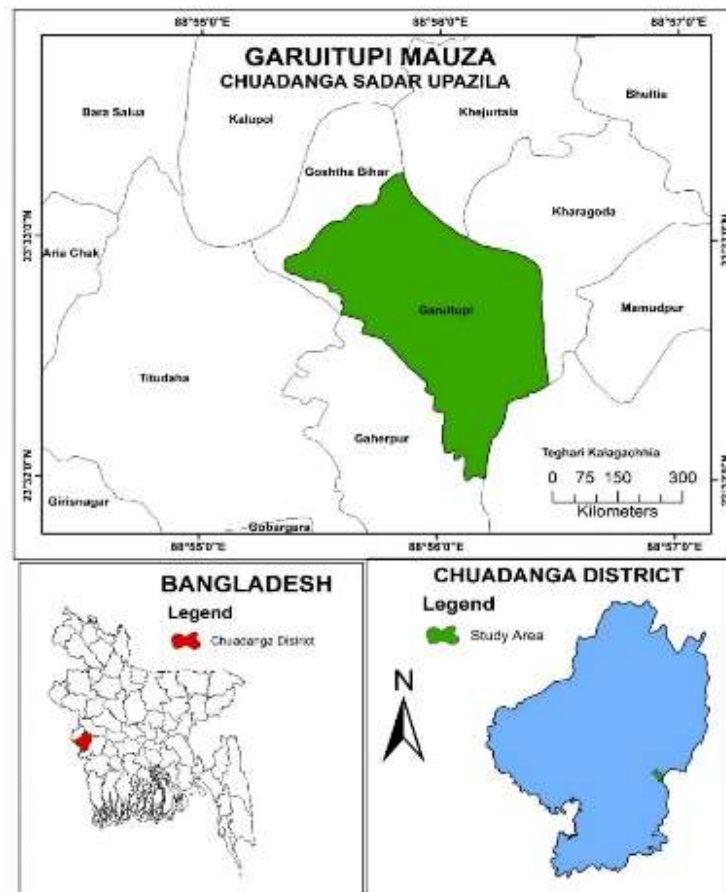
1.1 Aim & Objectives

The main aim of this research is to access the present sanitation, hygiene practices and knowledge and their impacts on health at Garuitupi Mauza in Chuadanga Sadar Upazila. The objectives of the study are-

- a) To examine the present sanitation system and hygiene practices in the study area;
- b) To identify the health status of the people of the study area;
- c) To draw a model regarding the relationship among sanitation system, hygiene practice and health.

2. Data Sources and Research Methodology

For this research the primary information was collected through questionnaire survey. The questionnaires contain information on household, socio economic information, sanitation system, hygiene practice, location and situation of water sources, different diseases that occurred among respondents during the last years. Data were collected from 60 households who permanently live in the study area. Secondary data were collected from different published and unpublished materials and books. Data obtained from the survey were analyzed using descriptive and inferential statistical tools. Different software such as, Microsoft word, Microsoft Excel, SPSS, Arc View GIS are used for data analysis. The Garuitupi Mauza has only one village. It has total 494 units of household and total area is 2.03 square kilometers. (BBS, 2011). Total population in Garuitupi Mauza is 1926. The ratio of male and female is 101:100 among them the male population is 968 and the female population is 958. (BBS, 2011). In the study area total literacy rate is 36.9%. (BBS, 2011). The study area of this study is one of the backward regions of the country and due this fact this study was carried to examine the health, hygiene and sanitation practices.



Source: LGED

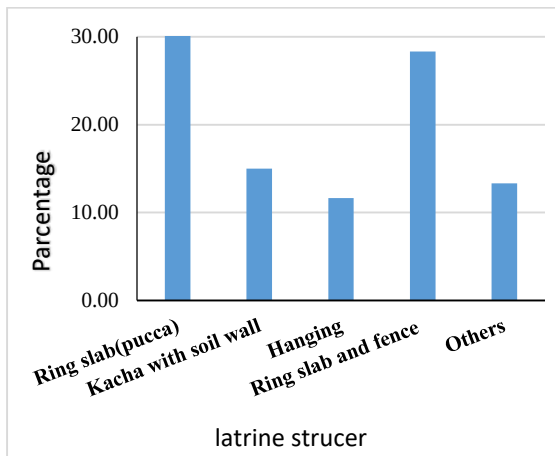
Fig-2.1: Garuitupi Mauza map

3. Present sanitation system and hygiene practices

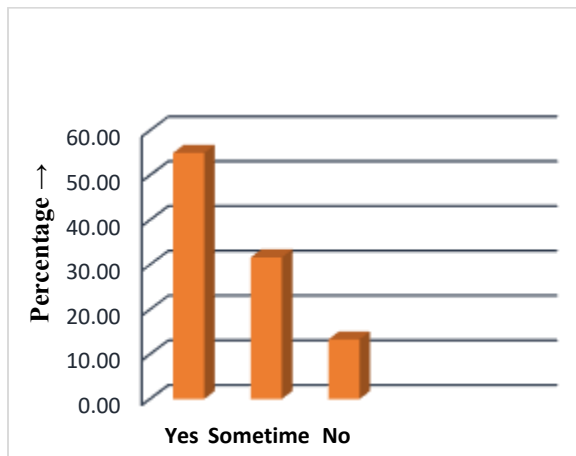
The word 'sanitation' also refers to the maintenance of hygienic conditions, through services such as garbage collection and wastewater disposal. “Sanitation is the hygienic means of promoting health through prevention of human contact with the hazards of wastes. It is the collection, transport, treatment and disposal or reuse of human excreta, domestic wastewater and solid waste, and associated hygiene promotion. (Velleman and Slaymaker, 2011)

3.1 Latrine structure and Shoe use practice

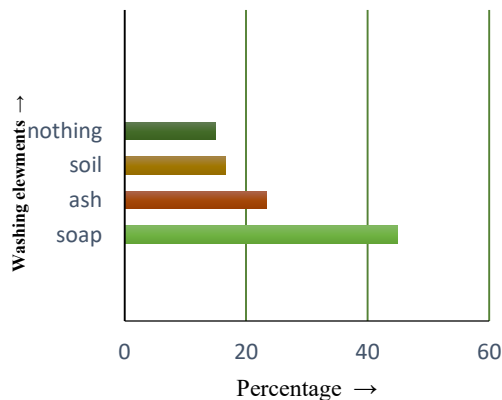
In Garuitupi Mauza most of the latrines are made of (31.67%) Ring slab with pucca wall With fence (Bamboo structure, Coconut or palm leaves, tin etc.) and 28.33% of the latrines are made using ring slab with fence (Bamboo structure, Coconut or palm leaves, tin etc.)(Fig 3.1). Other types included a toilet are kucha and made with mud and 11.67% latrine are hanging (Fig 3.1. Where a published sources show that about 57.95% households have hygiene sanitation system (DPHE, 2010). In the figure 3.2 revealed that in latrine 55 % respondent use shoes regularly, 31.67% respondents use occasionally and rest 13.33% respondent never use.



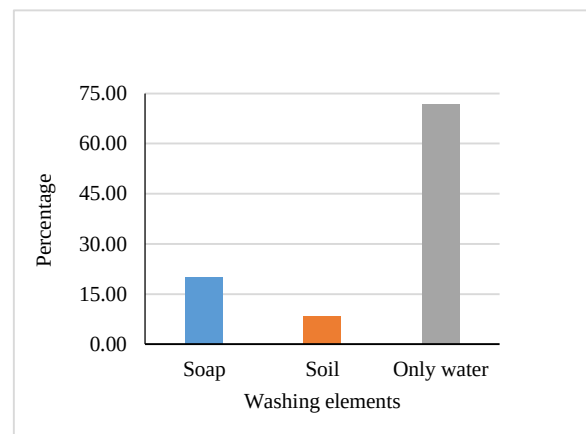
(Source: Questionnaire Survey, 2017)
Fig-3.1 Latrine Structure



(Source: Questionnaire Survey, 2017)
Fig-3.2 : Shoe use practice



(Source: Questionnaire Survey, 2017)
Fig-3.3: Hand wash practice after defecation



(Source: Questionnaire Survey, 2017)
Fig-3.4: Hand wash before taking food

3.2 Hand Wash after Defecation and before taking meal

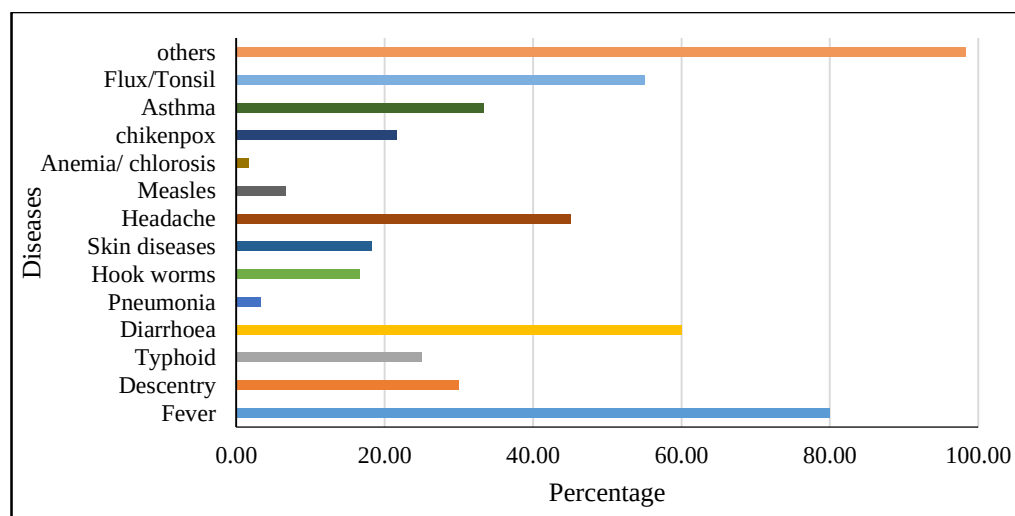
Evidence shows that hand washing can reduce the occurrence of diarrheal diseases by 14-40% (Haque, 2003). Hand wash after defecation is an important factor in hygiene practices. In the study, almost 45% of people used soap after defecation, 16.67% of people used soil, 23.33% of people used ash for cleaning hands, and 15% of people used nothing for washing their hands after defecation (fig-3.3). In a research on 50 sub-districts where BRAC WASH programme has been offering, it is found that about 88.1% of people use soap, 8.85% of people use only water, and 3.15% of people don't wash their hands after defecation (Rabby and Dey, 2013). It is observed that they usually use damp soil or ash near the toilet for washing their hands. In the figure 3.4, it is revealed that before taking a meal in the study area, 71.67% of people wash their hands with only water, 20% of people use soap, and 8.33% of people use soil to wash their hands.

4. Present Health status of the population of the study area

Health in its broader sense as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity (WHO, 1948). According to Business Dictionary (2010), "Health is a dynamic condition resulting from a body's constant adjustment and adaptation in response to stresses and changes in the environment for maintaining an inner equilibrium called homeostasis."

4.1 Different disease:

Fever is common diseases in this area. About 80% people are suffered by fever. Therefore Diarrhoea and Dysentery are another common disease. Fig 4.1 engrossed that among them 60% are suffered by Diarrhoea and 30% are suffered by Dysentery. Among communicable diseases Flux/ Tonsil (55%), Head ach (45%), Asthma (33.33%), and Typhoid (25%) are common(fig 4.1).Other diseases Lumbago, Heart Diseases, Gripe, skin diseases, pneumonia, hook worms Dental problem, Piles, Acidity, Tumour etc. are also found among the respondents.

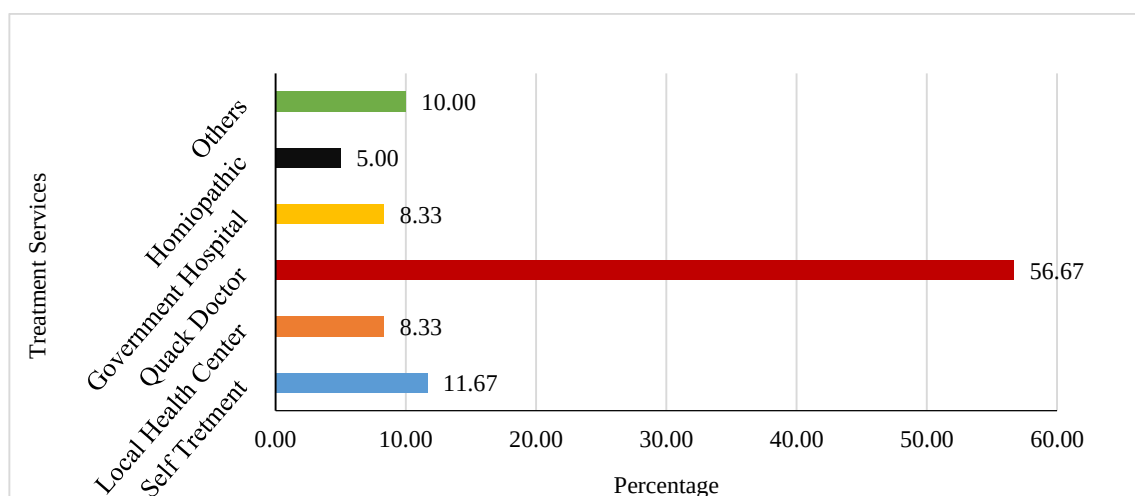


(Source: Questionnaire Survey, 2017)

Fig-4.1: Different Diseases in Study Area

4.2 Health Accessibility:

In the study area most of the people about 56.67% are go to Quack doctors for their treatment. There are about 8.33% people go to local health center and 5% people are take Homeopathic treatment (fig-4.2). People don't want to go to govt. hospitals because it is far (about 20 kilometer) from the study area. And there is no comfortable and easy transport system for going to hospital. In this area about 11.67% people are take self-treatment (fig-4.2).Kabiraz, Ayurbedik treatment etc.is observed too.



(Source: Questionnaire Survey, 2017)

Fig-4.2: Health Accessibility

5. SKH model regarding the relationship among sanitation system, hygiene practice and health

There is a close relationship among sanitation system knowledge about hygiene practice and health. Lacking of clear concept people in the study area don't emphasis on sanitation system. It is observed educated people are more aware and practice healthy sanitation system. SKH (Sanitation system, Knowledge & hygiene practice method and Health status) focused that relation.

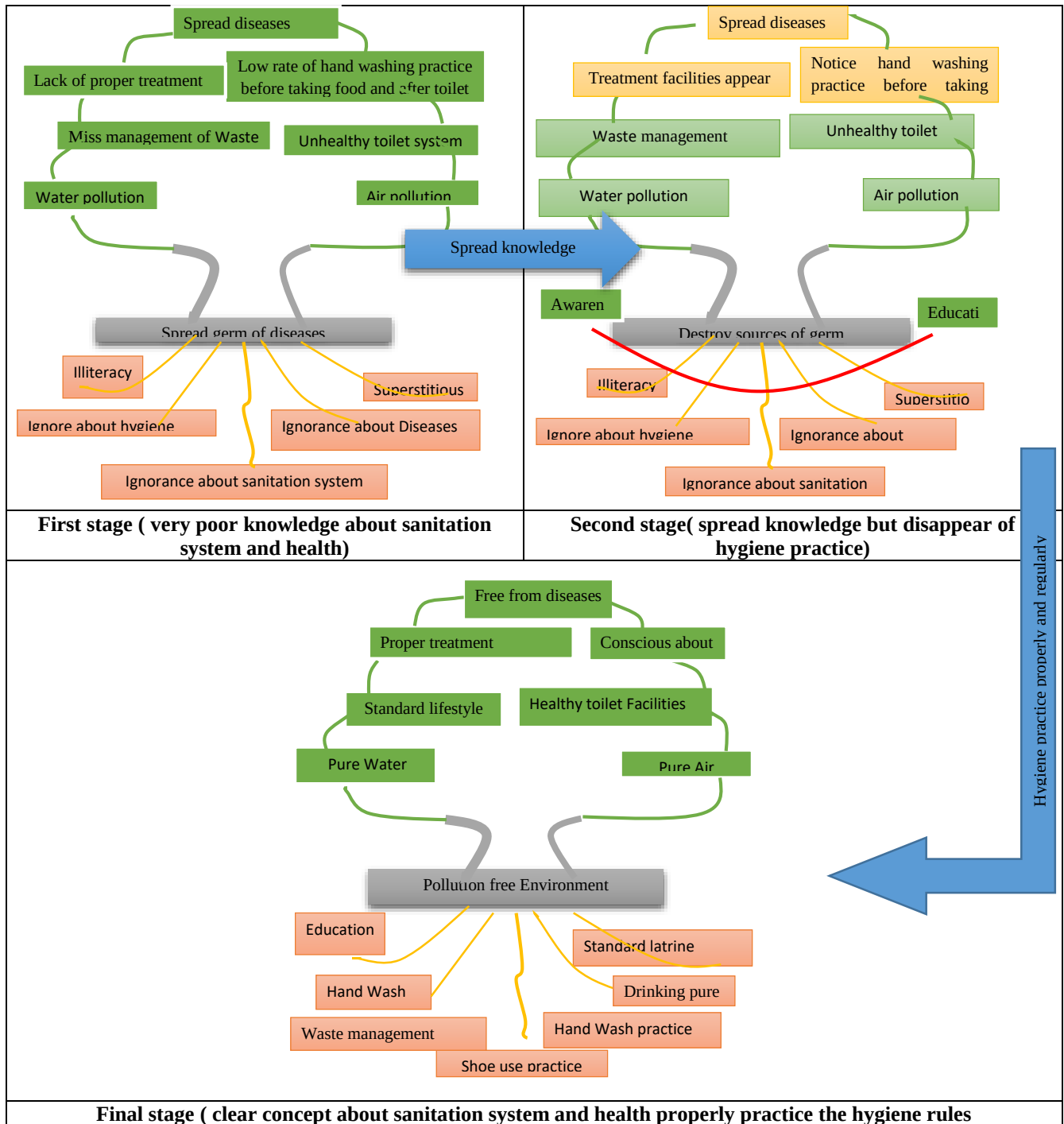


Fig-5.1 SKH model

5.1 First stage (very poor knowledge about sanitation system and health)

In the first stage represent a situation there have a poor knowledge about sanitation system and hygiene practice. Because of ignorance about sanitation system people use very unhealthy latrine as like as Kacha or defecation in open field. This study observed that who are illiterate or have a primary education are followed poor sanitation system. in the table 5.1 and 5.2 exhibit the relationship between hygiene practice and knowledge. 18.5% Illiterate people use only water where the habit are less among S.S.C(14.8%) and H.S.C passed people(14.8%).

Tab. 5.1: Crosstab table analysis education and hygiene practice

			Education					Total
			Illiterate	Primary	J.S.C	S.S.C	H.S.C	
Hand wash practice after latrine	Only Water	Count	5	9	5	4	4	27
		% within Hand wash practice after latrine	18.5%	33.3%	18.5%	14.8%	14.8%	100.0%
	Soil	Count	5	4	4	1	0	14
		% within Hand wash practice after latrine	35.7%	28.6%	28.6%	7.1%	.0%	100.0%
	Ash	Count	6	4	0	0	0	10
		% within Hand wash practice after latrine	60.0%	40.0%	.0%	.0%	.0%	100.0%
	Soap	Count	1	2	2	1	3	9
		% within Hand wash practice after latrine	11.11%	22.2%	22.2%	11.11%	33.3%	100.0%
Latrine types	Ring slab (pucca)	Count	4	6	6	3	4	23
		% within Latrine types	17.4%	26.08%	26.08%	13.0%	17.4%	100.0%
	Kacha	Count	1	1	0	0		2
		% within Latrine types	50.0%	50.0%	0.0%	0.0%	0.0%	100.0%
	Ring slab with fence	Count	5	4	1	0	0	10
		% within Latrine types	50.0%	40.0%	10.0%	.0%	.0%	100.0%
	others	Count	6	7	8	2	0	23
		% within Latrine types	26.1%	30.4%	34.8%	8.7%	.0%	100.0%

(Source: Questionnaire Survey, 2017)

Educated people are conscious about their health. This study exposed that educated people are less suffer from different sanitation related diseases than less educated or illiterate people. Table-5.2 reveal that who are illiterate or primary passed they are suffering from typhoid (respectively 33.3 % and 40%), Dysentery (44.4 % and 27.8%), Diarrhoea (20.8% and 50%) hookworm (50% and 30%) where who are H.S.C passed are suffering from typhoid (respectively 6.7 %), Diarrhoea (8.3%) hookworm (0%).

Tab. 5.2: Cross table analysis between Educational Status and Different diseases

			Education					Total
			Illiterate	Primary	J.S.C	S.S.C	H.S.C	

Typhoid	No	Count	15	14	8	5	3	45
		% within Typhoid	33.3%	31.1%	17.8%	11.1%	6.7%	100.0%
		% within Education	75.0%	70.0%	72.7%	100.0%	75.0%	75.0%
	Yes	Count	5	6	3	0	1	15
		% within Typhoid	33.3%	40.0%	20.0%	.0%	6.7%	100.0%
		% within Education	25.0%	30.0%	27.3%	.0%	25.0%	25.0%
Dysentery	No	Count	12	15	7	4	4	42
		% within Dysentery	28.6%	35.7%	16.7%	9.5%	9.5%	100.0%
		% within Education	60.0%	75.0%	63.6%	80.0%	100.0%	70.0%
	Yes	Count	8	5	4	1	0	18
		% within Dysentery	44.4%	27.8%	22.2%	5.6%	.0%	100.0%
		% within Education	40.0%	25.0%	36.4%	20.0%	.0%	30.0%
Diarrhoea	No	Count	5	12	4	1	2	24
		% within Diarrhoea	20.8%	50.0%	16.7%	4.2%	8.3%	100.0%
		% within Education	25.0%	60.0%	36.4%	20.0%	50.0%	40.0%
	Yes	Count	15	8	7	4	2	36
		% within Diarrhoea	41.7%	22.2%	19.4%	11.1%	5.6%	100.0%
		% within Education	75.0%	40.0%	63.6%	80.0%	50.0%	60.0%
Hookworm	No	Count	15	17	10	4	4	50
		% within Hookworm	30.0%	34.0%	20.0%	8.0%	8.0%	100.0%
		% within Education	75.0%	85.0%	90.9%	80.0%	100.0%	83.3%
	Yes	Count	5	3	1	1	0	10
		% within Hookworm	50.0%	30.0%	10.0%	10.0%	.0%	100.0%
		% within Education	25.0%	15.0%	9.1%	20.0%	.0%	16.7%
Skin diseases	No	Count	18	14	9	3	4	48
		% within Skin diseases	37.5%	29.2%	18.8%	6.2%	8.3%	100.0%
		% within Education	90.0%	70.0%	81.8%	75.0%	100.0%	81.4%
	Yes	Count	2	6	2	1	0	11
		% within Skin diseases	18.2%	54.5%	18.2%	9.1%	.0%	100.0%
		% within Education	10.0%	30.0%	18.2%	25.0%	.0%	18.6%

(Source: Questionnaire Survey, 2017)

5.2 Second stage (spread knowledge but disappear of hygiene practice)

In this stage people introduce about healthy sanitation system. light of education spread . People become aware. Government take different step to progress sanitation facilities. But the habit of long time not changed fully. They don't follow the rule of hygiene exactly. This research it focused that Garuitupi mauza people are prevailing this stage. In the study area it observed that all the people don't use soap, pucca latrine , shoes etc. again who use are irregularly sometimes fig-3.1, 3.3, tab 5.1). As a result sanitation related disease are found. But educated person who practice hygiene rule are less suffered than who never or irregularly

followed. In the study area it observed the respondent who use soap for washing their hand after using toilet they are less affected by different chronic diseases than those respondent who use only water. Table 5.3 focused that people only water user are suffer from dysentery 38.9%, Typhoid 46.7% and Diarrhoea 41.7%. Where soap user are suffer from dysentery 11.9%, Typhoid 20.0 % and Diarrhoea 13.9 %. The soap user are suffer from dysentery by 11.9%, diarrhoea by 6.7%, and typhoid by 20.0%, and other diseases by 15.3%. the soap user are less suffer from different diseases than soil, ash or only water user for washing their hand after using toilet.

Tab.5.3: Cross table analysis between Hand wash after Toilet use and Different diseases

			Hand wash after Toilet use				Total
			Only Water	Soil	Ash	Soap	
Dysentery	No	Count	20	9	8	5	42
		% within Dysentery	47.6%	21.4%	19.0%	11.9%	100.0%
		% of Total	33.3%	15.0%	13.3%	8.3%	70.0%
	Yes	Count	7	5	2	4	18
		% within Dysentery	38.9%	27.8%	11.1%	22.2%	100.0%
		% of Total	11.7%	8.3%	3.3%	6.7%	30.0%
Typhoid	No	Count	20	10	6	9	45
		% within Typhoid	44.4%	22.2%	13.3%	20.0%	100.0%
		% of Total	33.3%	16.7%	10.0%	15.0%	75.0%
	Yes	Count	7	4	4	0	15
		% within Typhoid	46.7%	26.7%	26.7%	.0%	100.0%
		% of Total	11.7%	6.7%	6.7%	.0%	25.0%
Diarrhoea	No	Count	12	4	4	4	24
		% within Diarrhoea	50.0%	16.7%	16.7%	16.7%	100.0%
		% of Total	20.0%	6.7%	6.7%	6.7%	40.0%
	Yes	Count	15	10	6	5	36
		% within Diarrhoea	41.7%	27.8%	16.7%	13.9%	100.0%
		% of Total	25.0%	16.7%	10.0%	8.3%	60.0%
Hookworm	No	Count	22	10	9	9	50
		% within Hookworm	44.0%	20.0%	18.0%	18.0%	100.0%
		% of Total	36.7%	16.7%	15.0%	15.0%	83.3%
	Yes	Count	5	4	1	0	10
		% within Hookworm	50.0%	40.0%	10.0%	.0%	100.0%
		% of Total	8.3%	6.7%	1.7%	.0%	16.7%
Other	No	Count	0	1	0	0	1
		% within Other	.0%	100.0%	.0%	.0%	100.0%
		% of Total	.0%	1.7%	.0%	.0%	1.7%
	Yes	Count	27	13	10	9	59
		% within Other	45.8%	22.0%	16.9%	15.3%	100.0%
		% of Total	45.0%	21.7%	16.7%	15.0%	98.3%

(Source: Questionnaire Survey, 2017)

5.3 Final stage (clear concept about sanitation system and health properly practice the hygiene rules

This stage focused if people are cognizant about proper sanitation system, hygiene rule and practice those regularly and properly, environment will be pollution free. All the diseases which are directly or indirectly depend on hygiene practice will be prevented automatically. In this stage the relationship among sanitation system hygiene practice and health are assessed (fig-5.1). In correlation analysis it notice that there is a negative correlation between education and disease. Table 5.4 exposed that there is a moderate and negative correlation between typhoid and education ($r = -0.373$) pneumonia and education ($r = -0.323$), skin diseases and education ($r = -0.314$). The table also focused that there is a negative and low correlation between dysentery and diarrhoea ($r = 0.1801$), diarrhoea and education ($r = -0.152$), and education and hook worm ($r = -0.157$). This relation indicates that the probability suffering from different disease decrease with increases the educational status of the study area population.

Tab.5.4: Correlation among Different Diseases and Education

Different Diseases		Education
Dysentery	Pearson Correlation	-0.181
	Sig. (2-tailed)	0.166
	N	60
Typhoid	Pearson Correlation	-0.373
	Sig. (2-tailed)	0.579
	N	60
Diarrhoea	Pearson Correlation	-0.152
	Sig. (2-tailed)	0.695
	N	60
Pneumonia	Pearson Correlation	-0.323
	Sig. (2-tailed)	0.350
	N	60
Hookworm	Pearson Correlation	-0.157
	Sig. (2-tailed)	.230
	N	60
Skin diseases	Pearson Correlation	-.314
	Sig. (2-tailed)	.016
	N	60

(Source: Questionnaire Survey, 2017)

There are various relationship between hand washing before taking meal and different diseases With the increasing of the number of respectively water user, soil user and only soap user for washing hand the probability by suffering from different disease such as dysentery , diarrhoea, Typhoid , hookworm etc. also decrease. Table 5.5 focused that there is a moderate correlation diarrhoea and hand washing before taking food where $r = -0.439$. There is a low and negative correlation between hand washing before taking food and dysentery ($r = -0.167$), hand washing before taking food and typhoid (-0.036) and hand washing before taking food and hookworm($r = -0.102$).

Table-5.5: Correlation among Different Diseases and Hand wash before taking food

		Hand wash before taking food
Dysentery	Pearson Correlation	-0.167
	Sig. (2-tailed)	.202
	N	60
Typhoid	Pearson Correlation	-0.036
	Sig. (2-tailed)	.186
	N	60
Diarrhoea	Pearson Correlation	-.417
	Sig. (2-tailed)	.098
	N	60
Hookworm	Pearson Correlation	-.102
	Sig. (2-tailed)	.439
	N	60
Other	Pearson Correlation	-.078
	Sig. (2-tailed)	.553
	N	60

(Source: Questionnaire Survey, 2017)

Science there is a relationship among the hygiene practice and knowledge, sanitation system and health this study it predicted if all the rule of hygiene of is practiced then sanitation related diseases such as diarrhoea, cholera, dysentery, hookworm etc. it will be possible to prevent them.

6. Conclusion

Health is a vital factor for human life. For good health hygiene practice and conscious about health is indispensable. Many people loss their life and wealth by suffering with different disease. The common diseases are diarrhoea, dysentery, cholera, jaundice, chickenpox, diabetes, hookworm, phthisis, cancer, heart attack, and others. Among the diseases most are related with sanitation system. By analyzing different phenomena of sanitation system and cause of different disease it is found that there is a close relationship between health and sanitation system. SKH model focused the interrelationship on the base of existing condition of study area. If another condition is unchanged, then only progressing knowledge about health and hygiene and following the hygiene rule regularly and properly is the only way to free from diarrhoea, dysentery, cholera, hookworm and other sanitation related diseases.to spread knowledge about health it is need to aware people by seminar, open discussion, exhibit short stage drama, broadcast & telecast sanitation system and hygiene related program through radio and television and educated people by arranging adult school, night school and others. To aware people about proper and healthy model of sanitary latrine, Local Govt. should take provide step to regarding this sector.

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Women Empowerment through Participation in Income Generation Activities in Slum Area: A case study of Rajshahi City

Sherazum Monira ¹, Md. Salman Reza ¹, Shabnaz Tabassum ¹

¹ Undergraduate student, Department of Urban & Regional Planning, Rajshahi University of Engineering and Technology, Rajshahi-6204, Bangladesh

Abstract

Women empowerment is an important factor to develop any developing country like Bangladesh. Though the half of the population of our country is female, it is impossible for us to develop our country without giving any consideration to this section. Nowadays, women are not only involved in household chores but also they are involved in outside works. But, the rate of women empowerment in the slum is literally low than the other educated women in the city. The aim of this study is to identify the existing condition of women's participation in income generation activities and to compare their income generation activities with men. For this study, Vodra rail slum area in Rajshahi has been selected as study area. Vodra rail slum area is not very far away from the city center but the life of people in this area is totally different from the people just of the opposite of the road. Participatory Rural Appraisal (PRA) is used as a method where cause-effect diagram and pair-wise matrix are used to find out the actual causes of their unemployment. Many causes have found why they have a problem and the effects of this problem. Finally, some recommendations are provided that why women empowerment is important to change the present condition of this slum. The result of this study will show the exact scenario of slums in Bangladesh.

Keyword: *Women Empowerment, Income Generation Activities, Participatory Rural Appraisal, Daily Activity Schedule, Cause-effect Diagram, Pair-wise Matrix and Service and Opportunity Map.*

1. Introduction

1.1 Background of the study:

Our study area is Railgate slum area. It is situated in the Vodra and between word no: 19 and 26 in Rajshahi City Corporation. The conditions of the people in this area are very poor. They lead a very complex life. Both the husband and wife are engaged in employment sector but the level of income is very low. The employment source is very common in this area. More than 70% women collect vangri, polythene, papers and begging, others are involved others household work (Field survey, 2017). Some of them are rickshaw puller and engaged as a maid in others household. As our study is on the women empowerment, the women are engaged in employment sector than a man in large number in this slum. It is heard that they also do needle work and the most attractive matter is that women also pull rickshaw and van here. Most of the people are illiterate. Only a few are able to sign their name. They do not get help from any NGOs except an NGO named "Shakti" who give a small amount of loan. But they have own "Mohila Somiti" running by them, aunty Janet an American lady is running a Morning star school

which has both educational and tanning facilities. Co-operation with NGOs and Social Organizations in Women Development, Work Plan and Program Strategy, Women Development Training Institute, Institutional Framework and Strategy are some recommendation to increase awareness for women empowerment.

1.2 Objectives:

- To identify the existing condition of women's participation in income generation activities.
- To compare their income generation activities with men.

2. Methodology

Different steps of the methodologies are described below :

2.1 Study area selection:

For our study, it was important for us to find an area where women participation in income generation activities is large. So we had to make a survey in many areas. But from our survey, we have found that women participation in income generation activity in Vodra rail Slum area is larger than other. So we decided to choose this area for our PRA survey.



Figure 01: Vodra rail slum
(Source: Google Earth Image ,2017)

2.2 Literature review:

Different types of literature, papers, policies, definitions that was relevant to this study had been reviewed.

2.3 Methods (PRA tools):

In order to identify the existing condition of women's participation in income generation activities, a variety of PRA tools such as Daily activity schedule, Cause-Effect Diagram, Pair-Wise Ranking Method, and Service and opportunity map have been used with ensuring the active participation of the slum women.

2.3.1 Daily activity schedule:

Daily activity schedule means daily schedule, daily activity profile, daily routine and 24 hours method is a popular PRA method. It is used to explore the activities of an individual, group or community on a daily basis. It increases gender sensitization and create and awareness about who is responsible for what activities in the community (Kumar S, 2002).

2.3.2 Cause Effect Diagram:

Cause and effect diagram is a popular PRA method which is also known as fishbone or Ishikawa diagram. It is the method which falls under the larger family of flow and linkage diagram methods. It also helps to find out the actual causal factors of a phenomenon, activity, event or problem and the effects thereof (Kumar S, 2002).

2.3.3 Pair-Wise Ranking Method:

Pair wise ranking is based on a history of wide application in market research which helps to determine people's priorities and preferences. It also leads to developing insights into people's decisions-making processes and the criteria used by them to arrive at their preferences (Kumar S, 2002).

2.3.4 Service and Opportunity Map:

Services and opportunities map is another PRA method which helps to explore the spatial realities of the local people with specific reference to the local people's perceptions of the services and opportunities available (Kumar S, 2002).

3. Data Analysis

In the data analysis part, we have analyzed our collected data with the help of different PRA tools. We have arranged this chapter according to our objectives. For our first objective which was to identify the existing condition of women's participation in income generation activities; we have used three different types of tools such as pair wise ranking, cause effect diagram and activity schedule mapping and for our second objectives which were to compare their (women) income generation activities with men; we have collected survey data through household survey from the slum people.

3.1 Daily Activity Schedule:

Daily activity schedule also referred to as daily schedule, daily activity profile, daily routine and 24 hours method is a popular PRA method used to explore the activities of an individual, group or community on a daily basis. Increase gender sensitization and create and awareness about who is responsible for what activities in the community (Kumar S, 2002).

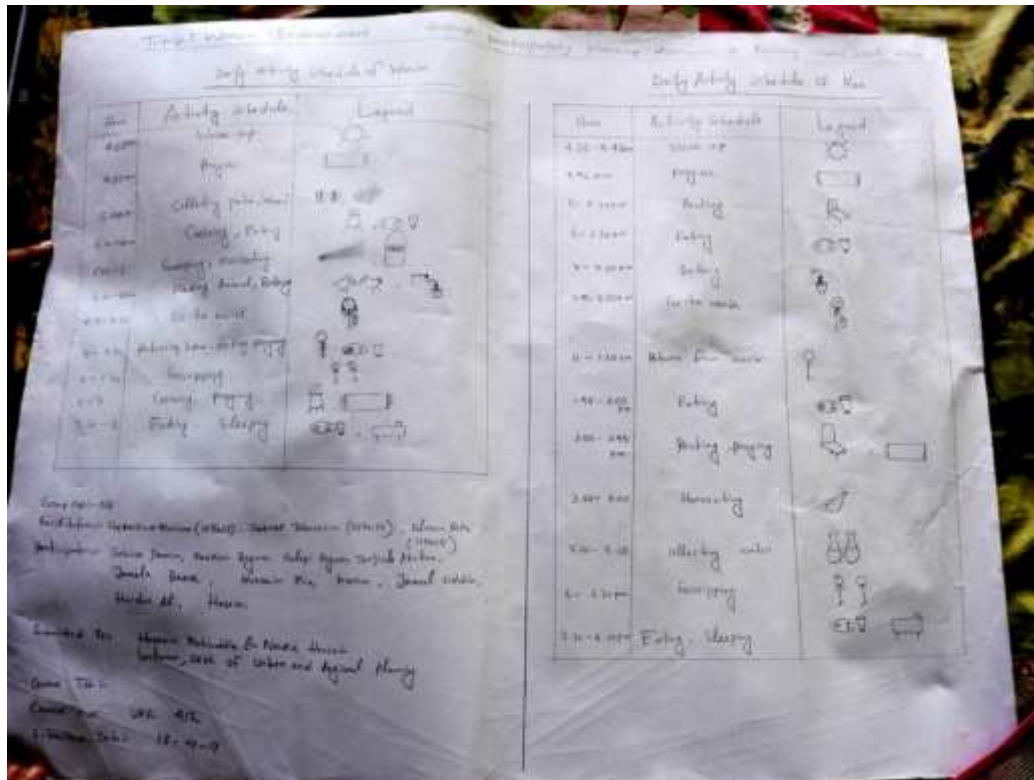


Figure 02: Daily activity schedule of rail bosti

Source: Field Survey, 2017

Both men and women wake up early in the morning and start their daily chores. Women start their day with working and they have no fixed time limitation of their work. In some family, women have to do both men and women duties. They have to work hard both inside and outside of the house. They are fully dedicated to their family and also work hard to maintain their family. Their outside work is to collect vangri, work in others house, pulling a van and working in husband's shop. From this diagram, it is also visible that men get some time to take their food where as women have to prepare it then if they get some time, they take their meal.

3.2 Cause-effect diagram & Pair-wise matrix:

From the field survey, according to our topic, it has found that the main problem is lack of women's employment opportunities. We have found nine main causes that are responsible behind this problem such as lack of entrepreneurship within community, illiteracy, poverty, migrated people, lack of skill, problems in family life, lack of own land ownership, lack of resources, no bank loan etc. For this problem, there are a lot of effects

on slum people. The effects are lack of social recognition, no savings, low income, low lifestyle, malnutrition, lack of shelter, child labor etc.

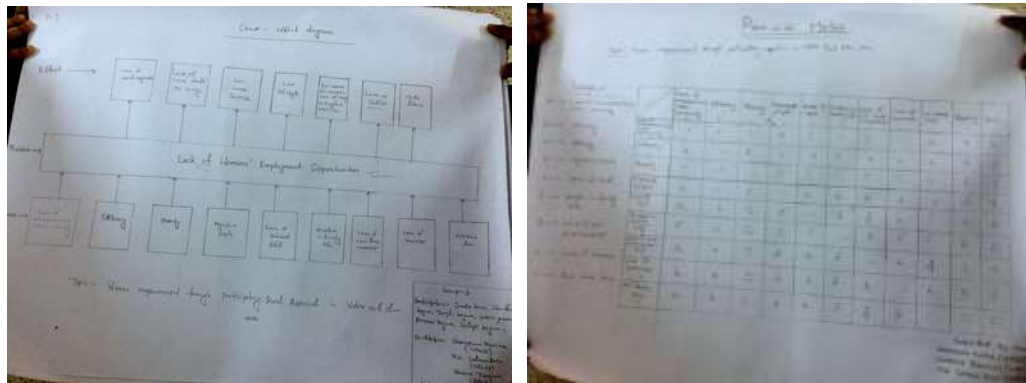


Figure 03: Cause effect diagram and Pair wise matrix of the study area

(Source: Field survey, 2017)

A pair-wise matrix has conducted to sort out the top ranked causes which are the most responsible for the problem. After conducting pair-wise matrix among nine causes, four top ranked causes are found and these causes are poverty, illiteracy, problems in family life and lack of resources. Again it is conducted cause-effect diagram for these sorted top ranked causes considering each of the causes itself a problem.

Firstly, to consider poverty itself a problem, from the field survey we found three causes behind this problem and they are illiteracy, lack of resources and lack of land ownership. Poverty has a various disastrous effect on social life such as low lifestyle, family problem, the rise of social crime, lack of social recognition and so on.

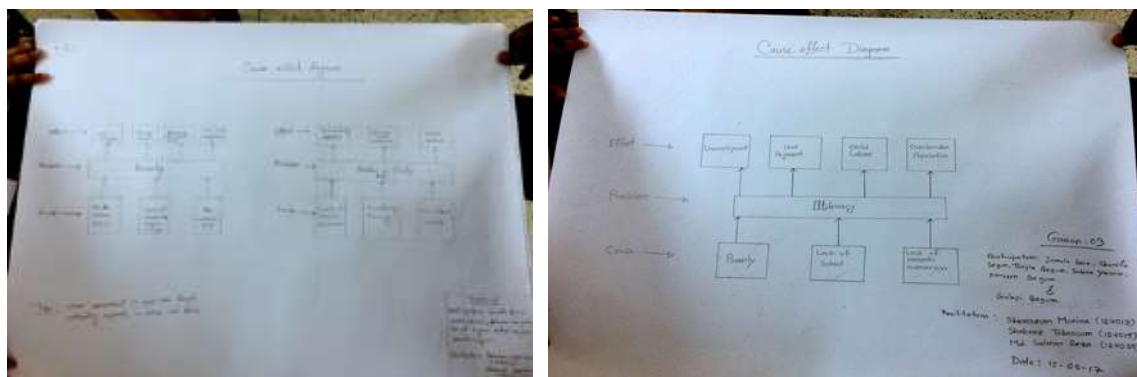


Figure 04: Cause effect diagram of the study area

(Source: Field survey, 2017)

And for illiteracy, causes are poverty, lack of school, lack of parent's awareness etc. Illiteracy creates many negative effects such as unemployment, low payment, child labor, overburden population etc.

Thirdly, we consider lack of resources as a problem and causes behind this problem are a seasonal storm, unconsciousness about family planning and little amount of inherited land etc. And the effects are unemployment, lack of savings, poor lifestyle, migration etc.

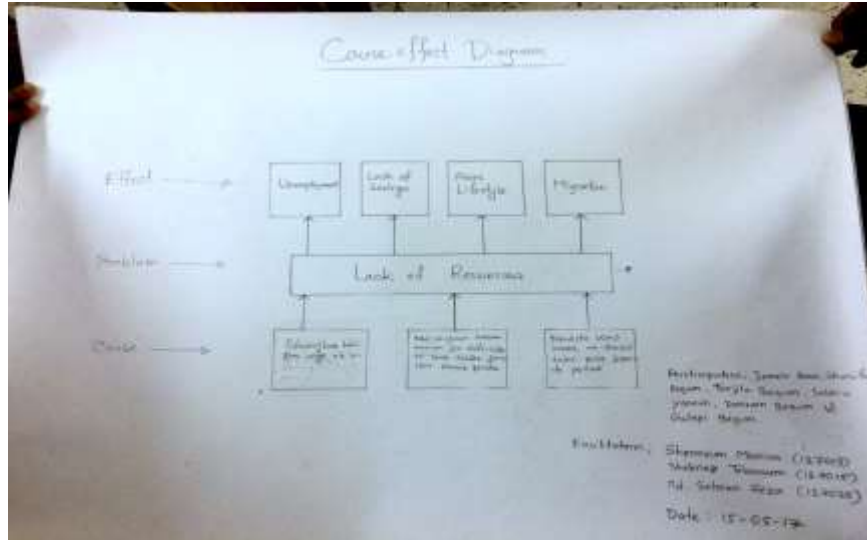


Figure 05: Cause effect diagram of the study area

(Source: Field survey, 2017)

And finally, the cause-effect diagram is drawn for problems in family life. From the field survey, we found the causes behind this problem and they are illiteracy, poverty, and unemployment rate. And the effects caused by the problem, are broken family relation, decrease social awareness, child labor etc.

