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ISSN 1019-9624

RDA JOURNAL

বাংলাদেশ পল্লী উন্নয়ন সমীক্ষা
Bangladesh Rural Development Studies

খন্ড ২৩ | ১৪২৭ | সংখ্যা ১
Volume XXIII | 2020 | Number 1

প্রবন্ধ । Article

Rural Development Academy (RDA), Bogura
Bangladesh

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Volume XXIII | Number 1 | August, 2020

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প্রকাশক ঃ **মহাপরিচালক**
পল্লী উন্নয়ন একাডেমী
বগুড়া-৫৮৪২,বাংলাদেশ।

Published by : **Director General**
Rural Development Academy (RDA)
Bogura-5842, Bangladesh
Phone: 88-051-51001, 051-78602, 051-78603
Fax: 88-051-51615
Cell: 88-01713200937, 88-01713200938
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মূল্য ঃ টাকা ২০০.০০ (প্রতিষ্ঠানের জন্য)
টাকা ১০০.০০ (ব্যক্তিগত ক্রয়ের জন্য)
মার্কিন ডলার ৪.০০

Price : Tk. 200.00 (For Institution)
Tk. 100.00 (For Individual)
US $ 4.00

Cover Design : **AKM Zakaria**
Md. Kamrul Islam

Computer Getup and Makeup : **Md. Ahsan Ullah Khan**

Printed by : Print Media, Bogura

সূচি
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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 01

Linking the Youth to their Livelihoods: A Case of Kurigram District

Dr. Md. Shafiqur Rashid[1]

ABSTRACT

This paper investigates the impact of National Service Programme (NSP), an effort to link the unemployed rural youth to their livelihoods by providing training and temporary job placement support. The beneficiaries were expected to be confident so as to manage a job or to get self-employed and thereby, improving their standard of livelihoods due to the intervention. The study pursues a non-experimental design and applies Mann–Whitney U test, logit and multiple regression models with the application of propensity score matching to assess the programme effect on confidence building, the probability of being employed and the improvement of livelihoods respectively. The study results show that the level of confidence of treated group was higher than that of the untreated group. A person who received training was 12.7% more likely to be employed than someone who did not receive training. The treated group outspent the untreated group in food, health and education expenditure per week by 3.40, 2.70 and 2.20$ respectively. The outcomes resulting from NSP ware found to be quite encouraging.

INTRODUCTION

In view of youth unemployment challenges, many governments of developing countries have taken policies of considerable investment in youth employment programmes making them complementary to general poverty reduction and employment policies. The government of Bangladesh is not an exception in this regard. In response to the challenges, National Service Programme (NSP) promoting employability of young people was iplemented. NSP is a welfare assistance porgramme which provided training and temporary employment to unemployed young people so that they could either ensure self-employment or manage a job. The study aims at evaluating the impact against some of major objectives of NSP.

1. Joint Director, Rural Development Academy (RDA), Bogura, Bangladesh

Overview of NSP

NSP was designed to promote employability of unemployed youth by offering knowledge, skills, and job experiences to help them manage either a job or self employment. NSP was government funded programme and implemented by Department of Youth Development (DYD) under the Ministry of Youth & Sports between March 2010 and October 2013. Each participant received a three month training programme along with a temporary job support for two consecutive years under nation building departments of the government of Bangladesh such as agriculture, administration, co-operatives, fishery etc. They received a lump sum monthly salary during this period. In the post intervention period, they were expected to get employed or self-employed and thereby, improving their livelihoods.

Beneficiary Selection

For a participant to be selected as a beneficiary of the programme, a youth had to satisfy the following three criteria. The candidate

- was unemployed at the time of application;
- was in the age group of 18 –35 years; and
- had at least 10 or 12 years of formal education.

Training Module

The following 10 training modules were designed for the beneficiaries:

- Nation and character building training module;
- Self-employment training module;
- Disaster management and social service training module;
- Basic computer training module;
- Module on idea of different service sectors of the government;
- Health and family planning service related training module;
- Agriculture, forest and environment related training module;
- Education and physical education related training module;
- Social security, law and order related module and
- Union *Parishad* (unit of local government) and *Upazila Parishad* (immediate upper level unit of Union *Parishad*) service related module.

The first four modules were compulsory for each beneficiary and they had to choose one of the last six modules during the three months' training period.

REVIEW OF LITERATURE

Evidence from various programmes designed to tackle youth unemployment worldwide has identified several factors responsible for youth unemployment (Betcherman, Godfrey, Puerto, Rother, & Stavreska, 2007). These are: a lack of skills and experience, the fluctuation of demand and supply of labour, low economic growth, labour market regulations and taxes against youth, school-to-work transition problem (the youth are at a loss what to do for developing career just after finishing their school education), rising youth population, and the lack of social network.

To address the youth unemployment emerging out of the dynamics of those factors, the interventions in different countries come forward with tools like career counseling, job search assistance, internships, entrepreneurship training, vocational and life skills training, loan facility, temporary wage subsidy, creation of opportunity of having temporary job experience etc. A programme aiming at promoting youth employment has used more than one tool together (World Bank Group, 2012). Youth Employment Inventory (YEI) has documented design, implementation, and results of more than 400 youth employment programmes from 90 countries (World Bank, 2010). According to YEI report, the knowledge about what works efficiently under an intervention is not elaborately known due to a lack of rigorous evaluation (Betcherman et al., 2007).

Every year a large number of young people with low quality of education and training and without a proper link enter the labour market. Lack of skills, experience and job search abilities, inadequate loan facility and lack of access to business networks cause higher barriers for the young people to face high constraints to enter into the labour market and to become entrepreneurs (Coenjaerts, Ernst, Fortuny, Rei, & Pilgrim, 2009). "underutilized young people incur significant economic costs as the national workforce is not being used to its full potential and can trigger a vicious circle of intergenerational poverty and social exclusion" (Coenjaerts et al., 2009:2). The youth represent potential human capital which Bangladesh as a poor resource base country cannot afford to neglect. Against this backdrop, the government of Bangladesh launched National Service Programme. Rural Development Academy, Bogura and Transparency International conducted two separate evaluation studies which did not focus on some aspects. Firstly, both studies mainly focused on process rather than outcome evaluation. Some major areas of investigation were: to what extent budgetary allocation and expenditure methodology was justified; the issue of transparency regarding monetary allocation and expenditure; the justification of fixing target group, the soundness of services delivery to the beneficiaries under the programme etc. (Transparency International Bangladesh, 2013). Some elements of process evaluation included the advertisement process, applicant selection process, the justification of curriculum preparation, appropriateness of training environment (Department of Youth Development, 2013). The transparency in spending money was quite satisfactory. However, the facilities of training venues were poor. The environment of training rooms was not as conducive to learning as was necessary for the participants to concentrate in training session. Poor venue facilities and training materials and huge number of trainees in most batches made the environment less conducive (Department of Youth Development, 2013, p. 23). Apart from such qualitative evaluation, the studies did not concentrate in quantitative enquiry on outcome

evaluation with inferential statistics. As a result, such evaluation was merely a gross evaluation rather than a precise and unbiased estimate of the programme effect. Finally, this type of intervention is on the rise in Bangladesh. Youth unemployment interventions have been implemented with limitations and challenges with diverse backgrounds in various countries. Hence outcome evaluation is considered to be necessary for figuring out what changes took place due to a specific programme. Thus, there is a constant need of feedback to cast light on critical areas for further improvement in making the programme more pro youth and effective.

The existing literature shows that caste, culture, sex, family, area (rural and urban), economic growth, demand and supply of labour and labour market regulations strongly influence the youth unemployment. A meta-analysis from a sample of 172 evaluated studies shows that "program success is not determined by the type of intervention but rather by the program's targeting strategies toward disadvantaged youth, the country level of development, and the flexibility of the labor market regulations" (Puerto, 2007: 18). The situation of youth unemployment is determined by how those factors play out in a dynamic growth context, will vary across countries and regions. The interventions to address the problem differ in context and in pursuing tools (instruments). The table below shows some interventions along with their instrument, study design and empirical findings.

Table-1 Interventions to Address Youth Employment with Empirical Findings

Programme	Instrument	Study Design	Empirical Findings of Evaluation
Entrepreneurship Training and Self-Employment among University Graduates implemented in 2009 in Tunisia	Training and seed capital to establish business	Quasi experimental design with a mixed method	Treated participants were on average 46 to 87 percent more likely to be self- employed than untreated participants (Premand et al., 2012). The programme fostered business skills, expanded networks, and affected a range of behavioral skills of treated participants (Premand, Brodmann, Almeida, Grun & Barouni, 2012).
Young Rural Entrepreneurs Training Programs implemented between 2004 and 2010 in Colombia	Training on technical skills	Quasi experimental with quantitative method	It increased participants' employment rate by about 14 percentage points compared to the control group (World Bank Group, 2012).
Youth Opportunity Program implemented between 2005 and 2009 in Uganda	Vocational andlife skills training with cash grant	Quasi experimental with quantitative method	Two thirds of the treated group found skilled work compared to one-third of the control group. The treated group reported a 45 percent increase in net earnings in the post intervention period (World Bank, 2012).
Ninaweza implemented between 2011 and2013 in Kenya	Technology and life skills training, internships, and job placement support	Experimental design with randomized controlled trial	Treatment group was 14% more likely to obtained jobs than control group. The gains in weekly income were 445 KES (Kenyan currency) higher for those in Treatment than control group (World Bank & International Youth Foundation, 2013).

As seen in the table above, evaluation studies also differ in designs, methodologies and objectives. Each programme to address unemployment is unique. One intervention does not bear a resemblance to another one in terms of attributes. However, one programme can benefit from another programme through modification and refinement. Thus, the continuance of impact evaluations is a must for indentifying loop-holes and feedback to engineer and better suit the programme in response to the intricacy of youth unemployment. NSP is worth evaluating from this perspective.

Research Question

The participants were expected to raise their level of confidence, manage a job or to get self-employed, and to improve their living standard due to the effect of intervention. In strict relevance, the study puts some questions to be answered through investigation. Did the intervention increase their confidence level? What was the probability of being employed or self-employed? Did the intervention improve their living standard?

OBJECTIVES OF THE STUDY

The intervention transferred technical and life skills training to enhance participant's employability skills and bolster their confidence level through attitudinal change so that they could be self-employed or employed in private or public sector. As such, the specific objectives of the study are:

I. To analyze the post intervention employment status of the participants;

II. To assess the level of confidence of the participants (if any) and

III. To analyze the outcome change in the livelihood status of the participants.

METHODOLOGY

An outcome is what a programme is expected to have changed. "Program effect refers to that portion of an outcome change that can be attributed uniquely to a program as opposed to the influence of some other factor" (Rossi, Lipsey, & Freeman, 2004: 236). The outcomes of NSP and the objectives of the evaluation study have been framed in the figure below. The figure shows three distinct areas where NSP aims to bring changes due to the intervention.

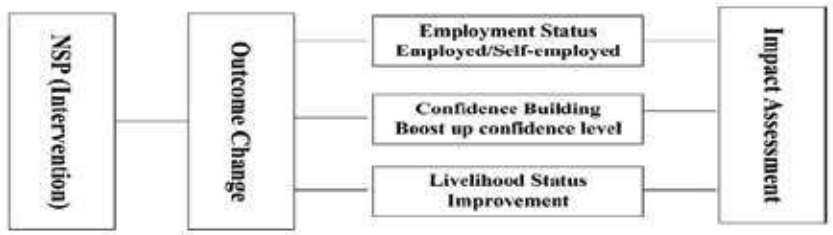

Figure 1: Conceptual Framework

Youth

The study lends the definition as has been taken in the project operational manual. Youth refers to the people between 18 and 35 years of age.

Unemployment

It refers to the state of being out of work or the engagement in temporary work with inadequate income to lead a decent life.