3.3 Service and Opportunity Map:

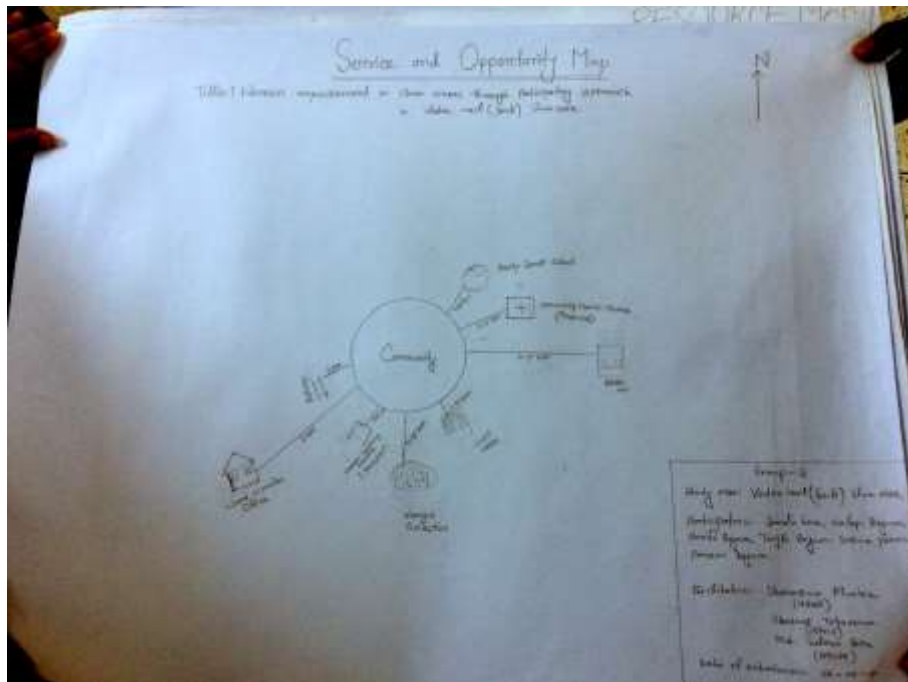


Figure 06: Service and opportunity analysis of Rail slum

(Source: Field survey, 2017)

From field survey, we have found that there exists many services and potential opportunities relating to women empowerment in slum areas through participating approach in Vodra rail (bosti) slum area. Vangi Collection activities has strong influence

on the community and it is located within the community which distance is only 0.15 km. Most of the women involve in vangri collection activity. Shakti NGO also has strong influence on the community which is only 0.25 km far away from the community. There is potentialities for a women training centre on south-western part of the study area and a community health care centre on the north-eastern zone, both will be located within 0.5 km from the community.

Though Morning star children care school established by an American women named Zanet is located 1.25 km away from the community but it has the strongest influence on the community's women as it provides sewing training for the slum women and provides education facilities for the unprivileged children of the slum area. An NGO named BRAC is located only 0.5 km away from the community but it has no influence on the community as community people don't get any help from this NGO. Railway and ward councilor office both are located within 1 km from the community but have very little influence on the community.

3.4 Survey data analysis:

After completing this analysis of the existing condition of women and the reason behind their condition; we have compared their role with their spouse and find some interesting result.

Table 01: Comparison between men and women involvement in income generation

Year	% of women involvement in income generation activities	% of men involvement in income generation activities
1968	5	95
1980	15	85
1987	45	45
2015	50	50
2017	60	40

activities

(Source: Field survey, 2017)

According to the survey, this sum was established in 1968. There was a less number of houses in this slum. For this reason, women involvement was only 5% of income generation activities because there was limited work for women. From Figure 07, it is shown that the percentage of women involvement has been increased with the passing of time and now-a-days more than half of the women involve in income generation activities to support their family.

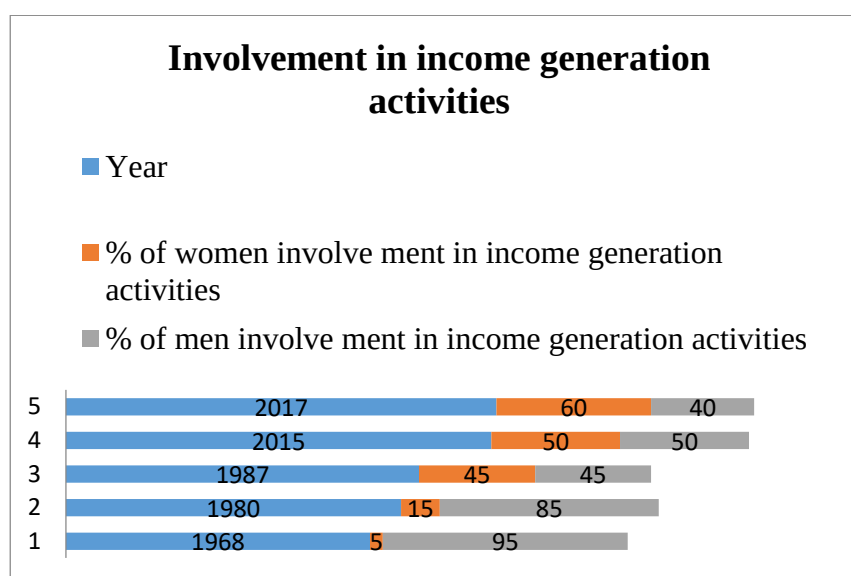


Figure 07: Involvement in income generation activities

(Source: Field survey, 2017)

From the Figure 07 it has been found that there is both increase and decrease of men involvement in income generation. That means in that year where men participation was less; the women of their house support their family most than them. In 1968 when the people came to live in this slum most of the men go another place to find some work. But when the participation of women increases in income generation sector men found competitors in this sector so their participation has been decreased.

Table 02: Activity of women

Name of activity	% of activity
swing	3
Pulling van	2
Vangri collection	50
Household worker	15
Begging	10
Helping husband in their work	20

(Source: Field survey, 2017)

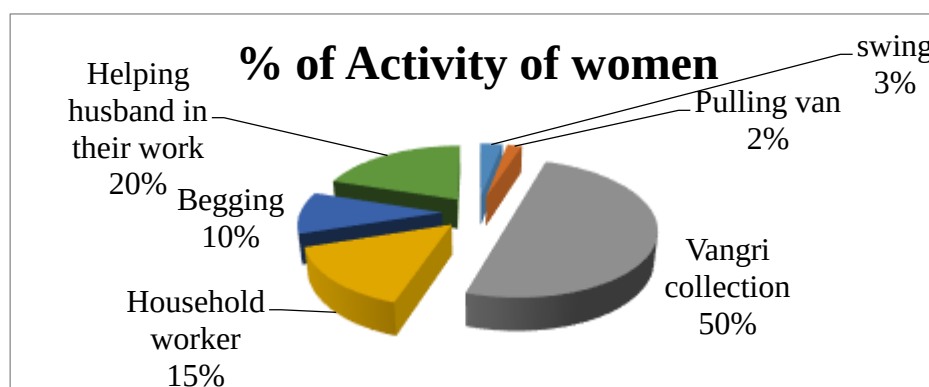


Fig 08: Activity of women

(Source: Field survey, 2017)

From the chart, it has been found that 50 % that means almost half of the women involved in the vangri collection that means in income generation activity and second large portion involve in another working sector that is work in others household. Almost 20% women help their husband in their work. With the help of foreign lady janet some women start to do swing work but this portion is very small. There are some disabled people in the slum. Their wife or daughter have no work in spite of begging. About 10% women beg for their family. Most interesting fact is that women pull van in this area to maintain her family.

Table 03: Activity of men in slum area

Name of activity	% of activity
Pulling van	5
Pulling rickshaw	30
Vangri collection	25
Begging	25
Working in stall	15

(Source: Field survey, 2017)

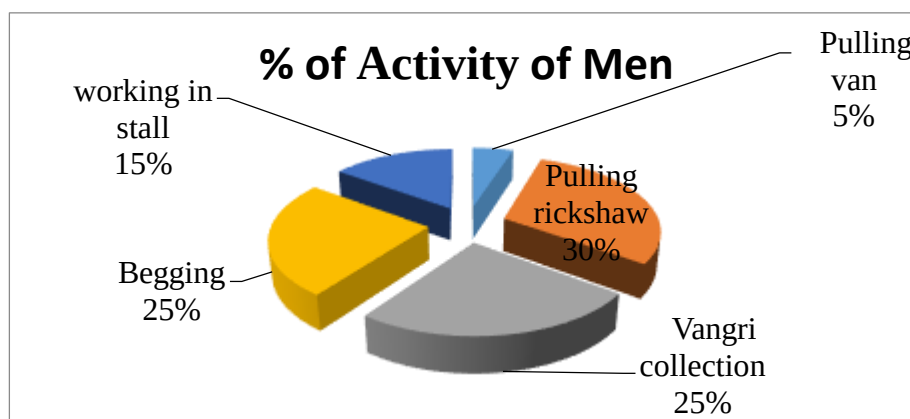


Figure 09: Activity of Men in slum area

(Source: Field survey, 2017)

From the figure 09, it has been found that men activity is very in this slum area. They pull rickshaw or van, work in the stall, and collect vangri or begging. But it is fact that 25 % that means one fourth people (men specially) involve in begging. The disable and old men in this area start begging very early in the morning in different part of Rajshahi city. About 25% men also collect family with their family member. Some of them work in stall and pull van. Though this portion is very small, a large number of people pull rickshaw which is 30 %.

Table 04: Women involvement in some savings works

Doing some saving works	% of Women
Doing mohila somiti	80
Take loan from NGO	20

(Source: Field survey, 2017)

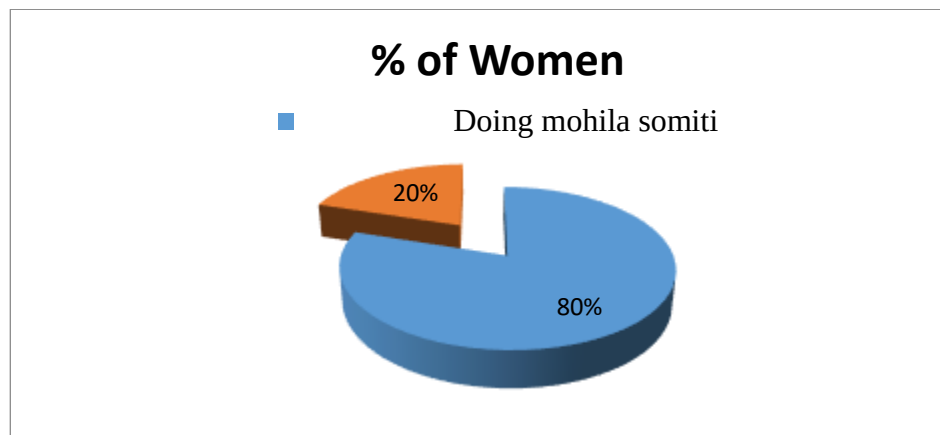


Figure 10: Women involvement in some saving works

(Source: Field survey, 2017)

From the Figure 10 it has been found that a huge number of women involve in somiti to make an amount of money to support their family. Almost 80% women involve in somiti and they do this somiti with themselves. There is a woman whose name is golapi, her house is used as the center for this somiti. Though the NGO's support is not maximum, sometimes they take a loan, arrange some money and then help their family at different times.

4. Findings & Recommendation

The study was conducted for two purposes. One is to identify the existing condition of women's participation in income generation activities. Another is to compare their income generation activities with men. Under the first objective, we have found some major findings. They are given the following:

- i. Most of the people are illiterate. Only a few are able to sign their name.
- ii. They do not get help from any NGOs except an NGO named "Shakti" who give a small amount of loan. But they have own "Mohila Somiti" running by them.
- iii. More than 70% women collect vangri, polythene, papers and begging, others are involved others household work.
- iv. There has a school named "Morning star" running by an American lady, provide free facilities to literate bosti children and women. She also teaches sewing work to the poor people but bosti people do not interested to go there.
- v. Also some students from "Biddanondo foundation" came in the slum in 2016. They taught the children three days in a week. People are not aware to educate their children.
- vi. Most of the women are engaged in begging and they go for a long distance to beg every day. That also a reason not to build up socially and economically their status.

To recommend some strategies for women contribution to their family we have made some policy review and have found the following to suggest. The things should be done is given in the following:

- i. To ensure full and equal participation of women in the mainstream socio-economic development.
- ii. To bring up women as educated and skilled human resources.
- iii. To establish gender equality in politics, administration, other areas of activity, socio-economic activity, education, culture, sports and in all areas of family life.
- iv. To provide overall assistance in ensuring the growth of women entrepreneurs
- v. To give appropriate recognition to women's contribution in socio-economic areas.

According to National Women Development Policy, 2011, some programs need to be established:

Programs such as co-operation with NGOs and social organizations in women development, work plan and program strategy, women development training institute and institutional framework and strategy etc. need to be held for an effective solution for women participation in income generation activities to support their family in slum areas (NWDP, 2011).

5. Conclusion

By using different PRA tools (such as Activity Schedule map, Pair wise ranking, Cause effect diagram, Service and opportunity map etc) we know about their existing condition. From Pair, wise ranking method and cause effect diagram we have found the main causes for the lack of employment opportunities problem and thereafter what its effect would occur. Poverty, lack of resource, illiteracy, and problem in family life etc. are the main problems that the slum women have faced in their life. Low income, low savings, an increase of child labor etc are main effects of the lack of women employment opportunities. Most of the slum women of our study area are engaged in paper or vangri collection, begging or served as a maid servant or domestic worker. Concerned authority such as government and different NGOs have to play a key role to help the slum women by providing them proper employment opportunities, educational facilities, different training programs on sewing work etc and thus women participation in income generation activities can be ensured.

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Inclusion of Agriculture in Climate Change Discourse: Developing Countries' Perspectives

Dr Mahfuzul Haque¹

Abstract

As climate change is taking its toll on agriculture in particular and food production in general, the policy makers and agricultural scientists are getting increasingly worried about food security in the face of climate change. It is not only affecting the food production systems but is also becoming a threat to lives and livelihoods of those dependent on agriculture. The concept of “Climate Smart Agriculture (CSA)” was evolved by the FAO and World Bank in order to ensure food security as a solution to offset adverse impacts caused by climate change on food production. In order to increase productivity and resilience, the new notion of agricultural system is said to reduce greenhouse gases and help achieving food sufficiency. Many developing countries including Bangladesh started undertaking projects and policies in line with climate smart agriculture. There are critiques that CSA over-produces food, destroys soil fertility and is responsible for deforestation, contamination of water, acidification of oceans and depletion of fisheries. The concept encourages increased food production through introduction of high yield variety seeds, agro-chemicals, insecticides and pesticides affecting the environment and biodiversity. Against this backdrop, the paper examined the philosophy behind CSA and tried to understand the hidden meaning of the term, as it is apprehended to benefit the corporates engaged in agri-business. The paper argues that although the terminology like “climate smart agriculture” sounds very catchy and convincing, the ultimate impact could be disastrous. Apparently innocuous, the very concept could beguile the policy makers, agriculture scientists, executives and thereby earn hefty profits for the multinational companies. The paper further argues that instead of CSA, agro-ecological cultivation could reduce adverse impacts of climate change, ensure food security and thereby protect the environment and biodiversity.

Key Words: Agro-ecology • Bangladesh • Climate Change • Climate Smart Agriculture

Introduction

Agricultural systems are highly affected by climate change and climate variations as cultivation of crops and livestock management practices are highly dependent on and susceptible to climatic factors. Developing countries despite their low emission of GHGs are highly vulnerable to climate change (UNDP, 2007). Climate change is already hampering agricultural growth.

¹ The author, a former Secretary, Government of Bangladesh, is currently teaching as an Adjunct Faculty in the Department of Development Studies, University of Dhaka. His areas of interest are environment and development; biodiversity conservation; natural resource management; dams and development; disaster risk reduction; and climate change. He could be reached at e.mail: drmahfuzulhaque@yahoo.com

According to the Intergovernmental Panel on Climate Change (IPCC), climate change affects crop production in several regions of the world, with negative effects more common than positive, and developing countries highly vulnerable to further negative impacts (Lipper et al 2014). Further to that, the poor communities in rain-fed agricultural areas are more vulnerable to adverse climatic conditions. In fact, poverty and vulnerability show a significant correlation. In developing countries, the adaptive capacity is rather low due to technological, economic, and non-economic factors. As a result they easily become victims to climate change-induced disasters. Climate change undermines the right to food, with disproportionate impacts on those who have contributed least to global warming and are most vulnerable to its harmful effects.

Agriculture as a sector came to the limelight, when the developed countries started discussing methane emission from wet-rice cultivation in the rice producing developing countries and from enteric fermentation process of cattle heads. IPCC Report, 2007 stated that agriculture sector contributes 14 percent of greenhouse gas emissions or approximately 30 per cent, when considering land-use change, including deforestation, driven by agricultural expansion for food, fibre and fuel (IPCC 2007; World Bank 2015). Within agriculture sector, 38 per cent of GHGs come from N₂O due to soil management and 32 per cent from methane due to enteric fermentation. Methane is also released from animal manure, which is 22 times more damaging than carbon dioxide. Referring to these statistics, the developed countries continued raising the issue of GHG emissions from agriculture sector in the developing world, although the UNFCCC (United Nations Framework Convention for Climate Change) 1992 in it's objective stated that combating climate change shouldn't affect food production.

As a panacea, FAO, World Bank and the developed countries led by some multinational agri-companies floated the concept of "Climate Smart Agriculture (CSA)" in 2010. Interestingly, the solutions incorporated to deal with the climate crisis is mostly based on the market based mechanisms where the industrialised states by funding carbon reducing projects in developing countries get the licence to do business as usual under Clean Development Mechanism (CDM). This paves the way for the corporate power to twist the climate agenda and to promote more profit-making solutions, such as "Climate Smart Agriculture".

The concept of "Climate Smart Agriculture" as illustrated through its objectives looks very appealing though. It talks about sustainably increasing agricultural productivity and income, adapting and building resilience to climate change; and reducing and/or removing greenhouse gases emissions, where possible. CSA is gaining increasing attention among governments, NGOs, academics and corporate agri-houses these days. The proponents made an attempt to use climate negotiations at the UNFCCC and the UN Secretary-General's Climate Summit, to obtain official endorsement of the concept (Action Aid, 2014). However, CSA has been criticised to be profit motivated and is political. It is further alleged that the agribusiness corporations are promoting synthetic fertilizers, agro-chemicals, industrial meat production, and large scale industrial agriculture, widely recognized as contributing to climate change and undermining the resilience of natural farming systems.

The paper introduces adverse impacts of climate change on agricultural production, soil and productivity. As a solution to offset climate change-induced adverse impacts on food security, the paper redefined climate smart agriculture as coined by FAO and World Bank and makes an

effort to unearth follies in the very terminology. Various emerging challenges due to introduction of “climate smart agriculture” practices are discussed. The age-old practices of agro-ecology, indigenous knowledge and practices as a solution to climate change related adverse impacts are also discussed. The paper at the end suggests some recommendations on how to overcome those emerging challenges.

Climate Smart Agriculture

Climate Smart Agriculture is an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change (Leslie *et al* 2014). As a concept, it emerged in 2010. According to FAO and the World Bank, ‘triple wins’ in agriculture could be achieved in mitigation (reducing greenhouse gas emissions), adaptation (supporting crops to grow in changing climate conditions), and increasing crop yields (World Bank, 2015; Action Aid 2014; Wijeratne, 2013). In September 2014, the FAO launched the “Global Alliance for Climate-Smart Agriculture (GACSA)” and described the alliance was for food security (Global South 2015). Some of the reputed fertilizer companies were also represented there. Companies introducing GM seeds like Yara, Syngenta, McDonald’s and Walmart are within this group.

The focus of CSA has been on promoting sustainable agricultural productivity, improving farmer’s livelihoods and developing more resilient food systems in the face of climate change. It talks about reducing GHGs caused by agriculture through practical techniques, such as mulching, inter-cropping, conservation agriculture, crop rotation, integrated crop-livestock management, agro-forestry, improved grazing, improved water management, drought and flood-tolerant crops and crop and livestock insurance (Global South 2015).

Looks apparently innocuous though, CSA would question the very existence of age-old agricultural systems, as the government would look for the alternatives. Moreover, use of agro-chemicals would continue to take tolls on the environment. As climate change is the biggest and most urgent threat to nature and humans, we need to radically transform our food systems away from an industrial model towards food sovereignty.

Synthetic fertilizer, a major ingredient of modern agriculture, is produced by burning large amount of fossil fuels causing CO₂ emissions. When applied to soil, they release Nitrous Oxide (N₂O), a highly potent greenhouse gas that has 298 times the atmospheric warming effect of CO₂ (Action Aid Int 2014). Synthetic nitrogen fertilizers can cause stable organic matter in the soil to convert to CO₂ emissions in the atmosphere.

Criticism of Climate Smart Agriculture

Climate-smart farming has been condemned as a deceptive and deeply contradictory initiative. Increasingly, civil society and farmer organisations are expressing concerns that the term can be used to “green-wash” agricultural practices that will harm future food production, such as industrial agriculture practices or soil carbon offsetting (Action Aid, 2014).

Some governments and NGOs also worry that pressure to adopt CSA will translate into obligations for developing countries' food systems to take on an unfair mitigation burden. They point out that their agricultural systems have contributed the least to the problem, but that mitigation obligations could limit their ability to effectively adapt to the climate challenges ahead. According to critics, the same so-called 'green revolution' industries of the 60s that have been widely criticized for their significant contribution to climate change and their negative environmental and social impacts on farmers and food systems, have simply re-branded themselves as 'Climate Smart'. Probably the criticism is not unfounded, as CSA promotes Genetically Modified Organisms (GMOs) for increased productivity. It is alleged that CSA over-produces food, destroys soil fertility and is responsible for deforestation, contamination of water, acidification of oceans and killing of fisheries. Because of use of the high yield varieties (HYV) and hybrid seeds, farmers' local seeds are stolen and sold back to them at an exorbitant price. CSA put significant pressure on the world's smallholder farmers surviving on subsistence agriculture.

CSA is being criticised by a large section of civil society organisations worldwide. Many international and national organizations in a joint statement before the UNFCCC Conference of the Parties (COP)-21 held in Paris in 2015 said "No" to CSA and urged the decision-makers to support agro-ecology. The civil society shared deep concern over the influence and agenda of CSA and the Global Alliance for CSA (GACSA). They stressed that climate change was the biggest and most urgent threat and called for radical transformation of our food systems away from an industrial model towards food sovereignty and safety.

Some of the governments and corporate lobbies at the UN climate conference want farmland to be considered as a carbon sink that polluting corporations can buy into to compensate for their harmful emissions. Rather than reducing carbon emissions at their source, carbon trading has created a lucrative market for polluters and speculators to buy and sell carbon credits while continuing to pollute. The governments of US and Australia, the World Bank and the corporate sector have long argued for treating farmland as carbon sink and for creation of carbon markets. In 2014, more than 100 international and national organizations including farmer movements wrote on the threat of CSA agenda with a release titled "Corporate smart greenwash: the Global Alliance for Climate-Smart Agriculture". The signatories mentioned that GACSA is a greenwash initiative designed to promote intensive profit-driven industrial agriculture at the expense of small farmers, environment, and the real solutions. They raised concern that the GACSA by endorsing the activities of the plant's worst climate offenders in agribusiness and industrial agriculture will undermine the very objectives that it claims to aim for. It is alleged that the so-called "green revolution" industries, widely criticized for their significant contribution to climate change and their negative environmental and social impacts on farmers and food systems, have simply re-branded themselves as 'Climate Smart' and continued as before.

Agro-ecology

Agro-ecology (agricultural ecology) is the study of living organisms and their inter-relations in the context of agriculture and land use. It is the scientific base for sustainable agriculture and applies ecological concepts and principles to the design and management of sustainable agro-

ecosystems (George & Jafri 2014). According to *Handbook on Agro-ecology: Farmers' Manual on Sustainable Practices*, agro-ecology is based on the following five principles:

- a) It enhances the recycling of biomass and optimizes and balances nutrient flow. On an agricultural farm, a huge amount of biomass is produced year after year (cow dung, wheat and paddy hay, corn husk etc.). Farmers recycle this biomass to enhance the nutrient levels in the soil. Agro-ecological practices enable a farmer to maximize the use of biomass to increase productivity;
- b) It enhances soil biotic activity by managing organic matter. Organic matter assists favorable soil conditions for better plant growth. Organic matter (both plant and animal residues), when decomposed, creates positive effects on soil properties and improves soil quality;
- c) It minimizes losses due to excess sunlight, heat, air and water. This is done through microclimate management, water harvesting and soil management through increased soil cover. Another benefit of microclimate management is that it allows the soil to absorb and retain moisture, depending on the composition of the soil and its use;
- d) It enhances species and genetic diversity. Selective breeding of plants leads to monocultures of genetically identical plants, which makes crops extremely susceptible to widespread diseases. In contrast, species and genetic diversity helps plants adapt to changing environments; and
- e) It enhances beneficial biological interactions among organisms. An organism's interactions with its environment are fundamental to its survival and to the functioning of the ecosystem as a whole.

The solutions for climate change in farmer's fields must be the climate resilient practices of ecologically based agricultural systems. The features of agro-ecological method of farming are based on sovereignty of food and seeds, promotion of indigenous varieties of seeds, introduction of agro-diversity, mulching, multi-cropping, composting and farming without the use of agro-chemicals. Agro-ecology promotes bio-pesticides with inputs from locally available *neem* leaves, cow-dung, cow urine, red-chilies, garlic, mustard with water to kill the pests.

Agro-ecology addresses the adverse impacts of "Green Revolution" of the 60s and promotes a subsistence agriculture, wherein the farmers of the fragmented lands could survive. Agro-ecology can be a better solution to deal with climate crisis. Agro-ecological farming holds immense mitigation and adaptation potential well suited to deal with climate crisis. Agro-ecological approaches promote inclusion of marginalized smallholder farmers, with the potential to improve food security and equitable economic development. They are knowledge-intensive rather than capital-intensive, minimizing financial outlay, and increasing access to systems of production for smallholder farmers. Most smallholders face constraints in accessing credit. Agro-ecological farming systems generate less carbon dioxide and nitrous oxide emissions due to increased plant cover, reduced soil erosion, and the omission of synthetic nitrogen fertilizers.

Diversification of crops increases the resilience of smallholder farmers to extreme weather events and climate change (Sugden J 2015).

It is alleged that agro-ecological practices won't provide yields necessary to feed global population. This argument focuses exclusively on yield maximization, negating other functions of agriculture. The aim is not simply to produce as much food as possible, but to implement systems of food production, distribution, and consumption that ensure sufficient, nutritious food for all people. Health of the soil, availability of underground water level and the biodiversity that supports complex ecological systems are no less important than food production. We all agree that the methods promoted in the name of "solutions" should be holistic in nature and they should address the root cause of the problem and not its symptoms.

Bangladesh Scenario

Mainly an agricultural country, Bangladesh has already been experiencing the adverse effects of climate change. Floods, cyclones, drought, excessive rainfall or untimely rainfall- all contributing to food insecurity of the country. In Bangladesh, climate change related plans and policies are based on productivity, efficiency and high yield influenced by green revolution of the sixties. Environmental considerations and the farmers' rights protection are always neglected. The agriculture policy in Bangladesh over the decades has shifted towards mechanization and commercialization of agriculture in response to the increasing demand of food supply.

Agriculture is the mainstay of Bangladesh economy contributing to 16.5% of country's Gross Domestic Product. Bangladesh's GHG emissions reached 192 megatons of CO₂ in 2014 and agriculture contributes to 39% of the country's GHG emissions (World Bank 2017). Cropland and enteric fermentation (livestock production) contributed equally to agricultural GHGs in 2013. Bangladesh continues to import seeds, fertilizer, insecticide and pesticide at a huge cost. In 2015-16, 2,20,030 MT of HYV seeds was imported and private sector's involvement was substantial. For import of chemical fertilizer, US\$ 1,044 ml was spent in 2016 and agri-subsidy was insufficient. Moreover, 33,371,60 MT of insecticide and pesticide was imported in 2016, detrimental to the environment (RIB 2017). Subsidy on insecticide was withdrawn since 1979 and the business was transferred in the hands of private sector.

There are applications of modern technologies, seed varieties, harvesting methods, fertilizers, pesticides, and management systems, and there also are concerns over our degraded natural systems – soil quality, biodiversity, ecology, and water system, and dependence on the hired and imported crop varieties, seeds, crop management systems, which bring in serious questions of food sovereignty of the farmers as well as the country.

The objectives of the National Agriculture Policy (2013) include, among others: ensuring sustainable and profitable agricultural production; conducting research and training in order to sustainably develop and expand high improved crop varieties as well as cultivation systems; increasing productivity, employment and income through appropriate technology expansion and inputs management; introducing and sustaining competitive agriculture through financialization; taking effective steps to achieve self-sustained agricultural systems adaptable to climate change and farmer's needs; ensuring fair price of agricultural products and improving sales systems;

encouraging to produce quality agricultural products in keeping with international market demands, and promoting export of agricultural products; processing of agricultural products and increasing agro-industries; diversifying agriculture to meet public nutritional demand, and encouraging production of more nutritional crops.

The agrarian strategy envisaged in the Seventh Five Year Plan (2016-2020) of Bangladesh aims to accelerate the process of transformation from already existing semi-subsistence farming to commercialization of agriculture. National Organic Policy 2016 of Bangladesh favours, in principle at least, agricultural management in line with physical, chemical, and organic values of soil, but it seems to have been motivated by and targeting to the larger extent commercial value of organic foods worldwide, but not addressing the issues of food sovereignty and ecology.

In addition, urea deep placement (UDP) project is also implemented in Bangladesh in the name of CSA. Initiatives of different international agencies have started to develop salinity-tolerant, drought-tolerant and short-maturing rice varieties by 2017, and establish one climate smart agriculture technology dissemination centre by 2020. In the field of climate smart agriculture, International Rice Research Institute (IRRI) is implementing a project called Climate Smart Agriculture Advisory Service (CSAAS) in Bangladesh which seeks to use ICT for promoting CSA technologies and advisory services. Under this project, a smartphone application called Rice Crop Manager (RCM) would be developed to enhance the crop management of the farmers. Bangladesh Rice Research Institute (BRRI) serves as the lead centre in this project whereas Bangladesh Agriculture Research Institute (BARI) assists in implementing climate-informed recommendations for maize and wheat in Bangladesh.

The role of the academia on CSA is less satisfactory. Universities and research organizations (focusing on agriculture and environment) are lagging behind in understanding deceptive term like CSA. Undertaking research and publication in earnest is required. Traditional knowledge and practices of the local and indigenous communities on agro-ecology, seed conservation etc are always neglected not only by the policy makers but also by the scientists. Convincing them would be a difficult task indeed.

Emerging Challenges

Integrating agro-ecological approaches into smallholder farming systems is not without challenges. We are to deconstruct the notion of climate solutions based on financing as well as to share and explore the experiences around climate smart agriculture from the perspective of those who are most vulnerable to the climate crisis. We are likely to face the following challenges in the coming days:

- Mindset of the policy makers, executives and the agricultural scientists towards productivity based crop production ignoring its adverse impacts on the environment and biodiversity, is a stumbling block, which needs to undergo a change. Spectre of “green revolution” of the 60s is present in all policies and plans of the government.
- Propagating CSA-alternatives is a tall order. Moreover, mainstreaming them in national plans and policies is a herculean task. All our plans and policies are based on productivity

and high yield. Environmental considerations and protecting rights of the farmers are always neglected.

- Existing policies and plans, in particular, Environment Policy 1992, Water Policy 1998, Agricultural Policy, Seed Policy and Pesticide Policy including the Seventh Five Year Plan (2016-2020) are all targeted towards increased crop production for ensuring food security. They are to be reviewed in proper perspective. Hence, looking at these policies and plans from a different perspective is not an easy job.
- Bangladesh is seriously pursuing implementation of the SDGs and finalizing the “Bangladesh Delta Plan 2100” in line with Dutch prescription. While finalizing these documents, CSA-alternatives are to be looked into.
- All our climate change documents (BCCSAP, NAPA, NDC etc) prepared by the Ministry of Environment and Forests are based on productivity and increased food production. Critically review of these documents is necessary.
- Climate change negotiators (from the public and private sectors) in the COP are not properly briefed on the newly introduced CSA related issues. They are to be sensitized and trained for the upcoming negotiations.
- Both print and electronic media could be geared up in sensitizing the general mas in understanding CSA in proper perspectives. Correct scientific writings on CSA are required in this regard.

Conclusion

It is true that so long, we in the name of “green revolution” were beguiled and went for productivity only without considering its adverse impacts on environment and biodiversity. In fact, the components like agro-chemicals and synthetic fertilizer are protecting vested interests of the multinational companies of the developed countries at the cost of subsistent farmers in the developing countries. It is apprehended that the concept of CSA will be used as a cover for the continuation of business as usual: unsustainable agricultural systems that marginalize smallholder farmers at the cost of achieving food security and equitable economic development. Introduction of CSA-alternatives is not an easy task. Agriculture extension services are to take up this project and establish demo farms in order to encourage the farmers adapt this practices. Moreover, the NGOs and environmental groups promoting agro-ecological farming are to be inspired as well. It is apprehended that in disguise of CSA, the multinationals would come in with prescriptions on “adaptation” and Bangladesh being one of the most vulnerable countries of the world to climate change, would easily fall prey. Literatures available in internet are mostly biased. The whole issue of science on climate change and agriculture needs to be clarified. Serious efforts are needed to unearth the follies of CSA scientifically and change the mind-set of the scientists and the academicians.

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Information, Innovation and Implementation Center (IIIC): Concept towards Smart Village

Tasnim Kamal¹, Farhana Jesmin Tuli², Mahedi Hassan³, Tahmid Hasan Rupam⁴, Walid Bin Habib⁵

¹²³ Department of Electrical and Electronic Engineering, University of Dhaka, Bangladesh

⁴ Department of Energy and Environmental Engineering, Kyushu University, Japan

⁵ Department of Sustainable Systems Engineering, Albert Ludwigs Universität Freiburg, Germany

¹ tasnim.du@ieee.org

Abstract

“Access to Information for all” that ensure the balanced development from root to vertex of a country. As village is considered as the root of every country in South Asia, it is needed to ensure the sustainable development for every village. Concept of Smart Village is arisen for this purpose where each villager is kept under the service of ICT that minimize the digital distance between urban and rural and escort the digital service along with technical help and vocational training in front of the villager’s door and make their lifestyle easier and drive their economic progress. But the poor illiterate villagers do not have the luxury of accessing modern technology due to poverty and also can not gain knowledge from the internet due to their lack of education. So, there must be a group of scholars along with some dedicated volunteers and professionals working under an institution in every village to make it a smart village and contribute to the development of the country. Information, Innovation & Implementation Center (IIIC) is such an institution which will dedicatedly work on different sectors in transforming a village into a smart and sustainable one.

Keywords: *smart village; modeling of IIIC; IT; sustainability;*

1. Introduction

While living in the 21st century; even in the rapid process of modernization, urbanization and globalization, the difference between the urban and rural areas is acute. More than half of the South Asian population of 1.7 billion people live in rural areas [1] and they contribute a potential part of these country’s economy. Due to lack of access of modern facilities in villages they migrate to urban areas unbalancing country’s population density and thus the villages are always lagged behind and suffer from various problems. UN come with the strategic plans of 17 Sustainable Development Goals (SDGs) focusing on mainly of these deprived people [2]. Sustainable development is possible only when the villages can be taken under schemes of long time with concrete planning. Hence the concept of ‘Smart Village’ arises. In the different period of time different smart village concepts have been proposed, already a good number of projects have been designed with the support of many international organizations including FAO, IFA, ITU, UNDESA, UNDP, UNESCO, the World Bank [3]. The proposed smart village concept in this paper is different from other existing concepts in several cases. Most of the model focuses on energy efficiency, poverty and hunger problems, while processes of community development and self-sustainable development in villages have been suggested commemorating technologies in their life style.

2. A Smart Village

2.1. What is a smart village?

The idea of 'Smart Village' is that energy access acts as an incentive for development-education, health, food security, productive enterprise, environment and participatory democracy. Energy access can provide a much required implementation for sustainable economic development and growth for a major, but neglected, sector of the world's economy. A smart village knows about its citizens, available resources, applicable services and schemes and knows what it needs and when it needs, and how it can be done[4].

2.2. Transition from traditional village to 'Smart Village'

Rural areas, mostly known as villages in the subcontinent are the areas located outside cities and towns. In the subcontinent on an average more than 60% people live in the rural areas for example in Bangladesh it's rate is 64.96 % in 2016 [5]. So, villages are the heart of the nation. Today's world, 1.3 billion people are deprived of electricity [4]. In addition, 3 billion are still cooking on dangerous and inefficient stoves living in remote areas [6]. Until the communities have access to modern energy services, a little progress can be made to develop their economies and improve their lives. There are a few critical issues; the roots of which lie embedded in society, economy and community. The issues are related to both the infrastructural arrangements and human development aspects as shown below:

- | | |
|----------------------------------|---|
| I. sources of livelihood | VI. health facility |
| II. Irrigation | VII. no alternative way of earning |
| III. credit supply | VIII. agricultural practices are outmoded |
| IV. low income-expenditure level | XI. the majority of the villagers are dependent on agriculture but the size of cultivable land is small |
| V. Illiteracy | X. hardly any supplementary source in the form of a thriving cottage industry |

If the concept of smart village is introduced in these areas, it will

- (a) create new learning opportunities
- (b) use technical expertise to develop and provide access to new health-care solutions
- (c) reduce climate change effects
- (d) support youth employment with vocational training
- (e) create access to clean water, sanitation and nutrition
- (f) growth of productive enterprises to boost incomes,
- (g) enhanced security,
- (h) ensure gender equality and
- (i) establish democratic engagement

Rural development implies economic betterment of people and therefore is needed for social transformation. This can be achieved if smart technology can be introduced in the life style of the people living in the villages existing in the subcontinent. For this to happen, it is imperative to involve rural people in development programs [7]. A schematic diagram of a sample smart village project is shown in Figure 1.

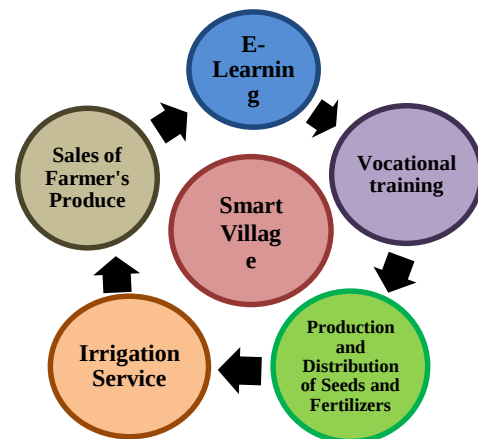


Figure 1: A smart village project

3. Modeling of Smart Village

Modeling of smart village is based on the concept of “Access to Information for Everybody” where the services of ICT are reached in front of the doors of village people through IIIC. Though the services of Information Technology (IT) expanded rapidly, most of these services are unreached to the village people. If the services of IT can be made accessible to the villagers, than it will be beneficial to a country and it will increase the GDP. The concept of Smart village is arisen to minimize the lifestyle difference between urban and rural people and create a direct Information & Communication technology (ICT) based link between them and ameliorate the condition of rural along with urban areas. IIIC can play a vital role to provide the proper ICT service along with agriculture related help to the villagers. Table 1 shows the IIIC requirements for smart village concept.

Tab. 1: IIIC for smart village Concept

Task of IIIC	Implementation		
	Activities	Required Materials	Additional requirements
Agriculture consultation and materials supply	1.To give new idea of cultivation, 2. To provide solutions for any kinds of agriculture related problems and debacles through collecting information from agriculture specialists who are living in remote 3. To supply best seeds, fertilizers and pesticides for cultivation, 4. To supply necessary machine for harvesting	1. Computer and internet connection equipped with agriculture related applications and software, Video conferencing materials 2. Tractor, drum seeder, harvesting machine, plough, harrows, seeders, fertilizer spreader, pesticide spreader, combine and baler	1. Skilled persons on agriculture sectors 2. Agriculture related machine suppliers
Health and Telemedicine	1. To provide health service for the villagers; 2. To create a connection among the village people between specialist doctor who lives in the city for any type of health consultation; 3. spread awareness on proper sanitation systems, water borne diseases and water purification systems	Computer and internet connection, video conferencing materials, medicines, purifying tablets, filter materials, sanitation system	Doctor or interns and trainer on water purification and sanitation system
Market Management	1. To create a direct link between producer and consumer and abridge the supply chain, the market will be expanded through competition which ensure the inclusive growth	Market analysis tools and software and transportation system	Skilled person in market management
Education	1. Expand the E-learning and Far-learning program that may increase the educational growth rate by providing education to village children	Internet, Educational related software and applications, Far-learning materials	Dedicated volunteers who are interested in the education expansion program
Law	Provide law support for the villagers	Telecommunication and video conferencing materials	Law specialist or persons skilled in law
Micro-financial skill assessment program	To give training to the village women for initiating the Small and medium enterprise related industries	Training materials related with SME	Skilled persons in SME

Initiate outsourcing program	Initiate the outsourcing program for the unemployment educated person of the village and make them skilled person in ICT	ICT related materials associated with Outsourcing training program	Person skilled in outsourcing
Disaster Management	1. Reliable and rapid communication for preparation, assessment, observation and positioning tools, especially when crucial on-the-ground infrastructure is damaged, 2. Sharing information on location and hazard specific long term mitigation options for informed decision-making, 3. Sharing instant knowledge and information on location specific climate change impact by sectors and analysing alternative options for preparation and ICT-based advisory services for efficient coordination, 4. Evaluation of disaster and risk reduction activities, long-term sustainable planning and policy formulation.	Village community radio	Skilled person on disaster management
Electrification	1. Encouraging village people to use renewable energy. 2. Designing hybrid solar grid system for the village. 3. Constructing bio-gas plants for the village houses.	LED light, solar panels, solar cookers, battery and other electrical equipment.	Expertise on solar system

4. How IIIC will work

IIIC will act as an info center, village knowledge center, IT center, tele center, community e-center etc. in a village which will provide easy access to the services regarding internet and technologies. As the main concept of smart village is to improve the living of rural people through (ICT) for reducing the digital divide between rural and urban areas, IIIC will enable the villagers to get connected with wider world and enhance their lifestyle without migrating to a city. To change a village into a smart village, IIIC will provide some social services as well as different trainings to create employment opportunities. After getting trained, each trainee will be bound to work under this center with the trainers at least for 6 months for improving their skills and keeping the center sustainable. Figure 2 shows the activities of our proposed IIIC interlinked with opportunities, services and development

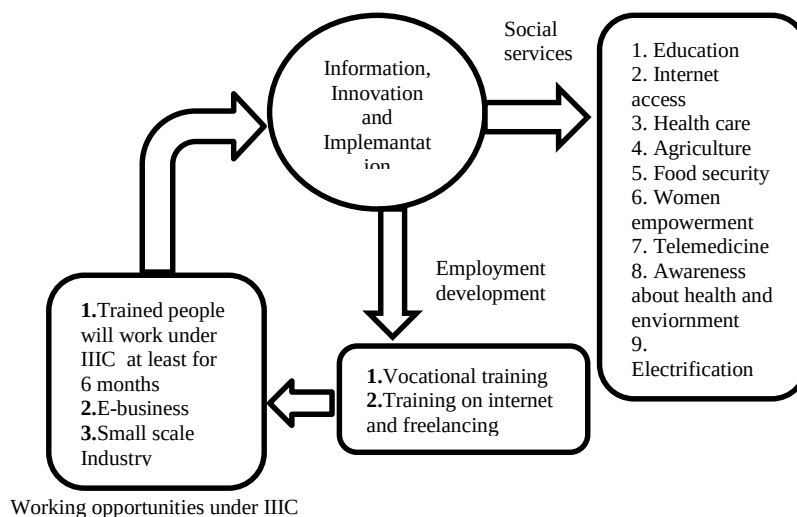


Figure 2: Block diagram of the activities of our proposed IIIC center.

5. Advantage of the proposed system

There are certain advantages of the proposed IIIC. When a center is established in a village it will work for making the village a smart village; a village which would provide all the modern facilities to its inhabitants. The major advantages the center will bring about in the village is mentioned in this section-

- Educate the villagers, create multimedia classrooms for teaching and training.
- Modernize the agricultural system.
- Make the farmers aware of new technologies and also provide them advanced machineries for farming.
- Reduce the unemployment problem by engaging women and teenagers in various productive works.
- Introduce telemedicine for better treatment of the villagers.
- Creating awareness among the villagers about good health, proper sanitation and food security.
- Teaching the villagers about the modern ways of dairy and poultry businesses. Make them learn about vaccination and medicines.
- Making ways for the villagers to get loans easily from the banks and NGOs.
- Help the villagers during natural calamities.
- And the best thing about the center is- it is sustainable. After getting the initial fund it can work on its own, and can return the initial cost within a short time and then it can contribute to GDP.

6. Uniqueness of the Proposed Model

There are several models that have been introduced for smart village. The proposed model is different from them. United Nations Sustainable Development Goal (SDGs) first agenda is to end poverty form everywhere [1]. Also there are in total 17 SDGs planned with the target of 2030 [9]. Smart Village is a concept that is directly connected with most of the SDGs and hence implementing the concept is imperative in the developing countries like us to step towards sustainable development. IEEE Smart Village (ISV) project has been conducted within 34 villages and it has provided 50,000 people with life changing opportunities [10]. Haiti, Cameroon, Benin, Nigeria, South Sudan, Kenya, Namibia, Zambia, India, Rwanda, Uganda, Philippines, Malawi, Democratic Republic (DR) of the Congo, Burkina Faso, and Nepal are the targeted countries for ISV Project [11]. There are also several projects and research that have been conducted and is being conducted in South East Asia and Africa regions, many of them are focused on electricity production and solving energy crisis [10] [11] [12].

Concept of IIIC is developed concentrating on UN SDGs and mitigate the challenges of it. The first uniqueness of IIIC is its self-sustainability after a fixed period. At the very beginning there's an initial fund needed which is an obvious element for all projects. But within a pre-determined amount of time, after successful completion of one or two training, IIIC will start incoming from the sources of project itself. IIIC is the core of our proposed smart village idea. So, making IIIC sustainable means fostering sustainable development in the village. IIIC will not only take the responsibility to connect urban and rural areas but also it will make proper arrangement of training sessions, technology spreading, mitigating climate change issues, health benefits and development of green economy through youth and women empowerment. Another promising fact of our proposed idea is it will work as a dedicated bridge of interconnection between local communities giving day to day problem's solution on life style and health.

7. Measurement of Sustainable Development through IIIC

Sustainable development is measured in terms of capitals and human well-being theory. If proposed economic capital, human capital, natural capital, social capital is achieved and it makes a positive impact in human and ecological well-being, the sustainability is assumed to be achieved. [13] Our proposed IIIC will create workspace for village people and it will make a positive impact in human's knowledge, skills, competencies and attributes embodied in individuals decreasing life style differences. This will contribute for human capital index. Similarly, the center is supposed to use village's land and its resources. We assume that with full functional ability the IIIC will use the best of its own resources and minimize use of embodied energy of materials' use being self-sustained in production and utilization. This indicates a positive influence in natural capital. A village centric center to develop the village itself would develop social respect, values and responsibility of the people leading to raise in social capital. The most influencing part of IIIC is the economic development in the village by making money by its own working process, indulging people in works, training them and the income through that process. This will make a high positive result in economic capitals. Summarizing all the three capitals will put contribution in human well-being and thus sustainable development.

8. Challenges of the proposed Model

Nevertheless, the proposed model has certain challenges, mostly will face at the initial stage. As IIIC is run by volunteer eager to work in sustainable development projects. Local and international NGO's participation is very crucial for this process. May be there are experts who can give training and make the IIIC in the village, but for the whole infrastructure there is a huge initial amount needed. Govt. support and subsidy is very important to success the project.

9. Conclusion

There are 7.4 billion people in the world according to an estimation in March, 2016. Of this population, more than 60% live in the rural area. From this 60% people about (20-25) % [14] people live in the remote area where they don't get any kind of facilities that will provide them a good and secure life. Smart village is a community based initiative, primarily aimed to introduce the benefits of Information, Innovation & Implementation center (IIIC) for the rural people. The initiative is a community effort to mobilize the collective strengths of people from various streams and integrate it with Information Technology to provide benefits to the rural community [14]. As expansion and modification of IIIC is possible in time to time, sustainable development is possible from the suggested model.

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Integrated Water Resource Management of Kushiyara River Catchment, Sylhet, Bangladesh

Fatima-Tuz-Zahra¹, Sharmin Akter¹, Delowar Hossain¹ and Md. Arif Chowdhury¹

¹ Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

Abstract

Integrated water resources management (IWRM) is a systematic process for the sustainable development, allocation and monitoring of water resource use in the context of social, economic and environmental objectives. As study area, the selected portion of Kushiyara river catchment is very important for its diversity, water supply and navigation property, along with several haors. At upper reach of this river occurs serious flash flood during peak flow of rainy season which ranges up to 30 or more times than average flow of the river. This hazard causes continuous erosion and deposition of large sediment load which further affects in river bank stabilization, navigation, flood control, fisheries and agriculture. Two major issues- insufficient lean period flow and river bank erosion, are included in this study to be brought under IWRM. Under these objectives the strategies were set and criteria under each strategy was analyzed using Multi criteria decision Analysis (MCA) system. Best strategies for Maintenance of environmental flow and Bank stabilization and protection found from the study respectively are storage basin and non-structural option-plantation. Therefore, integrated water resources management should be applied properly for the sake of holistic approach to manage this river basin in the north east area of Bangladesh. In this way, sectoral integration can be identified in priority basis and optimized system for any catchment with important surface water bodies.

Keywords: *Kushiyara River, Haor basin, Multi Criteria Analysis, Integrated water resource management*

1. Introduction

The Kushiyara is a very dynamic river and travels over a distance of about 130 km around Madna and flows to the Dhakeshwari River which at last turns to the upper Meghna River (Uddin 2010). The surface water system of the area consists of the major river networks, haors, beels, and the massive flood plains which become inundated during the monsoon season and used for cultivation for the rest of the year to supply most of the agricultural crops. The rivers contribute to the agriculture, general economy of the country by providing navigation, fish, water for irrigation and fresh alluvial sediment replenishing the soil. People are at the interface of the haors, beel and river ecosystem so there needs integrated approach ensuring man and woman participation for decision making in using resources of this catchment in a sustainable way.

Being an Environmentally Critical Area (ECA), haors have an intrinsic connection with the environmental flow in the river. The absence of environmental flow has become one of the major problems in the rivers of Bangladesh (Zahid 2016). This river-haor-ecosystem maintains the balance of instream flow required for river and haor habitat which is important for both aquatic flora & fauna and human population of this area. Moreover, beels are interconnected by rivers and canals and function as fish migratory route network within the haor system as well as with the adjacent rivers (Kafi 2008). Local people are mostly involved with capture fisheries in this catchment area especially from beels mostly. In the late dry season or early rainy season, the broods/parents migrate upstream and laterally to the inundated floodplains adjacent to the river

channel in order to spawn in the quiet sheltered and nutrient-rich waters. At the end of the rainy season, the adults and young of the year escape to the main rivers, canals and the deeper beels/haors to avoid the harsh conditions of the floodplain during dry season (Khan 2011).

The massive flash flood and the large sediment load causes continuous erosion and sedimentation, which affects river banks stabilization, navigation, flood control, fisheries and agriculture. There are lots of water control structures which creates serious problem during dry season due to lack of proper maintenance and functions. Again, overtopping of flood in spite of having embankments creates inundation and river bank erosion afterward. The erosion of the Surma and Kushiara along the Sylhet border is pushing the Bangladesh border inward, already resulting in the loss of thousands of acres of land to India in last few years (Siddique 2005). It was again found that, failure of the Surma-Kushiyara river system due to intensive river bank erosion in 2016 (The independent 2016)

It was tried to find out what would be the probable result if the objectives of these study are maintaining environmental flow in the Kushiayara River to balance water requirement in various sectors and ensuring river bank stabilization and protection under the goal of integrated river management. Depending on the present situation of the study area there are some issues identified which can be aggravated in the near future for which water resources management plans need to be prepared. Increased population growth will create pressure on surface water bodies; Increased river flow or flooding due to climate change may increase river bank erosion and Water management of upstream riparian countries with optimization will be needed economic development are the probable future scenarios of present issues identified. Integrated water resource management includes fresh water as finite and vulnerable resources which are essential to life, environment and ecology. To find the best strategy there were considered criteria or indicators from all sectors and integration was tried to be done in smaller aspect.

In this study, we will look forward to make an IWRM approach to manage and resolute the existing water use conflicts in the Kushiyara river and Haor catchment and to ensure sustainable resource utilization including environmental and economic efficiency and social equity.

2. Methodology

The catchment of river Kushiyara, and other haors which mainly link the Barak River and the Meghna River, is selected as the study area. The catchment lies between 24.469° and 24.638° north latitudes and between 91.699° and 92.229° east longitudes and includes both Sylhet and Moulvibazar districts (Figure 1). Sylhet Sadar, Golabganj, Beanibajar, Balaganj, and Fenchuganj upazillas in Sylhet district and Rajnagar, Barlekha, Kulaura, Moulvibajar Sadar, Kamalganj, and Sreemangal upazillas in Moulvibazar district are within the study area (Zilla Statistics 2011).

Multi-criteria Analysis (MCA):

Strategies under criteria has been ranked after calculation of total scoring ranging between 0-10 and weightage was given based on historical, environmental, economic and ecological importance along with social background of this catchment based on secondary information. Weightage means the relative importance of criteria or indicators. In this study, weight calculation has been used two times, one is among the criteria and another is among the indicators. As it is a subjective process, the result can vary from person to person. However, the factors considering all sectors are included in calculation process.

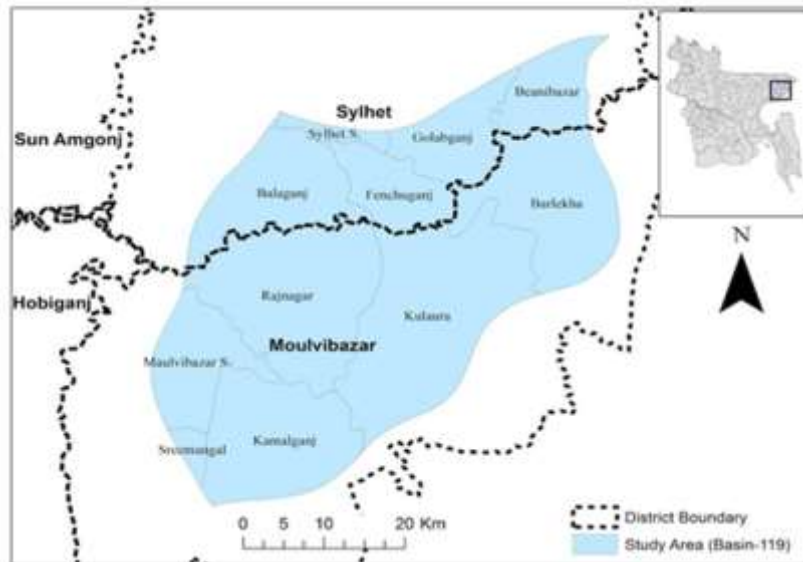


Fig. 1: THE KUSHIYARA RIVER AND HAOR CATCHMENT, SYLHET, BANGLADESH

Table 1 is containing the overall list of indicators under strategies and Table 2 and Table 3 are containing detailed trend of indicators were taken account to plan an integrated framework.

Table 1: List of Objectives, strategies, criteria/indicators

Goal: Integrated River Management			
Issues	Objectives	Strategies	Criteria/Indicator
Insufficient lean period flow	Maintenance of environmental flow	Storage basin, Rubber Dam	Water Level Fish Species Bird Species Capture Fisheries Sanctuaries
River bank erosion	Bank stabilization and protection	Structural (Revetment, Groin)	Livelihood Opportunity Migration Operation & Maintenance
		Non-structural (Plantation, Sandbag)	Erosion Rate

Table 4 provides information on scoring for each alternative strategy and for each criterion selected for the objective “Maintenance of environmental flow.” These scores for strategies were assigned after a scale from 0-1 (best = 1, worst = 0 and the others were in between). The weightages were chosen based on relative importance of each criterion.

In Table 5 and 6, the scores for each strategy were standardized using the following formula (formula 1), and the standardized scores were multiplied with the respective weightage of each criterion. Finally, the weighted scores for each strategy were summed up to obtain the best strategy.

Standardization = (Actual score – Worst score)/(Best score – Worst score)(1)

After standardization the weighted values for criteria/indicators all the weightage were summed up and the strategy which scored highest was counted as best strategy for IWRM framework.

Table 2: Detailed Objectives, criteria/indicators, strategies of Bank stabilization and protection

Goal: Integrated River Basin Management					
Objective	Criteria	Indicator	Strategy		
			Storage basin	Rubber Dam	Do Nothing
Maintenance of environmental flow	Water Level	Mean sea level	Increase	Increase	Existing decreasing trend
	Fish Species	Number	Increase	Less Increase	Existing decreasing trend
	Bird Species	Number	Increase	Less Increase	Existing decreasing trend
	Capture Fisheries	Ton/sq. m	Increase	Increase	Existing decreasing trend
	Sanctuaries	Class	Increase	Increase	Decrease
	Investment	Tk.	Medium	Low	No cost

Table 3: Detailed Objectives, criteria/indicators, strategies of Bank stabilization and protection

Goal: Integrated River Basin Management							
Objective	Criteria	Indicator	Strategy				
			Structural		Non Structural		Do Nothing
			Revetment	groin	Plantation	Sandbag	
Bank stabilization and protection	Investment	Tk./unit	High	High	Low	Medium	No cost
	Livelihood opportunity	No. of Employment	Increase	Increase	Increase	Increase	No Change
	Migration	No. of people	Less	Less	Less	Less	More
	O & M	Tk/unit	High	Low	Low	High	No cost

	Erosion Rate	m/yr	Decrease	Decrease	Decrease	Decrease	Increase
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3. Results and Scoring

3.1. Maintenance of environmental flow

In order to keep river water flow unobstructed reservoir and storage basin both are very important strategies. There needs to be optimization in cost minimization and conserving ecosystem as well as biodiversity. Keeping all that in consideration from Table 4 to Table 6 different criteria with weightage standardization and calculation best strategy was tried to find out. Moreover, fisheries being an important sector of income and livelihood have been prioritized in this multi criteria decision making process (Table 4).

Tab. 4: Weightage and Valuation of the Criteria of Maintaining Environmental Flow

Goal: Integrated River Basin Management					
Objective	Criteria	Weightage	Strategy		
Maintenance of environmental flow			Storage basin	Rubber Dam	Do Nothing
	Water Level	2	1	1	0
	Fish Species	1	1	0.5	0
	Bird Species	2	1	0.5	0
	Capture fisheries	1	1	1	0
	Sanctuaries	2	1	1	0
	Investment	2	0.25	0.5	1
	Total	10	5.25	4.50	1

Table 5: Standerdization of scores of Maintaining Environmental Flow

Goal: Integrated River Basin Management [Std = (act-worst)/(best-worst)]					
Objective	Criteria	Weightage	Strategy		
Maintenance of environmental			Storage basin	Rubber Dam	Do Nothing
	Water Level	2	1	1	0

flow	Fish Species	1	1	0.5	0
	Bird Species	2	1	0.5	0
	Capture fisheries	1	1	1	0
	Sanctuaries	2	1	1	0
	Investment	2	0	0.33	1
	Total	10	5	4.33	1

Table 6: Weighted sum of Maintaining Environmental Flow

Goal: Integrated River Basin Management					
Objective	Criteria	Weightage	Strategy		
Maintenance of environmental flow			Storage basin	Rubber Dam	Do Nothing
	Water Level	2	2	2	0
	Fish Species	1	1	0.5	0
	Bird Species	2	2	1	0
	Capture fisheries	1	1	1	0
	Sanctuaries	2	2	2	0
	Investment	2	0	0.66	2
	Total	10	8	7.16	2

3.2. Bank stabilization and protection

To select the best strategy for “Bank stabilization and protection,” the scores chosen for each strategy and weightage selected for each criterion were listed in Table 7. The similar methodology, used for the objective “Maintenance of environmental flow,” was also followed here to decide the scores as well as the weightages.

The selected scores were standardized after formula 1 and multiplied with their corresponding weightage in Table 8 and 9. The weighted scores, then, summed up for each strategy, and the best strategy were decided.

Table 7: Weightage and valuation of the Criteria of Bank stabilization and protection

Goal: Integrated River Basin Management							
Objective	Criteria	Weightage	Strategy				
			Structural		Non Structural		Do Nothing
			Revetment	Groin	Plantation	Sandbag	
Bank stabilization and protection	Investment	2	0	0	0.5	0.25	1
	Livelihood opportunity	1	1	1	1	1	0.5
	Migration	1	1	1	1	1	0
	O & M	3	0	0.5	0.5	0	1
	Erosion Rate	3	1	1	1	1	0
	Total	10	3	3.5	4	3.25	2.5

Table 8: Standerisation of scores of Bank stabilization and protection

Goal: Integrated River Basin Management [Std = (act-worst)/(best-worst)]							
Objective	Criteria	Weightage	Strategy				
			Structural		Non Structural		Do Nothing
			Revetment	Groin	Plantation	Sandbag	
Bank stabilization and protection	Investment	2	0	0	0.5	0.25	1
	Livelihood opportunity	1	1	1	1	1	0

	Migration	1	1	1	1	1	0
	O & M	3	0	0.5	0.5	0	1
	Erosion Rate	3	1	1	1	1	0
	Total	10	3	3.5	4	3.25	2

Table 9: Weighted sum of Bank stabilization and protection

Goal: Integrated River Basin Management							
Objective	Criteria	Weightage	Strategy				
			Structural		Non Structural		Do Nothing
			Revetment	Groin	Plantation	Sandbag	
Bank stabilization and protection	Investment	2	0	0	1	0.5	2
	Livelihood opportunity	1	1	1	1	1	0
	Migration	1	1	1	1	1	0
	O & M	3	0	1.5	1.5	0	3
	Erosion Rate	3	3	3	3	3	0
	Total	10	5	6.5	7.5	5.5	5

Table 10 listed the best strategies found from MCA for each objective. The best strategy for “Maintenance of environmental flow” were “Storage basin,” and Non-structural measure “Plantation” scored the highest for the objective “Bank stabilization and protection.

Table 10: Best strategies for Maintenance of environmental flow and Bank stabilization and protection

Issues	Objectives	Best Strategies from MCA
Insufficient Environmental flow	Maintenance of environmental flow	Storage basin
River bank erosion	Bank stabilization and protection	Non-structural option: Plantation

4. Conclusion

IWRM is still an emerging and new concept to people of grass root level (Nowreen 2010) which is being interpreted differently by different expertise. But as it's an approach of counting sectoral importance and prioritization, so it is possible to be the best approach for resolving water issues like bank erosion, lack of environmental flow, flooding etc. which will improve the social condition with bonus like habitat restoration, biodiversity conservation, livelihood improvement, economic security etc. The best and final strategy (Table 10) depicts that after taking account all sorts of sectoral and social indicators these can fulfill the demand of water and reduce the risk and damage of natural hazards. There also needs to address other issues as IWRM is a broader aspect which we can be studied further with more involvement of the expertise, local people and hydrological parameter. The Kushiya river catchment can be brought under a holistic approach integrating ecologically, economically and socially important haors connecting with it by adopting IWRM like this study before being susceptible and vulnerable to adverse impacts of climate change and other water related conflicts.

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Sustainable Livelihood for the Informal Waste Pickers of Dhaka City

Sayma Sayed ¹, A K M Maksud², Intiaj Rasul³, ABK Reza⁴ Khandaker Reaz Hossain⁵
Grambangla Unnayan Committee, House#93, Road#1, Mohammadia Housing Society,
Mohammadpur, Dhaka, Bangladesh

Abstract

This article aims to provide insights into the contribution and practices of informal waste pickers of Dhaka City to promote sustainable urban environment and green economy of the country and to show a way out for a sustainable livelihood for them. Both the qualitative and quantitative methods including interviews, Focus Group Discussions, sample surveys and literature review were used to collect and analyze data to explore the livelihood situation of waste pickers of Dhaka City. The analysis points out that waste pickers play a significant role to promote sustainable urban environment and green economy of the country. They are the front line workers to implement the objective of 3R Strategy i.e. Reduce, Reuse, and Recycle and decrease waste generation. The waste pickers contribute a lot in earning foreign currencies, reducing import cost and in creating jobs. From recycling and reusing wastes business, the country earns approximately US\$ 0.2 billion per year. In spite of all this contribution, they are unacknowledged workforce as they don't have legal accreditation for their services. They are deprived from opportunity of education, health services, social safety net services and livelihood security. So, for a decent and sustainable livelihood of the informal waste pickers, legal accreditation of their work is important. The sustainability of their livelihood will help to achieve Sustainable Development Goals-1, 2,3,4,5,6,8,10,11 and 13 and accomplish the theme "No one is left behind".

Key Words:

Waste Pickers, Reduce, Reuse, Recycle, Sustainable urban environment, Green economy, Legal Accreditation, Sustainable Livelihood.

1. Background and Introduction

Waste Pickers are informal group of people mostly are women and children engaged in searching, collecting, sorting, processing and selling of wastes to earn their livelihood. They are the representatives of the poorest citizen of a city. Mainly waste pickers are migrants from rural areas to cities because of poverty, climate change effects and natural disasters and family crises. According to Women in Informal Employment: Globalizing and Organizing (WIEGO), there is growing recognition that waste pickers contribute to the local economy, to public health and safety, and to environmental sustainability.

¹ Asst. Director, Grambangla Unnayan Committee

² Executive Director, Grambangla Unnayan Committee

³ Vice Chairman, Grambangla Unnayan Committee

⁴ Deputy Director, Grambangla Unnayan Committee

⁵ Director, Grambangla Unnayan Committee

The increasing volume of waste generated globally is one of the most prominent environmental issues the world faces. Bangladesh is not out of it. Usually, the responsibility for waste management lies with local authorities (mainly municipalities). In Municipality ordinance 2009, it has been stated that “(1) A municipality shall make adequate arrangements for the removal of refuse from all public streets, public latrines, urinals, drains, and all buildings and land vested in the municipality and for the collection and proper disposal of such refuse. (4) All refuse removed and collected by the staff of the municipality or under their control and supervision and all refuse deposited in the dustbins and other receptacles provided by the municipality shall be the property of the municipality”. But in reality, in Dhaka, only 60% of the solid waste generated daily is collected by the City Corporation (General Economics Division, Planning Commission, Government of the People's Republic of Bangladesh (2016). 7th Five Year Plan FY 2015/16-FY 2019/20: Accelerating Growth, Empowering Citizens, Dhaka, Bangladesh). The informal sector service providers such as the waste pickers remove a considerable quantum of daily waste from the city streets and dustbins. Together, they make an enormous contribution to urban solid waste management in the city, which is not well recognized or appreciated. (Department of Environment, Ministry of Environment and Forests, Government of the People’s Republic of Bangladesh (2009). National 3R Strategy for Waste Management (Second Draft), Dhaka, p.10). In Dhaka alone, approximately 120,000 urban poor are involved in the recycling trade chain. 15% of the total generated waste in Dhaka amounting to 475 tons/day are recycled daily (Department of Environment 2009) mainly by the waste pickers.

It is estimated that every year Tk. 10,706 million is being saved through recycling (Department of Environment 2009). A study of Grambangla Unnayan Committee found that they collect approximately 54 types of waste items e.g. paper and packaging materials, torn fabrics, refuses of garment factories, hair, tin, broken glass, iron piece, wood, shoes, used syringe and blood bags, bottle cork, brush, ball point pen, ice-cream pot, plastic pipes and bottles and other plastic materials, X-ray papers, polythene, rubber materials, vegetable and perishable items, bones etc. All these waste materials are recovered, collected, sorted and processed and sent to industries for recycling by the waste pickers from street, public places, dustbins and dump sites.

In spite of all these contributions, they work as invisible and unacknowledged workforce and do not have any legal accreditation for their services.

2. Objective of the paper

The board objective of this paper is to describe the waste pickers’ contribution to promote sustainable urban environment and green economy of the country and to show a way out for a sustainable livelihood for them.

3. Methodology and Sources of Data

Different methods were used to collect data to explore the livelihood situation of waste pickers of Dhaka City. The major techniques of data collection were: one-to-one interview with the waste pickers, sample surveys on 400 waste picker households of Dhaka City, Focus Group Discussion with the waste pickers, review of secondary sources of data e.g. national

and international conventions, policies, reports, books, journal articles, government and non-government statistics, newspaper articles.

4. Contribution of the Waste Pickers to the Nation through their Recycling Activities

Recycling is the process by which previously used objects and materials are converted into something else, rather than discarded. By picking up discarded material from public spaces, waste pickers contribute to cleanliness and help beautify the city. Mainly by recycling, waste pickers offer two benefits: economic thrift and environmental care.

4.1 Economic Benefits of the Recycling Works of the Waste Pickers:

Waste picking provides crucial income for people and households. According to an estimate there are 400,000 waste pickers in Bangladesh (Maksud 2010). In Dhaka City Corporation (DCC) area, 22,792 persons were working in the plastic waste recycling sector. In terms of employed labor force of DCC area, it is 1 percent (Enayetullah 2006). Around 150,000 people are currently employed in the informal garment waste (Jhoot) recycling sector (Dhaka Tribune, 22 Nov 2014). A study of Grambangla Unnayan Committee found that in Matuail sanitary land fill area 2500 people are running their families by picking and selling different types of wastes from the waste dump site.

Not only in job creation but also waste pickers contribute a lot to the country's economy by providing reusable materials to the recycling enterprises. In 2005 Bangladesh used 263,000 of tons recycled resin i.e. raw materials of plastic waste. Use of this recycled plastic waste saved import cost of US\$.405 million (Enayetullah 2006). Bangladesh expects to achieve a market size of plastic products of \$4 billion by 2020 from \$1 billion in 2008 (UNESCAP 2011). The market size of Ready Made Garment factories' waste (Jhoot) is over Tk.20 billion. Approximately, 3420 tons of lead is recovered per year from used lead-acid batteries in Bangladesh especially by the waste pickers and savings from import replacement was estimated at Tk.360 million (Waste Concern). In 2014-15 fiscal year, Bangladesh exported animal guts, bladders and stomachs – things that are almost always disposed off as wastes-worth a staggering US\$14.71m. Animal guts, bladders and stomachs were previously considered just as food of dogs and foxes at the waste dump site, but currently these are valuable export items for earning foreign currencies. Exporting of a container of animal guts, bladders and stomachs i.e. about 27 tons of processed items to China, Thailand, Vietnam or Hong Kong brings about US\$ 0.2 million (The Daily Star, 18 September 2017).

4.2 Environmental Benefits of Recycling Works by the Waste Pickers:

The recycling activities by the waste pickers bring environmental benefits. Recycling is very important as waste has a huge negative impact on the natural environment. Harmful chemicals and greenhouse gasses are released from rubbish in landfill sites. Recycling is one of the cheapest, fastest ways to reduce greenhouse gas emissions. Recycling reduces emissions 25 times more than incineration does (Tellus Institute 2008). Waste picking activities reduce the amount of wastes that need to be collected, transported, and disposed of, and they extend the life of waste dump sites and landfills. Reusing and recycling also render environmental benefits by reducing water and energy use and lowering pollution caused by solid, liquid, and gaseous by-products, compared with the manufacture of products from virgin resources.

Waste pickers improve efficiency in a society's use of natural resources, a necessary step toward minimizing the impact of human society on the environment and toward sustainable development. Thus, waste picking and recycling are socially desirable, economically viable, and environmentally sound.

4.3 A Green Business and Waste Pickers:

Supply of a large quantity of recyclable wastes for valuable material recovery is a potential area for the new entrepreneurs to venture their efforts into and municipal solid waste (MSW) sector is a potential area of green recycling business of recyclable materials. However, the existing informal recycling sector has created a considerable number of job employments for both skilled and unskilled people. Local light engineering sector is providing appropriate technologies and machineries for waste recycling. Financial sector has huge potential to invest in this new recycling sector. The existing recycling sector is recovering plastic, paper, cloth, garment wastes, rubber, glass, metals, bones etc. to supply to the relevant industries and reduce the monetary and environmental costs involved with new materials acquisition. Composting of organic waste has scopes to produce fertilizer, fish feed, plant nutrient, biogas and electricity. Composting can also help reduce a considerable amount of Green House Gases (GHS).

4.4 Waste Pickers and Their Contribution in Mitigating Climate Change Effects:

Long before the green economy concept was globally adopted, waste pickers and other recycling and waste workers in the informal economy have offered a public service with positive economic, social and environmental impact for their communities. (WIEGO (2013).

Waste prevention and recycling help address global climate change by decreasing the amount of greenhouse gas emissions (UNFCCC). The disposal and treatment of waste can produce emissions of several greenhouse gases (GHGs), which contribute to global climate change. The most significant GHG gas produced from waste is methane. It is released during the breakdown of organic matter in landfills. Other forms of waste disposal also produce GHGs but these are mainly in the form of carbon dioxide (a less powerful GHG). Reduction and recycling of wastes by the waste pickers help reduce emission of GHGs and mitigate effects of global climate change by decreasing the amount of greenhouse gas emissions and saving energy.

Recycling is a labour-intensive model of waste management providing thousands of jobs, and it is one of the cheapest and fastest ways to reduce greenhouse gas emissions. Reducing one ton of CO₂ emissions through recycling costs 30 per cent less than doing so through energy efficiency and 90 per cent less than through wind power. Recycling reduces emissions 25 times more than incineration does (Skumatz, L. 2008).

The rate of climate change is closely linked to waste; the more that gets thrown out, the more GHG will be produced. According to the latest reports, global warming is increasing at a far faster rate than previously predicted. Between 1990 and 2000 USA increased its heat trapping greenhouse gases almost by 20 percent (Rogers, Heather (2005). Most likely the result of these emissions, extreme weather has already caused a series of apocalyptic scenarios. A 2003 heat wave in France killed 15000. Bangladesh suffered the most violent flooding in a half century during the summer of 2004. Almost 800 people drowned, 30 million were left

homeless and countless crops were ruined. The storms left behind more than \$6 billion in damages to roads agriculture and industry (Rogers, Heather (2005).

4.5 Contribution of the Waste Pickers in Municipal Solid Waste Management of Dhaka City:

Dhaka City Corporation (DCC) is the MSW management authority in the corporation area (M.R. Hasan et al. (2009). Since independence in 1971, the urban population has grown at an average annual rate of 6% against the overall national growth of 2.2%. From a total of 20.8 million people in 1991, the country's urban population increased to 28.6 million in 2001 (Bangladesh Bureau of Statistics. 2001.). Because of rapid urbanization the country's urban population is expected to reach 89.5 million (from 39.5 million in 2005) by 2030 (NIPORT et al. 2008.)

It is estimated that approximately 13,332 tons of waste is produced per day in the urban areas of Bangladesh, which is over 4.86 million tons annually. It is projected that this amount will grow up to 47,000 tons/day and close to 17.2 million tons per year by 2025, due to growth both in population and the increase in per capita waste generation. Based on the present total urban population, per capita waste generation rate is found at 0.56 kg/capita/day in Dhaka City area (Department of Environment, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh (2009). *National 3R Strategy for Waste Management* (Second Draft), Dhaka.)

Hospital and clinic is another sector having serious implications for hazardous waste that is growing fast. There are 590 government hospitals, 1809 private hospitals & clinics and 1745 diagnostic laboratories in Bangladesh. Yearly generation of wastes from this group stood at 12,271 metric tons. Corresponding estimates for 2013 is: 19,578 tons (Department of Environment, People's Republic of Bangladesh, Asian Development Bank and Waste Concern (2010).

The big question is that where these types of hazardous wastes are getting dumped and how are the waste pickers who directly handling all types of discarded hazardous waste without any precaution or protective measures are injured and infected. However, the waste pickers collect all the plastic syringes, saline bags, blood bags from the dustbins for recycling with open hands.

Total population of Dhaka City was 17.32 million in 2015 and it is forecasted that Dhaka will be the 6th largest megacity of the world with a population of 27.37 million in 2030 (Rajuk and Asian Development Bank (2015).

The estimated population of Dhaka City is 18.32 million in 2017. Based on the rate of per capita waste generation (0.56 kg/capita/day), the total generated waste in Dhaka City area will be 10261 metric tons. If we consider the total population of Dhaka City as 18.32 million and household size as 4.34 (BBS 2012) the total households in Dhaka City will be 4,212,414. Since in Dhaka City, only 60% of the solid waste generated daily is collected by the City Corporation so there will be 2,527,448 households where from household waste is collected by private household waste collection vans (General Economics Division, Planning Commission, Government of the People's Republic of Bangladesh 2016). It is informed by the drivers of the household waste collection vans that a van can collect household wastes from around 200 households. So a total of 12,637 households waste collection vans are in operation in Dhaka City. With one household waste collection van at least 2 waste pickers work for collection of household wastes. Thus a total of 25,275 informal waste pickers are employed in household waste collection works in Dhaka city.

Since around 15% of the total generated waste is being recycled by the informal sector (Department of Environment, Ministry of Environment and Forests, Government of the People's Republic of Bangladesh (2009).

so the estimated amount of waste recovered and recycled by the waste pickers is 1539 metric tons of wastes per day. Thus the waste pickers reduce a total of 561,735 metric tons of waste in a year from the waste stream of Dhaka City. This amount of recovered and recycled wastes remarkably helps in reducing emission of Greenhouse Gases.

5. Socio-economic situation of the waste pickers of Dhaka City

A survey findings showed that waste pickers of Dhaka City pick wastes from the street, dustbins or waste dump sites. The average monthly income of the households was Tk.8,927 (US\$.112) and average monthly expenditure of the households was Tk.9,405 (US\$.118). The types of houses where they live are *kutchra* (earthen floor, wood/tin wall and tin/thatched roof) (90.0%), mud house (mud wall, earthen floor and tin/thatched roof) (8.0%) and semi pucca (Tin shed, cemented floor, wall) (2.0%). Majority of the waste picker families (82.0%) live in one-room house. Literacy rate among the waste pickers of 7 years or above is 14.7 percent. A large majority of the waste pickers (85.3%) cannot read, write or do simple calculations. It is important to note that 42.0 percent of the waste picker households could not afford to arrange three meals a day during the last 12 months i.e. 1 year for their household members. However, 58.0 percent of the households reported that they could afford three meals a day during the last 12 months. Findings show that 67.0 percent of the waste picker households lost income due to natural disaster situations such as heavy rain fall, cold wave, storm fire, etc. 47.8 percent of the households have children who are engaged in hazardous child labour. The reported types of hazardous child labour were waste picking (Tokai) (95.5%), welding and transport workers (rickshaw puller or helper of transports) (4.5%), domestic workers (2.3%) etc. All the waste pickers (100.0%) reported that they do not receive any benefits/entitlements of the Social Safety Net programs of Bangladesh. The survey also showed that waste pickers were suffer from different types of health hazards, e.g. injury from sharp waste objects (54.5%), frequent fever (5.8%), feeling of physical weakness after waste picking works (5.8%), pain in the limbs (5.0%), headache (4.1%), waist pain (2.5%), jaundice (2.5%), skin disease (1.7%) etc. Findings also show that 25.0 percent children under 5 suffered from diarrhea during the last 2 weeks. Findings also show that only 11.4 percent of the waste pickers received TT during their last pregnancies and 86.4 percent of the waste picker women did not have the opportunity to receive any type of ante natal care during their last pregnancy. A considerable portion of the waste pickers (40%) who suffered from any diseases or health conditions did not receive any medical treatment. The sources of medical treatment were Kabiraj (Traditional Health Practitioner/Healers) (48.7%), Paramedic/FWV/Nurse (20.5%), NGO Health Clinic (12.8%), Quack/Unqualified Medical Practitioner (7.7%), Govt. hospitals and health facilities (10.2%), MBBS doctor (5.1%) and Homeopaths (2.6%) (Maksud, A K M (2013).

6. Crises and Challenges of the Waste Pickers in Securing Sustainable Livelihood

Municipal authorities in Bangladesh have no effective policies to engage or deal with waste pickers. However, in Bangladesh the informal jobs of waste picking are considered as an inhuman, shameful and illegal. Landfills are officially declared as restricted area and access to these landfill areas are prohibited for the waste pickers. Sometimes waste pickers face extreme animosity and violence because they are blamed for stealing of lid cover of the street manholes, iron rods and construction materials. Though waste pickers contribute millions of

dollars through reducing, recycling and managing waste for city dwellers, industry and export trades but they are ignored and neglected by the Dhaka City Corporation authorities, environment ministry and other government agencies. Sometimes city authorities, law enforcing agencies develop relationships of exploitation, mutual profit, and mutual assistance with the waste pickers. However, state agencies always maintain an approach of neglect, unwillingness of acknowledgement and indifference towards waste pickers, one of the most beneficial community of urban life.

The Department of Environment has developed a draft Solid Waste Management Rules (SWMR) with provision of imposing fines to household or traders failing to segregate organic and inorganic waste from the primary sources. As an effect of the upcoming SWMR, there will be a big boost to the recycling sector and its economy (The Independent, 9 August 2017).

But it is unclear that how this SWMR will involve the informal waste pickers in MSWM system and acknowledge their contribution and how the new SWMR will affect the lives and livelihood of the informal waste pickers. There is a possibility that due to this upcoming system of municipal solid waste management the whole waste recycling business is going in the hands of waste business enterprises that may jeopardize the livelihoods of the informal waste pickers and other recycling workers. Introduction of SWMR may appear as a threatening issue for livelihoods of waste pickers who have traditionally collected, sorted and added value to waste. Moreover, new industries and big corporations may compete for the same recyclable materials that waste pickers have traditionally relied on for their occupations and to earn their livelihood. Still no step is visible to facilitate involvement of the informal sector waste pickers in MSWM system by the city corporations to save the lives and livelihood of these waste pickers.

7. Sustainable Livelihood for the Informal Waste Pickers of Dhaka City to Achieve Sustainable Development Goals

Although informal waste pickers contribute a lot for waste collection, recovery, reuse and recycling but municipal authority neither pay for their works nor acknowledge their contribution to municipal waste management. As a result, despite of all the contribution to the country's recycling and green economy and environment, they are invisible in the national statistics and excluded from social security system (old age allowance, disability allowance, maternity allowance, widow allowance, vulnerable good feeding/development program etc.) and other benefits of formal contracting. So, engaging the informal waste pickers in formal jobs by the city corporations, legal accreditation and acknowledgement of the contribution of the informal waste pickers is essential to ensure decent occupation and sustainable livelihood for them as citizens of Bangladesh.

The principal route out of poverty is work. But this happens only when work is decent, productive, provides fair wages, underpinned by rights. Decent work contributes directly to poverty eradication and reduction of income inequality. Article-15 of the Constitution of Bangladesh says that "It shall be a fundamental responsibility of the State to attain...(b) the right to work, that is the right to guaranteed employment at a reasonable wage having regard to the quantity and quality of work. The right to work is enshrined in the Universal Declaration of Human Rights and recognized in the International Covenant on Economic, Social and Cultural Rights. Moreover, "Article-15 of the Constitution of Bangladesh says that

"It shall be a fundamental responsibility of the State to attain...(d) the right to social security, that is to say, to public assistance in cases of undeserved want arising from unemployment, illness or disablement, or suffered by widows or orphans or in old age, or in other such cases". So, there is a constitutional obligation to ensure rights to decent work and sustainable livelihood, legal accreditation and acknowledgement of the work of waste pickers as a dignified profession.

The ILO Decent Work Agenda (DWA) provides a useful, rights-based reference for the understanding of decent work (International Trade Union Confederation 2012). Decent work is central to sustainable poverty reduction and sustainable development (ILO 2013).

Lack of access to services and entitlements is the major barrier to achieve the Sustainable Development Goals (SDG) like –"No Poverty (Goal 1)", " Zero hunger (Goal 2)", "Good Health and Well-being (Goal 3)", "Quality Education (Goal 4)", "Gender equality (Goal 5)", "Clean water and sanitation (Goal 6)", "Decent work and economic growth (Goal 8)", "Reduced Inequalities (Goal 10)", "Sustainable Cities and Communities (Goal 11)" and "Climate Action (Goal 13) for the waste picker community of Dhaka City. But still no support from government or donor agencies is visible for waste-pickers in Bangladesh. Government and its development partners should have space for waste pickers in their realistic planning to achieve SDGs.

8. Conclusions

Waste Pickers adding a considerable contribution to national income through recycling. Moreover, several thousands of recycling based industries (plastic, paper, metal, bone, rubber etc.) and many other industries are dependent on their collections. So government and private sector should think for human development of this waste picker community.

Every year waste pickers are recovering thousands tons of waste materials and sending those to recycling industries. Thus they are acting for reducing methane and carbon emission in the environment. So Bangladesh government as well as global communities should think for social security of this waste picker community. The development and crises issues of the children engaged in waste collection should be brought into notice of the media, civil society and policy planners.

Wastepicker children at Matuail more frequently get injured while walking on the waste at dumping spot e.g. cutting in the leg or foot by sharp metal or broken glass or tin, injury by needles of syringe or medical wastes. Waste pickers should get proper health education to minimize the risks and proper medical treatment due to injuries. The children and adult waste pickers who roam all the day in the waste dumping grounds should be saved from hazards and injury.

Waste pickers become ruthlessly exploited during selling of the collected wastes to the waste recycling shops. These waste pickers do not have exact information about the real value of the collected wastes. Children will spend more time if the rate of selling become low so ensuring better price of the collected wastes are needed to improve their sufferings. Cooperative initiatives of waste pickers may help them get better prices of their collections.

Government has a huge potential to earn foreign exchange through exporting recycled waste materials e.g. plastic materials, glass, rubber, iron etc. But government should have a well defined policy for waste management, recycling and reuse of waste, treatment of waste water and protection of the poor people engaged in waste management. Private sector and

government should explore the recycled waste markets and promote the trade through policy and interventions. But this business should not go ahead through victimizing and ignoring the health, hygiene and livelihood issues of the waste pickers those who are the real hero of Eco-Business i.e. business with the recycled wastes.

The efforts of waste pickers to gain recognition and legitimization as workers, as well as their expansion and formalization, should be supported, without undermining their existing and long-term contributions.

Government should recognize the existence of the occupation and the important environmental, social, technical and economic role played by waste pickers. Governments should also invest in resource recovery/protection programs and laws/policies that ensure stability in the occupation and decent livelihoods for waste pickers at the bottom of the recycling chain. They should promote policies that improve workers' conditions in the recycling industry—and not adopt technologies that displace large numbers of workers.

Most importantly, local governments should adopt a holistic approach to solid waste management that recognizes the economic and environmental benefits of including informal waste pickers in waste management and planning.

A stronger linkage between these informal activities and the formal sector is required. Informal waste pickers can be acknowledged for the work they are already doing. Waste Pickers can be given loans and technical assistance for both informal and municipal refuse collection. Household waste collection van drivers and helpers can be given loan to develop eco-enterprises i.e. their own enterprises for waste collection, transportation, disposal and recycling.