Employment and Self-employment

Employment refers to managing a permanent job either in public or private sector whereas self-employment refers to engagement of beneficiaries in small business of their own such as selling or buying or producing any product.

Employment Status

The study analyzed the probability of finding employment by the intervention (training), sex, age, education, area of residence (rural or urban), household income, marital status, grade score and personal capability score.

Confidence Building

As evidenced by relevant literature, socio-emotional skills enhance the employability and quality of employment. The employers value certain behaviors and attitudes which are linked to workers with higher productivity (Heckman, Stixrud & Urzua, 2006). Under NSP programme, the knowledge and skills were transferred to the trainees. Their attitudes changed accordingly and these were supposed to reflect in their level of confidence. The variable-confidence building-was measured by an 11 point (0—10) scale. Each individual was asked to rate six factors on the scale and thus generated 6 separate scores. These scores rated by an individual on all six factors were summed to create a single score. The group score (treated or untreated) was estimated by averaging all the individual scores of a group. The six factors which the respondents rated were:

- Rate your confidence of having appropriate knowledge in running a small business.
- Rate your confidence of having appropriate skills in running a small business.
- Rate your confidence of managing finance necessary to establish a small business.
- Rate your confidence of having appropriate knowledge in managing a job.
- Rate your confidence of having appropriate skills in managing a job.
- Rate your confidence of bearing expenditure needed in managing jobs.

Livelihood Status

The study lends the definition given by Chambers and Conway. "A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living" (Chambers & Conway, 1991: 11). A good livelihood necessarily means good standard of living. In order to capture the improvement of livelihood, the study concentrated in measuring the standard of living in terms of monthly expenditure increase in health, education and food.

Study Design

The study investigated a quantitative inquiry to answer the research questions, pursued a non experimental design and ran both parametric and non-parametric tests. Those who participated in the programme were regarded as treated group and those who did not participate were regarded as comparison group.

Study Area

National Service Program was implemented in *Kurigram* district of Bangladesh on pilot basis. The study covered all the nine *Upazilas* (immediate lower administrative unit of district) of *Kurigram* district.

Sampling and Data Collection

The data was collected from both primary and secondary sources. Secondary data was collected from the data bank maintained by the Department of Youth Development having its operating branch in each Upazila and primary data, from the respondents. Respondents were both the beneficiaries (treated) and non-beneficiaries (untreated) who applied for being considered as beneficiary but were not selected. The treated group consisted of 200 beneficiaries. The study followed a male and female ratio of 5:3 in selecting respondents as the same ratio was also maintained in selecting beneficiaries of NSP. These 200 beneficiaries were randomly selected from a data set containing a list of 1350 beneficiaries, 150 beneficiaries from each *Upazila*. The study used a data set of 600 non-beneficiaries to form the comparison group through propensity score matching. These non-beneficiaries (600) were also randomly selected from a larger data set containing a list of 1350 non-beneficiaries and 150 non-beneficiaries from each *Upazila*.

Variables

The study dealt with 15 variables for quantitative analysis. Among those 15 variables, 10 were independent and five were dependent variables. Out of 10 independent variables, eight were binary and two are continuous variables.

Independent Variables

i. Treatment Variable: (Where1= treated and 0 = untreated)

ii. Sex Variable: (Where 1= male and 0 = female)

iii. Age Variable: (Where 1= greater than or equal to 25 years of age and 0 = less than or below 25 years of age)

iv. Marital Status Variable: (Where 1= married and 0 = unmarried)

v. Residence Variable: (Where 1 = residence in urban area and 0 = residence in rural area)

vi. Study Background Variable: (Where 1= science and 0 = non-science)

vii. Grade Score Variable: (Where 1= good score and 0 = average score, grade score was calculated based on Secondary School Certificate (SSC) level education)

viii. Monthly Household Income Variable: (It is a continuous variable)

ix. Education Variable: (Where 1= education above Secondary School Certificate (SSC) and 0 = education up to Secondary School Certificate).

x. Personal Capability Score Variable (PCS): Each individual was asked to answer 10 close ended questions with yes/no answers and was given 1 score for the answer 'yes' and 0 for the answer 'no'. PCS is the total score of all the scores obtained by an individual from ten questions. Each respondent was asked to whether any of those factors could increase his or her likelihood of getting employed or self-employed. The factors put forward in question form were: i) Do you think --- i) help from your friends ii) help from relatives (help in the form of money, information or recommendation) iii) your mobility within country (movement from one place to another in search of a job) iv) the access to mobile v) the access to internet vi) the access to newspaper vii) the access to computer viii) the access to library ix) the ability to write application and prepare resume and x) the membership of job agency increased your chance of being employed or self-employed?

Output or Dependent Variables

The data set of the study had five dependent or outcome variables (Y). One out of five variables was dummy variables. Three variables were continuous and one variable was ordinal data.

i. Employment Variable: (where 1= if employed or self-employed and 0 otherwise)

ii. Food Expenditure Variable: This refers to monthly household expenditure increase in food and is a continuous variable.

iii. Health Expenditure Variable: This refers to monthly household expenditure increase in health and is a continuous variable.

iv. Education Expenditure Variable: This refers to monthly household expenditure increase in education and is a continuous variable.

v. Confidence Variable: This variable (ordinal data) has been measured by an 11 point (0—10) scale.

Data Analysis

The study has three areas of investigation, namely confidence building, post intervention employment status, and improvement of livelihood. The participants undergoing any training programme are necessarily expected to gain confidence. Having considered this perspective, the level of confidence of the treated and untreated groups was compared through Mann-Whitney U test. The probability of having been employed or self-employed by age, education, sex, area of residence (rural or urban), marital status, grade score and personal capability score was analyzed by logit mode along with propensity score matching. Finally, the livelihood improvement was assessed by estimating Average Treatment Effect on the Treated (ATT) through Ordinary Least Square regression. Stata has produced all the analyses.

Logit Model

Logit model is a probability model used to predict a binary response based on one or more predictor variables. It measures the relationship between a dependent variable (categorical) and one or more independent variables. It can be seen as a special case of generalised regression model and thus analogous to linear regression. The probability of assignment to the treatment is estimated as:

$$G(x) = \frac{e^{\beta 0 + x\,\beta 1}}{1 + e^{\beta 0 + x\,\beta 1}}$$

Propensity Score Matching (PSM)

In absence of an experimental design, an individual with treatment and an individual without treatment differs in both pre-treatment characteristics and treatment status. As a result, both participation and the outcome of interest are affected. Hence we need a non-treated individual who is similar to a treated individual (counterfactual). The impact of the intervention is estimated by comparing the difference of outcomes of treated individual and non-treated but similar to treated individual (counterfactual). The propensity score shows an individual's probability of belonging to the treatment group or conditional probability of being treated given the individual covariates. It balances all pretreatment group differences in observed covariates X. Covariates are balanced if the joint distribution of X is the same in the treatment and control group, i.e. $P(X \mid Z= 1) = P(X \mid Z = 0)$ (Rosenbaum & Rubin, 1983). Here Z denotes treatment variable. The propensity score has the property that treatment assignment Z is independent of covariates.

Matching Methods

Regarding the selection of matching algorithms for propensity score, the study used four matching methods as explained by (Becker & Ichino, 2002). In Nearest Neighbor Matching, for each treated observation, a control observation which has the closest x (covariates) is selected. In this regard, matching with replacement has been pursued. Matching with replacement increases the quality of matching and decreases the selection bias (Caliendo & Kopeinig 2005). In Radius

Matching, each treated observation is matched with control observations that fall within a specified radius. In Kernel Matching, each treated observation is matched with several control observations, with weights inversely proportional to the distance between treated and control observations. Stratification Matching compares the outcomes within intervals or blocks of propensity scores.

Mann–Whitney U Test

This test is non-parametric statistical hypothesis test for assessing whether two independent samples of observations have equally large values (Majhi & Khatua, 2013). In other words, it compares the differences between two independent samples when the variable is either ordinal or continuous, but not normally distributed.

RESULTS AND DISCUSSION

The study investigated three aspects of NSP which include the confidence building of the beneficiaries, the probability of being employed and the improvement of livelihood. The confidence levels of both groups were compared through Mann-Whitney U test. The null and alternative hypotheses under the test were as follows:

H_o: The level of confidence of both groups (treated and untreated) was equal

H_a: The level of confidence of treated group was higher than that of untreated group

Table-2 Mann-Whitney Test Result

Group	Observation	Rank-sum	Expected
Treated	200	58054	40100
Untreated	200	22146	40100
combin ed	400	80200	80200
		Unadjusted Variance	1336667
		Adjustment for ties	-77582.6
		Adjusted Variance	1259084
		Z =	16.001
		Pro>Z	0.000
		P{score(treated) > score(untreated} =	0.949

Since the test statistics from the table above shows that P score of treated group is greater than P score of untreated group and the result is statistically significant (Prob> z = 0.000), null hypothesis H_0 is rejected. Therefore, it can be concluded that the level of confidence of treated group was higher than that of untreated group.

The study assessed the probability of being employed of the youth under NSP in the light of 10 explanatory variables which include sex, age, education, household income, residence, study background, grade score, marital status, personal capability score and training.

Table-3 Probability of Employment as a Function of Independent Variables

Marginal effect after logit							
y = Pr (employment) (predict) = .02798033							
Variable	**dy/dx**	**Std.Err.**	**z**	**P>z**	**[95%**	**C.I.]**	**X**
Age	0.047	0.0116	4.05	0	0.024	0.07	0.496
Sex	-0.025	0.0096	-2.62	0.009	-0.044	-0.006	0.57
Marital Status	-0.0069	0.0076	-0.91	0.361	-0.021	0.007	0.483
Education	0.036	0.0113	3.16	0.002	0.013	0.058	0.495
Household Income	0.000	0.000	-1.35	0.178	-0.00004	7.4	100023.8
Residence	0.01	0.0104	1.05	0.296	-0.0095	0.031	0.397
Study Background	0.04	0.0146	2.75	0.006	0.0115	0.068	0.431
Grade Score	0.036	0.0123	2.94	0.003	0.012	0.06	0.431
P Capability Score	0.043	0.0091	4.69	0.000	0.025	0.061	6.5
Training	0.127	0.0371	3.42	0.001	0.054	0.199	0.25

The table above shows that the influence of marital status, household income and residence on the likelihood of being employed was not statistically significant. However, training, sex, age, education, study background, grade score and personal capability score variables were found to have statistically significant effect on the probability of being employed. The probability of being employed of a person receiving training was 12.7% higher than someone who did not receive training. A male compared to female was 4.7% more likely to get employed. The individuals above 25 years of age were 2.5% less likely to be employed than the individuals aged below or equal to 25. The youths with educational qualification above SSC level were 3.6% more likely to be employed than those with educational qualification up to SSC level. The probability of a person's having a job with science background was 4% higher than that of a person with non-science background (Table-3). The probability of finding a job for a person with a good grade score was 3.6% more than that of a person with a moderate grade score. For each additional unit change in personal capability score, the probability of finding employment increased by 4.3%.

The study assessed the improvement of livelihood on the basis of weekly expenditure increase in food, health and education items. The study assumed that an individual after getting employed would increase his or her expenditure due to the increase in income. As such, the increase of expenditure on those items points to the improvement of livelihood. ATET (Average Treatment Effect on the Treated) estimation on nearest neighbor matching (N.N.) shows that due to the programme effect, a treated individual spent 3.70 $ more on food than that of an untreated individual (Table-4).

Table-4 ATET Estimation of Expenditure on Food

Treated Individual	Untreated Individual	ATT($)	Std. Err.	t	Matching
200	183	3.70	12.633	15.876	N. N.
200	568	3.83	15.040	15.097	Radius
200	568	3.86	13.766	16.631	Kernel
200	568	3.82	18.361	12.301	Stratification

The other estimations (radius, kernel and stratification matching logarithms) show almost the same results. A treated individual compared to an untreated one spent 2.70 $ more on health (Table-5) and 2.20 $ more on education (Table-6).