Despite their daily efforts to improve their situation, waste pickers live at the bottom of the economic pyramid, struggling alongside their families just to survive. Although their efforts deliver almost all recyclable materials to the recycling chain, they remain the most vulnerable actors within a highly profitable industry, where the price of raw materials generates millions in profits for those at the top of the pyramid. Now it is necessary to make it possible for an environmentally sustainable economy to provide opportunities to waste pickers for decent work and to improve their social protection.

The principal route out of poverty is work. But this happens only when work is decent, productive, provides fair wages, underpinned by rights. Decent work contributes directly to poverty eradication and reduction of income inequality. The ILO Decent Work Agenda (DWA) provides a useful, rights-based reference for the understanding of decent work. Decent work is central to sustainable poverty reduction and sustainable development.

9. Recommendations

Based on the findings the following issues has been recommended for the betterment of waste picker community, recycling sector and solid waste management of Dhaka City:

- ❖ As citizens of Bangladesh all waste pickers should have ensured access to primary education and basic health services.
- ❖ Legal accreditation of informal waste pickers will help them to be acknowledged as worker and accelerate the process of their inclusion as a category of work in the National Labour Force Database.

- ❖ Formal involvement of the waste pickers or out-contracting the waste management related jobs to waste pickers or their cooperatives in MSWM system will acknowledge their contribution in promoting urban environment and national economy and pave the way for sustainable livelihood for waste pickers;
- ❖ Official data on waste pickers and recycling industry will help the policy planners in formulating effective policies and interventions for integrating waste pickers in MSWM and national development plans to achieve the SDGs.
- ❖ City Corporations should employ the informal waste pickers in formal jobs in the Municipal Waste Management Systems.
- ❖ Waste Pickers work in a very hazardous and risky environment without any occupational safety measure or skills. Government, DCC and development partners should emphasize on providing occupational safety equipment and occupational safety training to waste pickers.
- ❖ Because of poverty, sickness or accidents waste pickers are highly exposed to economic shock and it becomes almost impossible for them to get recovered. So, the government should adopt special Safety Net Programs for the waste pickers.
- ❖ Waste pickers are deprived of access to education, technical and vocational training, health care services or credit facilities. The government should allocate a special budget for the human development of the waste picker community.
- ❖ Skill training on recycling, transfer of appropriate technologies to waste pickers and entrepreneurship development opportunities for waste pickers and small recyclable material traders are required to promote green business i.e. recycling activities to promote decent jobs and sustainable cities.

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Motivation of Information Exchange in a Virtual Community of Practice: Evidence from a Facebook Group for Shrimp Farmers

Guenwoo Lee¹ and Aya Suzuki²

Abstract

The purpose of this study is to examine the motivation of information exchange among members of a virtual community of practice (VCoP). Similar to communities of practice (CoP) in the real world, VCoPs are often made up of individuals who are engaged in the same industry or related to the work, whereas those members' activities are mainly conducted in the cyberspace. Another difference between VCoP and CoP is that CoP usually consists of members who meet face-to-face, whereas members of VCoPs tend to be distributed throughout a country or the globe, and many of them may not meet face to face with other members (Wasko, 2005). These factors lead us to suppose that interpersonal ties between members in VCoPs are relatively weak compared to CoPs. Also, it can be assumed that the motivation for information exchange between CoP and VCoP members may be different. In other words, VCoP members may not require direct reciprocity each other for the reasons mentioned above. Therefore, indirect reciprocity, rather than direct reciprocity, may be an important motivation for the information exchange with other VCoP members (Lave, 1991; Lave & Wenger, 1991; Wasko, 2005; Wenger, 1998).

While many VCoPs exist in countries with internet access, there is a dearth of literature examining the motivation for information exchange among virtual community members. Therefore, this study uses a monthly panel data to addresses a Facebook group

¹ Corresponding author: Department of International Studies, Graduate School of Frontier Sciences, University of Tokyo, Environmental Studies Building #706, 5-1-5 Kashiwanoha, Kashiwa-shi, Chiba-ken 277-8563 Phone: +81 80-4726-6874 email: 0872607264@edu.k.u-tokyo.ac.jp

² Department of International Studies, Graduate School of Frontier Sciences, University of Tokyo

member's motivation for information sharing and asking from January 2015 to May 2017.

We tested our hypotheses related to the motivation for information exchange in the group and found that: 1) members who have previously asked questions are more active in sharing information than people who have never asked; 2) members' positive expressions such as clicking likes about information sharing promote information sharing; 3) the information sharing of a social network partner has a positive effect on the sharing of an individual; 4) the more the member shares information in the past, the more s/he asks information today

The findings 1 and 4 suggest that reciprocity is the significant motivation for information exchange in the virtual community of practice, similar to real communities of practice. The finding 2 indicates that professional reputation is one of motivations for information sharing. The finding 3 denotes that there is a positive correlation between the prosocial behavior of VCoP members and the peer effect.

The contribution of this paper is threefold. First, this paper verifies that reciprocity is an important motivation for information sharing and asking in the VCoP, as in the cases of CoP. Second, it exhibits evidence whether peer effects exist in the online community. Third, this study documents the case of one online community of practice, which is functioning very effectively to provide useful information among members, and offers a useful source to manage and to vitalize online communities of practice for small-scale farmers or small businesses which have difficulty obtaining practical information and need instant information particularly.

1. Introduction

The purpose of this study is to examine the motivation of information exchange among members of a virtual community of practice (VCoP). Similar to communities of practice (CoP) in the real world, VCoPs are often made up of individuals who are engaged in the same industry or related to the work, whereas those members' activities are mainly conducted in the cyberspace. Another difference between VCoP and CoP is that CoP usually consists of members who meet face-to-face, whereas members of VCoPs tend to be distributed throughout a country or the globe, and many of them may not meet face to face with other members (Wasko, 2005). These factors lead us to suppose that interpersonal ties between members in VCoPs are relatively weak compared to CoPs. Also, it can be assumed that the motivation for information exchange between CoP and VCoP members may be different. In other words, VCoP members may not require direct reciprocity³ each other for the reasons mentioned above. Therefore, indirect reciprocity,⁴ rather than direct reciprocity, may be an important motivation for the information exchange with other VCoP members (Lave, 1991; Lave & Wenger, 1991; Wasko, 2005; Wenger, 1998).

While many VCoPs exist in countries with internet access, there is a dearth of literature examining the motivation for information exchange among virtual community members. A study by Wasko et al. (2005) is most relevant to our study which examines how individual motivations and social capital influence information sharing in a legal experts' electronic bulletin board. Their finding suggests that the members of the group share their information when they perceive that sharing information will lead to improvements in their professional reputations. We agree with their finding, but the question has remained

³ The norm of direct reciprocity is to evokes moral obligations toward others based on past behavior of oneself and others. In other words, individual B, who has received help from individual A, somehow feels obliged to pay back help to A. Cooperation among members in CoP creates norms of direct reciprocity (Lave, 1991; Lave & Wenger, 1991; Nowak & Sigmund (2005); Wasko, 2005; Wenger, 1998).

⁴ Indirect reciprocity is that A helps strangers, either in response to their kindness to third parties or after receiving kindness from others oneself (Apeldoorn & Schram, 2016).

unanswered how social capital accumulated over many years can affect current information sharing because they do not consider time fixed effects. Moreover, their study does not reveal how the interactions among group members can affect the questioning behavior of group members.

Therefore, this study uses a monthly panel data to addresses a Facebook group member's motivation for information sharing and asking from January 2015 to May 2017. We tested our hypotheses related to the motivation for information exchange in the group and found that: 1) members who have previously asked questions are more active in sharing information than people who have never asked; 2) members' positive expressions such as clicking likes⁵ about information sharing promote information sharing; 3) the information sharing of a social network partner has a positive effect on the sharing of an individual; 4) the more the member shares information in the past, the more s/he asks information today

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The contribution of this paper is threefold. First, this paper verifies that reciprocity is an important motivation for information sharing and asking in the VCoP, as in the cases of CoP. Second, it exhibits evidence whether peer effects exist in the online community. Third, this study documents the case of one online community of practice, which is functioning very effectively to provide useful information among members, and offers a useful source to manage and to vitalize online communities of practice for small-scale farmers or small

⁵ Facebook has provided a like button function to users since on February 29, 2009. The Facebook like button is the function that enables users to interact with posts shared by friends, and advertisements. Those users usually click the button to visually indicate that s/he agree or enjoy a shared post (Facebook Help center, 2017).

businesses which have difficulty obtaining practical information and need instant information particularly.

The rest of the paper is organized as follows: Section 2 reviews the relevant extant literature on the motivation for information sharing behavior in cyberspace and describes the Facebook group's role and feature. Section 3 describes our hypotheses. In Section 4, we explain the data used herein, presents summary statistics, and describes variables for eliciting reciprocities and peer effects among members. Section 5 describes estimation methods used, and the results are presented in Section 6. Finally, Section 7 concludes the study.

2. Description of a VCoP

2.1 Previous Literatures

According to Nowak and Sigmund (2005), indirect reciprocity can be divided into upstream reciprocity and downstream reciprocity as shown in Figure 1. Upstream reciprocity is built on a recent positive experience. Individual B, who has just received help from A, help C. Downstream reciprocity is based on reputation. Individual A has helped B and therefore receives help from C (Nowak & Sigmund, 2005). As mentioned in Section 1, virtual community members are most of whom never met each other. Moreover, they may not remember some of those who helped them because they often receive help from a large number of people in a short period.⁶ Taking these matters into account, it seems that it is insufficient to explain the motivation of information exchange in VCoPs only with direct reciprocity. Thus, this study suggests that indirect reciprocity such as downstream and upstream should be considered to identify the motivation.

⁶ In our data, the average number of comments to questions is about 20. This average is the result excluding 0 comment.

The closest comparator to this study is provided by Wasko et al. (2005). They collected data from an electronic network of a national legal professional association in the United States and examined how individual motivations and social capital influence knowledge contribution in the electronic network.⁷ Since participation in the network was not anonymous, they assumed that knowledge contribution to the system would have a positive impact on the professional reputation of the individual who shared information. To test the above hypothesis empirically, the study employs the volume of contribution and helpfulness of contribution⁸ as dependent variables and finds that members, who are aware that knowledge contribution helps their professional reputation, are more active in sharing and that participation occurs disregarding expectations of direct reciprocity from others. While the study provides the key to understanding the motivation for individual knowledge sharing behavior among online community members, the model suggested by them has the disadvantage that it does not take into account time effects such as how social capital accumulated over many years can affect current knowledge sharing because they use cross-sectional data.

In contrast to our and Wasko et al.'s study on sharing information among specific online community members, Jung (2017) examines reasons why people share their knowledge with unspecified individuals in cyberspace using the game theory. Based on the social exchange theory (Cook & Rice, 2003; Homans & Merton), the author hypothesizes that the pro-social behavior of helping others online is motivated by self-interest such as reward maximization and cost minimization. Thus, the study set rewards such as mental satisfaction and reputation and costs such as time and effort. According to Jung (2017), in the model without application of social capital, if individual gains utility $u = \text{reward} - \text{cost}$ more

⁷ The virtual network of practice for its members, offered by the association, is similar to a web-based bulletin board and the exchange of information on this network is open to all members (Wasko, M, 2005).

⁸ The author rates responses as very helpful, helpful, somewhat helpful, and not helpful (Wasko, M, 2005).

than zero $u > 0$ when s/he provides knowledge to other players, the person chooses to share her/his knowledge with others. Otherwise, s/he chooses not to share if $u < 0$. In the model with the application of social capital, the player selects knowledge sharing if the social capital $f(x)$ accumulated until the previous round and the profit from sharing knowledge to others in this round are greater than zero, i.e., when $u + f(x) > 0$. Otherwise, the player chooses not to share if $u + f(x) < 0$. The advantage of Jung's study is to consider the impact of social capital over time on knowledge sharing study. However, those hypotheses are not supported by empirical evidence because the study is a theoretical study.

Fehr et al. (1993) examine peer effects in pro-social behavior using a three-person gift exchange experiment. The game has one employer and two employees. At first, the employer decides how much wage to give to the employees, and then the employees choose how much effort to make sequentially. The study reveals that the second employee's choice is determined by the effort choice of the first employee. The finding suggests that the pro-social behavior of an individual is influenced by whether or not his or her peer chooses pro-social behavior first (Fehr, Kirchsteiger, & Riedl, 1993; Gächter, Nosenzo, & Sefton, 2013).

2.2 Information Exchange among the Facebook group Members

To identify the motivation of information exchange in VCoPs, this study investigates the activities of a VCoP. The VCoP is a closed Facebook group, which is founded in November 2011 by a shrimp farmer in Thailand and has been managed by nine farmers. To join the group, the applicant must be a Facebook user and must be added by an existing member. By the end of May 2017, the group had a membership of over 18 000 and nearly 13 000 posts. Members of the group usually create posts to share their expertise in shrimp cultivation or to ask other users issues relating to shrimp farming. Regarding membership and activity, it seems that the group is a representative example of VCoPs.

According to Taya (2003), shrimp diseases such as White Spot Syndrome Virus (WSSV), Early Mortality Syndrome (EMS), and so on spread very rapidly. When a shrimp is infected with a virus, it quickly spreads to other shrimp in the same pond, and all the shrimp may die in a few days. Thus, instant and appropriate information would be vital for shrimp farmers to reduce the risk of shrimp diseases (Suzuki, 2016). As information exchange is important in shrimp farming, this network has been maintained very effectively over years.

Table 1 shows the number of members in the Facebook group. In the middle of 2017, it had 18,271 subscribers, which is equivalent to 60 percent of the total shrimp farms in Thailand (FAO, 2017). However, the actual percentage of farmers of this group in Thai total shrimp producers may be much lower than the number since the group is comprised of traders, researchers, and public administrators as well as shrimp farmers. Annual and monthly new membership growth shows mostly a positive linear trend. Approximately, the number of new members in 2016 is equal to the total number of members from 2011 to 2015. Rogers (1962) argues that there is a critical point⁹ which adoption of innovation is accelerated. Based on Rogers's diffusion of innovation theory (1962), it can be interpreted that the group's membership has increased dramatically as the group has already reached the critical point before 2016 because as shown in Appendix 1, the slope of membership growth increased sharply between 2015 and 2016, which is similar to the slope after reaching a critical point in the Rogers' diffusion s-curve (Rogers, 1962). Since the total for 2017 is not the annual total, but the sum of January to May, the number of members increased in 2017 is less than half of that in 2016. Regarding monthly mean new membership, the average in 2017 is about 5 percent higher than the monthly average in 2016, and standard deviation in 2017 is smaller

⁹ On the basis of innovativeness, adopters are classified five adopter categories such as innovators, early adopter, early majority, late majority, and laggards. The critical point is associated with the early adopter's category which has the highest degree of opinion leadership among the categories and has a strong influence on the decisions of others in the same community (Rogers, 1962).

than that in 2016. If this trend continues until the end of 2017, it is highly likely that new membership in 2017 will be more than the annual total in 2016.

Figure 2 depicts an approximate distribution of the group membership in Thailand. To draw the map, we randomly selected 1 000 people from the group members and extracted information on their residences from their Facebook profiles. Shades of black in Figure 2 are divided into five levels according to user concentration. The gradation of color means that the darker the color, the more users are in the area. Bangkok has the largest members with 24.65 percent, followed by Chantaburi and Chachoengsao. It seems that most users, who live in Bangkok, are engaged in foreign trade or intermediary agents related to shrimp aquaculture. Since the group started among farmers in Chantaburi, the percentage of users in Chantaburi is high. The large proportion of users in Chachoengsao is thought to be the geographical influence because Chachoengsao is located between Bangkok and Chantaburi. The percentage of users in the southern coastal areas, where shrimp farming is active, is the next, and inland users are less than one percent or zero.

3. Hypotheses

In order to identify the motivation of information exchange in the Facebook group, we set the following six hypotheses based on the previous studies. These hypotheses can be divided into two categories. Hypotheses 1 to 3 are hypotheses regarding the information sharing of the group members, and hypotheses 4 to 6 are hypotheses about the information asking of the group members.

We test Hypothesis 1 and 4 to verify whether reciprocity between members of the Facebook group can affect information sharing and asking, respectively. The aim of hypothesis 2 is to test that improvements in professional reputation promote information sharing in the Facebook group. Hypotheses 3 and 6 are tested to verify if there are peer

effects on information sharing and asking between the Facebook group members. Finally, we test hypothesis 5 to confirm that prosocial behavior of the group members is correlated to encouraging members' asking.

Hypothesis 1:

Members of the Facebook group who have previously asked information to other group members are more active in sharing information than those who did not.

Hypothesis 2:

When a person received a greater number of favorable ratings in the past, s/he is encouraged to share more information to other members of the group

Hypothesis 3:

The sharing behavior of a peer who added the member to the group is correlated with the member's sharing behavior.

Hypothesis 4:

The more the member shared information in the past, the more s/he asks for information today.

Hypothesis 5:

The more the member received answers to previous questions from other members, the more s/he asks information to the group members today

Hypothesis 6:

The asking behavior of a peer who added the member to the group affects the member's asking behavior.

4. Data

To identify the factors relating to information exchanges between the group members, we collected data posted to the Facebook group between November 2011 and May 2017. This study focuses on the behavior of members' information exchange from 2015 to 2017. Thus, members who joined the group from 2011 to 2014 are included in the sample, and members who joined after 2015 are excluded from the sample. Hence, we use only 4,968 members who joined the group by the end of 2014 for our analysis. The data used for the analysis also includes likes and comments¹⁰ for each post, along with 5,488 posts shared by them between January 2015 and May 2017.

Since the data is in Thai, we employed people who were native Thai speakers and first divided all the posts from November 2011 to May 2017 in the group into two categories according to their purpose of posting, which are 1) knowledge sharing and 2) asking questions. We then divided them into 6 categories as shown in Figure 3 according to their content. During the period, the total number of posts for knowledge sharing is 7 019 posts and the total number of posts for asking questions is 3 850 posts. First, Figure 3 indicates that most knowledge sharing in 2011 is related to personal because the initial purpose of the group was to promote friendship among alumni who graduated from the same major (fisheries science) of the same university. Since 2012, posts about shrimp farming technologies, inputs, and climate change were actively posted, and Facebook group has become a community of practice in shrimp farming. Overall, approximately 15 to 45 percent of the posts is related to shrimp farming skills, inputs, and equipment. That is significant information not only to improve productivity but also prevent shrimp diseases. Next, looking at the percentage of each question category, we can see that the question about shrimp

¹⁰ Facebook users can type their opinion about other people's post or answers to other users' question by clicking the comment link under the post (Facebook Help center, 2017).

diseases is consistently more than 10 percent of the total questions. Except for 2011, the question of shrimp farming skills is the most common, ranging from 46 percent to 70 percent of the total. On the other hand, the question about sellers and buyers accounts for the maximum of four percent, indicating that members mainly use the group to obtain information about practical skills rather than looking for a seller or buyer. The other categories of both sharing and question contain information about private conversations, other farming, recruitment, and political issues.

Such peer-to-peer information sharing is likely to have a high risk of leading to the spread of false information. There are nine admins in the group, and most of them are shrimp farmers and majored in fishery science at university. Each of them has expert or academic knowledge on shrimp farming such as bacterial, microorganisms, and so on, and when they find incorrect information relevant to their expertise, they make a comment that corrects the error with references. Because a lot of information is posted daily, even helpful posts in shrimp aquaculture are often scrolled down and become difficult to find it. To such discomfort in searching, admins distinguish posts in the group that will be helpful to other shrimp farmers and add them to a link collection of useful information. These activities of admins are volunteer activities.

Table 2 summarizes count data on each user's average monthly number of information sharing S and asking AS , the average number of likes of a post for information sharing L , and the average number of comments of a post for information asking C . The number of observation for the information sharing and asking indicates the number of users who joined before a year. The number of observations for the likes and comments refers to the number of sharing and asking in the group, respectively. By 2014, the average number of information sharing was 0.19 to 0.11, but it dropped to about 0.02 to 0.01 after 2015. This means that the percentage of members who do not share information in the group increases, which may be

related to membership growth. Similar to the decrease in the number of sharing, the average number of asking decreases, but it decreases gradually rather than the number of sharing. Furthermore, Table 2 implies that as the number of members increases, the number of comments on a question does not increase significantly, whereas the number of likes on a post for information sharing increases dramatically.

Figure 3 demonstrates a histogram showing the numbers of information sharing by the members during that period. The histogram does not include the knowledge sharing frequency of zero. The distribution of the histogram is skewed to the left. The density of shares between 1 and 2.4 is overwhelmingly high at 0.50, and the density of shares between 3.8 and 5.2 is the next at 0.05, followed by the density of shares between 2.4 and 3.8 at 0.04. The density of all other frequencies is close to zero.

A histogram as shown in Figure 4 illustrates the number of information asking to other members during the same period as in Figure 3. Also, the histogram does not include zero and is skewed to the left. The density of once question is overwhelmingly high at 3.65, and the density of twice questions is the next at 0.44, followed by the density of three times question at 0.17.

5. Empirical Strategies

This study empirically examines the above hypotheses using the Facebook group data described in Section 4. As mentioned in previous sections, the sharing and asking behavior of members may be influenced by the reaction of other members. We test that the number of comments or likes of one month or less may affect the members' behavior. According to Cameron and Trivedi (2013), Poisson regression model is considered appropriate for counter-dependent variables. Because those dependent variables in Equations (1) and (2) are counter

variables, we employ two-way fixed effect Poisson regression and take the behavioral changes of those members each month.

We first evaluate the two-way fixed effect Poisson regression for the number of shares as a dependent variable. We estimate:

$$S_{it} = \beta_1 S_{it-1} + \beta_2 AS_{it-1} + \beta_3 L_{it-1} + \beta_4 S_{jt-1} + \alpha_i + \lambda_t + u_{it} \quad (1)$$

where subscript i denotes individual, j denotes i 's social network partner who added i , and t is a month; S is the number of knowledge shared by i or j each month; AS denotes the number of questions that i asked each month; L refers to the average monthly number of likes that i obtained; α is the unobserved individual effect; λ is time fixed-effects; u is an error term.

Next, the dependent variable of equation (2) is the number of questions by i each month. We assume that the factors which encourage questioning behavior in the group are similar with the motive of knowledge sharing. The regression model is as follows:

$$AS_{it} = \beta_1 AS_{it-1} + \beta_2 S_{it-1} + \beta_3 C_{it-1} + \beta_4 AS_{jt-1} + \lambda_t + a_i + u_{it} \quad (2)$$

where C denotes the average monthly number of comments that i obtained.

Furthermore, the study employs pooled Poisson regressions for both dependent variables mentioned above to increase the sample size and for sampling from the population at different points in time. However, the Poisson regression model does not solve the problem of overdispersion, which is often observed in count variables. In addition to the Poisson models, we, therefore, use negative binomial regression models such as the mean-dispersion model (NB1) and the constant-dispersion model (NB2) for over-dispersed variables. All

models include time dummies to account for monthly fluctuations in those dependent variables (Cameron & Trivedi, 2013).

To reveal what determines the group members' sharing or asking in the VCoP, we create two binary variables for sharing and asking. Equations (3) and (4) are estimated using the average marginal probability effects (AMPE) in the two-way fixed effect Logit.

$$\Pr(S_{it} = 1) = \beta_1 S_{it-1} + \beta_2 AS_{it-1} + \beta_3 L_{it-1} + \beta_4 S_{jt-1} + \lambda_t + a_i + u_{it} \quad (3)$$

$$\Pr(AS_{it} = 1) = \beta_2 AS_{it-1} + \beta_1 S_{it-1} + \beta_3 C_{it-1} + \beta_4 AS_{jt-1} + \lambda_t + a_i + u_{it} \quad (4)$$

where S is the dummy for each member's sharing in the VCoP, equal to one if the member share information and 0 otherwise. AS is the binary variable for each member's asking, equal to one if the member asks other members any question and 0 otherwise.

6. Estimation Results

6.1 Determinants of Number of Information Sharing

We evaluate various models such as the fixed effect Poisson model, the pooled Poisson model, the pooled NB1, and the pooled NB2 to examine the count variable for information sharing as shown in Equation (1). The dependent variable in Table 3 is the number of information sharing of an individual i . To compare the goodness of fit of three pooled models, we perform the likelihood-ratio test. The result of the test suggests that NB1 and NB2 are the better fit than the pooled Poisson model because both overdispersion parameters $\alpha=0$ and $\delta=0$ are rejected. As the log likelihood of NB1 is higher than NB2, NB1 model appears to be the most suitable model among the pooled models.

In Column (1), there are statistically significant relationships between all explanatory variables and the number of information sharing of an individual i . The result of the number of an individual i 's information sharing a month ago Lag_S indicates that the number of the individual's shares this month increases by 0.05 unit, depending on how many times s/he has shared in the previous month. Also, if an individual were to increase the frequency of information asking a month ago lag_AS , the difference in the logs of expected counts would be expected to increase by 0.24 unit, while holding the other variables in the model constant. This result supports hypothesis 1 about reciprocity, which is one of the motivations of information sharing. The variable Lag_L , which denotes the number of likes for a post posted by an individual i a month ago, has a positive and significant impact on the number of the member's information sharing. This result is statistically significant and supports hypothesis 2 relating to professional reputation. The result in Column (1) shows that the significance level and sign of the explanatory variables except information sharing by an individual's social network partner Lag_J_S is the same as the result of NB1.

6.2 Determinants of Number of Information Asking

Table 4 indicates the results from estimating the Poisson models and negative binomial models in terms of equation (2). The dependent variable in Table 3 is the number of information asking of an individual i . The result of the likelihood-ratio test for comparing the goodness of fit of pooled models suggests that NB1 and NB2 are the better fit than the pooled Poisson model, and the result of the log likelihood indicates that NB1 model is the most appropriate model among the pooled models.

In Column (1), there is statistically significant relationships between the number of information asking a month ago lag_AS and the dependent variable for information asking. The result of the number of an individual i 's information asking a month ago Lag_AS

indicates that the number of the individual's asking this month increases by 0.32 unit, depending on how many times s/he has asked in the previous month. Similar to the result of the fixed effect Poisson model, the result of NB1 in Column (3) shows that the explanatory variable *Lag_AS* has a positive and significant impact on the number of information asking of individual *i*. In addition, the variable *Lag_C*, which denotes the number of comments for a question posted by an individual *i* a month ago, has a coefficient of 0.02, which is statistically significant at 5 percent level. This means that for each one-unit increase in the number of comments, the expected log count of the number of information asking increases by 0.02. This result is statistically significant and supports hypothesis 5, which is that pro-social behavior of the group members encourages members' asking. On the other hand, the variable *Lag_J_AS* is insignificant in all models in Table 4. This result indicates that hypothesis 6 mentioned in Section 3 is not supported.

6.3 Determinants of Information Sharing and Asking

Table 5 shows the marginal effects from estimating the Logistic model in terms of equation (3) and (4). The dummy variable for information sharing is the dependent variable in Column (1), and the dummy variable for information asking is the dependent variable in Column (2).

Most of the results in Table 5 are similar to the results in Tables 3 and 4. A notable difference from Table 4 is that the number of an individual *i*'s information sharing a month ago *Lag_S* has a positive and significant effect on increasing the probability of the individual *i*'s information asking this month. In magnitude, the probability of information asking by *i* increases by one percent as the number of information sharing a month ago increases by one unit. Although this result does not confirm hypothesis 4, it supports that reciprocity can affect the information asking in the VCoP.

6.3 Robustness Checks

The estimation results mentioned above may vary as the sample size and the data collection period. Therefore, we retest our hypotheses in Section 3 using data obtained from 7 764 members who joined the group by the end of 2015. The data includes their activity between January 2016 and May 2017.

Table 6 describes the results of the robustness checks. Columns (1) and (2) have dependent variables for information sharing. Columns (3) and (4) have dependent variables for information asking. Column (1) shows results similar to Column (1) in Table 3 except for the variable *Lag_AS*. In Column (2), the variable *Lag_J_AS* is statistically significant at 5 percent level unlike the result in Column (1) in Table 5. In Column (3), the results also slightly differ from the result of the model using data between 2015 and 2017. The explanatory variable *lag_AS* is statistically significant in Column (1) in Table 4, whereas the variable is insignificant in Column (3) in Table 6. Finally, Column (4) is the most different from the estimation results using data from 2015 to 2017 as compared to the other columns in Table 6. Unlike the results in Table 5, all explanatory variables in Column (4) in Table 6 are insignificant.

7. Conclusion

Although VCoP is used by many people in countries with internet access, the motivation and behavior of the users' information exchange are still unclear. Therefore, the present study was undertaken to identify reasons why people share their expertise in online communities using data from the Facebook group, which is a VCoP made up shrimp farmers in Thailand. The study hypothesizes that the behavior is motivated by reciprocity, professional reputation, and peer effects, and tests the hypotheses using various econometric models, including models which consider time fixed effects.

As a result, we found that members who have previously asked questions are more active in sharing information than people who have not asked. Also, our finding suggests that members' positive expressions such as clicking likes about posts promote information sharing. The results are robust to various estimation methods employed, including models which consider time fixed effects. Hypothesis 3, which the information sharing of a social network partner has a positive effect on the sharing of an individual, is supported by the result of most models except for the result of the pooled NB1 regression.

In terms of information asking, we were able to identify that people who had done the question before were more active in the question. We also revealed that members who have previously shared information ask more frequently than members who have not shared it. This behavior may come from reciprocity. Another finding is that pro-social behavior of the group members encourages members' asking. However, because the level of significance is different depending on the model, it seems that the results are not robust.

These findings clarify that there is reciprocity in the Facebook group and that both reciprocity and professional reputation are significant factors which promote professional knowledge exchange in the VCoP. If the motivation of the user is met in a VCoP, information exchange can be activated, and such active exchange of information will lead to the growth of the community.

Lastly, we should note that there are several limitations to this study. One limitation is that we were not able to distinguish between direct and indirect reciprocity in the virtual community due to lack of data. Therefore, an additional study should be conducted to examine direct reciprocity and indirect reciprocity effects separately. Moreover, a model which includes psychological variables should be studied further to clarify the motivation of information sharing more clearly. It is hoped that the findings that have been presented in this

paper will contribute to the management of virtual communities such as the activation of information exchange among group members.

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Table 1. The Increase in the Membership for Facebook group

	2011	2012	2013	2014	2015	2016	2017
New Member	7	179	1,034	3,748	2,796	7,215	3,292
Cumulative Total	7	186	1,220	4,968	7,764	14,979	18,271

Source: Based on a Facebook group data for 2011-2017

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
<i>Jan to Dec 2012</i>					
S	7	0.11	0.49	0.00	4.00
AS	7	0.11	0.41	0.00	3.00
L	328	6.32		0.00	10.00
C	121	11.68		0.00	33.00
<i>Jan to Dec 2013</i>					
S	186	0.19	1.77	0.00	57.00
AS	186	0.06	0.35	0.00	4.00
L	1,125	9.22		0.00	194.00
C	345	11.69		0.00	64.00
<i>Jan to Dec 2014</i>					
S	1,220	0.11	1.36	0.00	51.00
AS	1,220	0.02	0.21	0.00	8.00
L	2,465	28.21		0.00	480.00
C	1302	10.12		0.00	128.00
<i>Jan to Dec 2015</i>					
S	4,968	0.02	0.46	0.00	30.00
AS	4,968	0.01	0.10	0.00	6.00
L	1,313	43.56		0.00	527.00
C	514	11.14		0.00	234.00
<i>Jan to Dec 2016</i>					
S	7,764	0.01	0.35	0.00	39.00
AS	7,764	0.005	0.08	0.00	4.00
L	1,137	56.90		0.00	569.00
C	970	12.78		0.00	177.00
<i>Jan to May 2017</i>					
S	14,979	0.01	0.35	0.00	37.00
AS	14,979	0.01	0.10	0.00	7.00
L	647	46.00		0.00	527.00
C	595	13.74		0.00	125.00

Note: S=information sharing, AS=questioning, L=the number of likes, and C=the number of comments. The obs of S means the number of people who joined before. The number of observations for A and S indicates the number of users who joined before a year. The number of observations for L and C is the number of sharing and asking in the group, respectively.

Source: Based on a Facebook group data for 2011-2017

Table 3. The Estimation Result of the Number of Information Sharing (2015-2017)

VARIABLES	FE Poisson (1)	Pooled Poisson (2)	Pooled NB1 (3)	Pooled NB2 (4)
Lag_S	0.05*** (0.01)	0.19*** (0.01)	0.96*** (0.29)	0.17*** (0.01)
Lag_AS	0.24*** (0.07)	0.84*** (0.08)	2.11*** (0.24)	0.89*** (0.08)
Lag_L	0.003*** (0.001)	0.01*** (0.001)	0.03*** (0.004)	0.01*** (0.001)
Lag_J_S	0.04** (0.02)	0.01 (0.03)	-0.01 (0.02)	-0.01 (0.01)
Constant		-4.30*** (0.58)	-4.63*** (0.42)	-3.57*** (0.35)
Time Dummy	Yes	Yes	Yes	Yes
Observations	6,322	144,058	144,058	144,058
Number of <i>i</i>	218	4,968	4,968	4,968
Time Periods	29	29	29	29
Wald chi2(32)	1197.72	6180.03	575.35	5290.79
Pseudo R2		0.49	0.19	0.17
Log Likelihood	-2551.81	-8037.35	-4630.65	-4751.05
AIC	5167.61	16140.7		
α			19.84	
δ				4.14
LR test			chi2(1)=6813.39 Prob>chi2=0.00	chi2(1)=6572.60 Prob>chi2=0.00

Note: Pooled NB1 is a mean-dispersion model, Pooled NB2 is a constant-dispersion model, S=information sharing, AS=asking, L=the number of likes, and J_S= information sharing by j. In Column (1), robust standard errors in parentheses. In Columns (2), (3), and (4), standard errors in parentheses are adjusted for 4,968 clusters. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4. The Estimation Result of the Information Asking (2015-2017)

VARIABLES	FE Poisson (1)	Pooled Poisson (2)	Pooled NB1 (3)	Pooled NB2 (4)
Lag_AS	0.32*** (0.06)	1.38*** (0.09)	3.00*** (0.21)	1.36*** (0.08)
Lag_S	0.03 (0.03)	0.13*** (0.01)	0.50 (0.35)	0.13*** (0.01)
Lag_C	0.004 (0.003)	0.02*** (0.003)	0.02** (0.01)	0.02*** (0.003)
Lag_J_AS	-0.11 (0.25)	-0.11 (0.31)	-0.30 (0.33)	-0.12 (0.30)
Constant		-4.59*** (0.21)	-4.61*** (0.18)	-4.67*** (0.19)
Time Dummies	Yes	Yes	Yes	Yes
Observations	7,105	144,058	144,058	144,058
Number of <i>i</i>	245	4,968	4,968	4,968
Time Periods	29	29	29	29
Wald chi2(32)	263.64	1275.77	1079.61	1245.88
Pseudo R2		0.15	0.1	0.1
Log Likelihood	-1557.42	-3733.31	-3422.56	-3441.21
AIC	3178.84	7532.63		
α			19.66	
δ				0.45
LR test			chi2(1)=621.52 Prob>chi2=0.00	chi2(1)=584.20 Prob>chi2=0.00

Note: Pooled NB1 is a mean-dispersion model, Pooled NB2 is a constant-dispersion model, S=information sharing, AS=asking, C=the number of comments, and J_AS= asking by j. In Column (1), robust standard errors in parentheses. In Columns (2), (3), and (4), standard errors in parentheses are adjusted for 4,968 clusters. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 5. Determinants of information sharing and asking: Average Marginal Probability Effects from the Fixed Effect Logistic Model (2015-2017)

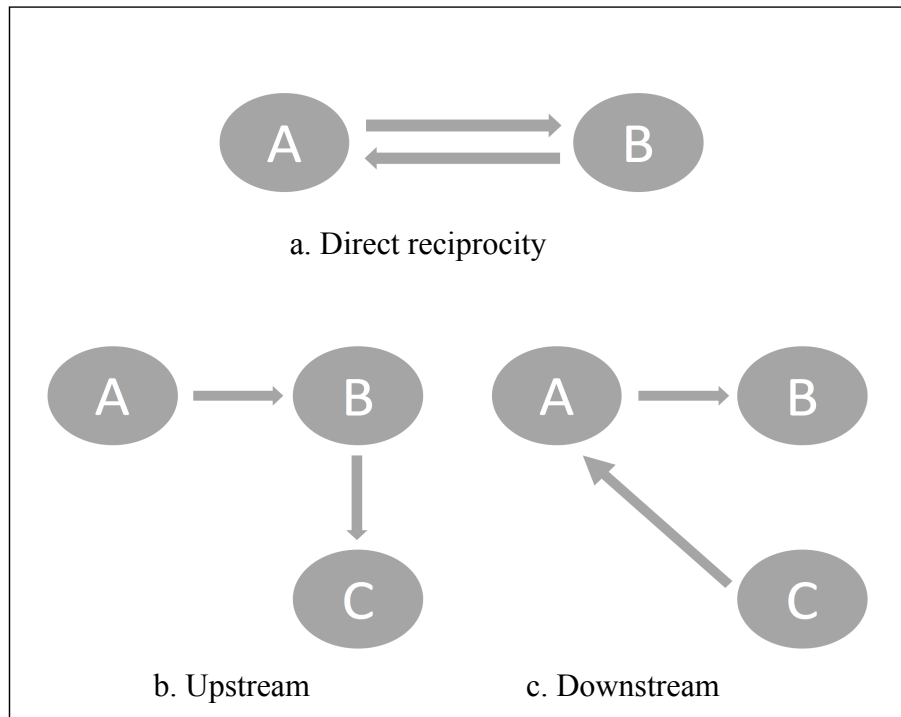
VARIABLES	Sharing (1)	Asking (2)
Lag_S	0.22*** (0.006)	0.01** (0.005)
Lag_AS	0.05*** (0.02)	0.06*** (0.02)
Lag_L	0.0003*** (0.0001)	
Lag_C		0.0002 (0.001)
Lag_J_S	0.001 (0.002)	
Lag_J_AS		-0.03 (0.04)
Time Dummy	Yes	Yes
Observations	6,264	7,105
Number of <i>i</i>	216	245
Time Periods	29	29
LR chi2(32)	278.99	196.83
Log Likelihood	-1235.54	-1283.06

Note: S=information sharing, AS=asking, L=the number of likes, C=the number of comments, and J_S= information sharing by j, J_AS= asking by j. Standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.

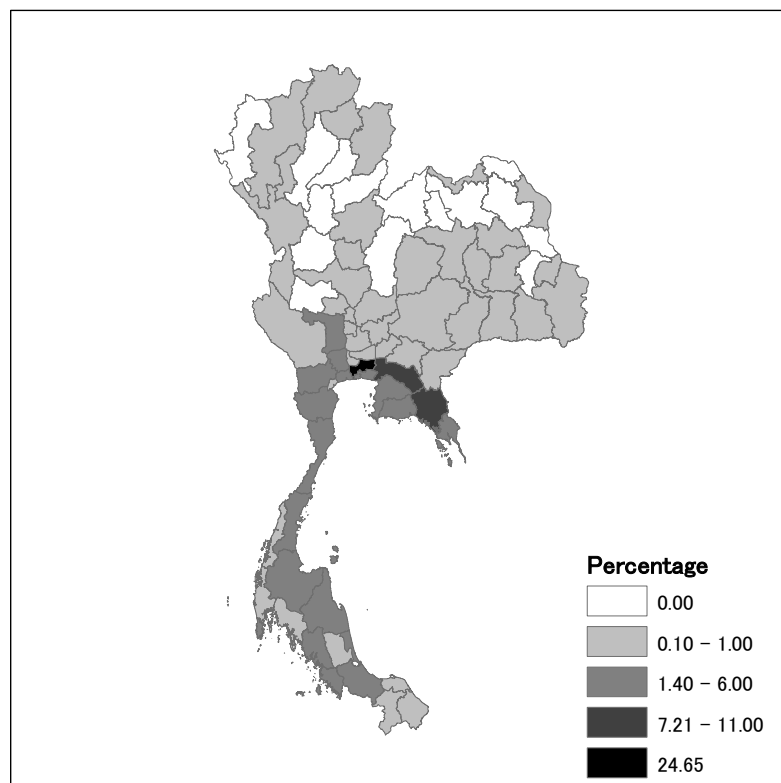
Table 6. Robustness Check (2016-2017)

	Sharing		Asking	
	FE Poisson (1)	FE Logit (2)	FE Poisson (3)	FE Logit (4)
Lag_S	0.05*** (0.01)	0.03*** (0.01)	0.10 (0.08)	0.02 (0.01)
Lag_AS	0.11 (0.11)	0.08** (0.04)	0.08 (0.06)	0.02 (0.03)
Lag_L	0.003*** (0.001)	0.0002 (0.0002)		
Lag_C			0.004 (0.004)	0.001 (0.001)
Lag_J_S	0.06** (0.02)	0.01* (0.003)		
Lag_J_AS			-0.21 (0.33)	-0.03 (0.08)
Constant				
Time Dummy	Yes	Yes	Yes	Yes
Observations	2,686	2,652	4,590	4,590
Number of <i>i</i>	158	156	270	270
Time Periods	17	17	17	17
Wald chi2(32)	454.11		56.85	
Log Likelihood	-1275.36	-662.47	-1271.88	-1967.83
AIC	2590.71		2583.75	

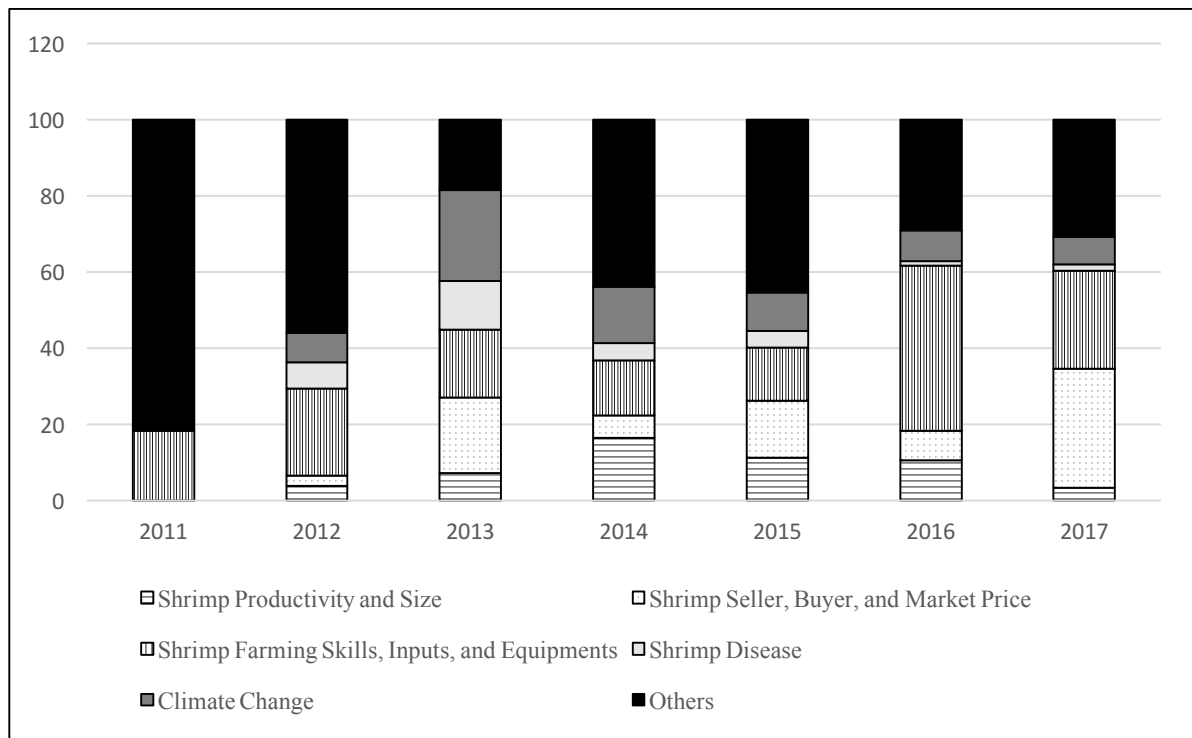
Note: S=information sharing, AS=asking, L=the number of likes, C=the number of comments, and J_S= information sharing by j, J_AS= asking by j. In Columns (1) and (3), robust standard errors in parentheses. In Columns (2) and (4), standard errors in parentheses. * significant at 10%; ** significant at 5%; *** significant at 1%.