Table-5 ATET Estimation of Expenditure on Health

Treated Individual	Untreated Individual	ATT($)	Std. Err.	t	Matching
200	183	2.70	11.731	17.299	N. N.
200	568	2.75	11.458	17.897	Radius
200	568	2.74	12.256	16.712	Kernel
200	568	2.72	12.993	15.743	Stratification

The amount of expenditure increase in food, health and education items according to the ATET estimation indicates a fairly improvement in the status of livelihood of treated individuals.

Table-6 ATET Estimation of Expenditure on Education

Treated Individual	Untreated Individual	ATT($)	Std. Err.	t	Matching
200	183	2.20	11.731	17.299	N. N.
200	568	2.24	11.458	17.897	Radius
200	568	2.23	12.256	16.712	Kernel
200	568	2.24	12.993	15.743	Stratificatio n

Limitation and Validity of Results

The success of an impact evaluation depends on finding a good comparison group (Khandker, Koolwal & Samad, 2010). "An evaluation is internally valid if it uses a valid comparison group" (Gertler, Martinez, Premand, Rawlings, & Vermeersch, 2011: 266). From this perspective, the findings could be questioned as the comparison group has not been formed through randomization as pursued in randomized experiment. Propensity Score Method (PSM) has been applied to minimize the selection bias while estimating treatment effects with observational data.

PSM defines "a subject's probability of receiving specific treatment conditional on the observed covariates. Conditioning on the propensity score allows one to replicate some of the characteristics of a randomized controlled trial" (Austin, 2007: 2039). It balances the distribution of baseline characteristics. As a result, the treated and untreated subjects which are matched on the propensity score become similar. It can produce unbiased estimates of the treatment effect given that the treatment selection is strongly ignorable. However, randomization is expected to balance both measured and unmeasured variables between treated and untreated subjects while PSM balances only measured baseline variables. Consequently, the subjects (treated and untreated) may not be balanced on unmeasured characteristics. This imbalance can cause biased estimation. This study is not free from such weakness. Another important point of validity is the external validity. "An evaluation is externally valid if the evaluation sample accurately represents the population of eligible units" (Gertler et el., 2011: 266). Post intervention baseline data was collected with due attention to the sample size, response error and under-coverage aspect to make the sample representative. Besides, the study ran Ramsey Reset test. The result [F (3, 786) = 109.41 line, Prob > F = 0.0000] shows that the model adopted by this study had no omitted variables. In other words, there was no evidence of misspecification, meaning that independent variables were not suffering from non-linear combinations as much as could be harmful for the model to produce bias estimation. The study also measured Variance Inflation Factors (VIF) to see multicollinearity in the regression analysis.

Table-7 Variance Inflation Factor (VIF)

No.	Variable	VIF
1.	Household Income	1.98
2.	Personal Capability Score	1.88
3.	Study Background	1.82
4.	Grade Score	1.79
5.	Residence	1.61
6.	Sex	1.16
7.	Education	1.15
8.	Training	1.14
9.	Age	1.05
10.	Marital Status	1.04
	Mean VIF	1.46

The mean VIF of all the explanatory variables under the study is 1.46 which indicates the acceptable degree of multicollinearity in the analysis (the mean score of VIF up to 10 is acceptable as a rule of thumb).

CONCLUSION

The study results show that the level of confidence of treated group was higher than that of the untreated group. The seven variables having statistically significant effect on the probability of being employed were training, sex, age, education, study background, grade score and personal capability score. A person who received training was 12.7% more likely to be employed than someone who did not receive training. For each additional unit change in personal capability score, the probability of being employed increased by 4.3%. The variable training had greater effect than all other variables. A fairly positive association was also found between personal capability score and employment. These associations are suggestive of actions to continue such programme and also actions to be taken to enhance personal capability score in future intervention. The study measures whether the livelihood of treated individual was improved. ATET estimation shows that a treated individual outspent an untreated individual on education by 2.2 $ a month, and on health 2.70 $ a month. The food spending of treated individual was also greater than an untreated individual by 3.70 $ per week. The treated and untreated groups had 35.5% and 21% employment (job and self-employment) rate respectively. Therefore, the success of NSP was quite encouraging. NSP dealt with the insufficiency of basic skills regarded as barrier to overcome unemployment. However, the success of this strategy is subject to the availability of jobs in the market. The other side of the coin is that even a skilled person may remain unemployed because of fewer job opportunities. In such a situation, a programme like NSP will not yield expected result. Therefore, any policy to address youth unemployment should be considered in wider context in the light of the interrelationship of economic growth, population growth rate and structure, urbanization, the expansion of service sector, skill mismatch and demand and supply of labour market.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 02

Status and Prospect of Ornamental Fishes in Selected Districts of North-Western Region of Bangladesh

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ABSTRACT

Ornamental fish is becoming popular both in domestic and international trade. The study was carried out to investigate the present status and prospects of ornamental fish culture, breeding and the trade. Three districts viz. Bogura, Rangpur and Dinajpur of North-Western region of Bangladesh were selected for the study. One ornamental hatchery, 20 fish traders, 20 fish keepers and 21 aquarium shops were interviewed through a semi-structured questionnaire from May 2018 to April 2019. A total of 46 species of ornamental fish were identified of which 32 were exotic and 14 were indigenous species. The exotic species were exported from Thailand, India, Japan, Singapore, USA, and South America. The exotic ornamental fish species belongs to 17 families and seven orders whereas indigenous species to seven families and four orders. The Cypriniformes (25%) was the dominant order followed by Cyprinodontiformes, Characiformes, Siluriformes, Perciformes and so on. Attractive color of ornamental fish was major criteria for preference of aquarium fish followed by body shape and behavior. Most of the respondent encompassed low level of knowledge of breeding biology, culture and management. The major problems were lack of information about available species, breeding technique, disease, trading facility etc. With increasing demand and suitable environment for propagation, it has potential to expand. So, contemporary research on breeding, culture, disease with treatment should be conducted. Profitable marketing channel along with potential markets in national and international level should also be developed for the sustainability of the business.

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INTRODUCTION

By born the peoples are pleasure seeker in nature. Therefore, human being engaged in different hobbies to be blissful. Ornamental fish keeping is one of the most popular hobbies in developed countries and became popular in developing countries day by day (Ansari et.al., 2014). Ornamental fish in aquarium provide rich aesthetic experience. Aquarium fish and accessories industry is now gaining importance due to its prospects and tremendous economic opportunities(Pandey and Mandal, 2017).Internationally, the ornamental fish keeping considers as an industry due to its high market demand and profitability.It has been rated as second most popular pet in industrialized country (Olivier, 2001). The US $ 5 Billion trade and an annual growth rate of 8 percent offers a lot of scope for development. The top exporting country is Singapore followed by Hong Kong, Malaysia, Thailand, Philippines, Srilanka, Taiwan, Indonesia and India. The largest importer of ornamental fish is the USA followed by Europe and Japan (Dar et.Al., 2010).Most of the ornamental fish lovers usually keep them in their houses and offices in order to bring a different look to the place where they staying. The aquarium fish business results in rapid cash production and is relatively easy to start as a hobby or small scale farming enterprises (Kangkon, 2013). For developing countries, the reproduction of ornamental fish represents a great opportunity for income growth in rural communities(Olivier, 2001).Bangladesh has a richness of natural resources such as suitable climate, natural rivers and traditional experience in the culture of fish so that the Bangladeshi farmer can readily culture aquarium fish (Rahman et.al., 2009) and it has been started already.

Bearing in mind the importance of this newly promising field, many young people's are drawn in aquarium fish trade. Aquarium fish business became very popular in many cities of Bangladesh such as Dhaka, Rajshahi, Khulna, Jessoreetc(Kangkon, 2013). There are vast opportunities of aquarium sector not only in the local market but also in world market. But, it is still couldn't develop according to the desire of the consumer as well as the provider. Information about status, trend and problems are available in worldwide (Woeltjes, 1995;Biffar, 1997; Andrews, 1990). Although, some information about status, trade, prospect, breeding of ornamental fishes are remaining in Bangladesh based on the Dhaka, Shylet, Barishal, Khulna city but in North-Western region it has been completely absent. By taking into account this, the objectives of this research are-

Objectives:

- To investigate the availability of ornamental fishes in three selected districts of North-Western regions
- To assess the problems and prospect of culture, breeding and trade of ornamental fishes in the study areas

MATERIAL AND METHOD

Location and duration of the study

For the purpose of the study three districts namely Bogura, Rangpur and Dinajpur of North-Western region (Figure-1) of Bangladesh were selected. The study was performed during May, 2018 to April, 2019.

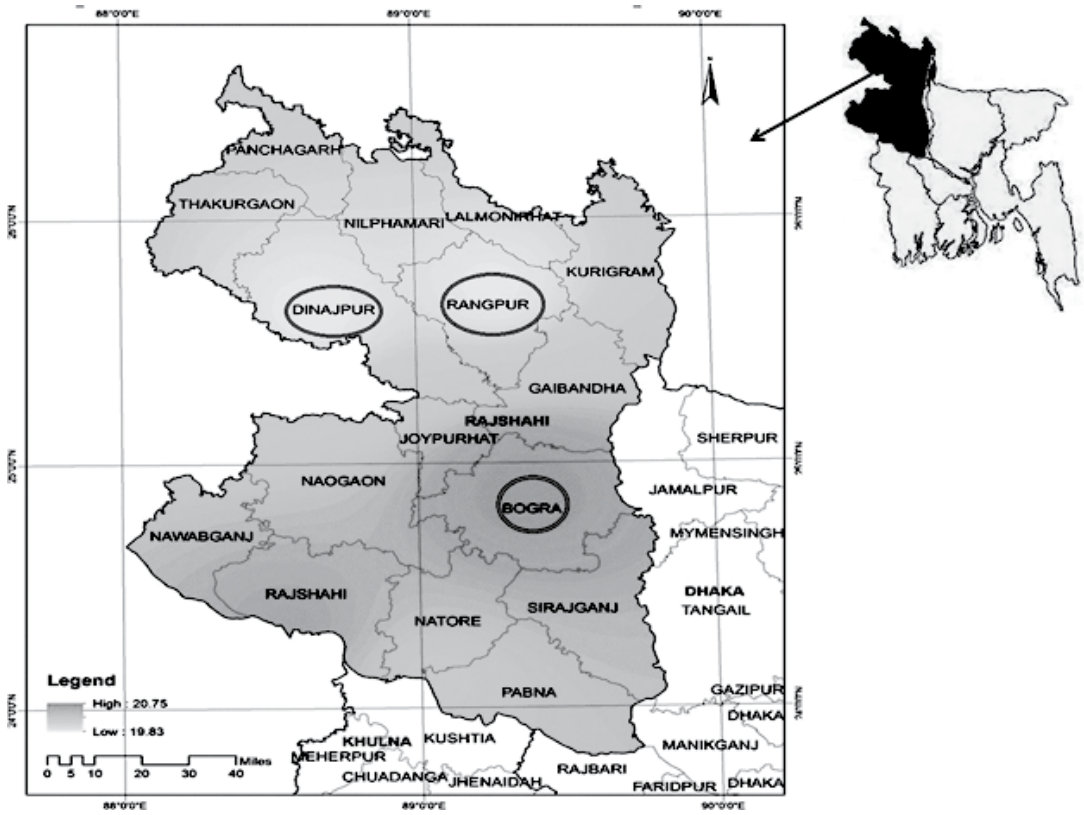

Figure-1: The marked area showing the study area (Source: Google map)

Data collection

A semi structured questionnaire was prepared for documenting all the primary data. Primary data were collected year round through face to face interview for getting the more reliable and useful information from one ornamental hatchery, 20 fish traders, 20 fish keepers and 21 aquarium shops of three selected districts.

Data analysis

The collected data were sorted out and analyzed by using Microsoft office excels 2007. Tables, pie-charts, diagrams etc. were used to interpret the results with the help of simple statistical measure like arithmetic mean, percentage and ratio.

RESULT AND DISCUSSION

A total of 46 species of ornamental fish including 32 exotic and 14 indigenous were identified from the selected study area. The available fishes are listed together with details of availability and their customer demand represented in Table-1 and 2.The origin of identified exotic ornamental species were Thailand, India, Japan, Singapore, USA, and South America. From the Barishal division 29 ornamental fish species wereidentified (Alamet.al., 2016). A total of 29 fish species were also identified from Khulna district. Among them 20 species were identified as exotic and rest of them were indigenous(Rahman et. al., 2009). Rahman (2005) recorded at least 25 aquarium fish species in Bangladesh and Mohsinet. al., (2007) found about 12 exotic and 2 indigenous aquarium fishes in Rajshahi city. Arifet. al.,(2018)observed 22 ornamental fish in Sylhet-SadarUpazilla. The available ornamental fish species is quite higher compared to other area and to previous years in the north-western region in Bangladesh. Thus this business were expanding with the course of time through importing from different countries.

Table-1: List of exotic ornamental fishes in selected districts of North-Western Region of Bangladesh (BOG=Bogura, RP= Rangpur, DP=Dinajpur; ***High demand, **Medium demand, *Low demand)

Order/Family	Local name	Scientific name	Origin	BOG	RP	DP
CYPRINIFORMES						
Cyprinidae				✓	✓	✓
Cyprinidae	Tiger Koi Carp	*** *Cyprinuscarpio*	Japan	✓	✓	✓
Cyprinidae	Assorted Koi Carp	*** *Cyprinuscarpio*	Japan	✓	✓	✓
Cyprinidae	Goldfish	*** *Carassiusauratus*	Thailand & India	✓	✓	✓
Cyprinidae	Black moor	*** *Carassiusauratus*	Thailand & India	✓	✓	
Cyprinidae	Tiger barb	* *Barbustetrazona*	Thailand & India	✓		
Cyprinidae	Rosy barb	*** *Barbusconchonius*	Thailand	✓	✓	
Cobitidae	Coolie loach	** *Acanthophthalmus semicinctus*	Thailand & Singapore		✓	
CYPRINODONTIFORMES						
Poeciliidae	Balloon Molly (Golden)	* *Poeciliasphenops*	Thailand & India	✓	✓	
Poeciliidae	Balloon Molly (White)	* *Poeciliasphenops*	Thailand & India		✓	✓

Order/Family	Local name	Scientific name	Origin	BOG	RP	DP
Poeciliidae	Black Molly	** *Poeciliasphenops*	Thailand & India			
Poeciliidae	Mixed Color Molly	*** *Poeciliasphenops*	Thailand & India	✓	✓	✓
Poeciliidae	White Molly	* *Poeciliasphenops*	Thailand & India	✓	✓	
Poeciliidae	Guppy	*** *Poeciliareticulata*	Thailand & India	✓	✓	✓
Poeciliidae	Sail fin Guppy	** *Poeciliareticulata*	Thailand & India	✓		
Poeciliidae	Platy	*** *Xiphophorusmaculatus*	Thailand & India	✓	✓	✓
CHARACIFORMES						
Characidae	Cardinal tetra	* *Cheirodonaxelrodi*	Thailand		✓	
Characidae	Golden tetra	** *Hemigrammusarmstrongi*	Thailand & Singapore	✓	✓	
Characidae	Yellow tetra	* *Hyphesobryconbifascia*	Thailand	✓		
Characidae	Silver dollar	*** *Metynnisroosevelti*	Thailand & Singapore	✓	✓	✓
Characidae	Glass tetra	* *Moenkhausiasanctaefil*	Thailand	✓		
Characidae	X-ray fish	* *Pristellariddlei*	Thailand & Singapore		✓	
Rivulidae	Longfin	** *Pterolebiaslongipinnis*	Thailand & Singapore	✓		✓
CICHLIFORMES						
Cichlidae	Angelfish	*** Pterophyllumscalare	Thailand & India	✓	✓	✓
Cichlidae	Blue acara	* Aequdenslatifrons	Thailand	✓		
Cichlidae	Festivum	* Cichlasomafestivum	Thailand	✓		
SILURIFORMES						
Siluridae	Glass catfish	*** *Kryptopterusbicirrhis*	Thailand & Singapore	✓	✓	✓
Pangasiidae	Thai Pangus	* *Pangasiussutchi*	Thailand	✓	✓	
Aspredinidae	Banjo catfish	* *Bunocephalus coracoideus*	Thailand	✓	✓	✓
Callichthyidae	Albino cat fish	* *Albino corydores*	South America	✓		

Order/Family	Local name	Scientific name	Origin	BOG	RP	DP
Loricariidae	Sucker mouth catfish	*** *Hypostomusplecostomus*	South American	✓	✓	✓
PERCHIFORMES						
Pomacanthidae	Blue angle fish	** *Holacanthusbermudensis*	USA	✓	✓	✓
Pomacanthidae	Arabian angelfish	* *Pomacanthusasfur*	USA	✓		
Scaridae	Parrot fish	*** *Bolbometopon sp.*	Thailand	✓	✓	✓
ANABANTIFORMES						
Osphronemidae	Siamese fighting fish	*** *Bettasplendens*	Thailand and India	✓	✓	✓
Osphronemidae	Paradise fish	*** *Macropodus opercularis*	Thailand & Singapore	✓	✓	✓
Osphronemidae	Blue gourami	** *Trichogastertrichopterus*	Thailand & Singapore	✓	✓	
ATHERINIFORMES						
Telmatherinidae	Celebes rainbowfish	** *Telmatherinaladigesi*	Thailand	✓	✓	✓
OSTEOGLOSSIFORMES						
Pantodontidae	Butterfly fish	* *Pantodonbuchholzi*	Thailand	✓	✓	

Table-2: List of indigenous ornamental fishesin selected districts of North-Western Region of Bangladesh (BOG=Bogura, RP= Rangpur, DP=Dinajpur; ***High demand, **Medium demand, *Low demand)

Family/ Groups	Local Name	English Name	Scientific Name	BOG	RP	DP
CYPRINIFORMES						
Cyprinidae	Darkina	Striped Rasbora	*** *Rasboradaniconius*	✓	✓	✓
Cyprinidae	Rani mach	Queen loach	*** *Botiadario*		✓	✓
Cyprinidae	Darkina	Zebra Danio	* *Brachydaniorerio*	✓	✓	✓

Family/ Groups	Local Name	English Name	Scientific Name	BOG	RP	DP
Cyprinidae	Kanchan Punti	Rosy barb	** *Pethiaconchonius*			✓
Cyprinidae	MolaPunti	Glass barb	* *Pethiaguganio*	✓	✓	✓
Cyprinidae	Tit punti	Ticto barb	* *Pethiaticto*			✓
PERCIFORMES						
Ambassidae	Chanda	Indian Glass Perch	** *Parambasisranga*	✓	✓	✓
Tetraodontidae		Ocellated puffer fish	*** *Tetradoncutcutia*		✓	
Tetraodontidae	Patoka	Milkspotted puffer	*** *Chelanodonpatoca*	✓	✓	
Osphronemidae	Lal Khailsha	Red Gourami	*** *Trichogasterlalius*	✓	✓	✓
SILURIFORMES						
Bagridae	Tengra	Striped Dwarf Catfish	* *Mystusvittatus*	✓	✓	✓
Heteropneustidae	Colored shing	Stinging catfish	* *Heteropneustesfossilis*		✓	
SYNBRANCHIFORMES						
Mastacembelidae	Baim	Tiretrack - Spinyeel	* *Mastacembelusarmatus*		✓	✓
Mastacembelidae	Baim	Spiny Eel	* *Macrognathus aculeatus*		✓	

Diversity of the identified ornamental fishes in the selected area

The identified ornamental fish species belonging to 21 families, 11 orders (Table-1 & 2). The ornamental fish diversity among 46 identified fish species were 32 exotic fishes and 14 indigenous fishes. The 32 exotic speciesbelong to 17 families and seven orders and the 14 indigenousspecies included sevenfamilies and four orders. The diversity of indigenous of ornamental fish species is lower than exotic ornamental fishes. Order wise diversity of the ornamental fishes from the selected area were determined (Figure-3). The highest number of fishes was found in Cypriniformes (25%) followed by Cyprinodontiformes (15%), Characiformes (14%), Siluriformes (13%), Perciformes (13%). Arif et. al., (2018) recorder only four order of ornamental fishes as Perciformes, Cypriniformes, Siluriformes and Characiformes of which Perciformes (45.45%) was dominant. Galib et al (2013) observed three order of fishes in Jashore district sold in the shop as Cypriniformes, Perciformes and Siluriformes. They found highest (52.94%) number of fish species in Cypriniformes order. Cypriniformesemerge as most dominant groups about 54% of the ornamental fish in Barishal division (Alam et. al., 2016). Mohsin et. al., (2013)also reported that Cypriniformes are the most common and dominant fish order in Bangladesh which supports our findings.

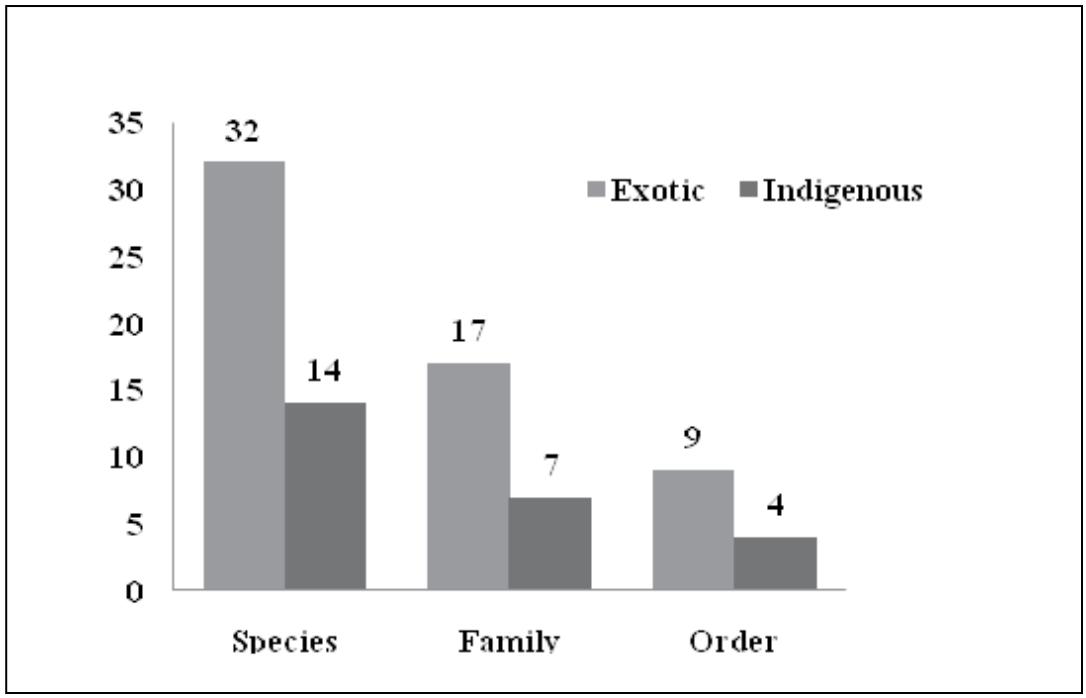

Figure-2: Diversity (Order, family and species) of the identified ornamental (Indigenous and exotic) fishes