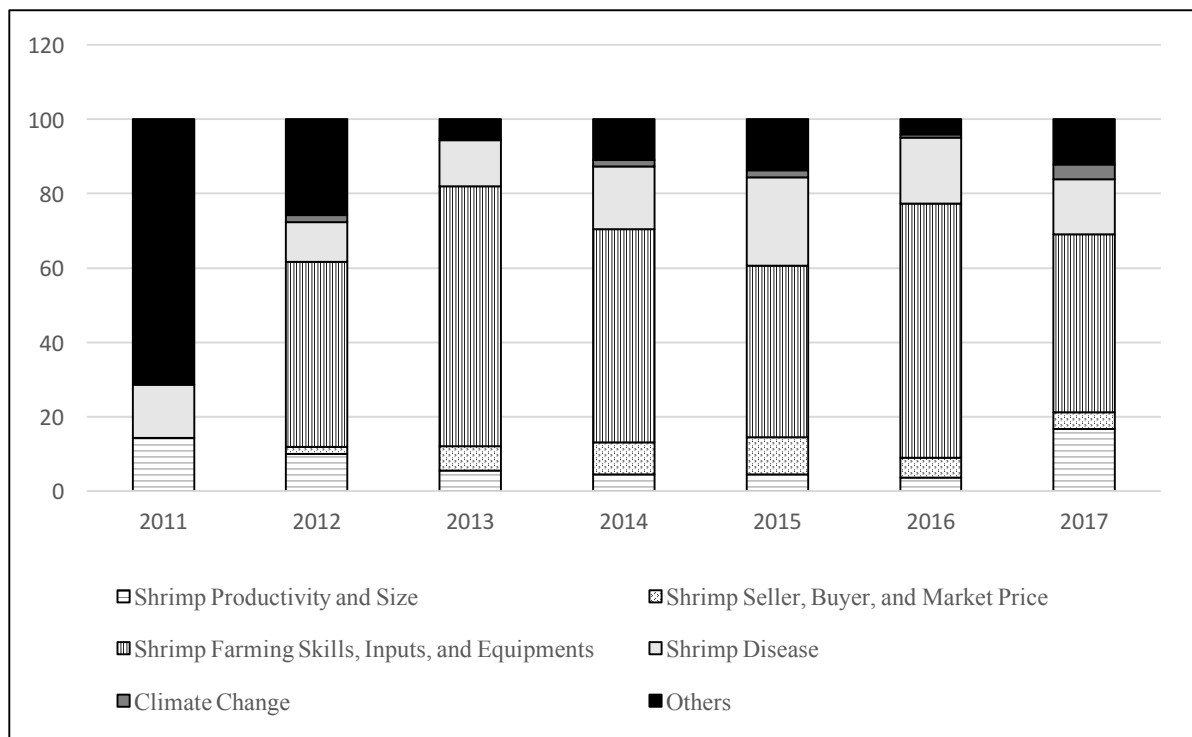
Source: Nowak and Sigmund (2005)
Figure 1. Direct and Indirect Reciprocity



Source: Based on a Facebook group data for 2017
Figure 2. Facebook group Membership Distribution



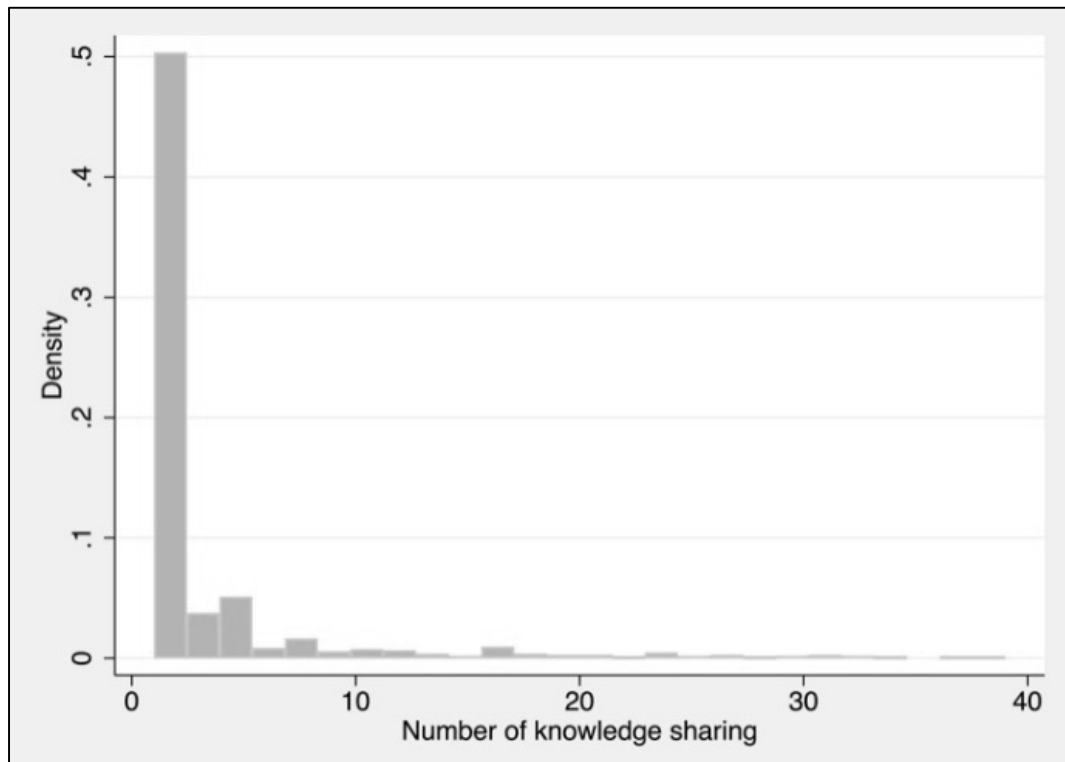
a. Sharing Categories



b. Asking Categories

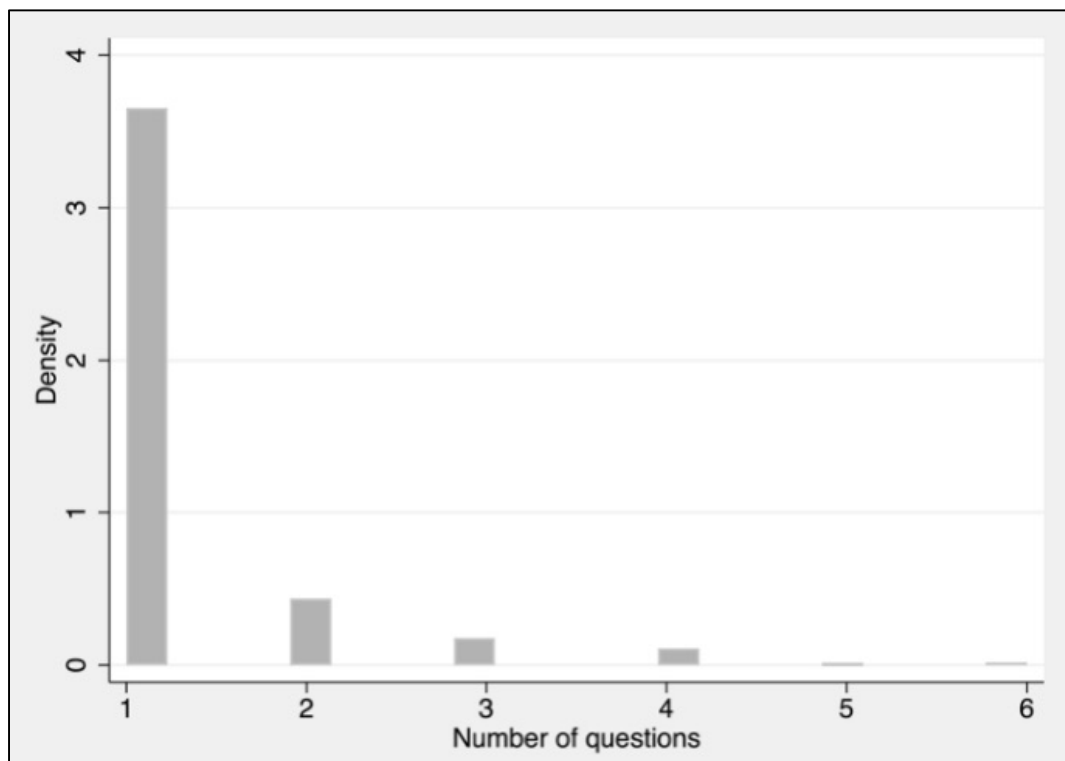
Source: Based on a Facebook group data for 2011-2017

Figure 3. Sharing and Asking Categories



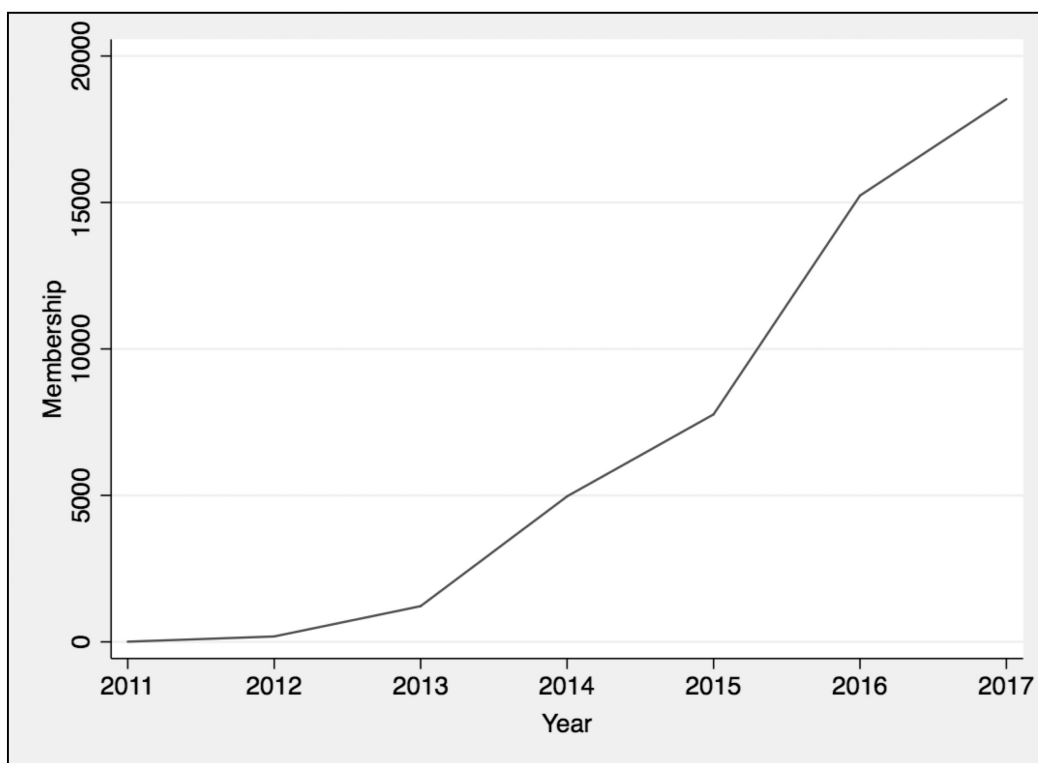
Source: Based on a Facebook group data for 2011-2017

Figure 3. Number of Sharing



Source: Based on a Facebook group data for 2011-2017

Figure 4. Number of Questions



Source: Facebook group (2017)

Appendix 1. Membership of the Facebook group

Capacity Assessment of ‘Pollution Control Agreements’ Model between Local Government and Industries in Bangladesh

Shishir Reza¹ Mizanur Rahman²

¹Associate Member, Bangladesh Economic Association;

²MS in Disaster Management, University of Dhaka

Abstract

Pollution control agreements between local government and industries are key element of environmental protection, Socio-economic development of society, stability of biosphere and individual ecosystems. These kinds of agreements control noise, water, air, soil, odor, radioactive, river, and industrial pollution; ensure land security; monitor forest, manage waste not only in urban level but in grass root level. All types of industries – agriculture, textiles, manufacturing, food, soap, construction and mining can follow the standard level of pollutants emission and management systems ordered by government agencies. This study explains why the linkage between capacities of local government and industries is essential to control industrial pollution and emission; ensure environmental security. It would also find out means and ways to enhance the potential of local government, to initiate a culture of ‘polluters-to-pay’, build a corporate image through introducing green products and to effectively monitoring noise, water, land, odor, air pollution and radiation of mobile towers. Particularly, it would be aimed at introducing society and people oriented policy formation and implementation to combine the environmental sustainability and economic development of Bangladesh.

Keywords: Pollution Control Agreements, Planning, Environment, Bangladesh, Economy, Local Government

1. Introduction

Environmental Planning and Management implies the socio-economic development of society as well as stability of biosphere and individual ecosystems. Pollution control agreements between local government and industries are important part of environmental management. This kind of agreement ensures to control noise, water, air, land, odor, radioactive, river, industrial pollution, forest monitoring, waste management not only in national level but in grass root level, environmental justice, systems of polluters-pay and open the floor for public participation in policy making. A social and politico-economic capital can be built both national and local level through pollution control agreements. All types of industries such as agriculture, textiles, manufacturing, food, construction and mining can follow the standard level of pollutants emission and management systems ordered by government authorities. In Bangladesh, there are 21 ‘Department of Environment’ at district level – mostly incapable to monitor and control

environmental pollution. In addition, various authorities positioned in districts, paurashava, city corporation, thana, upazila and union level. Other hand, our motherland is a home of forest resources, water resources, mineral resources, land resources generally placed in local level. But a gap between policy formation and enforcement of environmental regulations is widely characterized by less transparent functioning of environmental institution, poor administrative practices, lack of manpower and active public participation in the grass root level.

Over the last twenty years, Bangladesh has attained a consistent growth in different sectors such as industrialization, infrastructure development, health care, food productivity, social safety net etc. Such sector centered development merely embraced protection of natural resources and environmentally sound management practices in the development history of the country. Now she is going to establish 100 economic zones at different regional level. But we have no pollution control agreements and related experiences at local level to ensure environmental wellbeing.

In this context, Bangladesh needs pollution control agreements between local government and industries to control and monitor waste and effluent treatment plant operation, waste recycling systems, river encroachment and pollution, vehicles and construction induced noise pollution, radiation of mobile towers, excessive use of agro-chemicals, industries induced air pollution, alien species in forest, commercial cultivation in forest area, land use patterns and of course integrated environmental development. Agreements of pollution control can lend a hand for cooperative and integrated approach in environmental security through power sharing strategy among administrative actors and relative decentralization within vertical administration.

2. Objective of the study

1. To assess the potential of ‘pollution control agreements’ to make eco-infrastructure at local level in Bangladesh.
2. To identify the capacities of local government in sustainable environmental security.
3. How local people can participate in environmental management through pollution control agreements?

3. Methodology

Data has been collected by studying and reviewing different journals and articles, textbooks, news papers and websites. Primary source includes informal conversation with experts who understand the pros and cons of pollution control agreements and capacities of local government in environmental security.

4. Literature Review

In Japan, formation and implementation of environmental policy is deeply rooted in political economic structure, social norms and culture which addresses economic growth without compromising environmental protection. In Bangladesh, most of the time we have seen, rural to urban migration, environmental deterioration, food insecurity are caused by climate change. But the crises are also intimately related to land encroachment in forest, clash in char-land, river encroachment, deforestation, violation of eco-industrial laws – anthropogenic basically.

The potent combination of industrialization, urban development and mass consumption trends is exacerbated by foreign companies operating with little regard for the impact on the local environment. During the period of rapid economic growth after the Second World War, Japan experienced a variety of terrible environmental problems on a scale unprecedented in the world. Cooperative enforcement based on networking and close information exchange between government and industries lowered the cost of compliance (Hidefumi, 2008)

Toshionari (2008) identifies power sharing strategies among different stakeholders. Such as role of Ministry of Agriculture, Forestry and Fisheries in planning and drafting of agricultural policy aimed at conservation of the environment, environmental conservation related to livestock, Prevention of the pollution of soil used as agricultural land; forestry agency to conservation of forests; Ministry of Economy, Trade and Industry to prevent of industrial pollution, recycling of waste generated by industrial activities; Ministry of Land, Infrastructure, Transport and Tourism to environmental conservation as linked to social capital provision, sewerage installation and maintenance , prevention of automobile pollution, prevention of marine pollution, measures to counter aircraft noise; Japan Meteorological Agency to observe of the ozone layer, collection of data on greenhouse gases, etc.

Historical trends of environmental movement in Bangladesh was initiated by the national commitment of the country to Stockholm Conventions in 1972 which preceded the formulation of first Water Pollution Control Ordinance in 1973 followed by Environment Pollution Control Ordinance in 1977. In 1985, Department of Pollution Control Ordinance was established which subsequently renamed and structured as Department of Environment (DOE). The idea of environmental protection through national efforts was first recognized and declared with the adoption of the Environmental Policy 1992. Since the beginning of such interventions very few of the Environment Policy directives and guidelines have been translated into action. Till to date, Bangladesh Environment Conservation Act (ECA) 1995 serves as the only legal basis for Environment Conservation Rules (1997) that specifically deals with conservation and improvement of environmental standards for controlling and mitigating environmental pollution.

To reinforce the policy, Environment Conservation Rules (1997) was subsequently amended in 2000. For the implementation and leadership, the Ministry of Environment and Forest (MoEF) was assigned to play the role of lead agency. A National Environmental Committee was created with the Prime Minister as the as the Chairperson to give overall direction for implementation of this policy. However, various research studies have noted that the implementation of such policy initiatives and legislative measures have been hindered due to some institutional and functional limitations (Khan, and Belal 1999, Hanchett, 1997). Hence, the present situation calls for a periodic review, amendment, modification, reformation and proper implementation of the existing policies, acts, rules and regulation as part of the environmental management strategies with a view to address integrated and sustainable development of the country.

Decentralization is very important to any kind of development. It reduces the pressure from the national government. Relative decentralization of both authority and responsibility has been a key feature of Japanese environmental management at national level. Local governments are also doing effectively when it comes to dealing with specific environmental problems and issues. In Japan, today, over 70 percent of Japanese enterprises have a pollution control department. There are at present about 23,000 pollution control supervisors and 40,000 pollution control managers. The modern Japanese business structure actually originated from family-based companies. “Do as ordered from the top” is a very popular corporate culture. They make it as a corporate culture.

When government, business and the public – participate in environmental management according to their own functions and responsibilities, this is defined as the triangular model of actors. The government acts as a regulator and monitor; business as a self-governing and policy implementing body; and the public as a participant in environmental policymaking, by acting as a social supervisor as well as an actor protecting the environment through lifestyle changes.

4. Pollution Control Agreements: Meaning and Importance

People’s behavior towards environment and nature are altering for a long time. The development term neo-liberalism has fueled this culture aggressively. In general, economic development is intrinsically connected with global warming and climate change. Consequently, assimilation capacities of earth are lessening as of indiscriminate exploitation of natural resources. If fossil fuels were not used for industries and automobiles, the release of CO₂ would not have made the environment so hazardously dangerous for living. However, it needs revolutionary change for collective world and resources utilization. In terms of sustainable economy and environmental security, the new leaderships in France, New Zealand and Japan have blown in a fresh air. In their part, try level best to renovate national and regional collision free growth. What we need, just asses the environmental hazards free economic growth and peoples love for nature and surrounding people ecology nexus. The pollution control agreements model, in this may lend a hand for collective wellbeing.

Climatic Calamities: Bangladesh is globally known as one of the most vulnerable countries to the impacts of global warming and climate change. This is due to its geographic location, population explosion, dominants of floodplains, poverty and overwhelming dependence of natural resources (Reza, 2017). Climate change not only affects human development and biodiversity conservation but also poses a threat to human security with increased frequency of extreme weather events – floods, cyclones, draught, earthquake that are degrading our socio-economic conditions. No country and people know this better than Bangladesh, where millions of people are suffering. Scientists predict that, due to tropical cyclones and salinity intrusion into farming lands in coastal areas, environmental refugees will exceed 20 million in coming future. As a result, their demand for land, water, employment and other public services generate conflict with local residents. Through the Bangladesh climate change resilience and trust fund, we may create awareness on climatic impacts of natural resources among even marginal peoples.

Insecurity in Accessing Unadulterated Water: water security in Bangladesh is decreasing day by day due to the different factors. These factors include industrial pollution; improper use of agro-chemicals; indiscriminate disposal of municipal, industrial and residential wastes enter into the inland water systems, poorly designed drainage and irrigation works, lack of adequate regulatory measures and institutional setup for proper monitoring and control. Asian water development outlook (2016) mentions – 80% wastes are dumping into river in Bangladesh. Water security index indicates Bangladesh is 44th out of 48 countries. Around 250 industries are discharging chemical pollutants into Buriganga and Sitalakka River. In Dhaka, 25 canals have lost her life out of 43(daily sun, 2017). The same condition has prevailed among different division, City Corporation, district, paurashava, upazila and union level. Other hand, we have standard indicator and value of water quality ordered by Department of Environment (DoE), such pollution control agreements integrate local industries and govt. authorities to resolve environmental insurgencies.

Forest Land Security: Out of 46,000 acres in Madhupur Sal forest – 7,800 acres have been given out to commercial plantation; 25,000 acres has given into illegal possession. At hilly forest, tobacco farming is increasing rather than the mainstream farming. About 10 national and international companies are involved in tobacco farming. In 2000, about 300 hectares land was used which has increased 4232 hectares in 2010. Now the farming area is about 10,000 hectares. Also, shrimp farming has increased the rate of land encroachment more than double from 45,596 hectares in 2000 to 96,283 hectares in 2010 at Mangrove forest area (Reza, 2016). Commercial plantation and illegal possession in Sal forest; inappropriate jhumming, stone exploitation, brick fields, Bengali expansionism in hill forest as well as apiculture, shrimp by catching and animals hunting in Mangrove forest – all issues are swelling a concern about protection of forest biodiversity. Biodiversity and its conservation are very indispensable for human beings or any living organism. Context implies local forest authority for the sake of secured forest land, empower indigenous peoples and take their opinion for ecological, environmental and climatic security.

Air Toxicants and Public Health: Incidence of air pollution is not an isolated event but is a continuous process as the sources of pollution operate throughout the year. About 98% of cities in the low and middle income countries, like Bangladesh, consisting more than 100,000 populations violate the WHO air quality guidelines. Dhaka is assumed to be one of those cities. Regarding urban air pollutants, the annual mean concentration of fine particulate matter (PM_{2.5}), 2014; in Bangladesh-89.7, India- 73.6, Afganistan-64.1, Nepal-75.7, Bhutan-39.0 and Srilanka-28.6. In Bangladesh, the level of air pollution is highest in Dhaka followed by Chittagong and Khulna, the two other industrial cities. The concentration of CO, NO_x, PM₁₀ and CO₂ in Mohakhali is respectively, 2519 µg/m³, 376 µg/m³, 547 µg/m³ and 435 ppm; Farmgate- 7730 µg/m³, 752 µg/m³, 289.92 µg/m³, 590 ppm; Science lab- 5726 µg/m³, 113 µg/m³, 169.93 µg/m³, 500 ppm. Mogbazar- 5726 µg/m³, 339 µg/m³, 383.53 µg/m³, 475 ppm. In Chittagong, the concentration of PM_{2.5} was 307 in 2012 which is now 371(Financial Express, 2017). Basically, our urban areas are not free from air toxicants. Other hand, people's perception on toxicants is not clear. Perspective mentions, City Corporation or paurashava through the help of air quality laws and traffic police – jointly work to aware people and pose policy related threats on air pollutant emitters. There are a lot industries and factories in Dhaka city. Their percentages in air pollution are given below:

Industrial sectors	Contribution (%)
Pulp & paper	13.7
Cements/clay	16.6
Textiles	10.5
Food industry	38.7
Tobacco	4.5

(Source: Islam, et.al. 2013)

In addition, 86% of vehicle in Dhaka city exceed the acceptable limit of emission. Means of transportation type- air pollutants are:

Vehicle Type	CO (%)	HC (%)	NO _x (%)	PM (%)
truck	13.4	8.6	59.7	47.5
bus	10.3	9.7	18.5	29.4
minibus	7.3	3.9	6.5	19.1
car	38.2	18.2	6.5	1.2
Three wheelers	10.6	26.9	6.0	1.2
Motor cycle	14.0	28.3	0.3	1.0

(Source: Profile of Environment, Bangladesh, 2010)

5. Pollution Control Agreements: Capacities of Local Government

The concept of 'local governance' explicates the tasks as done by local government institutions in both developing and developed countries where collective public welfare is the leading concern. Locally the role of local government is very much important for sustainable environment. At the sub-national level, local institutions reproduce enormous differences in history, culture, environment, capacity, infrastructure and practices. There are two main components of a local governance system: a) prudence allowed to the local government to perform fundamental functions that allow them to represent the preferences of the citizens in decision making process, b) mechanisms that hold the local government accountable for appropriate use of this carefulness. To address the global environmental threats, locally resolve the natural or man-made crisis are urgent to go ahead.

Awareness on Toxic Agro-chemicals: Agricultural practices are intensifying including – land, labor, hybrid seeds, chemical fertilizers, pesticides, herbicides and extraction of huge ground water for irrigation. Even farmers are involved in commercial cultivation and contract farming with national and international companies. They employ potash, sulphate, calcium carbonate, triple super phosphate in land without the adequate knowledge on chemicals. Agrochemicals – carbendajin, wantap 50, wansilva 10, quinfis 25, denitol, festaq 2.5, melathion, corden, methoxicore, bydrin, dibrone, diajinon 10, lebasid, dimecron. Fenom, theovit, nexin, sevin 10, diplerox, monotuf 40, thiojen, polivit 500, kiridan 5, crijol 5, basudin 10, topsin mithyle, ripcord, dursburn 20 and sebin 60 are highly used in our agriculture (daily observer, 2017). Soil is a compact body of – water, air, mineral and organic matter. But agrochemical affects the composition of soil health and fractures the texture, structure, profile and fertility. Local government with the help of native people and through the ordered laws and policies may promote awareness program on toxic agrochemical, land security, pest and pollination and climate change.

Waste Dumping and Pollution: With the current practices in collection, transportation and crude dumping of solid and liquid wastes – city corporations, paurashava and upazila authority are generally faced with rapid deterioration of environmental and sanitation insecurity. Wastes are produced from various Pulp and paper, pharmaceuticals, Metals, Food, soap, Fertilizers/pesticides industries. Both urban and rural areas, wastes are discharging directly into the rivers and low-lying part around the urban areas. Every day 4000 tons solid waste & 22000 tons tannery waste mixes with water in Buriganga River. In south city corporation – 3500 tons waste are generated where 1900 tons are processed. But 1600 tons are out of processing. Consequently, the piles of organic waste materials generate foul stink across the environment which is known as odor pollution. Diverse national and international organization are playing role to resolve canal or river encroachment crisis, but it's not enough if we don't empower local government and native people.

Mass Media, Local Government and Environment: Mass media through the collective function of local authorities' spreads information among farmers how to use native pesticides, bio-fertilizers, seeds in a proper way and conserve land ecology. Even they promote awareness program to urban dwellers on nature, life, people and ecology nexus.

Water Induced Diseases: Media, the important element of local government can create awareness among mass people about the basic requirements of drinking or potable water, effect of impurities exist in water, water-borne diseases, responsible pathogens cure measures;

Water-borne diseases	pathogens
Viral diarrhoea	Rotavirus
Gastroenteritis	Enteric viruses
Poliomyelitis	Polivirus
Typhoid	Bacillus typhi
Shigellosis	Shigella spp.

(Source: Ahmed & Rahman, 2003)

Excessive Noise Insecurity: Excessive noise is very inimical for human health and Environment. Dhaka city is a multitude area in Bangladesh. We have conducted a survey on different industries, hospitals and bus stations in Dhaka city by taking insight of laborers, traffic polices, drivers, passengers, shopkeepers, doctors etc. Our observation is that average level of noise at industrial area is 88.59 DB, Hospital area is 70.57 DB and Bus station area is 100 DB. Every areas are go beyond the standard level of noise if we consider the standard level of noise at industrial area is 50-60 DB, Hospital area is 45 DB and Bus station area is 70 DB. In this context, lack of engineering controls, using analogue machines and lack of awareness of noise impacts on human health and Environment. Other hand, corporate grabbers are not cooperative to environment and general laborer, which creates auditory, psychological and physiological effects on general people. To control excessive noise insurgencies at both rural and urban area, under the 'noise control act – 2006' local government may arrange a agreement with automobiles groups, owner of different vehicles and specifically train the vehicles driver to resolve the noise pollution which is very harmful for public health and particularly for school going children and pregnant women.

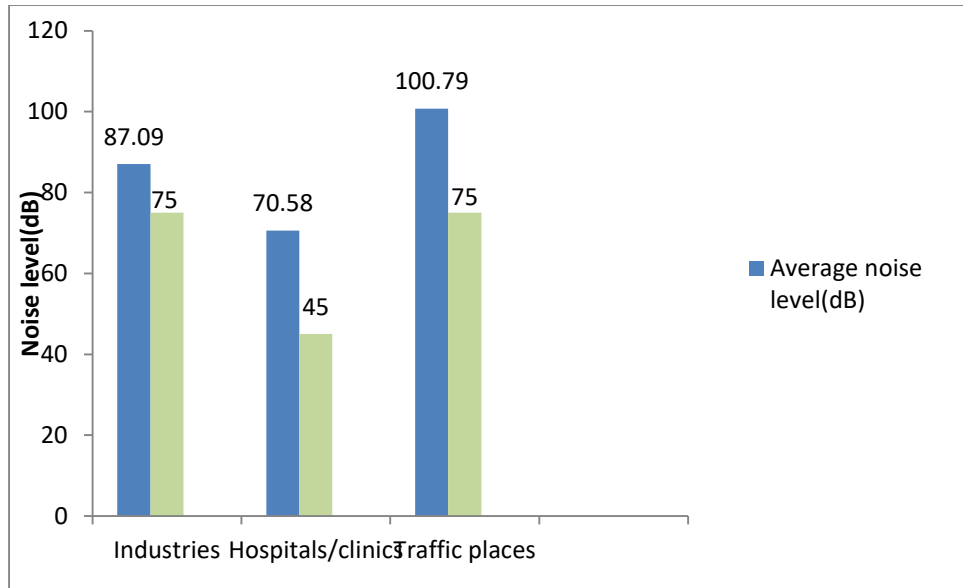


Figure1: Average Noise Level in Dhaka City

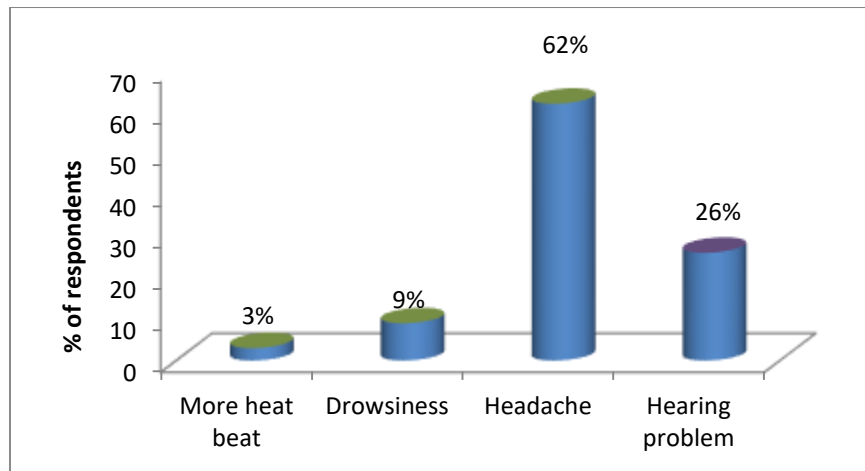


Figure 2: Health State of Workers, Staffs due to Excessive Noise

6. Conclusion

We can apply the pollution control agreements strategy to make the hand strong of local government in terms of environmental planning and management – water, air, land, canal and river security. Also, we can be in charge of excessive noise at urban and semi-urban areas. Consequently, we can initiate a culture to effective control and monitor of environmental pollution and polluters-pay.

It is high time to employ the capacities of local government in industrial pollution control; enhance the capability of native or affected people; start the culture of polluters-pay, build the green products oriented corporate image, effectively monitor the noise, water, land, odor, air pollution. Particularly, society and people oriented policy formation and implementation would ensure the environmental security of Bangladesh.

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Poverty, Human Rights and Capabilities:

Can these together lead to poverty reduction?

Tasmeem Chowdhury Bonhi
East Delta University, Chittagong, Bangladesh

Abstract

There is no debate that the most significant road towards sustainable development is through poverty reduction and tackling all its form. There has been considerable work done to figure out whether poverty is related to human rights. Poverty is no more defined in monetary terms only, it describes a situation of deprivation regarding different necessities of life. This crucial character of multidimensionality visible in both “poverty” and “human rights” concepts brings a scope of where both could be merged for a common cause. Application of rights-based approach can actually prove to be a critical social intervention against poverty that uses a bottom-up strategy with stakeholders. In the traditional poverty reduction strategies, when objectives were not achieved, it was not possible for poor people to actually make somebody accountable for failed approaches. Most significant feature of human rights approach is “Accountability” and this can drastically change the application of poverty reduction approaches. This theoretical work includes discussion on poverty reduction using human rights-based approach, links with capability approach and the potentials of this approach in attaining sustainable development. However suitable, fair and moral this approach seems, its adoption and application comes with a variety of challenges, this paper would also reflect on them. This paper suggests that viewing poverty using lenses of capability approach and human rights together can actually establish the solid foundation for future poverty reduction strategies.

Keywords: Poverty reduction, Human rights, capability approach, sustainable development

INTRODUCTION

When we are deprived of food, or money, or when health of our family is at risk, human rights as a concept is probably the remotest thought in our minds. But it is actually during these situations of deprivation when we realize the meaning and value of principles of human rights. The whole world is together aiming to achieve sustainable development and poverty reduction is one of the most crucial ways to achieve it. There has been considerable work/research done to figure out whether poverty is related to human rights, and if yes, how the concept of human rights can become helpful for poverty reduction. In the international arena, in recent years, use of human rights approach to reduce poverty has been gaining much popularity. This paper intends to begin with a discussion on human rights-based approach; a theoretical discussion on its link with poverty reduction and capability approach, the potentials and strengths of this approach. However suitable, fair and moral this approach seems, its adoption and application comes with a variety of

challenges, this paper would also reflect on some of them.

Rights based approach is strongly connected to the human rights perspectives which addresses issues of social, economic, legal and political rights of all (including poor people). According Lauren (1998), poverty was somehow not a central component of human rights approach, because major attention in the 20th century was given to civil/political rights. The main reason that was argued against inclusion of different form of rights was the fact that they were not enforceable by law. In the late 20th century, rights based approaches have been able to broaden their scope for social crisis like poverty. Rights based approaches are based on a shift from technical understanding of rights to a politically motivated understanding which is premised upon three components: (1) individuals have rights, (2) state is obliged to safeguard those rights, and (3) people need to participate to attain those rights (Eyben, 2005). The inclusion of rights decenters the mainstream debate on poverty where poverty is seen as an outcome of individual pathologies rather than as an outcome of exclusionary social structures. Right-based approach is premised on the belief that it is a counter to top-down policies and programs that have attempted to alleviate poverty without taking into account context of the people living in poverty. Application of rights-based approach would actually prove to be a critical social intervention against poverty that uses a bottom-up strategy with stakeholders (Deka, 2012). Similar to her, Jahan (2002) mentions three important initial observations which are significant to understand how human rights approach is related to poverty reduction:

- “Human rights are not limited to civil and political rights only; they encompass economic, social and political rights.
- Human poverty is a denial of human rights, because it infringes on human freedom, it destroys human dignity and it implies discrimination and injustice.
- The human rights-based approach to poverty reduction is not only an analytical issue, but it has practical and operational implications.”

When we talk about the wide range of human rights and how they are not limited to a certain area, it is easier notice a similar characteristic in concept of poverty as well. Like yester years, poverty is no more defined in terms of ‘income’ only, it describes a situation where a person could deprived of a wide range of necessities of life such as education, housing, health and security. This crucial character of multidimensionality visible in both “poverty” and “human rights” concepts brings a scope of where both could be merged for a common cause. Jahan (2002) identified distinctive analytical ways in which this approach can make a difference to poverty reduction. Firstly, in the traditional poverty reduction strategies, when objectives are not achieved, it was not possible for poor people to actually make somebody accountable for failed approaches. Whereas, in the human rights framework, there are responsible personnel or organization (both public and private) who are answerable to people when they believe their rights has been violated. Accountability is one core feature of human rights approach and this can improve the outcome of poverty reduction approaches by many folds. Secondly, in conventional poverty reduction approaches, what get most importance are the results or outcomes. But when human rights approach is used, as Jahan (2002) says, “*the process is as important as the outcome*”. When achievements of two nations are compared, for example, both achieved 90% rate of literacy, the conventional poverty reduction approach would conclude about both the nations performing equally. In this case, human rights approach would also evaluate the process employed to reach the results, ensuring effectiveness of implementation of strategies. Human rights approach also contributes by adding more

diverse range of indicators for measuring outcome and monitoring the process compared to the conventional set of indicators. It establishes a normative set of indicators for evaluation (Jahan, 2002).

Other researchers such as Mottershaw and Donald (2009) in their work discussed effectiveness of human rights based approach in poverty reduction, and mentions the following four ways:

- (1) “Human rights define poverty as having multiple dimensions,
- (2) Human rights enshrine socially and legally guaranteed entitlements,
- (3) Human rights provide a framework to pursue accountability for poverty,
- (4) Human rights promote dignity and autonomy of people experiencing poverty”.

HUMAN RIGHTS, POVERTY AND CAPABILITIES

Osmani (2005) writes a brilliant article exploring the relationship between human rights and poverty using a bridge called the theory of ‘capability approach’. Osmani believes, capability approach “*plays a foundational role in the characterization of both poverty and human rights.*” If this bridge is clearly explored and analyzed, it will not be tough to accept human rights as an important determinant of poverty status.

For years in the development community, there existed many discussions over poverty as a concept and various approaches of measurement of poverty have emerged with time. Traditionally, income approach was very common, where poverty has been termed as an entirely monetary problem. But from 1990’s, different concepts started coming to focus. Robert Chambers came up with the participatory approach, whose main theme was how people describe the situation they are in and how poverty varies from person to person, which eventually makes it diverse and very much contextual in nature. One more approach was found in Europe, called social exclusion. This approach focused on the fact that lack of income was not the only problem for people, but they were eventually not being able to take engage in regular social behavior and activities. Finally the very influential concept was developed by Amartya Sen, famously known as ‘capability approach’. This approach defines development as an expansion of human capabilities, and defines poverty as a state when a person lacks the fundamental capabilities to function in the society (Sakiko, 2007).

Osmani (2005) in his article makes a “proposition that poverty can be seen as denial of human rights, based on the following syllogism.

- a) Poverty can be seen as the failure to achieve basic capabilities.
- b) Many human rights can be seen as ‘capability rights’, which are rights to certain basic capabilities.
- c) Therefore, poverty can be seen as the failure to fulfill, or the denial of a range of rights.”

Similar to Osmani (2005), Deka (2012) also acknowledges Amartya Sen’s critical work on the connection between rights based approach and poverty, the work which has significantly influenced the development of rights based approach. She discusses the work of Eyben (2005), who indicated the significance of the relationship between poverty, opportunities and freedom. This relationship was emphasized by Sen (1999) who suggested that capability to function in a society is a decisive factor to explain welfare of any individual. She also shares work of Frediani (2010) according whom Amartya Sen’s capabilities approach and rights based complement each other in many ways. It gives a

structure to expand concept of freedom for those who are disadvantaged and also for those (e.g.: state) who can actively ensure their freedom.

ONHCR Report (2004) suggests that most of the current discussion on poverty draw upon capability approach but rarely do they employ the perspective of rights. But if well reflected, it is very easy to realize the existing association between rights and capabilities. Usually human rights talk about how a person should not be deprived of food and education, or live with diseases. In parallel, the capability approach evaluates how well a society is functioning on the basis of the extent human rights are safeguarded in that society. What are common between both the approaches are human rights being the focal point of any discussion. So when poverty is viewed using lenses of capability approach and human rights together will actually establish the solid foundation for future poverty reduction strategies and preserve rights of citizens.

HUMAN RIGHTS AND EMPOWERMENT OF THE POOR

The rights-based approaches have been used and understood in many different ways in the poverty and sustainable development literature; some of the fundamental principles of this perspective include: Transparency, participation, empowerment, equality and non-discrimination. The most important means by which rights-based approach add value to poverty reduction strategies is by the 'Empowerment of Poor'. This empowerment comes from the conception of rights. The most useful element of introducing human rights based approach in policies is that, it changes the conventional assumption of poor people are needy which is the main motivation for poverty reduction policies. Rights based approach gives more power to poor people as citizens and policy makers realize that being pulled out of poverty is not merely a need, rather those people are entitled to live a life free from poverty (OHCHR 2002).

Under the human rights framework, there are many components which are the strong pillars of this approach and have the potential to contribute significantly to the empowerment of poor. Each of the components individually (and together) is capable of improving poverty reduction situations and they are discussed in the following section:

ACCOUNTABILITY

As the name of this component suggests, human rights perspective highlights the importance of accountability of governing body and policy makers, or any stakeholders who could influence people's rights. When we mention rights, we automatically mean responsibilities which then bring the concept of liability. Accountability is an inherent feature of human rights approach and they focus on making sure that accountability has to exist at the core of institutions to execute successful poverty reduction projects (OHCHR 2002).

PARTICIPATION

What this component emphasizes is that whichever stage of poverty reduction strategies are being planned, it is important to encourage an active participation from the targeted poor people (which is their right to participate). In order to allow them to participate, they must be allowed to gather together (right to association), and express their opinions without any fear (freedom of speech) for which they must have the necessary knowledge and information (right to information) provided to them, especially when projects are being undertaken to change their lives. When strategies are developed with full participation from poor population, this brings out a more effective approach where the responsible body automatically takes care of many other rights (along with participation). (OHCHR 2002)

EQUALITY AND NON-DISCRIMINATION

One very vital aspect of human rights approach is how it introduces legal obligation in poverty reduction plans. When it introduces standards and principles of equality and non-discrimination, it makes the focus of poverty reductions policies more authentic and the relevant institution abides by international laws. Discrimination causes poverty, similarly poverty can cause discrimination. A human rights perspective towards poverty reduction makes governments and other stakeholders liable for any levels of injustice and inequality and they abort any unfair policies and practices to follow laws and regulation. (OHCHR 2002)

RECOGNITION OF INTERDEPENDENCE OF RIGHTS

It is very essential to understand the existing interdependence of rights, be it social, political, economic or civil rights. This recognition will have significant impact in reinforcing and widening the scale and capacity of poverty reduction plans. Human rights perspective strongly supports the idea of incorporating and considering every form of rights while developing poverty reduction strategies. (OHCHR, 2002)

LIMITATIONS OF HUMAN RIGHTS-BASED APPROACH

Many scholars have agreed that rights-based approach present several opportunities to understand and address issues of structural injustice, inequality and poverty, but adoption of this approach do not come without challenges. Jewell et al. (2009) state that there are specific challenges in implementing a human rights perspective in anti-poverty interventions. The three challenges they identified were: identity politics, legitimization from other organizations and organizational barriers. They also pointed out that given the historic nature of marginalization and identity formulations, it is hard to find common ground and language to address poverty concerns among many groups. On one hand the identity formulations provide visibility to subordinated groups, on the other hand it is harder for the groups to see how different issues can be connected to multiple identities. Therefore, it is a practical challenge to incorporate the intersection of poverty phenomenon with intersections of identities in a framework.