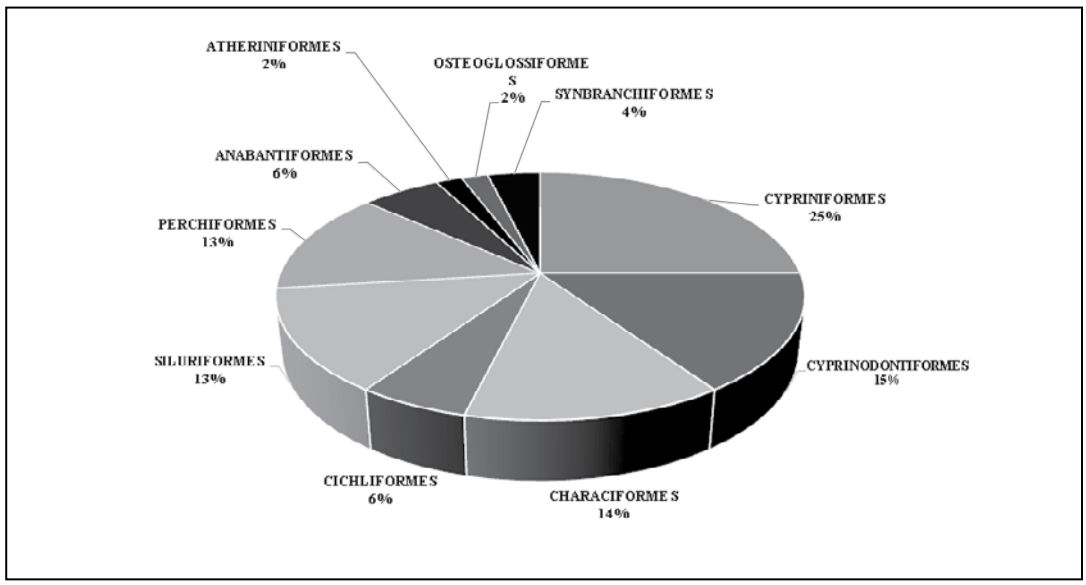

Figure-3: Order wise diversity of exotic ornamental fishes in selected areas

Demand of ornamental fish

The demands of the identified fishes are divided as highly demanded, medium demanded and low demanded from the selected area. About 43% fishes were recognized as highly demanded (Figure-4). The fishes are goldfish, tiger koi carp, assorted koi carp, black moor, rosy barb, platy, guppy, sail fin guppy, mixed color molly, silver dollar, angelfish, glass catfish, sucker mouth catfish, parrot fish, siamese fighting fish, paradise fish, striped rasbora, rani mach, ocellated puffer fish, red gourami and milk spotted puffer (Table 1 & 2).

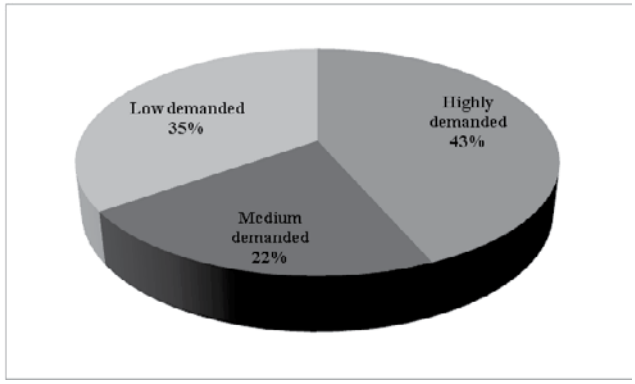

Figure -4: Percentage of ornamental fish demand in the selected districts in north-western of Bangladesh

Attraction in aquarium keeping

In most of the cases, color (37%) of fish becomes the privilege for aquarium keeping as it bring joyful environment. Body shape of the ornamental fish was found as second criteria for picking aquarium, followed by behavior (21%) (Figure-5). Whereas Arifet. al.,(2018) revealed that maximum number of the users (70%) was keeping aquarium fish for their attractive color.

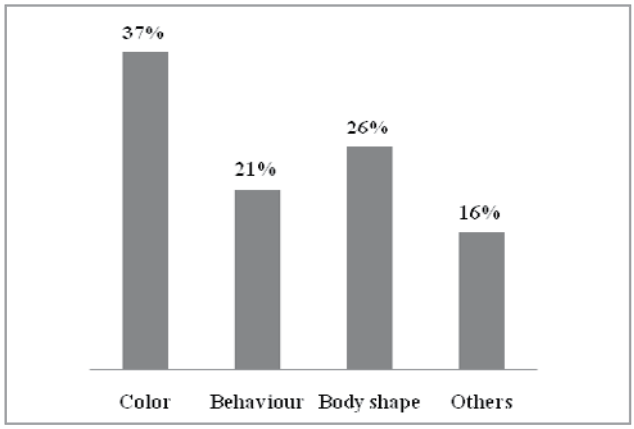

Figure-5: Preference criteria for attracting ornamental fish

Level of knowledge

Most of the stakeholder of ornamental fish as trader, fish keeper, and shop owner possesses low level of knowledge in breeding biology, culture, management and feeding in surveyed areas. Only 18% respondent gained high level of knowledge. Chowdhury et. al.,(2005) found that 73% employee of aquarium shop possess good knowledge in only keeping ornamental fish in aquarium.

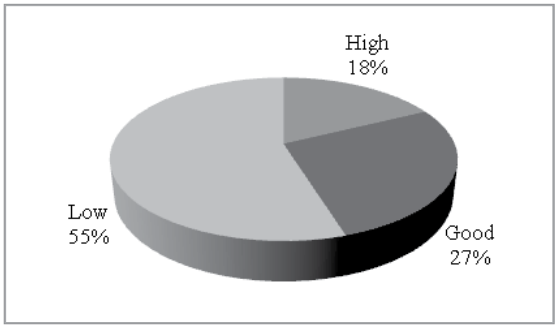

Figure-6: Percentage of level of knowledge of hatchery owner, ornamental fish trader, keeper and shop owner

Problems

Although aquarium fish business has immense opportunity in world market as well as in Bangladesh there exist many problems in context of our country. The major problems are-

- In our country, there are no reliable information about the status of ornamental fish species currently trades
- Gap exists through the integration in trading activities
- There is lack of information as well as interestto breed and produce the demandfull aquarium fishes rather the suppliers are more interested in importing
- Deficient of research based knowledge subsists about the behavior, feeding and breeding technology of ornamental fishes
- There is no proper document about the diseases and treatments of indigenous aquarium fish
- Acceptability of Bangladeshi aquarium fish in the world's market absent
- Available data about the native ornamental fishes to adopt as a aquarium fishes also lacking
- Aappropriate marketing channel for buying and selling the aquarium fishes is needed for commencement and sustainability of the business
- As a lack of the proper knowledge the selected hatchery owners cross breed the ornamental fishes with other species and deterioted the quality ofthe respected fishes like color, size, body shape etc.

Prospects

Globally, ornamental fish culture is getting great impetus due to its tremendous economic opportunities and prospects, and is holding second position among the popular hobbies next to photography(Pandey and Mandal, 2017). Since this sector has greater potential in earning foreign exchange and employment generation, it is valued as a momentous sector across the globe. Majority of the elite people keep aquarium for decorating house and office. Lots of people want to touch the nature when back to the home. Many of the people keep aquarium as symbol of status and sometimes as hobby. Besides this, now aquaria are kept in the high quality diagnostic centers, some educational institutes, shopping centers, cinema halls, seminar and conference halls etc.Ornamental fishes have great demand in world market as well as Bangladesh. In Bangladesh, it has huge resources, suitable market, available of man power and suitable environment. Till now, majority of demandable fish like silver shark, tiger barb, giant danio, red-tailed shark, molly, guppy, platy, angelfish, siamesefighting fish which were being produced locally in India and exported to our country. As a result, a lots of money we expand for importing to meet up the demand of ornamental fishes. If we breed the demandable ornamental fishes which are imported from various countries; may build ornamental fish hatchery and produce commercially ornamental fry and can save a lot of money every year. Besides, the high quality produced ornamental fishes has a great demand in world market. So, we can earn a lot of foreign money by exporting good quality ornamental fishes. The activities of aquarium preparation are very easy and feasible. The involvement as an entrepreneur of educated, young and unemployment people can increase the prospect of this work. Not only this, for the management of ornamental fishes in aquarium there have need fish feed, medicine, aquarium accessories.These will increase job opportunity and employment of many people.Tourism is one of sources of foreign exchange in our country. We have many tourist spots. We can keep aquarium in the public place, show room, high class shopping center, gymnasium etc. Thus, these will attract people and increase the value of these places. Besides this, exhibition of ornamental fish can be taken at different place of the country. In this case, feed are provided by the viewers. But they should buy that feed from the exhibition center. This will also increase the demand of ornamental fish culture.

Recommendations

In our country, we have great potential of ornamental fish culture, management, business besides some problems. Thus following recommendation should be emphasized to overcome.

- Identification of the indigenous ornamental fish and the feasibility as a aquarium fish should be studied
- Intensive research should be taken for demandable ornamental fish production in our country
- Ornamental exotic fish breeding technology should be improved
- Culture technique of high quality ornamental fish should be improved so that can easily access the global market and reduced the amount of import of aquarium fish

- Identification of Aquarium fish diseases and appropriate treatment may be identified and make it available in the fish market
- Cross breeding technique to improve the variety and color of the aquarium fish may be developed
- Profitable marketing channels and potential development of markets for selling aquarium fish is also high preference
- Credit from both the government and non-government for the development of this sector should be allocated.

CONCLUSION

Ornamental fish farming can be a promising substitute for rural livelihood. The study represents potential of exploring ornamental fish sector in Bangladesh through proper initiatives. Therefore species specific research is prerequisite for the required information of ornamental fish.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 03

Constraints Faced by the CCDB Beneficiaries for Biochar Promotion

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ABSTRACT

The study was undertaken to determine the extent of constraints as faced by the CCDB beneficiariesfor biochar promotion. The study was conducted in NawabganjUpazila under Dinajpurdistrict. Ninety eight (98) CCDB beneficiaries were selected as sample from a recent list biochar promoters using random sampling method. Data were collected by a pre-tested interview schedule during 15 March to 15 May 2017. Besides the usual descriptive statistical parameter, Pearson's Product Moment Correlation Coefficient (r) was used for the statistical analysis. The highest proportion (60.2 percent) of the CCDB beneficiarieshad faced medium constraint, while 36.7 percent had low and only 3.1 percent had faced high constraint for biochar promotion. Among the 10 selected characteristics of the CCDB beneficiaries, four (4) of them namely annual income, credit received, innovativeness and knowledge on biochar showed negative and significant relationship with the constraints of biochar promotion. The top rank constraint faced by the CCDB beneficiaries was 'lack of fuel-wood materials' followed by 'cooking habit with traditional stove' was 2nd and 'difficult to control Chula temperature' was the 3rd constraint for biochar promotion.

Key words: *Constraints, CCDB Beneficiaries, Biochar Promotion*

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INTRODUCTION

General background

Bangladesh is the largest deltaic country with a population density of 1253 people live per square kilometer area in the country. There are around 15.18 million farm households and over 45.0% people of the country directly rely on agriculture. The contribution of agriculture to national GDP is 14.17% of which 10.98% come from the crop sector. The government predicts that with a high growth rate 1.59%, the total population will rise to approximately 265 million by 2050, putting increasing pressure on scarce resources (land and forest) for additional demand of food and energy (BBS, 2017).Climate change is another threat and it is frequently cited Bangladesh as one of the most vulnerable countries in the world (Karim, 2015; Huq and Ayers, 2007). In addition, Bangladesh has been suffering frequent disaster due to global climatic change (Karim and Thiel, 2017).Bangladesh's Intended Nationally Determined Contribution (INDC), published in September 2015 and puts forth an unconditional contribution to reduce GHG emissions by 5% within 2030 from existing mitigation actions, such as: improve energy efficiency, renewable energy development, lower emissions from agricultural land and waste as well as afforestation (MOEF, 2015).