In their paper, Nyamu- Musembi and Cornwall (2004), discussed about the perspectives of international development agencies in use of rights-based approach for tackling poverty. They talked about the following ways human rights are utilized in rights based approach for poverty reduction and development:

- “As a set of normative principles to guide the way in which development is done,
- As a set of instruments with which to develop assessments, checklists and indicators against which interventions might be judged,
- As a component to be integrated into programming,
- As the underlying justification for interventions aimed at strengthening institutions (whether to develop the advocacy skills of organizations representing marginalized people/or to create or strengthen accountable governance institutions)”

The four points above are individually strong but they also have their set of limitations. For example, when discussing about the ‘broad set of principles defining an overarching development’, this point can mean to many policy makers that this is just another way of covering up older interventions in new boxes. This can imply that adopting this approach would only need you to employ a sincere purpose and goal (and nothing new to add). This

might give policy makers a vague idea about only focusing on good objectives without making important changes to the other segments of the strategy.

When rights based approach narrows itself down to a 'set of instruments', it is often possible for policy makers and implementers to think of it as merely a checklist or an unimportant step and hence provide an insincere effort to maintain it. This might impose another problem, which comes when development practitioners rely more on popular and globally recognized set of human rights, which reduces the scope of policy makers to dig out for more diverse rights which might be significantly important. When it comes to the 3rd dimension stated above, is that it might conceptualize rights as just another component integrated into the strategies, with no fundamental value, whereas under this approach rights are actually an intrinsic feature of poverty reductions strategies. (Nyamu-Musembi and Cornwall, 2004).

The other challenge in incorporating a rights-based approach in anti-poverty interventions is that institutions are generally classist in nature, and because this perspective confronts the basis of this institutional classism, it is possible that institutions may alienate themselves from poverty movements (Jewell et al. 2009). As with any movement or organization fighting against poverty and structural injustice, rights based advocates are likely to face resource constraints particularly given the nature of work. Like many other advocacy and social change strategies, this approach requires a certain kind of political will from various stakeholders for it to be successful. Given the complexity of the nature of this intervention in unearthing power and oppressions, and mobilizing stakeholders, there are considerable challenges in steering the work (Deka, 2012). Deka (2012) finds rights based approach very much relevant for poverty reduction. This is an efficient strategy as it talks about humanity which is universal in nature irrespective of an individual's ethnic background, gender, or country. However, one important fact to remember is that context is essential when the concept of rights arises. A limitation of this approach is the interference of context in the process of ensuring rights. Here, ideas of Ife and Fiske (2006) could be useful who introduced the concept of localization of universal rights.

Similar views were discussed by Hamm (2001), according who, understanding of human rights is the necessary and sufficient contextual prerequisite, which mean that there should hardly exist any question on the association of development and human rights. So to ensure universality of human rights, not only application but necessary circumstances are also required to realize human rights. Ensuring universal conditions for applying concept of human rights in reduction of poverty in developing countries can often be a huge barrier to adoption of such approach to policy making.

CONCLUSION

In recent years, the world is moving towards sustainable development and eradication of poverty. Human rights are undoubtedly a very significant component of poverty reduction. For developing effective poverty reduction strategies it will be a functional way to consider human rights. These rights when supported by international legal framework and related plans are implemented in proper situations, will prove to be the most effective tool for poverty reduction strategies. Many currently existing Poverty Reduction Strategies (PRS) have incorporated elements of human rights. The importance given to public participation relates to the right of people relevant to expression and association. Strategies that mentions transparent government processes can be linked to the right to information, whereas, safety nets are consistent with individual's right to the minimum standard of living (OHCHR, 2004).

It is a very positive growth that many state and organizations are using this approach to design pro poor policies, and also putting effort to overcome the contextual and institutional barriers. The limitations are, however, visible and have the capability to influence the expected success of PRSs. However, I strongly believe, for now (and more in future), the rights-based approach has incredible potential. The benefits in the long term will outweigh the challenges it presents now, by many folds. At the global level, this approach will contribute to the current policy debates on poverty reduction. To implement more successful policies, I believe human rights organization can participate actively in policy dialogues on poverty (both national and international). To tackle such complexly multidimensional concept like poverty, right activists and policy makers need to come together to reduce global poverty levels and ensures citizen had protected rights.

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Sustainable livelihood Challenges and Adaptation Strategy in Haor Region in Bangladesh

Engr. Md Waji Ullah¹. Dr. Dilruba² Ahmed. Amith Dutta³.

Abstract

Haors have their unique hydro-ecological characteristics recognized as the large bowl-shaped floodplain depressions located in the north-eastern region of Bangladesh having 1.99 million ha of area and accommodation of 19.37 million people. The Haors have significant characteristics with wetland habitats including rivers, streams, canals, large areas of seasonally flooded cultivated plains and beels. However, agriculture is the main source of livelihood option for Haor people but the physical setting and hydrology of the haor region are signatory and creating constraints for the inhabitant's livelihood in the haor region. Annual rainfall ranges from 2,200 mm along the western boundary to 5,800 mm in its north east corner and is as high as 12,000 mm in the headwaters of some catchments extending to India. The region receives water from the catchment slopes of the Shillong Plateau across the borders in India to the north and the Tripura Hills in India to the south-east. Flash flood is the main disaster in the haor area which engulfs the primary production sector (e.g. agriculture) and threatens the lives and livelihoods of the people. In this aspect, using both primary and secondary data, this paper identified the major challenges for people's livelihood opportunity during flash flood how people adapt with the changing condition creating alternative livelihood options and strategic measures for sustainability. In this paper, the trend of flash flood and its impact on people's livelihood has been depicted through this study. Besides, the socio-cultural phenomena and people's struggle to adapt with the regular changes has been identified and analyzed taking notion from the narrative of micro ground at the Haor region in Bangladesh.

Keywords: Flash Flood, Haor, Livelihood, Adaptation Strategy, Challenges

1. Introduction

Haor, a wetland ecosystem in the northeastern part of Bangladesh remains covered by water almost half of the year starting from the monsoon season. As lands in Haor remain inundated six to seven months (from June to November), the Haor people are used to living in this condition although it causes numerous sufferings to their lives. It confines them to their small homes, limits their mobility, and practically eliminates the possibility of finding jobs. The Unique hydro-ecological characteristics recognized as the large bowl-shaped floodplain depressions located in the north-eastern region of Bangladesh having 1.99 million ha of area and accommodation of 19.37 million people. The livelihood of the Haor people depends on the Haor ecosystem as agriculture and fisheries are the significant source of income and livelihood opportunities. The first definition of livelihood proposed by the World Commission on Environment and Development (WCED) in 1987 and defined as Livelihood as adequate stocks and flows of food, and cash to meet needs. On the other hand, security refers to secure ownership of, or access to, resources and income-earning activities, including reserves and assets to offset risk, ease shocks and meet contingences. The concept of sustainable livelihood enhances the capability through the

¹ Executive Director, CEGIS

² Director, Socio-economic and Institutional Division, CEGIS

³ Research Associate, Socio-economic and Institutional Division, CEGIS

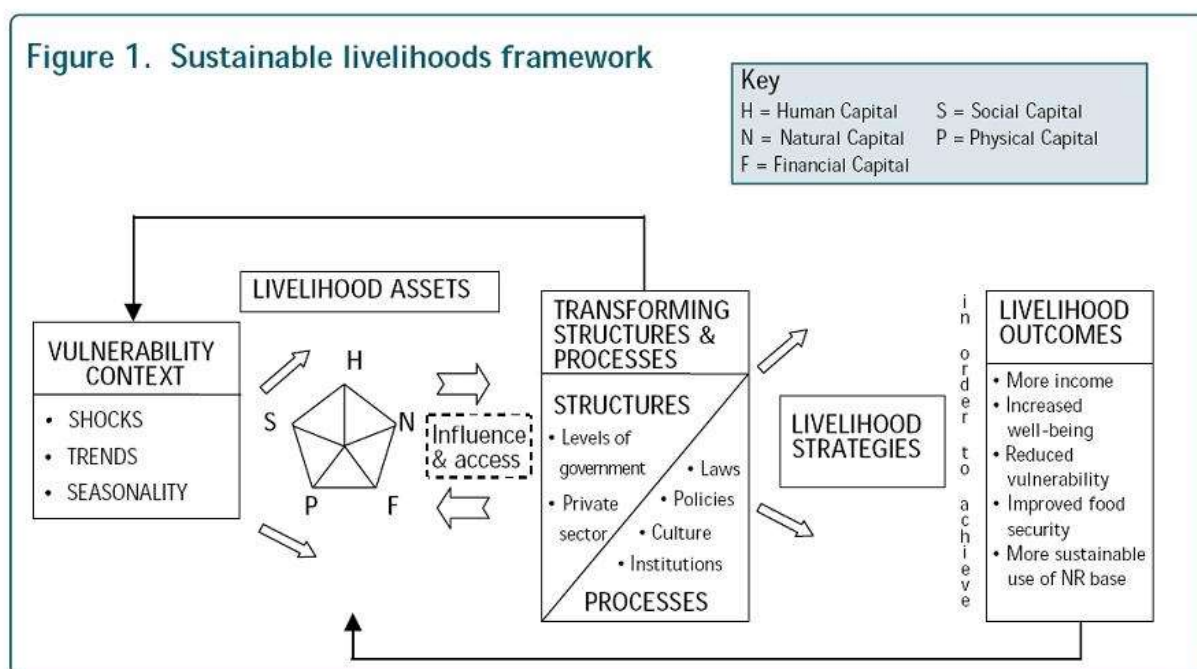
improvement of equity and social sustainability (Solesbury, 2003). It refers to the maintenance or enhancement of resource productivity for a life long time. It comprises the capabilities, assets (stores, resources, claims and access) and activities which is required for the living means and able to cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term” (Chambers and Conway, 1991, p 6). The livelihood options of the Haor people made a concern for the sustainability and became crucial due to the regular flash flood in the Haor region. Regarding this situation, people of this region struggle and choose other alternative livelihood options as their means of livelihood and regulate their lives. This paper tried to explore the livelihood challenges what people face due to flash flood and adaptation strategies are taken by the local people to reduce vulnerabilities making resilience in this context. In this aspect, this study is conducted at the Naidar basin (located at the Chattok upazilla, Sunamganj) and got the findings regarding the study objectives using both primary and secondary data. In addition, this paper identified some suggestions to meet future challenges in this regarding flash flood and enhance sustainable livelihood for the Haor people in Bangladesh.

2. Study Area and Methods of Data Collection

This study area is located at Naidar Haor basin in Sunamganj district under the Dowarabazar and Chattok thana. Primary data has been collected through the intensive fieldwork using social tools and techniques (i.e. KII, FGD, and Consultation with local people). Besides, secondary data was collected through library work and other relevant secondary literary sources in the form of books, journals and articles.

3. The Concept of Sustainable Livelihood: An Unresponsive Image

The sustainable livelihoods idea was first introduced by the Brundtland Commission on Environment and Development to link the socioeconomic and ecological considerations in a cohesive, policy-relevant structure. The concept expanded, especially in the context of Agenda 21, and advocated for the achievement of sustainable livelihoods as a broad goal for poverty eradication in the 1992 United Nations Conference on Environment and Development (UNCED). In this way, the sustainable livelihood could serve as ‘an integrating factor that allows policies to address ‘development, sustainable resource management, and poverty eradication simultaneously. In a classic 1992 paper, Sustainable Rural Livelihoods: Practical concepts for the 21st Century, Robert Chambers and Gordon Conway proposed the following composite definition of a sustainable rural livelihood: A livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living; a livelihood is sustainable which can cope with and recover from stress and shocks, maintain or enhance its capabilities and assets, and provide sustainable livelihood opportunities for the next generation; and which contributes net benefits to other livelihoods at the local and global levels and in the short and long term.



(Source: UK Department for International Development)

Figure1: Sustainable Livelihoods Framework

A livelihood is sustainable when it can cope with and recover from stress and shocks; maintain or enhance its capabilities and assets while not undermining the natural resource base, from the above definitions, five key elements can be extracted: (i) creation of working days, (ii) poverty reduction, (iii) well-being and capabilities, (iv) livelihood adaptation, vulnerability and resilience, and (v) natural base sustainability. The livelihoods in the Haor region fall under pressure due to the regular flash flood, water logging, and lack of drainage facilities regarding the agricultural production. The traditional agriculture production base strategy became vulnerable as people cannot make their livelihood strategy considering the threat and shocks for this Haor region.

Human Capital

The skill of Haor people linked with traditional practice of agriculture and fisheries. In consultation with the local people, it is found that 36% of people are found to be involved in non-paying household work followed by 27% in agricultural work. 4% of people are involved in business while 9% is involved in other different types of activities.

Natural Capital

The natural capital of the Haor area, have a plenty of opportunity to provide support for continuing and sustaining the livelihood strategy. There are three types of natural resources found in Naidar Haor basin. These are land resource, water resource and forest resources (i.e. Hijol, Koroch and Natural Vegetation). The land resource is the main force of agriculture whereas water and forest resource are linked with fisheries in this Haor area.

Social Capital

The Naidar Haor is closed to the Chattok Upazilla which considered as the industrial area and a well known place for business. People from different area come and do business. From this aspect, people of this area is connected with different people and do various kinds of works.

Physical Capital

Physical capital is directly linked with the people livelihood in this Haor area. However, people use modern tractor for agriculture but physical labor is still used for ploughing, harrowing and harvesting. Besides, physical capital is used during duck rearing, cattle raising and providing labor in agricultural and fishing in this Haor area.

Financial Capital

As mentioned earlier, financial capital come from primary and secondary occupation. The main source of financial capital come from mostly agriculture, fisheries and other alternative livelihood options. Besides, people have their small farming and leasing option in which they can earn money and run their livelihood. In addition, some other alternative sources like physical labor, loan from NGOs, bank and remittance considered as another source of income in this Haor area. Based on the field findings, it is found that about 20% of households were found to have earned around Taka 5,000 per month while 30% of households spent the same amount. 40% of households reported that their monthly income was over Taka 5000 to Taka 9000 while 35% of households were found to have spent the same amount. On the other hand, 30% of households reported that their monthly income was more than Taka 9000 and 35% of households spent the same amount.

Due to flash flood, these five capitals became vulnerable and force to choose alternative options instead of traditional livelihood options. The concept of sustainable livelihood is not responsive in this Haor area. The regular trends of natural calamity (i.e. Flash Flood) hinder on the way of its sustainability and triggered as a challenge in this Haor area.

4. Livelihood Strategy: Traditional Options Losing Out

Presently, about 141,401 people are living in this Haor region and Rice is the main crop grown in this study area. All rice crops are vulnerable due to floods in both during pre-monsoon and monsoon period. About 36% of people are found to be involved in non-paying household work followed by 27% in agricultural work. 4% of people are involved in business while 9% is involved in other different types of activities.

With the period of time, the income opportunity based on fishing had been declined and only some people from fishing community got access only to do work as a seasonal labor in this particular area. Due to leasing arrangements which are often controlled by local elites resulting in highly restricted access to open water fisheries by the poor. From the last decades, water logging is one of the major problem broke all records in damaging agricultural production.

Some areas of this Haor land facing this problem as acute level whereas people are forced to accept alternative livelihood options. The options to do work in the agricultural field is declining, as a result, agricultural labors are motivated to do alternative options like stone breaking, auto driving, industrial labor, boat laborer etc. In addition, some people (20%)¹ from Naidar Haor go to Dhaka, Chittagong and Sylhet to do different sorts of work to keep their income and livelihood options. Here it is noted that people who have some sorts of affordability are going abroad to generate income opportunities involving different sorts of works.

5. Flash Flood and Water Logging: Challenge of Resilience for Adaptation

Flash Flood occurs at the Naidar haor during the months of April-May and damages the main crop (i.e. Boro rice) before the harvesting most of the year. In last 4-5 years, the damage due to flash flood increasing in this Haor area. The excessive flash flood water

¹ Field Data, 2017

mainly comes the upstream of the Surma River, enters through Khaliuri Khal and extends to Bishnai Khal and Kawakhali Khal near Dowara bazar sadar headquarters. Over the last five years, the flood situation has steadily deteriorated and in 2010, it became worse creating immense suffering to the people of this area. The submersible embankment of the haor has deteriorated much. Excessive upstream flow frequently enters into the haor area through some vulnerable segments of the submersible embankment and damages Boro crops due to the lack of proper rehabilitation of the embankment. During full monsoon, floods engulf almost 75% of the haor area and only the settlement areas along the periphery remain above flood level. On average, around 40% of the haor becomes vulnerable to flood during pre-monsoon.

Drainage and water logging are also acute problems in Naidar Haor. The low lying southern part of Naidar Haor where beels are located presently faces drainage problems. Water mainly drains out through different internal khals via Khaliuri Khal to the Surma River. Over the years, the bed levels of the rivers and internal khals have become raised due to continuous sedimentation in which the drainage system of the haor has become impeded. Besides, some khals namely Khaliuri Khal, Bishnai Khal, Kawakhali Khal, Laxmibaor Khal, and Doler Khal that mainly control the drainage system of the haor are moderately silted up, and losing their conveyance capacity due to lack of maintenance. There is no drainage structure haor for proper drainage of the haor which ultimately hinders Boro cultivation in the relatively lower areas. On average, 12-15% of the haor faces drainage congestion and water logging.

In addition, this Haor Basin is at particular risk for climate change. It is a tectonic depression, and is being pushed down as the Indian plate collides with the Eurasian plate. The Sylhet sub-basin is estimated to be sinking at 2.1 cm per year because of down-thrusting under the Shillong massif.¹⁰ However, based on analysis of sediment thickness, some say the rate of sinking is much less at 2-4 mm/year.¹¹ In any case, this sinking will mean that annual flooding will become more extensive.

Adaptation to Environmental change is defined in the adaptation literature as an adjustment in ecological social system in response to observed or expected changes in environmental stimuli and their effects and impacts to alleviate adverse impact of change (Nelson, Adger, and Brown, 2007). This adaptation has a strategy with a process in which knowledge, experience, and institutional structure can be combined together and determine the actions. Resilience is contingent on social values regarding what we deem important and how we ought to allocate resources to foster it. Resilience provides a useful framework to analyze the adaptation processes and try to identify the appropriate policy responses what would be from both micro and macro perspectives.

In this Haor area, people have the own mechanism to make their options resilient tackling the risks from the flash flood. But it is happening to some extent which would be though as the situation is going beyond their control mechanism when the flash flood made a situation more vulnerable in the regular basis.

6. The Poverty incidence: A Great Challenge

In Haor area 29.56% of the population lives below the Lower Poverty Level (LPL), which is slightly higher than the national average of 29.26%. Using the upper poverty line, the HCR report 2016 shows that the incidence of poverty is the highest for “agriculture, forestry and fisheries” with a HCR of 32.0% followed by “service workers” with 26.6. The estimates of HCR using the lower poverty line shows that the incidence of poverty is the highest for “agriculture, forestry and fisheries” with 18.2% followed by “head not working” with 14.9% and “service workers with 14.0%. Linking with that condition, people of this study area cannot concentrate to think other options which would be better as their additional livelihood options. As per their assessment, the food security of 30% of

households is not ensured and falls in the deficit category followed by the break-even (40%) and surplus (30%) categories. In this aspect, about 30% people of this Haor area live with poverty and face problem due to the heat of regular flash flood. The status of food security strategies is unsatisfactory problem arises for ensuring food security, education, employment opportunities, and basic amenities in haor areas in comparison with other parts of rural Bangladesh.

7. Indigenous Technique: A Key to Creating a Resilient Community

The connection between indigenous knowledge systems and disaster resilience derives from both theory and practice highlighting potential contributions of indigenous knowledge to building resilient communities (Mavhura, Manyena, Collins, and Manatsa, 2013). The indigenous knowledge is very fruitful to enhance resilience due to flash floods in terms of geophysical locations, exposure to flooding and socio-economic abilities.

The coping mechanism is one of the major components to build the adaptive capacity. Besides, the cultural and ecological adaptations lead to build long-term adaptive strategies. On the other hand, adaptations such as flexibility in seasonal hunting patterns, traditional knowledge that allows the community through different activities, networks and utilize other resources, and intercommunity trade are longer-term, culturally ingrained mechanisms (Berkes, F. and Jolly, D., 2002).

In Bangladesh, with the changing climatic hazards, people are changing their livelihood status, and try to adapt themselves with the changing climate through changing their own behavior and introducing some adaptation strategies (Anik and Khan, 2012).

People of this Haor region are just like but some of the indigenous techniques they have to tackle the situation during the flash flood. One of the common indigenous techniques used in this study which is called as public or loop cutting. As no warning system for flash flood developed in this Haor area but people understand based on experience and planned a way to mitigate the damage due to Flash Flood. When the force became severe, people apply their knowledge and use public cut method for reduce the force and make the water way easy to enter at this Haor area.

8. Alternative Livelihood Options: A Strategy of Coping Mechanism

Alternative livelihood options come to people of this haor region regarding some changes in environmental, political and economic conditions and to do adjustments in resource use systems due to regular flash flood in this region. The strategy created a way to adapt with the changing condition in terms of stress and flooding condition. Presently, they do business, rickshaw pulling, working in the stone field when they do not have the option to working in the agriculture and fisheries. In this study, it is found from the local people's insight that the tendency is growing because of the damage in the last 4 to 5 years. Besides, water logging have come as another problem and confined some area in which people did not get the access to do cultivation for a long time. Therefore, the stress enhances and pressurizes to choose alternative options as their livelihoods. Thus, it is found here that about 40% people are going to take it as challenge choosing alternative source like laboring, duck rearing, cow raising, business and going for work in dhaka, sylhet and chittagong cities. In this way, this choosing option (i.e alternative options) strengthening their coping mechanism and sometimes working as the recovery in terms of stress, shocks and seasonality changes in this haor area.

9. Participation in Practice: A Strategy for Mainstreaming, Efficiency and Sustainability

There has been an increasing tendency to ‘mainstream’ the disaster risk into development since late 1990s, and trying to address risks emanating from natural hazards in medium-term strategic frameworks and institutional structures for those countries recognized as the hazard-prone countries. For Mainstreaming, it requires analyzing both the potential hazard events which could affect the performance of policies, programmes and projects, and in turn the impact of those policies, programmes and projects on vulnerability to natural hazards. The participation in decision-making is complex undertakes the different purposes and reflected in different levels of involvement, different contexts and different activities.

The prediction for ‘Win-win’ solutions to secure the sustainable development, reducing poverty and strengthening hazard resilience, therefore, need to be explicitly and actively sought, particularly as climate change looks set to increase the incidence of floods¹.

The requirement to understand the people’s perspective come into being and claim to get the strategy as people centered would be reflected in mainstreaming and building resilience regarding the hazard prone events(l.e.Flash flood). Prioritizing the events taking account from the people’s response, the interest is growing through public seminar, written documents and news and print media. From their experience, people share voice and open up a channel to make a way forwarding the influence in which the program and policy can get the insight for mitigation and adaptation and develop a way for the efficiency and sustainability of the program or policy in this Haor area during the natural calamities. In identifying and addressing livelihood priorities the centered response would be very effective and enable policy makers to listen and respond to the affected people. In this way, micro-level activity through the development of policy can create an environment support people to build upon their own strengths.

10. Migration: A Strategy to Adapt with the Changing Condition

The diversity of rural livelihoods in low income developing countries is receiving and increased attention in discussions about rural poverty reduction (Ellis, F. 2000)

Due to the seasonality, risk, labour markets, credit markets, assets and coping strategies people tend to find alternative livelihood options and made a particular arrangement in which they can sustain with the changing condition. In this option, the seasonal migration occurred and people find different strategy to get new income opportunities and possible solution for their lives and livelihood.

In this aspect, considering better employment opportunity for the day laborer, seasonal out- and in-migration is observed in the Naidar Haor area. Out-migration from the study area is medium (20%) from mid-June to mid-October. These out-migrated people are generally engaged in farming activities. Seasonal out-migrants often go to Chittagong and Sylhet for better employment. On the other hand, a significant proportion (60%) of people comes for agricultural work from mid-April to mid-May in the Naidar Haor area from different districts like Rajshahi, Rangpur, Sirajganj and Faridpur. As a result, nearly 60% of people come for agricultural work from mid-April to mid-May. No permanent in- or out-migration is found in Naidar Haor area.

¹ The 2006 Stern Review similarly argues in relation to climate change that adaptation, including efforts to enhance hazard resilience, should be mainstreamed into development and specifically states that “the key to successful DRR [disaster risk reduction] is ensuring it is integrated into development and humanitarian policy and planning” (HM Treasury and Cabinet Office (2006) p. 566).

11. Conclusion

Agriculture and fishery are considered as the two major livelihoods options for the people in this Naidar haor region whereas agriculture is recognized as the prime source of livelihood option. However, the cropped area increased with the period of time led to provide more employment opportunities and agricultural production but repeated inundation (due to flash flood) of the major Boro crop every year, and shrinking of fishing opportunity for fishermen impacted negatively in the households of the Haor regions. The losses of crops and fishing opportunities have created push factor for those who had been dependent on these two livelihood options (agriculture and fishery) and led them to search alternative livelihood option in and beyond the community.

In addition, agricultural production increased due to change in the crop variety and cropping intensity at the post project period. Presently, agricultural production and agricultural wage labor base income has been increased but income opportunity based on fishing has been declined and some people from fishing community got access only to do work as a seasonal labor in this particular area. Secured income opportunities from agriculture possess the local people to construct better household for their living. On the other hand, direct impact on literacy and health is marginal but the indirect benefit to education and health services is increased the affordability of small and medium farm households to avail those services. Moreover, the more production opportunity created the value of agricultural land and uphold the the communication system as comfortable at least in the dry season due to some development activities in this haor region. Furthermore, the lack of participatory governance system in this Haor area created problems and made people concern regarding the damaged roads, embankments and overall socio economic condition in the Haor regions. The livelihood challenge due to regular flash flood enhance people's vulnerability in which people have some strategy to meet the challenge and adapt with the changing condition. The indigenous technique, alternative livelihood options, seasonal migration created way for enhancing people's resilience and strengthening vulnerabilities of the haor people.

Way to forward

As the study findings, this paper also found some measures which are suggested from the context and local people's concern. The measures and suggestions are presented in the following ways:

- ✓ A functional monitoring team should be formed to play proactive role considering the all stakeholders concern for O&M in the haor region
- ✓ Local People's feedback should be taken before the implementation of any policy, plan and program in the haor
- ✓ Soft loan would be provided to enhance resilience for the development of entrepreneurship.
- ✓ Technical training for both male and female would be initiated in which people can be adaptive during the flash at this haor region.

Thus, the risks of livelihood would be mitigated in which people can enhance resilience and take initiatives for the income generation through entrepreneurship development and alternative livelihood options. The livelihood security would be ensured and made a way for its sustainability due to climatic hazards like heavy flash flood, seasonality change and unusual rain.

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The Impacts of Corruption on the Efficacy of Public Expenditure on Health: Evidence from Bangladesh

Muntasir Murshed¹ and Syed Yusuf Saadat²

¹ North South University, Dhaka, Bangladesh

² North South University, Dhaka, Bangladesh

Abstract

The importance of health expenditure has gone on to becoming a crucial sector of public investment irrespective of the economic status of a nation. The prime importance of sustainable healthcare has also been acknowledged in the United Nations' 2030 Sustainable Development Agenda in which SDG 3 particularly stresses on ensuring global healthy lives and promoting well-being for all at all ages. However, good governance is a key prerequisite when it comes to the overall attainment of the Sustainable Development Goals. Lack of good governance is a concern for the Least Developed Countries (LDCs) in particular to which Bangladesh, being the largest LDC in the world, is no exception. More precisely, corruption is believed to be the main attribute to the poor governance scenario in Bangladesh. Thus, the aim of this paper is to empirically investigate the impacts of corruption on the efficacy of government expenditure on health in order to understand the key importance of ensuring good governance in the economy. Against this backdrop, this paper incorporates annual time series data stemming across 1993 to 2016 in context of the Bangladesh economy and considers a set of linear regression models in which some of the crucial health indicators, as mentioned under the SDG 3, are expressed as separate functions of corruption, public health sector allocation and other control variables. As part of the methodology, this paper resorts to the use of Dynamic Ordinary Least Squares (DOLS) and Fully Modified Ordinary Least Squares (FMOLS) regression techniques to probe into the nexus engulfing the state of governance and health outcomes in Bangladesh. In addition, Granger causality test and Vector Error Correction Model (VECM) approach are also tapped to conclude on the causal association as well. In light of the estimated results, it can be concluded that most of the findings corroborate to the a priori hypotheses which were built in light of the conventional economic literature. Moreover, it is also found that corruption shrinks the efficacy of public health expenditure with respect to achieving the desired health outcomes. These imply that good governance attributes to effective and efficient public service deliveries, especially in relevance to the health sector. Thus, promoting good governance within the economy can eventually lead to attainment of health sustainability and can also contribute to the achievement of the other SDGs as well.

Keywords: **corruption, health, public expenditure, Bangladesh, SDG**

1. Introduction

Corruption is prevalent in all sectors of the economy in Bangladesh. Healthcare is by no means an exception. From mis-invoicing the price of medical equipment to pretending to be doctors, corrupt individuals have adopted many methods to use public resources for their private gain. This pervasive nature of corruption tends to reduce the effectiveness of government spending in healthcare. As a result, in Bangladesh the quality of healthcare is appalling and the quantity of healthcare is inadequate.

Although healthcare is a perennial development issue, it has recently been brought to the limelight through the United Nations Sustainable Development Goals (SDGs) (United Nations, 2015). SDG 3

emphasizes the importance of healthcare by stating that ensuring healthy lives and promoting well-being at all ages is a key objective for all developing countries. On the other hand, SDG target 16.5 calls upon nations to reduce corruption and bribery in all its forms. Our study advocates that the aforementioned goals and targets can be best achieved in tandem. The novelty of our paper is that it acknowledges that health outcomes are influenced by both socio-political and economic variables. Therefore, we have designed our study so that it reflects the effect of both economic issues and governance issues on healthcare. Our main research question is “Does corruption reduce the effectiveness of public healthcare expenditure in Bangladesh?”

The remainder of this paper is structured as follows: section 2 briefly sheds light on some of the relevant literature on the topic, section 3 describes the variables used in the study, section 4 explains the research methodology, section 5 discusses the findings, and section 6 ends with a conclusion.

2. Literature Review

We can analyze the impact of corruption on public health expenditure using a simple model (Shleifer and Vishny, 1993). In the absence of corruption, the government provides healthcare services at a price equal to P^* , as shown in Figure 1. However, if public healthcare services are dispensed through a government official, then the official in charge is susceptible to corruption. Under such circumstances, the government official may behave like a monopolist and restrict access to healthcare services. Thus quantity of healthcare services offered to the public with corruption, Q , is lower than the quantity of healthcare services provided without corruption, Q^* . Moreover, instead of charging the government mandated price, P^* , the government official charges a bribe, B . Thus the government official succeeds in completely sidelining the government and becomes the de facto provider of healthcare services. Since the government is deprived of the revenue from the sales of healthcare services, its ability to fund healthcare expenditure in the future is seriously hampered. Furthermore, the effectiveness of government expenditure in healthcare is reduced since fewer people benefit from healthcare services in the presence of corruption.

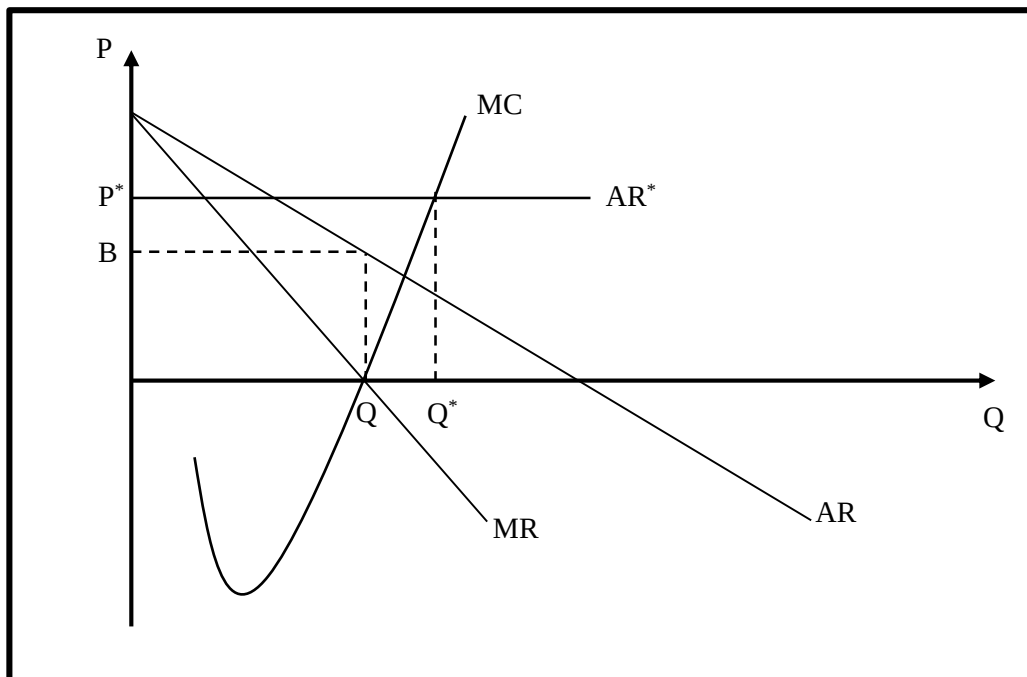


Fig. 1: Effect of corruption on the market for healthcare

Research has shown that corruption can reduce the returns to investment in healthcare (Lewis,

2006). The incidence of high infant mortality rate and low birth-weight of babies can both be decreased by curbing corruption in public healthcare services (Gupta, Dovoodi, et.al., 2006). This implies that corruption stands in the way of achieving the better health outcomes. In Bangladesh, studies have revealed that patients are incentivized to pay bribes through the promise of better quality healthcare in public hospitals (Abdallah, Chowdhury, et.al, 2015). However, to the best of our knowledge, there has been no study in Bangladesh which looks into the relationship between corruption and government healthcare expenditure. The aim of our research is to fill in this gap in the literature by investigating this issue, and providing hard evidence for our hypothesis that corruption reduces the efficacy of government healthcare expenditure.

3. Model Specification and Data

The regression model used in this study expresses the six health indicators as separate functions of public health expenditure and other control variables including corruption. The regression model is given by:

$$AFR = f(PHE, PHE*COC, GDPPC, INF) \text{ ----- (i)}$$

$$MMR = f(PHE, PHE*COC, GDPPC, INF) \text{ ----- (ii)}$$

$$NNMR = f(PHE, PHE*COC, GDPPC, INF) \text{ -----(iii)}$$

$$IMR = f(PHE, PHE*COC, GDPPC, INF) \text{ ----- (iv)}$$

$$UFMR = f(PHE, PHE*COC, GDPPC, INF) \text{ ----- (v)}$$

$$LEXP = f(PHE, PHE*COC, GDPPC, INF) \text{ ----- (vi)}$$

where AFR refers to adolescent fertility rate, MMR refers to maternal mortality ratio, NNMR is the neonatal mortality rate, IMR is the infant mortality rate, UFMR is the under five mortality rate and LEXP is the life expectancy at birth. These are the six health indicators considered in this paper. The explanatory variables are PHE, PHE*COC, GDPPC and INF which refer to public health expenditure, interaction term between public health expenditure and control of corruption, gross domestic product per capita and inflation respectively. The control for corruption variable is considered in our model to proxy for corruption while GDPPC and INF are used as proxies for economic growth and economic stability respectively. Relevant data in the context of all the aforementioned variables are annual time series data stemming from 1995 to 2016. Table 1 presents a brief description of all the variables in our model and also reports the corresponding data sources.

Variable	Definition	Source
Adolescent fertility rate	Number of births per 1,000 women ages 15-19.	World Development Indicators
Maternal mortality ratio	Maternal mortality ratio is the number of women who die from pregnancy-related causes while pregnant or within 42 days of pregnancy termination per 100,000 live births. The data are estimated with a regression model using information on the proportion of maternal deaths among non-AIDS deaths in women ages 15-49, fertility, birth attendants, and GDP.	
Neonatal mortality rate	Neonatal mortality rate is the number of neonates dying before reaching 28 days of age, per 1,000 live births in a given year.	
Infant mortality rate	Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.	

Under five mortality rate	Under-five mortality rate is the probability per 1,000 that a new-born baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.	
Life expectancy	Life expectancy at birth indicates the number of years a new-born infant would live if prevailing patterns of mortality at the time of its birth were to stay the same throughout its life.	
Public health expenditure as percentage of GDP	Public health expenditure consists of recurrent and capital spending from government (central and local) budgets, external borrowings and grants (including donations from international agencies and nongovernmental organizations), and social (or compulsory) health insurance funds.	
Control of corruption	Estimate of corruption (ranges from approximately -2.5 (high corruption) to 2.5 (strong) governance performance) (Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.)	Worldwide Governance Indicators
Inflation	Percentage annual change in consumer prices	World Development Indicators
GDP per capita	Gross Domestic Product per capita at constant 2010 US dollars	

Table 1: Variables

4. Methodology

At first, we resorted to using the Augmented Dickey-Fuller (ADF) unit root test to detect possible unit roots in our data set. It is important to check for unit roots since existence of unit roots in the data would lead to our regression being spurious. Following the completion of the ADF unit root test, we perform the Johansen cointegration test to identify possible long run cointegrating equations in our model. It is crucial to check for cointegration since it is a pre-requisite to analyzing causal associations between the variables considered in this paper. The Granger causality test is then employed to investigate the long run causal associations, particularly between the health indicators and the explanatory variables. Finally, we estimate our econometric model using the technique of Dynamic Ordinary Least Squares (DOLS) (Stock and Watson, 1993).

The DOLS estimator was chosen since it is consistent and asymptotically efficient even if the independent and dependent variables are cointegrated. The generic specification of the DOLS model is as follows:

$$Y_t = \beta_0 + \theta X_t + \sum_{j=-p}^p \delta_j \Delta X_{t-j} + u_t$$

Where,

ΔX_{t-p} = value of independent variable X, lagged P units in the past

X_t = value of the independent variable X at time t

ΔX_{t+p} = value of independent variable X, lagged P units in the future

If the dependent and independent variables are cointegrated then they have a shared stochastic trend. Under such circumstances, the DOLS estimator is especially useful since it is consistent

even if the independent variables are endogenous. However, since cointegration tests can often be misleading, it is imperative that models are firmly grounded on economic theory and sound logical reasoning.

4. Results

The ADF test results in the context of our regression model are reported in Table 2. From the table it can be seen that all our variables are found to be stationary at their first differences which implies that the possibility of any unit root problem in our data set is nullified. Thus, our results are supportive in asserting that our regression is not a spurious one.

Variable	t-Statistic	Probability
AFR	-1.7749	0.0725
MMR		
NNMR	-3.5836	0.0011
IMR	-5.7820	0.0000
UFMR	-6.7189	0.0000
LEXP	-5.4403	0.0772
PHE	-3.5936	0.0611
PHE*COC	-5.2554	0.0022
GDPPC	-4.8635	0.0944
INF	-5.6584	0.0012

Note: Considering trend and intercept; the optimal lag selection is based on the Schwarz Information Criterion (SIC).

Table 2: Results of Augmented Dickey-Fuller Test at 1st Difference (Lag=8)

Results from the Johanssen cointegration test are reported in Table 3. The results from both the trace test and the maximum Eigen value test reveal that there are cointegrating equations in our model which imply that our variables are cointegrated in the long run. Thus, the supportive results from the ADF and the Johansen cointegration tests allowed us to proceed to performing the Granger causality test.

No. of CEs	At most 0	At most 1	At most 2	At most 3	At most 4	At most 5
Dep. Variable	Unrestricted Cointegration Rank Test (Trace)					
AFR	198.133* (95.753)	118.735* (69.818)	64.330* (47.856)	34.436* (29.7970)	10.274* (15.494)	1.074* (3.841)
MMR	201.185* (95.753)	129.481* (69.818)	73.894* (47.856)	41.974* (29.797)	20.666* (15.494)	3.519 (3.841)
IMR	216.339* (95.753)	138.141* (69.818)	82.610* (47.856)	42.858* (29.797)	19.058* (15.494)	3.239 (3.841)
NNMR	249.551* (95.753)	159.892* (69.818)	93.514* (47.856)	40.278* (29.797)	15.733* (15.494)	2.590 (3.841)
UFMR	207.508* (95.753)	144.031* (69.818)	90.711* (47.856)	43.898* (29.797)	19.078* (15.494)	5.294* (3.841)
LEXP	240.019* (95.753)	167.998* (69.818)	103.667* (47.856)	54.684* (29.797)	31.735* (15.494)	11.816* (3.841)
Dep. Variable	Unrestricted Cointegration Rank Test (Maximum Eigenvalue)					
AFR	79.397* (40.077)	54.404* (33.876)	29.894* (27.584)	24.161* (21.131)	9.200 (14.264)	1.074 (3.841)
MMR	71.704* (40.077)	55.587* (33.876)	31.920* (27.584)	21.308* (21.131)	17.146* (14.264)	3.519 (3.841)
IMR	78.197* (40.077)	55.531* (33.876)	39.751* (27.584)	23.799* (21.131)	15.819* (14.264)	3.239 (3.841)
NNMR	89.658* (40.077)	66.377* (33.876)	53.236* (27.584)	24.545* (21.131)	13.142 (14.264)	2.590 (3.841)
UFMR	63.476* (40.077)	53.320* (33.876)	46.812* (27.584)	24.819* (21.131)	13.784 (14.264)	5.294* (3.841)
LEXP	72.021* (40.077)	64.330* (33.876)	48.982* (27.584)	22.949* (21.131)	19.918* (14.264)	11.816* (3.841)

Note: * denotes rejection of the hypothesis at the 5* significance level

Table 3: The Johansen Cointegration Test Results

The long run causal associations between our health indicators and the explanatory variables in our regression model are analysed using the Granger causality test. The corresponding results are provided in Tables 4a, 4b, 4c, 4d, 4e and 4f. From table 4a, it can be seen that as far as the AFR is concerned, there is a unidirectional long run causal association running from GDPPC to AFR without the feedback. This implies that per capita economic growth influences changes in the AFR in Bangladesh. In addition, a unidirectional causal chain from AFR to INF was also found in light of the results found. However, PHE and other control variables were found to be statistically insignificant in causally influencing the AFR from neither directions.

Null Hypothesis	F-Stat.	Prob.	Decision on Causality
PHE does not Granger Cause AFR	2.4226	0.1225	No Causal Association
AFR does not Granger Cause PHE	0.7419	0.4929	
PHE*COC does not Granger Cause AFR	2.6387	0.1043	No Causal Association
AFR does not Granger Cause PHE*COC	1.4466	0.2664	
GDPPC does not Granger Cause AFR	4.2305	0.0349	Unidirectional Causality from GDPPC to AFR
AFR does not Granger Cause GDPPC	0.3258	0.7269	
INF does not Granger Cause AFR	0.2988	0.7460	Unidirectional Causality from AFR to INF
AFR does not Granger Cause INF	4.0487	0.0393	

Table 4a: Results of Granger Causality Tests for equation (i)

Table 4b reports the Granger causality test results in context of equation (ii). According to the results found, we find that there is a unidirectional long run causal association running from GDPPC to MMR. This, much in the case of AFR, implies that as the economic growth per capita in Bangladesh changes it stimulates a change in the MMR as well. In contrast, no other causal association between MMR and the other regressors could be established in accordance to the results found.

Null Hypothesis	F-Stat.	Prob.	Decision on Causality
PHE does not Granger Cause MMR	1.69078	0.2177	No Causal Association
MMRdoes not Granger Cause PHE	0.85412	0.4454	
PHE*COC does not Granger Cause AFR	0.51200	0.6094	No Causal Association
MMRdoes not Granger Cause PHE*COC	1.39198	0.2789	
GDPPC does not Granger Cause MMR	2.82695	0.0908	Unidirectional Causality from GDPPC to MMR
MMRdoes not Granger Cause GDPPC	0.51294	0.6089	
INF does not Granger Cause MMR	0.70621	0.5092	No Causal Association
MMRdoes not Granger Cause INF	1.07057	0.3676	

Table 4b: Results of Granger Causality Tests for equation (ii)

The Granger causality test results in context of equation (iii), as reported in Table 4c, reveal that in the long run all of the explanatory variables do no impose any causal association between them and IMR.

Null Hypothesis	F-Stat.	Prob.	Decision on Causality
PHE does not Granger Cause IMR	0.33401	0.7212	No Causal Association
IMR does not Granger Cause PHE	0.82597	0.4568	
PHE*COC does not Granger Cause IMR	0.13125	0.8780	No Causal Association
IMR does not Granger Cause PHE*COC	2.05476	0.1627	
GDPPC does not Granger Cause IMR	0.41556	0.6673	No Causal Association
IMRdoes not Granger Cause GDPPC	1.15066	0.3428	
INF does not Granger Cause IMR	1.00459	0.3895	No Causal Association
IMRdoes not Granger Cause INF	0.36430	0.7007	

Table 4c: Results of Granger Causality Tests for equation (iii)

The results of derived from the Granger causality test in context of equation (iv) are provided in Table 4d. A close analysis of the table reveal that both PHE and PHE*COC are found to be statistically significant in influencing changes in the NNMR in the long run. This is evident from the fact that two unidirectional causalities are found to be running towards NNMR from PHE and PHE*COC respectively.

Null Hypothesis	F-Stat.	Prob.	Decision on Causality
PHE does not Granger Cause NNMR	4.19381	0.0358	Unidirectional Causality from PHE to NNMR
NNMR does not Granger Cause PHE	0.84267	0.4500	
PHE*COC does not Granger Cause NNMR	3.13138	0.0730	Unidirectional Causality from PHE*COC to NNMR
NNMR does not Granger Cause PHE*COC	2.12874	0.1535	
GDPPC does not Granger Cause NNMR	1.16778	0.3378	No Causal Association
NNMRdoes not Granger Cause GDPPC	0.66893	0.5269	
INF does not Granger Cause NNMR	0.86192	0.4422	No Causal Association
NNMRdoes not Granger Cause INF	1.02651	0.3821	

Table 4d: Results of Granger Causality Tests for equation (iv)

Table 4e reports the Granger causality test in context of equation (v). According to the results obtained it can be seen that the causal relationships between UFMR and PHE and PHE*COC are similar to the ones found in context of NNMR and these two explanatory variables. Thus, it implies that government's health expenditure alone, and coupled with the state of corruption in the economy, are effective in influencing changes in the UFMR in Bangladesh.

Null Hypothesis	F-Stat.	Prob.	Decision on Causality
PHE does not Granger Cause UFMR	3.16809	0.0712	Unidirectional Causality from PHE to UFMR
UFMR does not Granger Cause PHE	0.64006	0.5411	
PHE*COC does not Granger Cause UFMR	2.81608	0.0915	Unidirectional Causality from PHE*COC to UFMR
UFMR does not Granger Cause PHE*COC	1.02995	0.3809	
GDPPC does not Granger Cause UFMR	1.60392	0.2337	No Causal Association
UFMRdoes not Granger Cause GDPPC	0.47824	0.6290	
INF does not Granger Cause UFMR	1.14525	0.3445	No Causal Association
UFMRdoes not Granger Cause INF	0.34890	0.7110	

Table 4e: Results of Granger Causality Tests for equation (v)

Finally, Table 4f reports the Granger causality test in context of equation (vi). According to the results found, we see a unidirectional causality running from LEXP to PHE*COC without the feedback, However, a more meaningful result is found in the manner that another unidirectional causal association was found to be running from GDPPC to LEXP which implies that economic growth influences the LEXP in Bangladesh in the long run.

Null Hypothesis	F-Stat.	Prob.	Decision on Causality
PHE does not Granger Cause LEXP	2.37431	0.1271	No Causal Association
LEXP does not Granger Cause PHE	1.59205	0.2360	
PHE*COC does not Granger Cause LEXP	2.05301	0.1629	Unidirectional Causality from LEXP to PHE*COC
LEXP does not Granger Cause PHE*COC	4.10484	0.0379	
GDPPC does not Granger Cause LEXP	6.72686	0.0082	Unidirectional Causality from GDPPC to LEXP
LEXPdoes not Granger Cause GDPPC	0.92042	0.4197	
INF does not Granger Cause LEXP	0.56340	0.5809	No Causal Association
LEXPdoes not Granger Cause INF	0.33128	0.7231	

Table 4f: Results of Granger Causality Tests for equation (vi)

Although, it is important to understand the causal relationships between the targeted variables, the health indicators, and the explanatory variables it is insufficient in explaining the mode in which one variable affects the other. Thus, it is ideal to employ regression analyses as well. The

regression results from the DOLS and the FMOLS estimations of our regression model are presented in Table 5. The estimated coefficients across the DOLS and the FMOLS estimations are more or less similar in terms of the sign but the DOLS estimation resulted in more statistically significant results with relevance to the a priori expected results.

The DOLS estimations reveal that in the cases of all the six health indicators, the efficacy of public spending in the health sector gets reduced due to the incidence of corruption in the economy. This is evident from the fact that the estimated coefficients attached to PHE are greater than the estimated coefficients attached to PHE*COC which implies that as corruption increases in the economy, the health indicators, somewhat, tend to be undermined whereby the improvement in the health indicators fall below par. For instance, our regression results reveal that PHE is negatively associated with AFR, MMR, IMR, NNMR and UFMR and are also statistically significant while a statistically significant positive relationship between PHE and LEXP is also visible in light of the results. However, the value of the coefficients attached to PHE*COC, despite depicting the same sign, is relatively less as compared to that of the estimated coefficients attached to PHE. This implies that corruption, a conventional yardstick to measure the state of governance within an economy, tends to hold back healthcare development in Bangladesh to some extent by prolonging the overall rate of development of the country's health sector.

Independent Variables	Dependent Variables					
	AFR	MMR	IMR	NNMR	UFMR	LEXP
PHE	-156.145** (35.566)	-779.720** (141.624)	-139.984** (25.725)	-83.057** (11.768)	-229.809** (43.457)	25.807** (4.648)
PHE*COC	-102.144* (34.671)	-523.582* (138.061)	-95.543* (25.078)	-58.903** (11.472)	-157.628* (42.364)	17.469* (4.531)
GDPPC	-0.179*** (0.017)	-1.040*** (0.070)	-0.184*** (0.012)	0.005*** (0.005)	-0.287*** (0.021)	0.036*** (0.002)
C	406.751** (41.813)	1917.899*** (166.500)	340.315*** (30.244)	200.976*** (13.835)	532.981*** (51.091)	12.432 (5.465)
R squared	0.669993	0.812299	0.757099	0.869099	0.695399	0.803999
Adjusted R squared	0.429299	0.791999	0.730999	0.854999	0.661999	0.782999

Table 5: Results of Dynamic Ordinary Least Squares (DOLS) Estimation

5. Conclusion

In compliance with the global and local commitments to leaving no one behind in ensuring quality health and well being, there are no two ways other than improving the key health indicators in any economy. Health sustainability has also been enlisted as one of the utmost important means of achieving socioeconomic development, with the ultimate aim of attaining the 2030 Sustainable Development Agenda of the United Nations. The gravity of this notion is even higher from the perspectives of a LMIC like Bangladesh since failure to develop the nation's health sector could eventually result in Bangladesh being caught in the MIT and could also prolong its graduation from the Least Developed Countries (LDCs) group as well. However, in the process of executing appropriate strategies aimed at the betterment of health, the issue of good governance in the form of reduced level of corruption should also be given simultaneous priority. This is because in the presence corruption in the economy, healthcare service deliveries often get hindered, attributing to

a marginalizing effect on the efficacy of public health expenditures in accomplishing the desired national health target. In order to resolve the problem of corruption in the healthcare sector, a holistic approach is required that involves general anti-corruption policies coupled with specific healthcare sector measures. Moreover a social paradigm shift is necessary so that rejection of corruption becomes the norm.

In line with the results derived from our investigation in this paper, we can conclude that corruption in the economy leads to a reduction in the efficacy of PHE, whereby the level of health improvement in Bangladesh remains below the potential level that could have been resulted in the absence of corruption in the economy. This imply that lack of good governance, especially in the form of high corruption levels, indeed is a threat to the overall health sustainability in Bangladesh which strongly urges for the adoption of effective anti-corruption measures across the nation. It is ideal for the government to simultaneously pursue corruption minimization and health development policies following the deep interlinkage between these two core macroeconomic variables.

Data constraint was the main limitation of our paper which restricted us from incorporating other aggregated indicators of governance apart from corruption which might have resulted in further information regarding the factors that curb the efficacy of public health expenditure in Bangladesh. As part of the future scope of research is concerned, cross-sectional and panel analyses can be performed in order to understand the region-specific differences in the governance-health development nexus for further robustness check of our findings.

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The role of tidal river management for sustainable agriculture

Md. Mahedi Al Masud^{*1,2} Abul Kalam Azad²

^{*1}*Department of Social Services under the Ministry of Social Welfare, Dhaka 1207, Bangladesh*

²*Environmental Science Discipline, Khulna University, Khulna 9208, Bangladesh*

Abstract

Bangladesh is advancing with continuous economic growth by alleviating poverty and providing peace and prosperity to people. Anthropogenic events as well as climate change induced floods and water-logging undermine the Southwest region of Bangladesh to meet sustainable development goals (SDGs). It is essential to make right choices for tidal river management (TRM) to mitigate climate change effects and permanent solution of water-logging towards a sustainable agriculture to improve life for future generations. Firstly, the study identifies research gaps in the context of TRM and sustainable agriculture, secondly, fixes the objectives then finally, fills out these gaps through exhibiting the contribution of TRM in food security and households' income and accounting the benefits of TRM in agriculture.

Keywords: TRM, Climate change, Water-logging, Food security, Sustainable agriculture.

1. Introduction

Bangladesh is the riverine country, has been belonged the second largest river system in the world confluence of the Ganges (Padma), Brahmaputra (Jamuna), and Meghna Rivers (originate from the world largest mountain Himalaya) and their tributaries flow through the country passing Nepal, China and India and fall to the Sea Bay of Bengal, and evolve the Bengal Delta (Hellin, Albu & Rob 2004). This is either blessing for carrying huge nutrient born sediment that makes the agricultural land fertile for good crops or curse as the monsoonal floods to the floodplains of the delta causing a disruption of agricultural production, contamination of drinking water, and the displacement of thousands of people (Adri 2009). There had been devastating floods taken place in Bengal Delta in 1954, 1955 and 1956, hampered agriculture and livelihoods of coastal people seriously. The East Pakistan (former name of Bangladesh) Government had been felt the necessity particularly to establish an agency named The East Pakistan Water and Power Development Authority (EPWAPDA) in 1959 for managing rivers to control floods and increase agricultural production with providing proper irrigation facilities. EPWAPDA was recommended by the Krug Mission of United Nations, is known as Bangladesh Water Development Board (BWDB) at present (PDO-ICZM 2002; Gain, Benson, Rahman, Datta & Rouillard 2017).

EPWAPDA had taken a high ambitious project as the Dutch experienced named the Coastal Embankment Project (CEP) major financed by the USAID, built high earthen embankments along tidal rivers of the southern coastline to protect the agricultural land from tidal influx of saline water as well as to protect it from floods and cyclones. There several types of drainage structures for example regulators, sluice gates were installed across river and canal sections and along Tidal Basin in the CEP for managing tidal rivers in coastal area. The polder system was fruitful to safe agricultural land from brackish water due to tidal effects, coastal community from floods and cyclones (De Die 2013; Paul, Nath & Abbas 2013), yielding 2 to 3 crops per annum, intensifying crop production, bringing prosperity and flood of joys to coastal people up to 1980s (Kibria 2011).

The tidal rivers of the Southwest region have been silted up and are going to die one after another due to the consequences of CEP. It created troublesome water-logging in Beel Dakatia, Beel Bhaina, Beel Khukshia, Beel Buruli, Beel Madhugram, Beel Kapalia, Beel Bakor, Beel Patra, Beel Baruna, Beel Kaderia and another 20-30 Beels of Bhabadaho area. Coastal people were fallen in a great danger. They had no experienced of water-logging before 1980s. Mainly they experienced with several floods in pre-polders. Flood water went back to the sea within one or two weeks. But in water-logging, flood water was still stagnant not only in agricultural land but also in the settlement area from 6 to 8 months up to pre-monsoon. Water-logging was very badly experienced with damaging agriculture, destroying settlement, degrading environment, ill health, unemployment and permanent migration to the coastal people.

Coastal community mainly depends on proper management of tidal river and its floodplain for their livelihoods. They practiced agriculture age to age in ¹Beels (Tidal Basin) by the earthen built embankment and dykes along the river for eight months of a year called *Ostomashi Badh*. In *Zamindary* system this embankment was built by *Zaminder* with the help of local people. After abolition of *Zamindary* system in pre-polder the embankment was built by collectively community people then it named *Dosher Badh* (Kibria 2011). Basically, the floodplain area was open (no embankment) another four months in monsoon to enter sediment and deposited it in Beels to make the agricultural land fertile. This indigenous practice was naturally developed in coastal area by local people to manage tidal river and its catchment area. After failure of BWDB, local people took initiatives based on their indigenous knowledge to solve water-logging problem by allowing sediment deposition in the Tidal Basin of a tidal river called TRM. They firstly applied TRM at Beel Dakatia (1991-1994) and secondly at Beel Bhaina (1997-2001). Centre for Environment and Geographic Information Services (CEGIS), Institute of Water Modelling (IWM), Asian Development Bank (ADB) and United Nations Development Program (UNDP) accepted the TRM as indigenous and eco-technical concept (Tutu, 2005) and recommended to the government for water resources management in the Southwest region of Bangladesh. Bangladesh Water Development Board (BWDB) implemented TRM successfully at East Beel Khukshia (2006-2013) for the first time. At present, TRM is going on at Beel Pakhimara.

Moreover, it is the question for the TRM in this study:

1. Is TRM having the capacity to improve agricultural production?
2. Has any role of TRM to increase households' income?
3. Is TRM effective to ensure the food security?
4. What are the benefits of TRM in agriculture?

1.1 Procedure and State of TRM

Local people cut the embankment in 1990 and connected Beel Dakatia to the Hamkura River with their indigenous practice to manage tidal river and floodplain for solving water-logging. They called it TRM. Therefore, Tidal River Management (TRM) is an indigenous and eco-technical concept to solve water-logging problem of the Southwest region. TRM would allow natural movement of sediment-borne tidal water into a Beel which is called Tidal Basin and allow deposition of sediment in the Beel and it removes water-logging from the Beel and locality. It needs a strong participation and consensus of coastal

¹A *Beel* is a term for billabong or a lake-like wetland with static water in the Ganges - Brahmaputra flood plains of the Eastern Indian states of West Bengal, and Assam and in the country of Bangladesh.

community with a great sacrifice of their Beel for a specific period 3 to 5 or more years (Al Masud, Moni, Azadi & Van Passel 2018).

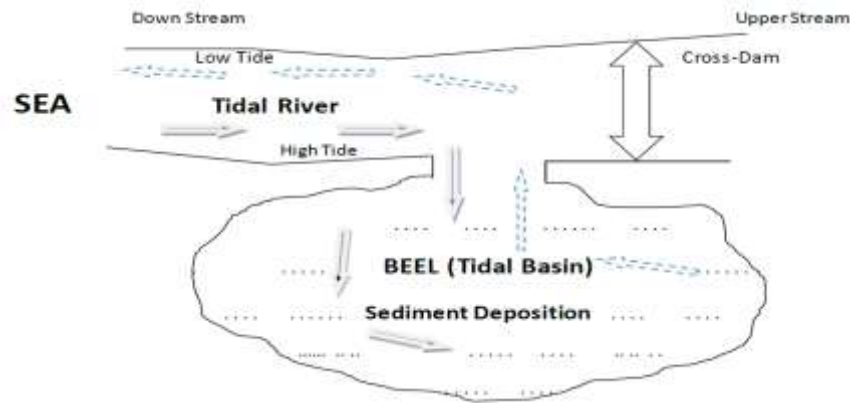


Fig. 1: The mechanism of TRM (Al Masud, Moni, Azadi & Van Passel 2018).

The study involves three states of TRM to explain the role of TRM on agriculture i.e. before TRM, during TRM and after TRM. Before TRM is the scenario of the Tidal Basin and the catchment area of a tidal river when TRM is not implemented that includes the time period after construction of polders from mid 1960s to early 1980s (before water-logging). During TRM is the scenario of the floodplain area of a tidal river when TRM is implemented through sediment management in a Tidal Basin with connecting the tidal river that includes time period (4 to 6 years) as example for Beel Bhaina it was from 1997 to 2001 and for Beel Khukshia it was 2006 to 2013 under the Hari River. After TRM is the scenario of the catchment area and Beels when closure the embankment along the tidal river that includes the time period (depends on government's decision and community acception) up to starting a new TRM of a tidal river.

2. TRM and Agricultural Sustainability

Southwest coastal region of Bangladesh is the most disaster-prone area due to climate change induced cyclones and floods as well as anthropogenic events. People have been struggling to adapt themselves with agriculture for their livelihoods from Zamindari system to the current age under polder. They faced several floods in pre-polder, introducing polder did not give them permanent remedies for sustainable agricultural practice as they are fronting water-logging in post-polder. Besides, geo-physically this floodplain was formed by clay-peat soil, soft in nature (Roy, Gain, Mallick & Vogt, 2017). Therefore, the land is continuously settled with subsidence (General Economic Division, 2015; Gain, Benson, Rahman, Datta & Rouillard 2017) under active Bengal Delta. Furthermore, sea level has been rising due to global warming of climate change, which increasing susceptible of vulnerability to the coastal people who stand only 1m to 3m high from the sea level (Huq, Huge, Boon & Gain 2015) around the 100 km of the coast (Paul, Nath & Abbas 2013). Moreover, the agricultural land of Tidal Basin of floodplain area has to fight against rising sea levels for its sustaining in future. Obviously, the settlement and livelihoods more than 70% dependence on agriculture are in great danger for going under sea within half of a century.

TRM is the new term of *Ostomashi Badh* or *Dosher Badh*, an indigenous practice of integrated water resource management both for Tidal Basin and tidal river, came from local people as experience in Beel Dakatia for solving water-logging by managing Hamkura River (PDO-ICZM, 2002; Tutu 2005) to facilitate agriculture of its catchment area. In TRM the time period is extended than *Ostomashi Badh* up to 6 years, assists

agricultural practice 10 to 20 Beels at a time during TRM of the catchment area where *Ostomashi Badh* supported agriculture only in a Beel. In the floodplain area every Beel included a separate Badh along the tidal river before polder system. A single TRM of Tidal Basin under polder system plays role in sustaining agricultural practice to the whole catchment area by removing water-logging and supporting irrigation facilities while raising TRM Beel from 0.5 m to 1.5 m (Centre for Environment and Geographic Information Services 2003; Sterrett 2011; Al Masud, Moni, Azadi & Van Passel 2018). Moreover, TRM can develop networking system between upper stream and downstream of a tidal river as well as one river to another river with connecting their Beels of the floodplain area (Institute of Water Modeling 2010; Shoeab, Alam, Sultana, Haque & Hossain, 2012; Uttaran, Paani Committee, CEGIS & Institute of Water Modeling 2013). In rotation wise one after another Beel can serve as Tidal Basin for TRM implementation under the catchment area of a tidal river for instance through Hari-Teka-Mukteshawri River TRM was implemented firstly in Beel Bhaina-Tidal Basin (1997 to 2001) then secondly in Beel Kaderia-Tidal Basin (2002 to 2005) after that thirdly in East Beel Khukshia (2006 to 2013) and fourthly in Beel Kapalia-Tidal Basin was proposed for TRM implementation (De Die 2013; Uttaran, Paani Committee, CEGIS & Institute of Water Modeling 2013). During these TRM the catchment area of Bhadra River was benefitted with proper agricultural practice to its Beels. Therefore, TRM would be a sustainable solution both for increasing resistance capacity against flood and water-logging with mitigating rising sea levels by raising TRM Beel and improving crop production with continuous diversified agricultural practice in the catchment area.

3. Finding Research Gap of Recent Literatures

Tidal River has greater impact of climate change induced sea level rise (Sterrett 2011) through melting of Himalayan ice (Huq, Huge, Boon & Gain 2015). The downstream are always affected by upper stream's water flow in quantity and quality under floodplain area by natural and anthropogenic interventions (Gain, Benson, Rahman, Datta & Rouillard 2017) which decrease fresh water flow to downstream and increase salinity intrusion with sedimentation process (Shoeab, Alam, Sultana, Haque & Hossain 2012; Shampa & Paramanik 2012; Huq, Huge, Boon & Gain 2015; Al Masud, Moni, Azadi & Van Passel 2018). Some rivers of the Southwest region are already silted up and some are disconnected from upstream flow that creates water-logging and makes instability of agricultural practice at downstream (Kibria 2011; Shoeab, Alam, Sultana, Haque & Hossain, 2012; Huq, Huge, Boon & Gain 2015). Therefore, Southwest region is continuously water-logged for six to eight months as a result people get scope to produce rice crops for rest four to six months of a year. Water-logging results decreasing cultivable land and reducing agricultural production (Haider & Moni 2008; Adri 2009) which compels the farmers to change their existing occupation. Same experience has also been observed for people related with fishing (Haider & Moni 2008). They are severely affected of food insecurity and malnutrition in degraded environment due to prolonged water-logging. Poor people who depend on ecosystem services become jobless to support their livelihoods (Hossain, Dearing, Rahman & Salehin 2016) and bound to migrate nearest city areas like Khulna and Jessore as *rikshaw* pullers, *van* pullers, daily basis industry workers or shop keepers (Haider & Moni 2008). TRM is a community-driven process that involves GOs, NGOs and CBOs must work together and agree to set aside each Tidal Basin of a tidal river for TRM implementation (Sterrett 2011; Uttaran, Paani Committee, CEGIS & Institute of Water Modeling 2013). Landowners as well as landless dependable people are not be able to use this TRM Beel for agriculture and may have to be compensated (Center for Environment and Geographic Information Services 2003; Sterrett 2011). A flexible

and poor friendly compensation system would be developed through proper consultations with communities and landowners (Uttaran, Paani Committee, Center for Environment and Geographic Information Services 2003 & Institute of Water Modeling 2013). The success of TRM in disaster management depend on shifting shrimp ghers from link canals or rivers, utilizing all potential *Beels* for sequential operation as tidal basins for TRM as well as to execute TRM basin-wise from one river basin to another river basin (Paul, Nath & Abbas 2013; Uttaran, Paani Committee, CEGIS & IWM, 2013; Institute of Water Modeling, 2010). TRM introduces new alluvial land in tidal wetlands by sediment deposition, greater conservation of bio-diversity with developing more ecological balance for diversified crop production and fisheries to enhance livelihoods of coastal people (Paul, Nath & Abbas 2013; Hossain, Dearing, Rahman & Salehin 2016). It reduces flood hazards and having possible mitigation of climate change induced by sea level rise (Sterrett 2011; Kibria 2011; Paul, Nath & Abbas 2013; Al Masud, Moni, Azadi & Van Passel 2018).

By reviewing the recent literatures the study identifies few research gaps. Firstly, none of these literatures include three scenarios of TRM (before TRM, during TRM and after TRM) to explain the benefits of TRM in agricultural production in the context of TRM Beel as well as catchment area. Secondly, there is no accounting of economic valuation for measuring the benefits TRM from agriculture. Thirdly, the contribution of TRM for increasing households' income in the context of agriculture is not present. Fourthly, the comparison in agricultural production between TRM Beel and non-TRM Beel after TRM implementation is not covered to explain food security of their studies. Moreover, diversified crops production is vital issue to sustainable agriculture where TRM's contribution is not lighted of their literatures.

3.1. Objectives

- a. To assess the impacts of TRM on agricultural production,
- b. To measure the impacts of TRM on households' income,
- c. To find out the contribution of TRM to the food security and
- d. To account the benefits of TRM in agriculture.

4. Methods

The study has conducted an Open TRM (without village protection dam and initiated by the local people) at Beel Bhaina at Kashabpur upazila under Jessore district. It selects Sholgotia village at Dumuria upazila under Khulna District and Duhuri and Agarhati village at Kashabpur upazila under Jessore district. Primary data are collected through Interview Schedules, Key Informant Interview (KII) and Focus Group Discussion (FGD). Farmers who have less than 200 decimals cultivable land in the Tidal Basin are the target population in this study. Farmers' households are regarded as the sample unit. The study has involved 20 households from Sholgotia Village, 17 households from Duhuri Village and 28 households from Agarhati Village as sample. The study involves Landsat data for satellite images of the catchment area of Hari-Teka and Bhadra rivers in different time collected from earth explorer of United State Geological Survey (USGS) with the condition of 10% cloud coverage. Data was pre-processed in ERDAS imagine 2014 for geo-referencing, mosaicking and sub-setting of the image on the basis of Area of Interest (AOI). All satellite data are studied by assigning per-pixel signatures and differentiating three classes water body, vegetation and settlement on the bases of the specific Digital Number (DN) value of different landscape elements. The study also includes Beel Kapalia, Beel Buruli and Beel Baruna for Non-TRM Beel and Beel Bhaina for TRM Beel in the catchment area.

Methods for accounting the benefit for increased land productivity in the context of the catchment area (Adapted from Ison et al., 2002).

The benefit for increased land productivity,

$$B = \sum_{i=1}^n (X_i \times M_{pi} + M_i) \times L \text{ BDT}$$

Where, the increase rate of paddy, fish and vegetables production (X) = Production per unit area per year during TRM– Production per unit area per year after TRM, and

Decrease of production cost for maintenance per unit area M_p = (Production cost per unit area after TRM– Production cost per unit area during TRM)

M = Average present market price of 1 (one) unit product

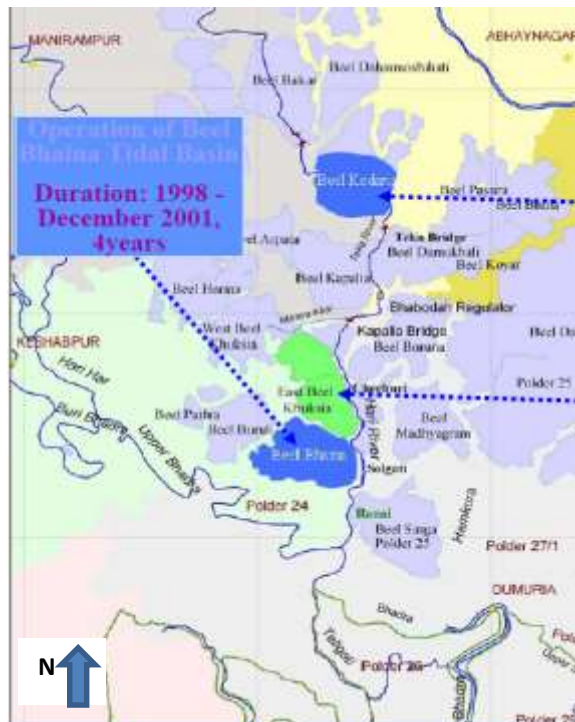
L = Total agricultural land of the catchment area

The study has compared data among two scenarios of TRM (with TRM and without TRM) involving TRM Beel and Non-TRM Beel in the context of catchment area as well as before TRM and after TRM in the context of TRM Beel for measuring the impacts of TRM on agricultural production and its contribution to the agricultural sustainability, food security and households' income.

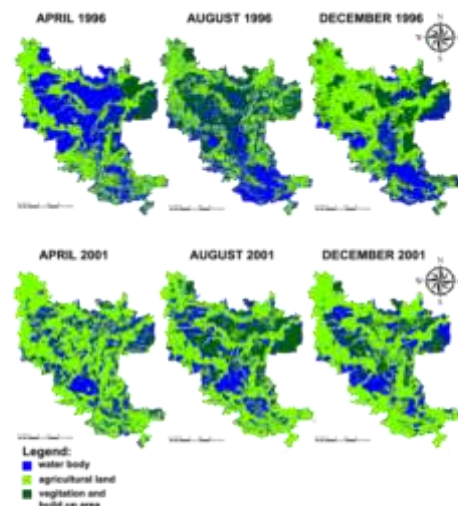
5. The Role of TRM in agriculture

5.1. Land use changes in the catchment area

The catchment area includes both TRM Beel and Non-TRM Beel of Hari-Teka River and Bhadra River to prove the benefits of TRM in agriculture. The satellite images of this catchment area capture 13 unions (the smallest administrative unit of local government) of 5 sub-districts (upazila) under Khulna and Jessore districts that require total 30381 ha of land. Beel Bhaina is situated under Gaurighona union of Jessore district. The drainage capacity of the Hari River has been developed from 60 m to 100 m width and 2 m to 10 m depth within 1 km of the cutting point by TRM implementation at Beel Bhaina.



(a) Beels and Rivers (Source: IWM, 2010)



(b) Satellite images

Fig. 2: (a) Map of TRM Beel (with blue and green colored) and Non-TRM Beel and (b) the satellite images at different seasons (pre-monsoon, monsoon post-monsoon) for before TRM in 1996 and during TRM in 2001 of the catchment area under Hari-Teka River and Bhadra River of Khulna and Jessore districts.

The out fall tidal current from Tidal Basin in ebb tide has removed sediment deposition to downstream up to 20 km or 25 km (Field survey, 2013) as well as saved Hari River, Bhadra River, Teligati River and Ghangrail River from siltation in river beds.

The permanent water body was 8123 ha of land on December in 1996. The water body was increased by monsoonal effects in the rainy season. It was raised to 11381 ha of land on August and it reached to the peak level by 14298 ha of land on April. Moreover, 6175 ha of land was gone under water-logging on April in 1996. On the other hand, the permanent water body was 7905 ha of land on April in 2001. The water body was increased by monsoonal effect in the rainy season. It was soared to 8070 ha of land on December and it reached to the top level by 8379 ha of land on August. In addition, 474 ha of land were water-logged on August in 2001. Therefore, 5701 ha of land was free from water-logged in the monsoon of the Hari-Teka and Bhadra Basins by developing drainage capacity of the Hari River under TRM implementation at Beel Bhaina.

The agricultural land was increased in 2001 with comparison to 1996, the area was 659 ha of land in pre-monsoon (April), 4266 ha of land in monsoon (August) and 2849 ha of land in post-monsoon (December). In addition, more than 2000 ha of land were covered with Aman (one variety of paddy) and 3000 ha of land with Boro production in 2001 during TRM regarding to 1996 before TRM. For this reason, 5,000 ton Aman and 22,500 ton Boro as well as 1,000 ton vegetables production were increased in the catchment area during TRM (Field Survey, 2013). Moreover, the settlement and built environment (vegetation) was developed in 2001 regarding to 1996 from 2170 ha to 3027 ha by TRM application at Beel Bhaina (1997 to 2001). Therefore, it was increased by 857 ha of land in the catchment area of Hari-Teka River.

5.2. Food Security

Increase in agricultural production and its sustainability are important for food security. The accessibility of crops production in agricultural land and the availability of food for community with improving agricultural production are main components to demonstrate food security of a catchment area. TRM plays a vital role to upsurge in agricultural production and promotes diversified crops in agricultural land of the catchment area. 100% of agricultural land is coverage in paddy production and 50% to 60% land is coverage for vegetables production with TRM (Tab. 1). Besides, the catchment area without TRM decreases agricultural production 3.33 ton of paddy, 2.14 ton of vegetables per hector (Tab. 2) and 0.0525 ton of shrimp, 0.18 ton of prawn and 0.62 ton of white fish per hector (Tab. 3) including cultivation area coverage 70% for paddy and 20% for vegetables in Non-TRM Beel. In addition, catchment area reduces agricultural production 12% of paddy and fish, 40% of vegetables involving cultivation area coverage 100% of Boro and 60% of vegetables in TRM Beel (Fig. 3). Therefore, TRM Beel is more adaptive to water-logged situation than Non-TRM Beel. TRM Beel produces more 3.6 ton for paddy, 3.59 ton for vegetables and 86 ton for fish production than Non-TRM Beel in the catchment area without TRM.

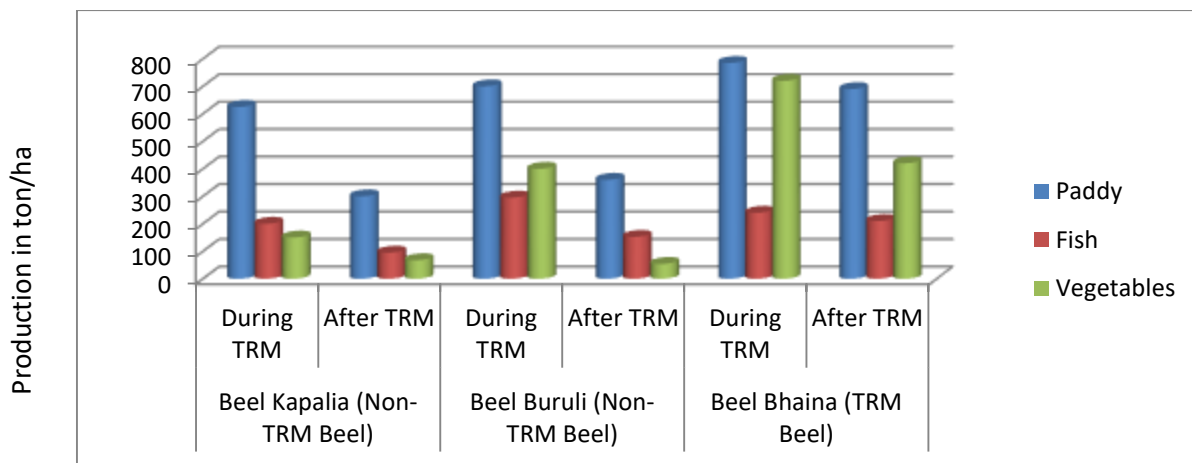
Tab. 1: The area coverage (in percentage) under agricultural production of paddy, fish and vegetables of different Beels of the catchment area during TRM implementation (2006 to 2013) at Beel Khukshia through Hari River.

Agricultural Coverage in percentage of different TRM		Beel Kapalia (Non-TRM Beel under Hari-Teka Basin)		Beel Buruli (Non-TRM Beel under Bhadra Basin)		Beel Bhaina (TRM Beel under Hari-Teka Basin)	
		During TRM (2007 to 2013)	After TRM (2014 to 2016)	During TRM (2007 to 2013)	After TRM (2014 to 2016)	During TRM (2007 to 2013)	After TRM (2014 to 2016)
Paddy	Boro	100	60	100	80	100	100
	Aman	-	-	-	-	10	6
Fish	Prawn (Galda) + White fish	15	25	50	30	-	-
	Shrimp (Bagda) + Prawn (Galda) + White fish	85	75	-	-	100	100
	White fish	-	-	50	70	-	-
Vegetables	Summer	-	-	40	10	80	50
	Winter	50	30	60	20	100	70

Note: During TRM is similar to with TRM and After TRM is similar to without TRM

Data source: Field survey in 2017

Tab. 1 shows that catchment area with TRM is in more coverage for agricultural production than without TRM. TRM Beel makes the catchment area is more sustainable to produce paddy, fish and vegetables with consideration of Non-TRM Beel.



Production in different scenarios of TRM

Data source: Field survey in 2017

Fig. 3: Total production of paddy, fish and vegetables (in ton/ha) during TRM implementation (2007 to 2013) regarding after TRM (2014 to 2016) with consideration of 100 ha land for every Beel of the catchment area.

Fig. 3 shows that TRM Beel produces more 15% of paddy and 140% of vegetables with TRM and 220% of paddy, 41% of overall fish and 680% of vegetables without TRM than Non-TRM Beel in the catchment area.

Tab. 2: The average production for paddy and vegetables in the catchment area.

Agricultural Production (ton/ha)	Beel Kapalia (Non-TRM Beel)		Beel Buruli (Non-TRM Beel)		On average production	
	During TRM	After TRM	During TRM	After TRM	During TRM	After TRM
Paddy	6.25	3	7	3.6	6.63	3.3
Vegetables	1.50	0.675	4	0.54	2.75	0.61

Tab. 2 shows that the catchment area with TRM increases agricultural production 50% of paddy and 80% of vegetables regarding without TRM.

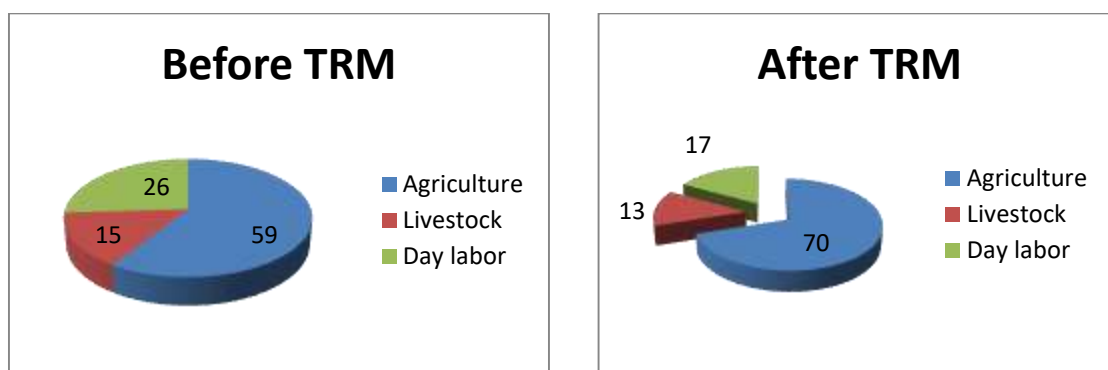
Tab. 3: The average production for paddy and vegetables in the catchment area.

Fish Production (ton/100ha)	Beel Kapalia		Beel Buruli		Baruna Beel		On average production	
	D-TRM	A- TRM	D-TRM	A- TRM	D-TRM	A- TRM	D-TRM	A- TRM
Shrimp	34.5	18.75	-	-	-	-	11.5	6.25
Prawn	51.5	20	30	6	42.5	42.5	41	23
White fish	114.5	56.25	265	146.5	93.5	85	158	96

Note: D-TRM for During TRM and A-TRM for After TRM

Data source: Field survey in 2017

Tab. 3 shows that the catchment area with TRM increases agricultural production 45% of shrimp, 25% of prawn and 40% of white fish considering without TRM.



Data source: Household survey in 2016

Fig. 4: The contribution to households' income of different sources (in percentage) at Beel Bhaina.

Agricultural production is improved per hector land from 3.53 to 6.61 ton of paddy, 2.87 to 3.47 ton winter vegetables and 0.85 ton capture fishes to 1.5 ton culture fishes after application of TRM at Beel Bhaina regarding before TRM. The present average market price for per kg product of paddy, vegetables, shrimp (bagda), prawn (galda) and white fish is 20,30, 700, 500 and 125 BDT respectively. Fig. 4 shows that the contribution of agriculture is increased by 11% to the households' income after TRM implementation at Beel Bhaina.

5.3 Accounting the benefits of TRM in agriculture

The catchment area comprised 19285 ha agricultural land on December (post monsoon) in 2001 during TRM at Beel Bhaina as the satellite image. Therefore, the agricultural land may be developed as the same as Beel Bhaina for the similar catchment area during TRM at East Beel Khukshia (2006-2013) by diminishing water-logging and drainage congestion Hari-Teka and Bhadra Rivers. At this time, Beels under catchment area need less fuel oil consumption for irrigation. On the other side, after TRM implementation Beels demand more fuel oil consumption for irrigation. Because the river is gradually silted up and the catchment area is further water-logged. It needs both irrigation out for preparing the land for cultivable to Boro and irrigation in the land at growing stage of paddy. In addition, Beels require more net for fish protection in monsoon after TRM due to water-logging in the catchment area.

Tab. 4: The agricultural maintenance cost for irrigation and fish protection per hector land.

Agricultural maintenance cost per hector land for Non-TRM Beel	Fuel oil consumption/height of net on the ² Veri		Cost (in BDT)	
	During TRM	After TRM	During TRM	After TRM
Irrigation for Paddy	125 liter	250 liter	8750	17500
Fish protection with net in monsoon	2-3 feet	5-6 feet	17000	42500

Data source: Field survey in 2017

Therefore, the benefits of TRM in agriculture, $B = \sum_{i=1}^n (X_i \times M_{pi} + M_i) \times L$ BDT

Where, $M_{pi} = (17500 + 42500 - 8750 - 17000) = 34250$ BDT

$M_i \times X_i = M_i \times (X_{paddy} + X_{vegetables} + X_{shrimp} + X_{prawn} + X_{white\ fish})$

$= (20 \times 3.33 + 30 \times 2.14 + 700 \times 0.0525 + 500 \times 0.18 + 125 \times 0.62)$ thousand BDT

$= 66.6 + 64.2 + 36.75 + 90 + 77.5 = 335050$ BDT

$L = 19285$ ha

$= (335050 + 34250) \times 19285$ BDT

$= 7.12$ Billion BDT

6. Discussion

TRM is essential for intensifying agricultural production with removal of water-logging from catchment area by improving drainage capacity of tidal rivers. This paper supports as Sterrett (2011), Institute of Water Modeling (2010) and Paul, Nath & Abbas (2013) operation of TRM to develop TRM Beel strengthen against susceptibility of floods and water-logging due to rising sea levels. The study presents TRM Beel producing 2 times more of paddy, 7 times more of vegetables and 41% more of overall fishes than Non-TRM Beel in the catchment area without TRM. The agricultural production improves by 50% of paddy, 80% of vegetables, 45% of shrimp, 25% of prawn and 40% of white fish with TRM in the catchment area. Khadim, Kar, Halder, Rahman and Morshed (2013) have claimed that agricultural land is increased by 24% and cropping intensity is improved by 57% and per capita food production is increased by 17% during TRM at East Beel Khukshia in 2012 regarding TRM at Beel Kaderia (unsuccessful TRM due to Bhabodah regulators) in 2002. Besides, the study shows the difference between TRM Beel and Non-TRM Beel as well as with TRM and without TRM in the context of catchment area and between before TRM and after TRM in the context of TRM Beel mentioning paddy, vegetables and fishes separately in agricultural production. Paul, Nath & Abbas (2013) and Khadim, Kar, Halder, Rahman and Morshed (2013) have included a satellite image for a year where as the study involves three satellite images for pre-monsoon, monsoon and post-monsoon in a year to explain perfectly the impacts of TRM on agriculture, water body and settlement. Moreover, the study accounts the benefits of TRM with economic valuation i.e. 7.12 Billion BDT per year with TRM from 2007 to 2013 regarding without TRM from 2014 to 2016. Therefore, the study claims likely as Paul, Nath & Abbas (2013) and Uttaran, Paani Committee, CEGIS & IWM (2013) for persistence of TRM application one Tidal Basin to another Tidal Basin as well as one tidal river to another tidal river under a networking system of the catchment area to gain continuous benefits from TRM, and portrays more clarification regarding the role of TRM towards sustainable agriculture and food security.

² Veri is a small (in width) embankment made of mud, separates one *gher* (farm)/crop land from another farm, generally 3-4 to 5-6 feet height from the bottom land in the Beel where vegetables are produced.

7. Conclusions

TRM is inevitable for integrated water resources management to solve water-logging and drainage congestion problem in the coastal region. The catchment area with TRM is 40% more secured in food production regarding without TRM. TRM makes the catchment area 30% more sustainable for paddy, vegetables and fishes production. The study will stimulate researchers to go further research for integrated coastal zone management, sustainable water resources management and disaster management based on TRM.