Biocharis charcoal made from organic residues that are carbonized at temperatures between 450-750°C in the absence of oxygen or pyrolysis process (BBI, 2015). Biochar is produced in an environmentally friendly manner by recycling plant waste (Cui, 2015, Lehmann, 2009) that is often used as a soil amendment (Leach *et al.*, 2010). Biochar is a multi-purpose innovation which is rapidly growing the attention of researchers. An ideal use of biochar is waste management for promoting eco-friendly agriculture. The benefits of organic farming seemed to be environmentally friendly and helpful for climate change mitigation (Karim, 2018_a).It is proved from biological research that when biochar is combined with compost or manure it absorbs soluble minerals, and reduces greenhouse gas to the atmosphere. Biochar also increases water-holding capacity, pore space and microbial activities in the soil (FAO, 2010). Transforming biomass into biochar may prevent emissions of greenhouse gases (Scholz *et al.*, 2014). Biochar producing stoves *Akha* provides clean energy for cooking andbiochar for soil amendment (Karim, 2018_b).

In 2013, Bangladesh Biochar Initiative (BBI) is formulated to foster the use of biochar producing stove and its end product biochar for environment friendly cooking mechanism and agricultural development. Canadian scientist Professor Dr. Julian Winter and CCDB(Christian Commission for Development in Bangladesh) policy advisor MdMahbubul Islam recently invented low cost natural draft-Top-Lit-Up-Draft (TLUD) gasified stove (local name *Akha Chula*) which is environment and agriculture friendly and can be used for cooking and heating with locally available biomass (BBI, 2015). CCDB has been fostering biochar promotion for the improvement of socio-economic conditions of the marginal and poor ethnic communities. The study was undertaken to assess the constraints for promoting biochar produced through *Akha Chula* or Top-Lit-Up-Draft (TLUD) among the beneficiaries of tribal households.

OBJECTIVES OF THE STUDY

a) To determine and describe the selected characteristics of the CCDB beneficiaries.
b) To determine the constraints faced by CCDB beneficiaries for biochar promotion.
c) To explore relationship between selected characteristics of CCDB beneficiaries and their constraints faced for biochar promotion.

Importance of the study

Around 98-99% of the rural household women burn biomass fuels by traditional cook stoves for cooking and heating their daily food materials. A traditional stove is a mud built cylinder with three raised points on which cooking utensil keep (Mobarak *et al.*, 2012).The governmenthas been working for solving indoor air pollution and fuel wastage through inefficient traditional stoves. Since 2000, different government and non-government organizations have been involved in the designing and disseminating of Improved Cook Stoves (ICSs). As per the Country Action Plan for clean cook stove (CAP-2013), the Government of Bangladesh set the vision of achieving 100% clean cooking by 2030. It is estimated that Bangladesh market still has the potential to empower 24 to 27 million households to adopt clean and improved cookstove. The target of this CAP is to disseminate improved cookstoves to over 30 million households in Bangladesh by 2030 (BCAP, 2013). Within this context that application of organic manure, in the form of biochar, may emerge as a possible solution for the small-scale agricultural sector in Bangladesh. The emphasis on the local production of biochar is made possible through the introduction of improved stoves (TLUD)/*Akha*, allowing household to produce own organic matter, simultaneouslygenerating efficient heat for cooking food materials as well as reducing hazardous smoke during cooking.Biochar using is a challenging job because it is not as like as normal firing. Therefore, production and using of biochar can be increased, if constraints faced by the beneficiaries in practicing this technology are identified and minimized. As a result, wider dissemination of biochartechnology will become possible.

METHODOLOGY

Locale of the study

The study was conducted in Nawabganj Upazila under Dinajpur district. Most of the CCDB beneficiaries of this area are directly engaged in biochar promotion activities. The map of Dinajpur district and Nawabganj Upazila are presented in Figure 1.

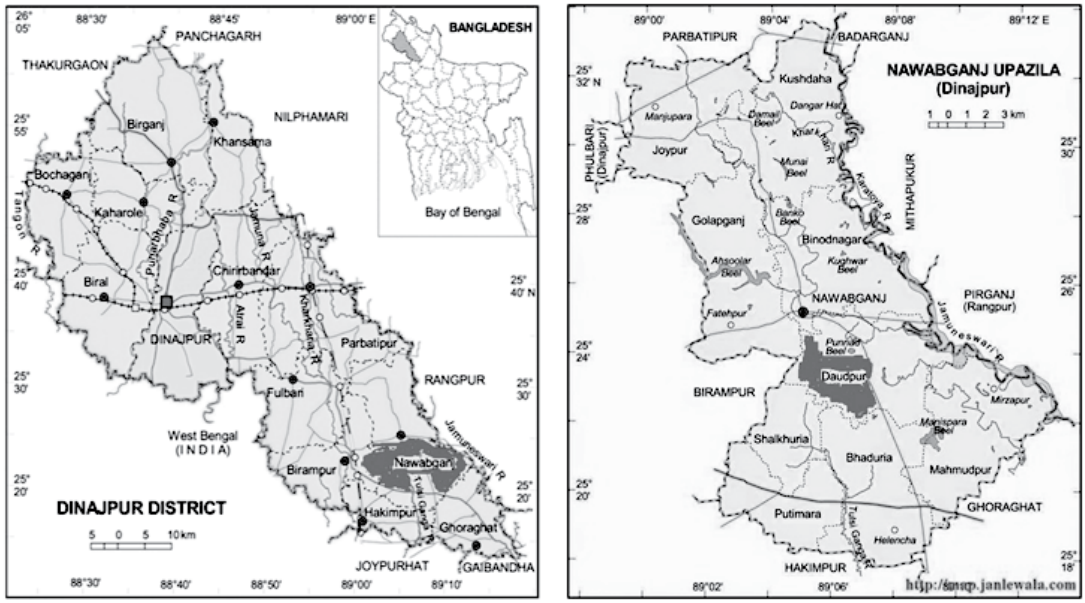

Figure 1. Maps of Dinajpur District and NawabganjUpazila indicating the study area

Sampling procedure

Bangladesh Biochar Initiatives (BBI) with the support of Christian Commission for Development in Bangladesh (CCDB) has been implementing biochar promotion program in Nawabganj Upazila under Dinajpur district. An updated list of 229 beneficiaries of biochar promotion programwas collected from CCDB record. So, the total population of this study was 229. Among the 229 beneficiaries, a sample of 98 was selected by random sampling technique.

2.3 Measurement of selected characteristics and focus issue

The selected characteristics were measured following appropriate techniques. Constraints for biochar promotion werethe focus issue. Four point rating scale was used to determine constraints. The scale contained 10 constraints of biochar promotion related to biochar promotion activities. Each respondent was asked to express his/her opinion in the form of one of the 4 responses such not at all, low, medium and high and scores of 0, 1, 2 and 3 were assigned respectively in the responses for an item. The overall constraints of biochar promotion were computed by adding together all the individual scores obtained by him/her for all the constraints. Therefore, the possible overall constraints score of a respondent could range from '0 to 30' where 0 indicating no constraint and 30 indicating very high constraint faced by the respondents. In order to compare the constraints, the Constraints Facing Index (CFI) was computed using the following formula:

$$CFI = (C_n \times 0) + (C_l \times 1) + (C_m \times 2) + (C_h \times 3)$$

Where,

C_n = Number of respondents indicating constraint as 'not at all'
C_l = Number of respondents indicating constraint as 'low'
C_m = Number of respondents indicating constraint as 'medium'
C_h = Number of respondents indicating the constraint as 'high'

Constraints Facing Index (CFI) for any one of the selected constraint could range from 0 to 294, where, 0 indicated no constraint and 294 indicated highest constraint.

Data collection, processing and analysis

An interview schedule was prepared both with close and open form questions. Data for this research were collected from the respondents through personal interviewing during 15 March to 15 May 2017. After data collection, data were coded, compiled, tabulated and analyzed in accordance with the objectives of the study. The analysis was performed using Statistical Package for Social Science (SPSS 20.0) computer package.

RESULTS AND DISCUSSION

Selected characteristics of the CCDB beneficiaries

The salient features of the selected characteristics were described in Table 1. Data revealed that 48 percent of the respondents were young aged followed by 38.8 percent of the respondents belonged to the middle aged categories and 13.3 percent were in the old aged category. It meant that majority of the CCDB beneficiaries in the study area were young aged. They are innovative and adopted new ideas and technologies for agricultural development.

Table 1. Distribution of the respondents according to their selected characteristics

Characteristics (measuring unit)	Categories	Respondents		Mean	Standard Deviation
		Frequency	Percent		
Age (Year)	Young (up to 35)	47	48.0	37.64	11.464
	Middle aged (36-50)	38	38.8		
	Old (>50)	13	13.3		
Education (Year of schooling)	Illiterate (0)	2	2.0	4.883	3.6204
	Can sign only (0.5)	27	27.6		
	Primary (1-5)	25	25.5		
	Secondary (6-10)	43	43.9		
	Above SSC (<10)	1	1.0		
Family size (Number)	Small (≤ 4)	75	76.5	3.61	1.622
	Medium (5-6)	15	15.3		
	Large (above 6)	8	8.2		

Characteristics (measuring unit)	Categories	Respondents		Mean	Standard Deviation
		Frequency	Percent		
Farm size (Hectare)	Landless (<0.02)	9	9.2	0.8761	0.87862
	Marginal (0.02-0.20)	20	20.4		
	Small (0.21-1.0)	44	44.9		
	Medium (1.01-3.0)	25	25.5		
	Large (above 3.0)	0	0.0		
Annual income ('000' BDT)	Low (≤93)	67	68.4	82.16	43.032
	Medium (94-186)	27	27.6		
	High (above 186)	4	4.1		
Training received (Day)	No training (0)	27	27.6	3.53	4.059
	Short (0-5)	48	49.0		
	Moderate (6-10)	14	14.3		
	Long (>10)	9	9.2		
Credit received ('000' BDT)	No credit (0)	31	31.6	3.49	4.512
	Low (1-10)	63	64.3		
	Medium (10-20)	3	3.1		
	High (>20)	1	1.0		
Innovativeness (Score)	Low (≤5)	15	15.3	9.19	3.955
	Medium (6-10)	43	43.9		
	High (above 10)	40	40.8		
Extension media contact (Score)	Low (8-13)	52	53.1	13.31	3.474
	Medium (14-19)	42	42.9		
	High (>19)	4	4.1		
Knowledge on biochar (Score)	low (≤6)	44	44.9	8.6	6.063
	Medium (7-12)	24	24.5		
	High (above 12)	30	30.6		

Findings indicated that highest proportion (43.9 percent) of the respondents had secondary education, 27.6 percent could sign only, and 25.5 percent had primary and only 2 percent of them were illiterate. It revealed that majority of the CCDB beneficiaries had primary and secondary level of education.More than two-third (76.5 percent) of the respondents had small family size followed by 15.3 percent had medium and only 8.2 percent had large family. It meant that majority of the CCDB beneficiary had small family size. About 45 percent of the respondents were small farm sized followed by 20.4 percent marginal, 25.5 percent medium farm size and only 9.2 percent were landless. There was no large farm size respondents found in the study area. Therefore, majority of the CCDB beneficiaries had small farm size in the study area. Majority (68.4 percent) of the respondents had low family income compared to 27.6 percent had medium and only 4.1 percent under high income group. So, majority of the CCDB

beneficiaries had low income in the study area. About 49.0 percent of the farmers had short training compared to 27.6 percent under no training, 14.3 percent under moderate training and only 9.2 percent had long term training. It could be said that majority CCDB beneficiaries had short term training in the study area. More than half (64.3 percent) of the respondents received low credit compared to 31.6 percent no credit, 3.1 percent medium credit and only 1.0 percent received high credit from different sources. It indicated that majority of the CCDB beneficiaries had low credit opportunities in the study area. Around 44 percent of the CCDB beneficiaries had medium innovativeness followed by 40.8 percent high innovativeness and only15.3 percent had low innovativeness. It could be said that majority (84.70 percent) of the CCDB beneficiaries had medium to high innovativeness in terms of practicing improved agricultural practices. Therefore, innovativeness to new agricultural technologies was satisfactory in the study area. About 43 percent of the CCDB beneficiaries had medium extension media contact, 53.1 percent had low extension media contact and only 4.1 percent had high extension media contact. It meant that more than half of the CCDB beneficiaries had low extension media contact. This may be due to the reason that CCDB beneficiaries had less opportunity to contact with different extension media. About 45 percent of the farmers had low knowledge on biochar compared to 24.5 percent medium knowledge and 30.6 percent had high knowledge on biochar. Therefore, majority (55.10 percent) of the CCDB beneficiaries had medium to high knowledge on biochar. It could be said that knowledge on biochar of the CCDB beneficiaries was satisfactory in the study area (Table 1).

Overall constraints faced by the CCDB beneficiaries for biochar promotion

The overall constraintsof the CCDB beneficiaries varied from 8 to 23 varied against the possible score 0 to 30. The mean and standard deviation of the overall constraints were 13.87 and 2.863 respectively. On the basis of the overall constraints, the respondents were distributed into three categories as presented in Table 2.

Table 2. Distribution of the respondents according to their overall constraints

Range		Categories	Respondents		Mean	Standard Deviation
Possible	Observed		Frequency	Percent		
0-30	8-23	Low (8-13)	36	36.7	13.87	2.863
		Medium (14-19)	59	60.2		
		High (above 19)	3	3.1		
		Total	98	100		

Data contained in Table 2 indicated that the highest proportion (60.2 percent) of the farmer had faced medium constraint, while 36.7 percent had low and only 3.1 percent had faced high constraint of using biochar. It could be said that more than half of the CCDB beneficiaries faced medium constraints in biochar promotion. Similar findings of facing medium overall constraints were observed by Roy (2014) and Noman (2012) in their respective studies.

Rank order of the constraints for biochar promotion

The constraints faced by the CCDB beneficiaries were measured by Constraint Facing Index (CFI). The CFI varied from 43 to 203 against the range of 0 to 294. Based onCFI, the constraints were distributed into following categories as presented in Table 3.

Table 3.Rank order of the constraints for biochar promotion

Sl. No.	Constraints for biochar promotion	Frequency of respondents				CFI	Rank order
		Not at all	Low	Medium	High		
1.	Cooking habit with traditional stove	12	8	41	37	201	2nd
2.	High price of *Akha Chula*	56	41	1	0	43	10th
3.	Unavailability of *Akha Chula*	24	38	25	11	121	6th
4.	Lack of fuel-wood materials	2	16	47	31	203	1st
5.	Inadequate training on *AkhaChula* use	27	46	21	4	100	8th
6.	Storage problem ofbiochar	34	29	26	9	108	7th
7.	Biochar use confined to small farm	9	27	40	22	173	5th
8.	Difficult to control *Chula* temperature	14	6	45	33	195	3rd
9.	Lack of information for biochar use	0	33	52	13	176	4th
10.	High price of biochar	39	46	13	0	72	9th

Data obtained in Table 3 revealed that top rank constraint facedby the CCDB beneficiaries was 'lack of fuel-wood materials' followed by 'cooking habit with traditional stove' was 2nd and 'difficult to control *Chula* temperature' was the 3rd constraint for biochar promotion. The lowest constraint faced by the CCDB beneficiaries was 'high price of *Akha Chula*'.

Relationships between the focus issue and selected characteristics

This section deals with the relationship between the 10 selected characteristics of the CCDB beneficiaries and their constraints faced for biochar promotion. The relationships were computed by using the Pearson's product moment correlation co-efficient (r). The co-efficient of correlation (5% level) was used to test the null hypothesis and analysis is presented in Table 4.

Table 4. Relationships between the focus issue and selected characteristics

Focus issue	Selected characteristics	Computed values of 'r' with 78 d.f.
Constraints for biochar promotion	Age	-0.052
	Education	0.017
	Family size	0.015
	Farm size	0.014
	Annual income	-0.321**
	Training received	-0.171
	Credit received	-0.240*
	Innovativeness	-0.199*
	Extension media contact	-0.198
	Knowledge on biochar	-0.310**

* Significant at 5 percent level of significance

** Significant at 1 percent level of significance

Among the 10 selected characteristics of the CCDB beneficiaries,four of them namely annual income, credit received, innovativeness, and knowledge on biochar showed negative and significant relationship with the constraints of biochar promotion.These characteristics of the CCDB beneficiaries play an important role for biochar promotion.The rest of the characteristics of the CCDB beneficiaries such age, education, family size, farm size, training received and extension media contact did not showed significant relationship with the constraints of biochar promotion.

CONCLUSION AND RECOMMENDATIONS

Conclusion

In the light of relevant facts and findings, conclusions are presented below:

a) More than half of the CCDB beneficiaries faced medium constraints in biochar promotion. The top rank constraint faced by the CCDB beneficiaries was 'lack of fuel-wood materials'. Hence, CCDB beneficiaries faced lack of fuel wood materials for cooking in *Akha* for biochar production.

b) The majority of the respondents had low annual family income. So, economic condition of CCDB beneficiaries is not so favorable. In addition, highest proportion of the CCDB beneficiaries had low opportunities for training and credit in the study area.

c) Majority of the CCDB beneficiaries had low to medium extension media contact. So, the CCDB beneficiaries had low contact with different extension media of the government and non-government organizations.

d) Four characteristics such as annual income, credit received, innovativeness and knowledge on biochar showed negative and significant relationship with the constraints of biochar promotion. These characteristics of the CCDB beneficiaries play an important role for biochar promotion.

Recommendations

The following recommendations are formulated based on the conclusion drawn:

a) As majority of the CCDB beneficiariesfaced medium constraint, therefore programs should be arranged to overcome the constraints inbiochar promotion. The concern authority like CCDB should take proper step to use other raw materials such as leaves, straw, jute sticks, dry cowdung or bamboo for biochar production.

b) Government, NGOs and other organizations regarding these issues should take income generating activities program for increasing income in the study area.

c) The concern organizations should take propersteps for increasing training and credit facilities for biochar promotion activities.

d) The CCDB should emphasize on significant characteristics while working with beneficiaries for biochar promotion.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 04

In Vitro Regeneration of *Gladiolus sp.var.* Neelima from the Cormel-Sprout Explant

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ABSTRACT

Micropropagation provides an economic advantage for the propagation of a particular crop like Gladiolus, a beautiful flowering plant which emits expression of love. As it has huge demand throughout the country it demands more production to ensure quick supply. But the problem is that propagation of Gladiolus by the conventional method is a slow process, and pathogen keeps on accumulation generation after generation which reduces yield and quality of flower and also generates insufficient propagules. An efficient propagation system could overcome those variabilities and meet the increasing demand of propagules production for fast growing of Gladiolus in the country while it is an exporting plant in Bangladesh. Moreover, the establishment of a plant regeneration system through direct organogenesis or via callus is also a prerequisite to further in vitro genetic manipulation of the cultivar. Demand for disease-free planting materials is increasing day by day and crop like vegetatively propagated plant is an appropriate means to generate propagules through in vitro techniques. Production of sufficient numbers of plants of a unique genotype is possible using in vitro culture system. In this study, the effect of various concentrations and combinations of plant growth regulators for in vitro regeneration of Gladiolus was described using cormel sprout as explants. However, an efficient in vitro plant regeneration protocol in locally cultivated pink color Gladiolus var. Neelima was established on MS media with various hormonal supplements using cormel-sprout as explants. Ninety percent of the explants responded for shooting on 0.5 mg L^{-1} N-benzyl adenine + 0.5 mg L^{-1} Kin within the culture initiation period of 90 day. The average number of shoot per explants was 8 ± 1.20 and the average shoot length was observed 12.40 ± 2.15 cm in this medium. Shoots were rooted well when they were excised individually and implanted on half strength of MS medium supplemented with 1.0 mg L^{-1} indole-3-butyric acid, in

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which 90% of the shoot induced roots. The average number of root per shoot was 10 ± 1.20, and the average root length was observed 8.50 ± 1.25 cm in this medium after culture of 30 days. Eighty percent of the in vitro raised plantlets were survived in the natural environment.

Key Words: Cormel-sprout explants, *in vitro* regeneration, N-benzyl adenine, indole-3 -butyric acid, Kin.

INTRODUCTION

Gladiolus (*Gladiolus sp.*) is one of the best bulbous ornamental year round flower crops under *Iridaceae* family. It is a very popular flowering plant in international cut flower trade grown throughout the world in a wide range of climatic conditions. Gladiolus is an important flower estimated 8th in the world cut flower trade grown for its elegant attractive spikes of different hues and good keeping quality (Sinha and Roy, 2002). The major producing countries are the United States (Florida and California), Holland, Italy, France, Poland, Bulgaria, Brazil, India, Australia and Israel. In the United States, the best selling bulb is the Gladiolus with an estimated annual sale of more than 370 million corms (Narain, 2004).

In India its cultivation dates back to nineteenth century and in Bangladesh gladiolus was introduced in the year 1992 from India. It has recently become popular in Bangladesh and its demand is increasing day by day. Profitable cultivation of gladiolus flower is gaining popularity among farmers in Jhikarjasa upazila of Jessore district famous for flower growing. Gladiolus sticks of different colours like white, red, yellow, scarlet, pink, violet, rosy, lipstick colour and blue can be grown in the same plot (Shaheenuzzaman et al 2011). The flower is harvested within 70 days and grows all the year round. It has long lasting flower stalks, attractive colors and numerous forms that these make its an all-time favorite for flower lovers and is said to be the queen of bulbous flowers (Nagaraju et al. 2002). The genus Gladiolus covered more than 180 species, yet only 20 of them were used for ornamentals purposes. Now a days, more than 10,000 cultivars have been developed and commercially grown all over the world (Roy et al 2006).

The conventional propagation of gladiolus in the field now a days has faced some problem due to the slow growth and low multiplication rate of cormel and disease infestation. In vitro technique was expected to be a break through in alleviating the technical problem in vegetative conventional propagation with seeds/cormels of gladiolus. Micro propagation techniques increase multiplication rates and it also had been provided propagules free from viruses and other pathogens (Blom and Aartrijk, 1985; Van et al., 1990). In spite of there being several protocols of micro propagation of *Gladiolus sp.*, different clones or varieties of a same species, demonstrate different behaviours in *in vitro* culture. Therefore, it is necessary to adopt this protocol to material genetic specifics (Choudhary et al 2010; Mohamed et al. 2000). The tissue culture is also a powerful tool that can accelerate the genetic breeding (Memon et al. 2013). This study was undertaken to develop a rapid in vitro propagation protocol of *Gladiolus sp.* for local environmental condition of Bangladesh.

The flower farming is an important and profitable enterprise in the agriculture sector of Bangladesh. Nursery and flower business has rapidly expanding in different cities of Bangladesh. The demand of Gladiolus is increasing because of its elegant spike, varied colours and long vase life. According to the report'2017 prepared by Bangladesh Tarrif Commission- A farmer earns minimum 2 lac taka from the Gladioli per acre (Mohiuddin, 2016). In 2012 a study reported that in Godkhali, Jeshore, gladiolus flowers were sold to Tk 21 lakh and seeds worth around Tk 16 lakh while the total cost of production was Tk 18 lakh. And so, the yearly profit stood at Tk 19 lakh. During the first two and a half months of that year, farmers had sold flowers worth Tk 4.65 lakh. Farming of gladiolus flower has turned into a profitable venture for many poor farmers at Godagari upazila in Rajshahi district as well. It was reported that sowing of 20,000 gladiolus seeds in one-bigha land with a cost of taka 1.0 lac that brought income of taka 2.5 lac by selling the flowers round the year in Rajshahi.