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The Use of Sustainable Financing in the Solar Energy Sector in Bangladesh: A Literature Review

Shakila Aziz

United International University

Abstract

The World in general and Bangladesh in particular are facing an energy crisis. The demand for energy consumption is increasing due to increasing population and industrialization, but the supply is projected to diminish because of depleting reserves of conventional fossil fuel energy. There is a drive to discover or invent new alternative, clean sources of energy in the form of renewable energy, which does not depend on finite sources. Bangladesh participates in this drive by exploring and investing in various renewable energy technology and industries, and solar energy in particular. The existing state of the art in renewable energy technology does not make it financially competitive with conventional energy solutions, and as such renewable energy projects cannot compete with conventional energy for commercial financing. However, improvements in technology and market structure, increasing price of fossil fuels, and increasing consumer purchasing power will make renewable energy an economically viable option in the Bangladeshi economy.

Keywords: Solar PV, Sustainable financing.

1. Introduction

Bangladesh has a very successful renewable energy program for rural electrification among developing countries. Its Solar Home System program is an exemplary world leader in terms of market dissemination and penetration. Under the Infrastructure Development Company Limited's (IDCOL) national SHS program, around 4.12 Million SHS has already been installed upto May 2017["The Solar Home System Initiative in Bangladesh", 2017].

Innovative energy service systems are also implemented in Bangladesh in the form of Solar minigrids. The financing scheme of these renewable energy development projects is credited with their uncommon success. These projects are originally financed heavily by foreign donor agencies like the World Bank, KFW, GIZ, DFID, JICA, IDB, GPOBA, Asian Development Bank etc. In Bangladesh, the money from these donors is channeled to local Partner Organizations like Grameen Shakti, BRDB etc, through the financing organization IDCOL. These partner organizations invest their own equity financing in addition to loans and grants from the donors, and are able to bring renewable energy solutions like solar energy to the remote energy deprived populations of the country.

Until now, these renewable energy development projects have been heavily dependent on the soft loans and grants of foreign donors, which often comprise 80% of the total financing costs. This is a temporary solution to financing, and not sustainable. The challenge is to make the renewable energy projects profitable and sustainable enough to become competitive with other commercial or industrial projects. Renewable energy like solar energy and biogas have to compete on price with cheaper grid power. Furthermore, the government itself subsidizes grid electricity. The limitations of renewable energy technology and the subsidization of fossil fuel electricity make it a challenge for renewable energy projects to be commercially viable.

However, it is predicted by energy experts that the costs of fossil fuels will gradually rise as global reserves deplete. Moreover, the efficiencies of renewable energy technologies are improving continuously, and renewable energy and clean energy have already become mainstream commercially viable alternatives in many countries in many applications.

The future worldwide demand for energy will come mostly from the emerging economies of the world, increasing total global demand by a third. According to the estimates of IEA, renewable energy sources will comprise almost half of the additional energy production by 2035.¹

In Bangladesh 40% of population, or approximately 65 million people, are without access to electricity [UN, 2014]. For the grid-based electricity access, the government plans an increase in renewable energy's share to 10% by 2020 [GoB, 2008].

Yadoo & Cruickshank (2012) estimate that about half of the off-grid population today could be best supplied with decentralized microgrids. As of 2014, there was only one solar minigrid in Sandwip island [Khan & Huque, 2014]. The next growth spurt in the renewable energy off grid market will come from solar diesel hybrid mini grids in off grid locations. Several such projects, each with the capacity of 100 to 250 KWp have been initiated in Bangladesh. These mini grids will serve remote off grid populations that are unlikely to be served by the national grid in the foreseeable future. (Aziz et al, 2016)

2. History and Economic forecasts of Electricity Demand in Bangladesh

Access to energy and electricity are vital in any country for economic growth, poverty eradication and human development. About a third of the population of Bangladesh still does not have access to electricity. At the time of liberation, about three percent of the Bangladeshi population had access to electricity, but this situation has been improving steadily. The installed capacity has increased from 667MW in 1974-75 to 12780MW in 2016. Most of the recent growth in electricity consumption comes from growth in domestic consumers, who were initially neglected in favor of industrial consumers. The cost of electricity is rising, however, due to increase in fuel prices, decreasing ability of the government to fund increasing subsidies. (Islam & Khan, 2017)

Bangladesh has one of the lowest electricity and energy consumption per capita GDP compared to other countries of a comparable economic development. This shows that the relative productivity of energy usage in Bangladesh is very high.(Ibid)

It has been found that the price elasticity of demand for gas and energy in Bangladesh is statistically not different from zero. Although this is counterintuitive in the case of a normal good like electricity, it suggests that consumers have a hidden demand for electricity that is much higher than the current supply, and are willing to pay higher prices to be able to consume more. Bangladesh is in a phase of high GDP growth rate, and the demand for power will not decrease with an increase in price at the given price levels. (Wadud et al, 2011).

Furthermore, the long run income elasticity of natural gas demand in Bangladesh up to 2025 is estimated to be around 1.47. Bangladesh is a developing country and the demand for power will increase as peoples incomes increase, because much of the need for power is still unfulfilled. (ibid)

¹International Energy Agency. *World Energy Outlook 2013* (IEA, 2013).

According to a forecast study using LEAP software for the increase in energy demand in Bangladesh, the electric power sector constitutes the largest single sector for gas energy demand, and also accounts for the largest future increase in energy demand, compared to other industrial uses. (Khan et al, 2011)

There is still a large proportion of the rural population of Bangladesh that does not have access to grid electricity, and their main energy consumption is in the form of biomass for the purposes of cooking. However, as the GDP of the country increases, there is an increasing demand for electricity to run electric appliances. There is a forecast factoring population growth, GDP increase, access to the grid and appliance use, which projects the demand for energy to increase up to three times the demand of 2010 by 2050. If the supply of electricity from conventional sources falls short, there will be a market for alternative energy to meet the shortfall. (Debnath et al, 2015)

In Bangladesh, the current energy mix includes locally extracted natural gas, imported oil, untapped coal reserves, limited hydropower and various renewable energy resources. Among renewable sources of energy, solar energy is already used for off grid electricity generation, whereas biomass is used for cooking and heating. However, available biomass sources in Bangladesh shows potential for electricity generation and gasification as well, with potential electricity generation capacity of up to 323TWh from various sources such as agricultural crop residue, recoverable waste, wood, sawdust etc. The most potential in solar energy use is in solar home systems, and now grid connected solar PV systems. (Islam et al, 2014)

3. Risks Faced by the Power Sector in Bangladesh

The power sector in Bangladesh is also vulnerable to extreme weather events and climate change. Events such as extreme rainfall, temperature, drought, cyclones, storms and floods will impose irregular demands on power supplies and disrupt power generation systems and infrastructure. Increase in temperature will lead to transmission loss in electricity and decrease in transformer lifetime. Severe cyclones and storms lead to power outages when power plants trip and fail. Irregular rainfall place unexpected demand for electricity for irrigation purposes. Increased salinity in river water and decreased rainfall can reduce the supply of water for cooling power plants, thus hampering their operations. (Shahid, 2012)

4. The Role of Government Subsidies and Fossil Fuels Supply on Electricity Prices

Governments of the world provide subsidies to electricity suppliers from fossil fuel generation technologies, and this artificially reduces the cost of grid electricity, making it difficult for renewable energy technologies to compete on price.

Electricity subsidy is defined as the difference between the tariffs charged and the cost of supplying electricity. In Bangladesh, the price of electricity or tariff varies from urban to rural areas and according to the number of units consumed. Households that consume below a certain threshold receive a subsidy, and those consuming above the threshold have a cross subsidy (paying a rate above the supply cost). The width of a subsidy is the proportion of electricity units consumed that enjoy subsidy. The depth of a subsidy is the degree to which the average connected household is subsidized. (Ahmed et al, 2013)

Compared to Pakistan and India, however, Bangladesh provides a lower amount of subsidy for urban households. The main argument in favor of subsidies is providing affordable power for the poor. However, households in the richest quintile receive more subsidies than households in the poorest. This shows that there is leakage to the households who don't need subsidy support. (ibid)

Renewable sources like solar and wind energy have the problem of intermittent power supply, which does not match peak load with peak production times. As a result, the value of including solar power without storage will peak at a certain generation capacity of the entire demand. This means that other sources of power must be provided for example at night when the demand is high and solar output is low (IER, 2017)

According to Biswas et al, the government should consider the following strategies to make PV based grid connected systems more competitive.

Including a feed in tariff to boost investor confidence.

The feed in tariff should adjust over the lifetime of the project and be adapted for time and location.

Make tax exemptions for the import of components, and for project investments.

Explore carbon emission subsidies if available.

Reduce interest rate of debt.

Increase project lifetime.

As early as 2013, the World Bank identified a trend in increasing the subsidy for grid electricity in Bangladesh, which increased from .2% to .8% of the GDP from FY 2010 to FY 2012. This contributed significantly to the increase in overall fiscal deficit. Another problem identified was how to reduce leakage to rich households. (Ahmed et al, 2013)

5. Government Policy and Action in the Energy Sector

In FY 2010, the government of Bangladesh formulated a twenty year master plan for power generation. The installed capacity increased from 5823 MW to 10,618MW. This amounts to an annual growth rate of 16%. The population's access increased from 47% in 2010 to around 70% in 2015. The average consumption increased from 170 KWH to around 300KWH in the same period. This is seen as a rapid increase in installed capacity, distribution infrastructure and consumption volume compared to previous periods. (Alam, 2015)

In addition to government efforts, there is the drive to include the public sector to participate in the generation. The share of private power supply as a percentage of installed capacity increased from 26% in FY2008 to 42% in FY2013. Transmission and distribution losses have also been reduced from 32% in FY2000 to 14% in 2014, which is considered quite good by even international standards. (Ibid)

The bad news is that the increased installed capacity from private plants and imports has increased the price of electricity. The cost of electricity from private sources is 150% greater, because they use more expensive oil based generation. The bulk supply tariff has increased seven times from 2008 from 2.37 to 5.71 Tk/kwh in 2014/15. (Ibid)

The supply of natural gas is decreasing, and this has led to the total percentage reduction in gas based production, and the bulk of the increase is coming from imported fuel oil. Hydro and coal have no significant change. The cost of electricity supply is increasing at a much higher rate than the increase in tariffs. This puts a load on the national budget, and increases subsidies. The electricity subsidy increased from tk 12 billion in 2010 to around tk 70 billion in 2015. (Ibid)

There are sectoral reforms which improve collections and billings by installing computerized metering and accounts receivable collections.

The pricing of electricity is a complex process because of the mix of sources, price of fuels and also the political sensitivity of the decision.

The pricing involves two steps.

Fixing the bulk tariff rate fixed by Bangladesh Power Development Board on the distributors such as Dhaka Electricity Supply Company (DESCO).

Fixing the retail tariff rates that are imposed by the distribution companies on consumers. (Mujery et al, 2014)

Retail tariff depends on categories of consumers (domestic, irrigation, small industry, non-residential and commercial), the amount of usage (in case of domestic users) and the time of usage (peak versus off peak hours). (ibid)

The Bangladeshi tariff structure operates using the following principles and guidelines.

The tariff should recover costs and generate a surplus if possible.

If necessary, the government may subsidize directly from the budget.

Tariffs will encourage technical and commercial efficiency and pass on generation costs to end users.

Tariffs should be reviewed quarterly and adjusted annually for changes in fuel prices, generation mix, exchange rate and inflation. If the variation exceeds 10%, the tariff will be reviewed.

Tariffs will vary according to peak and off peak consumption, and generation plants will have two tariffs, one for fixed capacity and one for variable capacity. (ibid)

Decisions regarding tariff hikes should also consider the following factors.

The bulk and retail tariff rates must be increased in a balanced way to prevent a disproportionate disadvantage to either the consumer or the distributor.

High system losses should be reduced to decrease distribution costs.

Wastage of electricity should be reduced to contain excessive demand. (ibid)

6. Potential for Renewable Energy Electricity Generation in Bangladesh

Currently, renewable energy has a very low share of the electricity market, but the aim is to make it 10% by 2020. Out of all renewables, solar electricity is considered the most promising, and as of 2017, around 4 million solar home systems have been installed across the country. They serve 18 million people, or 11% of the total population. Sixteen solar minigrids have been approved, out of which seven are operational and the rest are under construction. There is the plan to install 50 additional minigrids by 2018. (Islam and Khan, 2017)

Bangladesh enjoys a healthy and encouraging environment for the development of alternative energy solutions for electric power. The most popular source of renewable energy in Bangladesh after hydroelectricity is solar electricity. Hydroelectric power cannot be expanded because of circumstances of geography, but solar power is expanding. Biogas is used for cooking purposes mostly. (Basu and Sharma, 2015)

The government has a favorable treatment regarding tax and duty on imported equipment. Rural Bangladesh has the highest usage of solar home systems in the world, numbering 3.5 million households. Additional 50,000 to 100,000 households are estimated to get rooftop solar connections every month in rural areas. Infrastructure Development Company Ltd (IDCOL) with around 60 partner organizations had a role in this dissemination of solar home systems. IDCOL itself receives financing from multilateral national and international donors. The sales of the solar home systems are on a microcredit basis, but collections are around 90%, which is considered an efficiency problem. (ibid)

The next stage of development in the solar energy market in Bangladesh is the minigrids. Rural households are not satisfied with only lighting and fans, but now demand to use fridges, computers and simple manufacturing devices for industrial production. They hope to create economic activity even in rural areas using solar energy. One of the advantages of the minigrid model is that it itself offers a storage device by networking different consumer profiles. This is a more efficient model, because of the major bottlenecks to reducing solar energy cost is battery storage costs. Minigrids can protect customers against load shedding, and are increasing in resilience, value and sophistication. (ibid)

Rooftop solar power in city buildings has been less of a success story, because owners acquire it as a formality to receive grid connection, and the rooftop systems remain inactive.

A study by Rahman et al predicts that the demand for electricity consumption is expected to increase exponentially, reaching 57447MW in 2040. Past records show that the actual demand of a given year exceeds the forecast demand, and we have been underestimating demand.

There was an extensive modeling study conducted using the MARKAL model by Mondal (2010) to provide decision support for optimizing the long term power supply in Bangladesh with a focus on renewable energy. The results of the study reveal that Bangladesh has a good potential for renewable energy. Among solar, wind, biomass and hydro, solar energy seems to have the best potential because of its high technical potential, and technological improvements and cost reductions are taking place.

According to this model, electricity consumption can increase to 131.6 TWh by 2035 in the low GDP growth scenario, and 1451 TWh in the high growth scenario. Of this capacity, solar PV technological improvements will determine its share in the energy mix. (Mondal, 2010)

Another study using GeoSpatial Toolkit, NASA solar radiation data and HOMER software found solar PV enjoyed the most favourable conditions for installation, and will reduce greenhouse gases. Financial indicators like Internal Rate of Return, NPV, benefit-cost ratio and simple payback all proved favourable. (Mondal and Islam, 2010).

7. Current Modes of Financing for Solar Energy in Bangladesh

The private sector plays a vital role in financing the development of the renewable energy electricity sector in Bangladesh. The most common are the private commercial banks, foreign commercial banks, NGOs and retailers. The largest financiers are the commercial banks, which provide 90% of the total financing for renewable projects. NGOs play a vital role by playing the intermediary between Infrastructure Development Corporation Ltd (IDCOL), and the end customers, by distributing loans in the form of microcredits. (SREP, 2015)

Foreign donors that contribute to the fund of IDCOL are GIZ, KFW, ADB, IDB, GPOBA, JICA, USAID, and DFID. The main partner organizations are Grameen Shakti, Rural Services Foundation, Srizon Bangladesh, and BRAC foundation. Households pay the partner organization 10-15% of the cost up front, and the rest over a three year microcredit period over a flat interest rate of 12 to 15%. Households can buy the systems outright. (ibid)

The most popular financing programs are the government led ones, with support from donor organizations. Several market based business models are under research for the rural households. There should be a market based instrument to overcome the shortage of cash for the initial high investment costs. Some consumer finance models are possible with the consumer getting credit directly from the dealer, and paying in installation, with ensured after sales services. Yet another financing option is leasing, where the dealer buys the systems in bulk, leases them to end users but retains ownership. However the lease life is longer than the other financing lives. (Kundu, 2014)

The government is encouraging the investment in renewable energy projects from the banking sector and from entrepreneurs by encouraging practices of green banking and implementing various waivers of import taxes and duties and VATs. (Habib and Shah, 2016)

According to a study by Asian Development Bank, the Infrastructure Development company limited has near term plans to install up to six million solar home systems, one hundred thousand biogas plants, 1550 solar irrigation pumps, 50 solar minigrids, and 130 biogas based power plants. The subsidy provided to solar home system purchases decreased from 25% in 2004 to 10% in 2012, due to the falling prices and improving technology of the systems. This is one indicator in the long run that renewable energy options will become more affordable. (Marro and Bertsch, 2015)

A study of the institutional barriers to renewable energy dissemination in Bangladesh reveals that an exclusive dependence on the government slows down the process due to shortage of funding, unfavorable utilities regulations, lack of coordination among agencies, slow processing and higher priorities. If the renewable energy sector were more privatized, there would be more private funding and independent entrepreneurial ventures. (Mondal et al, 2010)

8. Methodology

This study will use the following tools to gather information.

- a. Financing data will be taken from the databases of the financing organization IDCOL and other financial institutes, and the business records of the partner organizations, minigrid and grid tied project entrepreneurs.
- b. Information about government plans and policies will be gathered from government energy ministry records, and in depth interviews of key personnel in policy and decision making and implementation.

- c. Information about donor agency plans and policies will be gathered from in depth interviews of the respective people in these organizations, and any relevant organizational documents.
- d. Information about industry participants will be gathered using questionnaire surveys and interviews.
- e. Information about customer satisfaction, behavior, and preferences can be gathered using questionnaire surveys.
- f. Forecasts about future scenarios will be done with financial scenario analysis and simulation techniques using quantitative models.

9. Scope

Bangladesh has projects and activities in various renewable energy technologies like hydroelectricity, solar photovoltaic electricity, solar thermal energy and biogas. This study will focus only on the following particular sectors of the renewable energy industry of Bangladesh.

- a. Grid Connected Solar PV systems
- b. Grid Connected Rooftop solar PV systems
- c. The solar minigrid sector.
- d. Solar-diesel hybrid plants.

10. Limitations

- a. Disruptive technologies: Technology can develop is sudden milestones instead of incremental improvement, and these milestones cannot be accurately predicted.
- b. New legislation: The same apply to international and national energy policies, which are often politically decided. The assumptions about these factors will be based on hypothetical scenarios in the future, and will aim to show outcomes in commonly anticipated scenarios. This aspect of the study will be exploratory.
- c. Changes in customer behavior: Furthermore, some industries in solar energy like solar minigrids are a new industry in Bangladesh, and the consumers are new and relatively few. Their own energy and technology usage patterns and preferences will evolve rapidly, often in unpredictable ways.
- d. Changes in investment climate: There can be changes in the investment climate due to changes in the government budget, availability of private, public and foreign funds, and relative attractiveness of other industries.

Information about this will evolve from the time the research starts and throughout the research period. Therefore, in this study, some assumptions and data have to be periodically updated and changed to reflect new realities.

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Women's Right to Inheritance in Bangladesh and Turkey; A Legal Analysis

S. M. Mamun - Bin – Alam¹, Md. Abu Bakkar Siddique²

¹ Master's Student, Department of Private Law, Ataturk University, Erzurum, Turkey

² BSS (Hon's), MSS (Political Science), University of Dhaka, Bangladesh

Abstract

Inheritance is one of the important branches of personal law. It always tries to distribute the property to the legal heirs of the propositus in uniform way. Women's rights to inheritance are always a burning issue in the contemporary perspective. In the past history of human civilization it has always been seen that men were in the dominant position so the rights of women were totally disregarded. To reduce this discrimination various multinational instruments have been come to the place. All the countries are trying to secure gender equality in their respective state perspective. In this regard, inheritance law has been amended in different countries. Although Muslim law of inheritance is regulated under the direction of holy Quran, but some countries has changed this law to secure the principle of equality. This reality is very apparent in Hindu law perspective whereas under the Traditional Hindu Law there was no right to inheritance for women. But in India this traditional law has been amended. In Turkey, the rights to inheritance are regulated under the Turkish Civil Code. The fundamental guideline of this Civil Code is to secure gender equality in Turkey. So, to examine the women's rights to inheritance in Bangladesh and Turkey is a matter of great importance. The ultimate aim of this study is to analyze the women's rights to inheritance in Bangladesh and Turkey under the prevailing laws of those countries.

Key Words: Inheritance, Law of Inheritance in Bangladesh and Turkey, Women's right to inheritance.

Introduction

Law of inheritance is one of the important branches of civil law. The patterns and rights of inheritance vary between societies and sometimes they are influenced by cultural, racial, political, and legal factors. But this law becomes a great matter of issue in securing gender equality. Women's rights to inheritance come to the place to reduce the gender discrimination. As civilized nations, Bangladesh and Turkey always show their willingness to protect human dignity in domestic and international sphere. The legal system of Bangladesh is totally based on the British colonial system unlike that of Turkey. Major population of this country is Muslim. Rests of them are Hindu, Buddhist and Christian. But the country's philosophy is absolutely the secularism although Islam is the state religion of this country. Personal laws are applied for the Muslim and Hindu people of this country according to their own religion text. So, the role of Personal law is highly valued in this country. On the other hand, historically and geopolitically, Turkey is one of the influential countries in the world. Turkey is a republic which based on secular, democratic, and pluralistic principles. It was established in 1923 by Mustafa Kemal Atatürk and constitutionally protects personal rights and freedoms. Although most of its population is Muslim but it is a secular state with no official state religion. Turkish Constitution

provides for freedom of religion and conscience. The legal diversity of these countries is always a keen interest of legal study. So, the study on women's rights to inheritance of these countries is a matter of great importance.

Concept of Inheritance

Generally, the term "Inheritance" refers to the passing on property, debts, and obligations upon the death of an individual. In law, an heir is a person who is entitled to receive a share of the deceased's property, subject to the rules of inheritance of which the deceased was subject. Nobody can be an heir before the death of the deceased, since the exact identity of the persons entitled to inherit is determined only after death of the predecessor. Inheritance law governs the rights of a decedent's survivors to inherit property. These are basically those statutes and regulations affecting who is entitled to receive what from the estate of a deceased relative. It is also called as succession law (Rheinstein, Max and Glendon, Mary Ann, 1998). Succession generally means following another. In legal parlance, it means succeeding to the rights of another. This word possesses technical meaning in the law and signifies the taking of property by inheritance from the estate of a decedent; and excludes those have been taken by deed; grant, gift, or any form of purchase or contract (USLEGAL, 2012). It is to be remarkable that personal laws played the vital role for the development of this law.

Inheritance Law in Bangladesh

Bangladesh has come into existence on 26 March, 1971 after the heroic war of independence. After the war of independence, on 4th November 1972 the country adopted the Constitution. Under the constitution the Supreme Court has been established. Details power and function of the Supreme Court has been elaborately mentioned in the Constitution. But the establishment, power and function of the lower judiciary is totally the same as the British colonial system. Major population of this country is Muslim. Rests of them are Hindu, Buddhist and Christian. Although Islam is the state religion of this country but the fundamental philosophy of this state is absolute secularism. Personal laws are applied for the Muslim and Hindu people of this country according to their own religion text. But other issue is resolved under the acts of Parliament which are remarkably based on British colonial system.

The Muslim Personal Law (Shariat) Application Act, 1937 (ACT NO. XXVI OF 1937) mentioned the application of the shariat law. According to section 2 of this act, notwithstanding any custom or usage to the contrary, in all questions regarding intestate succession, special property of females, including personal property inherited or obtained under contract or gift or any other provision of Personal Law, marriage, dissolution of marriage, including talaq, ila, zihar, lian, khula and mubaraat, maintenance, dower, guardianship, gifts, trusts and trust properties, and waqfs other than charities and charitable institutions and charitable and religious endowments the rule of decision in cases where the parties are Muslims shall be the Muslim Personal Law (Shariat). So it is very clear that succession of Muslims is regulated under the personal shariat law. Muslim personal law is saliently categorized as Sunni and Shiite school. In Bangladesh, Sunni law is widely applied in all cases. Moreover, under section 4 of the Muslim Family Laws Ordinance, 1961 (ORDINANCE NO. VIII OF 1961) mentioned some criteria of distribution of property. According to this section, in the event of the death of any son or daughter of the propositus before the opening of succession, the children of such son or daughter, if any, living at the time the succession opens, shall per stirpes receive a share equivalent to the

share which such son or daughter, as the case may be, would have received if alive. In Hindu law perspective, there are two famous schools of Hindu law namely Dayabhaga and Mitakshara (Patwari, Dr. A B M. Mofizul Islam, 2005; pp 24-26). The Hindus live in Bangladesh and West Bengal of India regulates their life under the Dayabhaga School. Rest of the Hindu lives in the India follows the Mitakshara School (Patwari, Dr. A B M. Mofizul Islam, 2005; pp 27-29).

They have a so many differences on following the way of religion and cultural perspective. It is to be remarkable that, in India, the general provisions relating to the succession, is laid down in Hindu Succession Act, 1956. These provisions apply to all the properties irrespective of the fact whether it is left by a male or a female Hindu dying intestate. This act is a codification of the Hindu law of intestate succession. It introduced key changes to classic Hindu law of intestate succession. It is now uniformly applicable to all the schools of Hindus in India (Desai, 2005, pp, 283–284). But in Bangladesh, all the Hindus are belonged to Dayabhaga School. They are stick to follow the religious text. Although this acts seems discriminatory to women or any other particular class of person but Hindus are following this from time immemorial. So the Hindu laws in Bangladesh have their foundation stone on the old Hindu text, customs etc. Considering this reality, in Bangladesh, right to inheritance of a Hindu is totally governed according to their religious texts, customs and other sourced laws.

Inheritance under Muslim Law

Islam is the complete code of life. It has established through the Prophet Muhammad (pbuh). Sharia is an Arabic word means "the right path" and it generally refers to traditional Islamic Law. The Sharia comes from the Quran which Muslims consider the actual word of God. Sharia also originated from the teaching and practices of Prophet Muhammad (pbuh). Later these laws are also interpreted by certain Muslim legal scholars. Considering this reality, the ultimate sources of Islamic Inheritance Law is the Quran and teaching of the Prophet Muhammad (pbuh). So, Muslim law of inheritance is regulated under the guidance of Quran and the practice of Prophet Muhammad (pbuh).

Order of Distribution of Property

In Islam the estate of any person is distributed in the following order (Rehman, Dr. Lutf ur & Nashville, TN; 2014): Firstly, Pay for funeral expense, Secondly, Pay for the debts, Thirdly, Pay for any bequeaths and lastly, Distribution to the inheritor- The remaining part of the estate is divided among the inheritors.

Classes of Heirs

The Sunni law recognizes three classes of heirs (Husain, Athar, 2010):

- ***Ashabul faraiz***- The sharers whose shares or proportions have been fixed in the Quran.
- **The Asabah or Agnates**- They are also called Residuaries in English.

- **Dhauil-arham or Cognates or Uterine Relations-** They are also called distant kindred who do not fall in the category of sharers or Agnates.

The Sharers under Sunni Law

The sharers or Ashabul-faraiz are altogether twelve in number among them four are males and eight are females (Husain, Athar, 2010). The **four males** are: the father, the grandfather or lineal male ascendant (when not excluded), the uterine brothers, and the husband. And the **eight females** are: wife, daughter, son's daughter or the daughter of a lineal male descendant howsoever low, mother, true grandmother, full sister, consanguine sister i.e. half-sister on the father's side, and Uterine sister i.e. half-sisters on the mother's side.

Muslim Women's Right to Inheritance

Under Sunni Law of Succession, the portions of **eight female** sharers are enumerated below:

1. **Widow:** When the deceased has left no child or the child of a son she will get $\frac{1}{4}^{\text{th}}$ of the property. But when there is child or the child of a son she will get $\frac{1}{8}^{\text{th}}$ of the property.
2. **Daughter:** When she is only one and no son is there, she becomes residuary and gets $\frac{1}{2}$ of the property.

But if they are two or more, they will get $\frac{2}{3}^{\text{rd}}$ of the property.

3. **Son's daughter or the daughter of a lineal male descendant howsoever low:** With one daughter Son's daughter gets $\frac{1}{3}^{\text{rd}}$ of the property. But if there is two or more daughter son's daughter is excluded.
4. **Mother:** When co-existing with a child of the propositus or a child of his or her son, or two or more brothers and sisters whether consanguine or uterine, then she will get $\frac{1}{6}^{\text{th}}$ of the property.

When they are not available, then she will get $\frac{1}{3}^{\text{rd}}$ of the property.

5. **The grandmother:** However high if she is not excluded by a nearer true female ancestor, then she will get $\frac{1}{6}^{\text{th}}$ of the property.
6. **Full sisters:** When only one and no son or son's son, true grandfather, daughter, son's daughter or brother, she will get $\frac{1}{2}$ of the property.

When they are two or more and no such excluders, then they will get $\frac{2}{3}^{\text{rd}}$ of the property.

7. **Consanguine sisters:** When only one and no excluder as above she will get $\frac{1}{2}$ of the property.

When one, and co-existing with one full sister, then she will get $\frac{1}{6}$ of the property.

When they are two or more and no such excluder, then they will get 1/3rd of the property.

8. **Uterine sisters:** Get the same share as uterine brother, 1/6th of the property.

The portions of these heirs are mentioned in the Quran so they are called as Quaranic heirs and these females heir can never be excluded.

Hindu Women's Right to Inheritance

In Bangladesh the Hindu woman's right to property may be discussed under two headings i.e. property of which she is the absolute owner; **Stridhan** and property of which she is the limited owner **Women's estate**.

Women's absolute Property; Stridhan

Stridhan means woman's property. Whether it is stridhan or woman's estate, depends on the source from which it has been obtained (Sirothiya, Vibha, 1998; pp 2-4). However, these kinds of property may be stridhan:

- Gifts and bequests from relations
- Gifts and bequests from non-relations
- Property acquired by self-exertion, science and arts
- Property purchased with the income of stridhan
- Property purchased under a compromise
- Property obtained by adverse possession
- Property obtained in lieu of maintenance

For a married woman stridhan falls under two heads (Sirothiya, Vibha, 1998; pp 5-6):

- The sauadayika (gifts of love and affection) - gifts received by a woman from relations on both sides (parents and husband).
- The non-saudayika- all other types of stridhan such as gifts from stranger, property acquired by self-exertion or mechanical art.

Stridhan has all the characteristics of absolute ownership of property. The stridhan being her absolute property, the female has full rights of its alienation. This means that she can sell, gift, mortgage, lease, and exchange her property (Sirothiya, Vibha, 1998; pp 8-9). According to section 14 of the Hindu Succession Act, 1956, any property possessed by a female Hindu, whether acquired before or after the commencement of this Act, shall be held by her as full owner thereof and not as a limited owner. Prior to the coming into force of this Act, a woman's ownership of property was hedged in by certain delimitations on her right of disposal and also testamentary power in respect of that property (Jain, Tarun, 2008, pp 15-16).

In Bangladesh, the law regarding stridhan is completely same to that of India. But here are some differences to the succession to Stridhan. In Bangladesh Stridhan heirs are either males or

females. If a male inherits stridhan then he takes it absolutely, and on his death it passes to his heirs. But if a female inherits stridhan then she takes a limited interest in it. On her death, property passes not to her heirs but to the next stridhan heir of the female from whom she had inherited it (Zahur, Mahua, 2016, p 81).

Limited Ownership on Women's estate

The female owner of an estate has a limited power to transfer. She can transfer it only for legal necessity or for the benefit of the estate. In the case of a woman's estate, on the death of this female owner, the property does not pass to her heirs but to the heir of the last male heir.

Female Heirs

Under the Dayabhaga School, there are only eight female heirs. They are (Zahur, Mahua, 2016, p 82): the widow, daughter, mother, father's mother, father's father's mother, the son's daughter, daughter's daughter and sister. They are entitled to rank in the order of succession next after the father's father.

Widow's right

A Hindu woman can inherit property from both males and females. If a Hindu man dies leaving a widow or widows, the widow and the widows together will get a share equal to that of a son. The widow of a pre-deceased son will get the same share which is equal to that of a son if that pre-deceased son leaves behind no son. But she will get a share equal to that of a son's son if any son or son's son of a predeceased son is living. But in all cases the women will get limited interest in her husband's property. This limited interest entitles a widow to hold the property during her lifetime and she cannot transfer it without legal necessity. However a Hindu widow can claim partition of her husband's property like a male owner (Zahur, Mahua, 2016, pp 83-84).

At the ancient time a Hindu women couldn't able to marry at her widowhood. In 1856 Hindu Widow's Remarriage Act was passed by the British colonial government. Now this law is applicable also to Hindus of Bangladesh. According to this law a Hindu widow in Bangladesh can validly remarry after their husbands' death. But after such marriage a Hindu widow cannot claim her deceased husband's property as an inheritor (Zahur, Mahua, 2016, p 84).

Rights of a daughter

In the absence of a son, son's son, son's son's son and widows the daughter can inherit the property. Daughters do not inherit until all the widows are dead. Firstly the unmarried daughters have the right to have their fathers' properties ; then the married daughter who has or likely to have male issue. Two or more daughters of same class take the property jointly (Zahur, Mahua, 2016, p 84). If anyone died then the property pass to the surviving daughter. Any daughter may transfer her life interest in the property but it does not affect the rights of survivorship of the other daughters. Under the Dayabhaga law an unchaste daughter is not entitled to inherit her father's property. But if the property is transferred to her, it cannot be divested by subsequent unchastity (Zahur, Mahua, 2016, p 85).The daughter always takes limited interest in her father's property. On her death the property passes not to her heirs, but to the heir of her father (Zahur, Mahua, 2016, p 85).

Rights of other female heirs

According to Hindu succession law, a mother is also included in the list of heirs. According to the serial she takes the property after the father. An unchaste mother is excluded from succeeding to her son. But once the estate has been vested in her, it cannot be divested by subsequent unchastity (Zahur, Mahua, 2016, p 85). Remarriage also does not deprive her of the right of inheritance from the son. A mother can also inherit the stridhana of her daughter (Zahur, Mahua, 2016, p 84). Paternal grandmother and paternal great grandmother can also inherit the property of their grandsons and great grandsons. Females succeeding as heirs, whether to a male or a female take a limited estate in the property inherited by them (Zahur, Mahua, 2016, p 85).

Exclusion from inheritance under Hindu Law

There are several grounds for the exclusion from inheritance under Hindu Law. Which are (Patwari, Dr. A B M. Mofizul Islam, 2005; pp 75-76):

Moral or Religious grounds: Conversion to other religion, Deprivation from Society, Unchastity, Committing grievous sin, Committing murder, Nunhood.

Mental disability grounds: Insanity, Madness.

Physical disability: Blindness, Dumbness, Hearing disability, Impotence, Mayhem, Leprosy, Other incurable diseases

So the female heirs are also subject to these rules of exclusion (Patwari, Dr. A B M. Mofizul Islam, 2005; pp 77-78). If the any of the abovementioned ground of exclusion is found to any female heir then she will be excluded from inheritance.

Inheritance under Christian Law

In Bangladesh succession to the property of a Christian citizen is regulated under the relevant provisions of the Succession Act of 1925 (Hoque, Kazi Ebadul, 2014). Section 2(d) of the Succession Act defined "Bangladesh Christian" as a citizen of Bangladesh who is, or in good faith claims to be, of unmixed Asiatic descent and who professes any form of the Christian religion. Moreover section 5 of this act states the relationship between domicile and applicable law. According to this section, succession to the immoveable property in Bangladesh of a person deceased shall be regulated by the law of Bangladesh, wherever such person may have had his domicile at the time of his death. And succession to the moveable property of a person deceased is regulated by the law of the country in which such person had his domicile at the time of his death. So section 5 of this act specifically mentioned that succession to the movable property of the deceased will be governed by the *lex loci* i.e. where he had his domicile at the time of his death. But, succession to his immovable property will be governed by the law of Bangladesh (*lex loci rei sitae*) no matter where he was domiciled at the time of his death. Furthermore, section 6 says that a person can have only one domicile for the purpose of the succession to his moveable property.

Rights of the Widow and Widower

Sections 33, 33-A and 34 of this Act specifically say about the succession of widow. According to section 33, where the intestate has left a widow-

- (a) if he has also left any lineal descendants, one-third of his property shall belong to his widow, and the remaining two-thirds shall go to his lineal descendants, according to the rules hereinafter contained;
- (b) if he has left no lineal descendant, but has left persons who are of kindred to him, one-half of his property shall belong to his widow, and the other half shall go to those who are of kindred to him, in the order and according to the rules hereinafter contained
- (c) if he has left none who are of kindred to him, the whole of his property shall belong to his widow.

Furthermore, under section 35, A husband surviving his wife has the same rights in respect of her property, if she dies intestate, as a widow has in respect of her husband's property, if he dies intestate.

Rights of Children

According to section 36, the distribution of the intestate's property amongst his lineal descendants arises after deducting the widow's share. Moreover, under section 37, where the intestate has left surviving him a child or children and no more remote lineal descendant through a deceased child, then the property shall belong to his surviving child or children and will be equally divided among all his children. And as per 38, where the intestate has not left surviving him any child but has left a grandchild or grandchildren and no more remote descendant through a deceased grandchild, then the property shall belong to his surviving grandchild or grandchildren and shall be equally divided among the surviving grandchildren.

Rights of Mother, Brothers and Sisters

Under section 43, If the intestate's father is dead but the intestate's mother, brothers or sisters are living, and if there is no child of any deceased brother or sister, then the mother and brother or sister shall succeed to the property in equal shares. Moreover, as per section 44, If the intestate's father is dead, but the intestate's mother is living, and if any brother or sister and the child or children of any brother or sister who may have died in the intestate's lifetime are also living, then the mother and each living brother or sister, and the living child or children or each deceased brother or sister, shall be entitled to the property in equal shares. Here it is to be remarkable that such children (if more than one) taking in equal shares only the shares which their respective parents would have taken if living at the intestate's death.

Another way, under section 45, If the intestate's father is dead, but the intestate's mother is living, and the brothers and sisters are all dead, but all or any of them have left children who survived the intestate, the mother and the child or children of each deceased brother or sister shall be entitled to the property in equal shares. Here also such children (if more than one) taking in equal shares only the shares which their respective parents would

have taken if living at the intestate's death. Furthermore, according to section 46, If the intestate's father is dead, but the intestate's mother is living, and there is neither brother, nor sister, nor child of any brother or sister of the intestate, the property shall belong to the mother.

Turkish Inheritance Law

Turkey is a transcontinental country in Eurasia, mainly in Anatolia in Western Asia. It is a secular state with no official state religion; the Turkish Constitution provides for freedom of religion and conscience. The Constitution of the Republic of Turkey is known as the Constitution of 1982. It is Turkey's fundamental law. It was ratified by popular referendum during the military junta of 1980-1983 (Özbudun, Ergun, 2011, pp 192-194). The current constitution has overseen many important events and changes in the Republic of Turkey, and it has been modified many times to keep up with global and regional geopolitical conjunctures. Turkish judicial system has been wholly integrated with the system of continental Europe.

Here laws are passed by the parliament and it is uniformly applicable to all citizens. The Principle of equality is always maintained in every sphere of national levels. In succession law Turkey has focused on equality between man and woman (O'Neil, Mary Lou & Toktas, Sule, 2014, pp, 30-32). So the Turkish inheritance law is quite different to those of any religious Law.

Principles of Turkish Inheritance Law

In Turkey, inheritance laws and procedures are strictly regulated by the state. The source of these laws is Turkish Civil Code. **Turkish civil code** (*Türk Medeni Kanunu*) is one of the earliest laws in the history of Turkey within the scope of Turkish reforms. The Turkish Parliament formed a committee to compare the civil codes of European countries. To this purpose, Austrian, German, French and Swiss civil codes were examined. Finally on 25 December 1925 the commission decided the model of Swiss Civil Code will be followed for the Turkish civil code (Zweigert, Konrad & Kötz, Hein, 1979, p 176). This Code was enacted on 17 February 1926. It firstly mentioned that men and women were made equal with regard to inheritance and testimony. It made legal marriage as compulsory and banned the polygamy. The women were given the right to choose any profession. From Article 495 to 682 of Turkish civil code the rules and procedure of inheritance has been enumerated. This law is strictly tied to bloodlines and gives priority to children through a system of protected shares. The law maintains strict gender equality and says that all heirs are entitled to receive an inheritance regardless of gender (O'Neil, Mary Lou & Toktas, Sule, 2014, p 31).

Turkish Civil Code's Articles on Inheritance

Article 495 says that the successors of first degree are the deceased person's descendants, and that the children are equal successors. If there are any children deceased before the deceased person, the descendants of such deceased children will inherit in the descendants place. In Article 496, the succession of the mother and the father of the deceased person are embodied. In this instance, if the deceased person has no descendants, the mother and the father of the deceased person will be equal successors. If either one of the parties does not have any successors, then the other party will inherit all. Moreover, if deceased persons do not have parents and their descendants, then it will be succeeded by their grandmothers and grandfathers. Article 497 says like this, so that if a grandparent is deceased his/her descendants would be successors in his/her

stead. It is highly mentionable that according to Article 498, non-marital children whose parentage relations are established either by recognition or by court's judgment are successors to the deceased person as marital relatives. Furthermore, Article 500 states the rights of adoptee. Under this section the adoptee and his/her descendants will be considered as blood relative in the case of succession. The inheritance rights from the adoptee's own family will be valid. However, the adopter and his/her relatives are not successors to the adoptee in case of adoptee's death. Finally article 501 mentioned that State will be the successor of a person that does not leave any legal or testamentary successors. So the State is a secondary intestate successor.

Inheritance of Spouse

In the Turkish inheritance law, surviving spouses are also provided for inheritance (Anıl, Ela; Arın, Canan; Hacımırzaoğlu, Ayşe Berktaş; Bingöllü ,Mehveş; & İlkaracan, Pınar; 2002,p 22). Importantly, for the purposes of inheritance, the law only recognizes those spouses resulting from a civil marriage as performed by the state, officially registered and confirmed by an official marriage certificate. But if once divorced an individual may no longer inherit from their previous spouse.

According to Article 499 of the Civil Code, the proportion of the inheritance can be received by the surviving spouse varies according to with whom it will be shared:

- If the other heirs are the children of the deceased, the surviving spouse receives one quarter of the property
- If the other heirs are the parents of the deceased, the spouse receives one half of the property
- If the other heirs are the grandparents and the children of the grandparents of the deceased, the spouse receives three quarters of the property
- If there is no other heir except the spouse, he or she receives all of the property

Rights of other Female Heirs

Article 506 of the Civil Code specifies a minimum share of the deceased's property, which must go to the surviving spouse, children, parents or grandparents. A woman's marital status does not affect her right to inherit from a blood relative. As Article 649 of the Civil Code establishes equality between heirs and women enjoy the same rights of inheritance as their brothers (Anıl, Ela; Arın, Canan; Hacımırzaoğlu, Ayşe Berktaş; Bingöllü ,Mehveş; & İlkaracan, Pınar; 2002, p 23). Even the will of the deceased cannot change the obligatory legal share of the woman in any way. In the event of any infringement of this right, the woman has access to the courts. Furthermore, there is no difference in the shares of inheritance conferred upon foreigners marrying Turkish citizens. They have the right to claim the same proportion of inheritance as their counterparts who are citizens of Turkey.

Conclusion

Under the above discussion, it is very clear that in Turkey, inheritance law is regulated through the principle of gender equality. This has been made through the Atatürk's Reforms policy. This

policy contained a series of political, legal, religious, cultural, social, and economic policy changes that were designed to convert the new Republic of Turkey into a secular, modern state. So the application of personal laws is totally undermined in this country. On the other hand, In Bangladesh, the role of personal law is highly valued. Law of inheritance for Muslims and Hindus is totally regulated under the personal laws. But it is very clear that Hindu Law of Inheritance is absolutely discriminatory. Here the women's right to inheritance is totally disregarded. To resolve this problem, Hindu Succession Act, 1956 has been made in India and this is uniformly applicable to all Hindus in India. So it's high time to pass such kind of legislation in Bangladesh. If Bangladesh Government passes this kind of legislation for the protection of Hindu Women's rights to inheritance, then definitely it will be a bold step ahead to protect the women's right in Bangladesh.

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