Gladiolus commercial cultivation is not dependent on seed propagation as seed propagation is only used to evolve new and improved varieties by hybridization (Singh, 1992). Due to very low natural propagation rate, Gladiolus takes many years to grow before the cultivar can be released. Therefore, novel cultivars need to be rapid multiplication for mass population by using in vitro propagation techniques in order to fulfill supply gap of huge demand in local market which is not possible through conventional methods (Kabir et al. 2014; Budiarto, 2009). Therefore, it needs to establish in vitro propagation protocol from the cormel-sprouts of *Galdiolus var.* by using certain plant growth regulators in the medium. Gladiolus can form multiple shoots from the cormel explants and appears to be suitable for large-scale production.

OBJECTIVE OF THE STUDY

The objective of the study is to establish a suitable protocol for in vitro micropropagation of pink color *Gladiolus var.* Neelima and its establishment at field level in specific Barind environmental condition.

MATERIALS AND METHODS

The corm of pink color Gladiolus cv. Neelima was collected from the farmers field at Jeshore and planted at the experimental field of Plant Biotechnology and Genetic Engineering Division, Atomic Energy Research Establishment, Savar, Dhaka. The explants of cormel-sprouts were obtained from the plant adjacent to the corms planting after 3 months. The explants were grown from the surface of the protective brown color of the corms and cormels and were collected for surface sterilization. The cormel-sprouts were washed with liquid detergent "Trix" and surface sterilized with 1% autostin for 10 minutes and again washed with running tap water for 20 minutes. The cormel-sprouts were then treated with 0.1% HgCl2 accompanied with 2 drops of Tween 20 for 10 minutes in the laminar airflow cabinet under aseptic conditions. Rinsing was done 3 times for 5 minutes each with sterile distilled water.

Sterilized cormel-sprouts were then cultured onto media containing MS supplemented with different concentrations of N-benzyl adenine (BA) and Kin alone or in combinations with BA + Kin, BA + naphthalene acetic acid (NAA), BA + Ads and BA + urea for multiple shoot induction. Subculture was done 30 days interval for promoting strong and healthy multiple shoots. Healthy shoots were excised individually and transferred to half strength of MS media supplemented with different concentrations of indole-3butyric acid (IBA), indole-3-acetic acid (IAA) and NAA for root induction. The sucrose (table sugar) concentration was used 30 g L^{-1} and the pH of the media adjusted to 5.8 prior to autoclaving.

Cultures were incubated at 25 ± 2°C with 16 h illumination of 5,000 lux provided by cool white fluorescent tubes. Data were collected on different characters at day 90 for multiple shooting and at day 30 for rooting of *in vitro* raised shoots. Observations on cultures were carried out every alternative day. The experiments were arranged in a completely randomized design with three replications for each treatment and used five explants per replication. Each experiment was repeated twice. A descriptive analysis was performed using the recorded data. Each value represents the mean ± standard errors. *In vitro* raised plantlets were removed from culture vessels, washed thoroughly to remove traces of nutrient medium, transferred to polybags and placed outdoor condition for acclimatization.

RESULTS AND DISCUSSION

The investigation was carried out to establish a suitable protocol for large scale *in vitro* propagation of locally cultivated pink color Gladiolus cv. Neelima using cormel sprout as explants with the interaction of different concentrations and combination of plant growth regulators and other supplements. The multiple shoot regeneration potential from cormel-sprout explants was found at all media type studied, but most satisfactory results of 90% explants produced multiple shoots on medium containing MS + 0.5 mg L^{-1}, BA + 0.5 mg L^{-1} Kin within the culture period of 90 days. The average number of shoot formed per explants was 8 ± 1.20 and the average shoot length of 12.40 ± 2.15 cm was observed in this medium (Table 1).

Table 1: Effect of different concentrations and combinations of plant growth regulators on MS media for shoot formation of cormel-sporut explants in gladiolus var. Neelima at 90 days

Different concentrtions and combinations of plant growth regulators (mg L^{-1})	Percentage explants Forming shoots	Mean ± SE	
		Avarage number of shoots formed/explants	Avarage shoots lenth explants (cm)
BA			
0.5	60	4.0±0.03	5.50±0.65
1.0	60	6.0±0.45	10.20±0.85
1.5	65	5.0±0.30	7.50±0.45
2.0	50	5.0±0.40	5.20±0.40
Kin			
0.5	60	4.0±0.60	4.50±0.30
1.0	60	4.0±0.20	5.60±0.40
1.5	50	3.0±0.10	3.25±0.10
2.0	40	3.0±0.20	3.10±0.20
BA+Kin			
0.5+0.5	90	8.0±1.20	12.40±2.15
1.0+0.5	70	6.0±0.75	8.50±1.80
1.5+0.5	65	5.0±0.40	5.40±0.90
2.0+0.5	60	4.0±0.10	5.20±0.45
BA+NAA			
0.5+0.1	50	4.0±0.35	4.20±0.20
1.0+0.1	70	5.0±0.65	8.50±0.75
1.5+0.1	45	3.0±0.20	5.10±0.85
2.0+0.1	40	3.0±0.10	2.50±0.10
BA+Ads			
0.5+60	45	3.0±0.10	3.45±0.20
1.0+60	45	3.0±0.30	3.65±0.10
1.5+60	20	2.0±0.40	2.50±0.60
2.0+60	20	2.0±0.20	2.40±0.40
BA+Urea			
0.5+0.1	40	3.0±0.25	2.90±0.30
1.0+0.1	40	2.90±0.20	3.50±0.40
1.5+0.1	10	3.40±0.60	2.50±0.20
2.0+0.1	10	3.0±0.40	2.60±0.10

Variables given are mean ± SE. BA: N-benzyl adenine,
NAA: Naphthalene acetic acid, SE: Standard errors

Actively growing and maximum number of multiple shoot formation from cormel explants were observed in white and yellow color Gladiolus using BA singly at the concentrations of 0.75 mg L^{-1} and 1.0 mg L^{-1} respectively (Nagaraju and Parthasarathy, 1995; Aftab et al., 2008). The results reveal that maximum shoot multiplications occurred in the combinations of BA + Kin and at the concentrations of 0.5 mg L^{-1} each, which might be due to the effect of genotypes. The combination of two growth regulators other than using single was found better toward multiple shoot formation also reported by many authors with other plants (Roy et al., 2011; Roy and Kabir, 2006; Roy and Kabir, 2007; Roy and Kabir, 2007; Rahman et al., 1999; Munshi et al., 2007; Kabir et al., 2006). These indicate that genotypes, type of explants, growth regulators and their concentrations and combinations and also genetic make-up of the explants influenced greatly in plant micropropagation. From the study, it was obvious that all concentrations of BA and Kin alone and in combinations of BA + NAA, BA+ Ads and BA+ urea showed the decreased trend of explants responding for shooting, average number of shoot production and the performance of average shoot length induction compared to the combinations of BA+Kin. These suggest that the combinations of BA+Kin performed excellent for shoot proliferation and shoot multiplication in pink color Gladiolus cv. Neelima and 0.5 mg L^{-1} BA + 0.5 mg L^{-1} Kin were found to be the most suitable.

This study proved again that together with two growth regulators sometimes works well. The rooting response differed according to the concentrations of different auxins used in the study (Table 2).

Table 2: Effect of IBA, IAA and NAA on half strength of MS media in root induction of in vitro raised shoots of Gladiolus cv. Neelima at 30 days

Name of the hormones	Concentratios (mg L^{-1})	Percentage of shoot inducing roots	Mean±SE	
			Average number of root induced/shoot	Average root length (cm)
No hormones (MSo)		50	6.0±0.65	4.20±0.45
IBA	0.5	60	8.0±0.60	6.25±0.50
	1.0	90	10.0±1.20	8.50±1.25
	1.5	60	8.0±0.75	6.20±0.90
	2.0	50	5.0±0.10	4.50±0.20
IAA	0.5	40	5.0±0.45	4.45±0.40
	1.0	40	4.0±0.20	3.90±0.20
	1.5	-	-	-
	2.0	-	-	-
NAA	0.5	-	-	-
	1.0	40	5.0±0.45	3.20±0.10
	1.5	30	3.0±0.10	3.0±0.20
	2.0	-		-

Variables given are mean ± SE.-: No response, SE: Standard errors, IBA: Indole-3-butyric acid, IAA: Indole-3-acetic acid, NAA: Napthalene acetic acid

Among the auxins used, IBA was found to be best for root induction and 1.0 mg L^{-1} BA showed better performance for root induction, in which 90% shoots rooted within 30 days of culture. The average number of root-induced a shoot was 10 ± 1.20 and the average root lengths of 8.50 ± 1.25 cm were observed in this medium. Best rooting response was obtained from shoots using 2 mg L^{-1} IBA (Aftab et al., 2008) whilst using 0.5 mg L^{-1} IBA also found better rooting in Gladiolus genotypes (Begum and Haddiuzaman, 1995), but in this study most efficient rooting response was observed using 1.0 mg L^{-1} IBA which might be due to the fact that *in vitro* rooting also genotype dependent. This also indicates that root induction potential also varies with the IBA concentrations due to genotypes and shoots derived from the explants (Figure 1).

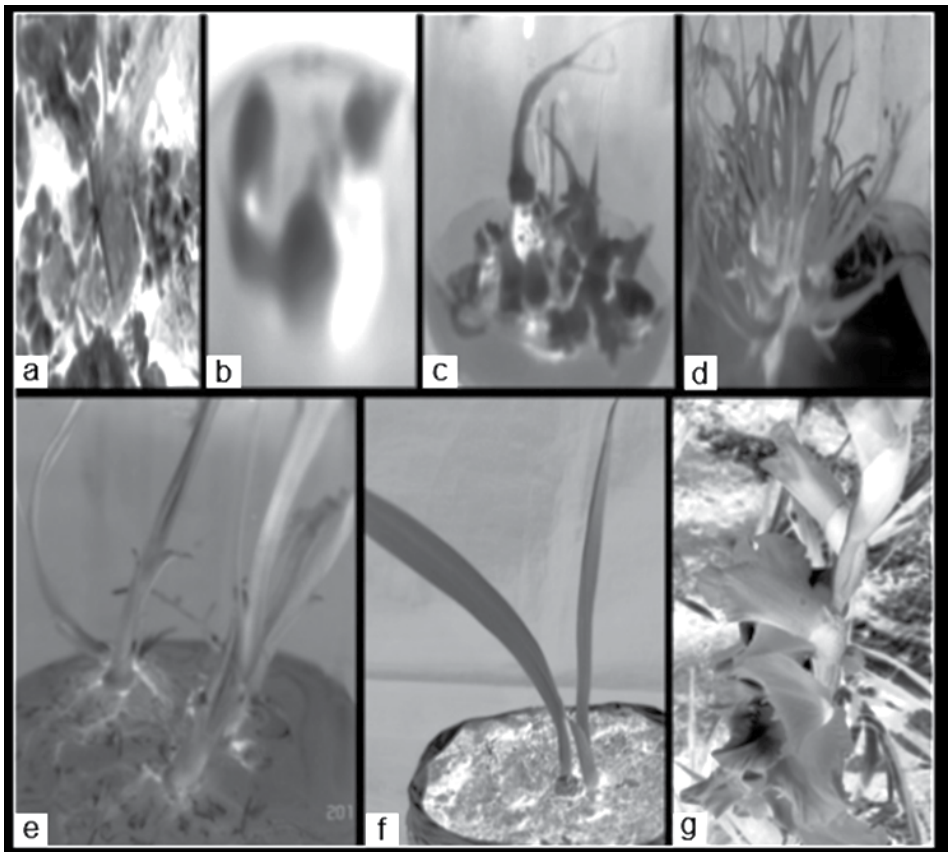

Figure 1: In vitro plant regeneration of locally cultivated pink color Gladiolus L. var. Neelima through cormel sprout culture: (a) Cormel sprout explants, (b) shoot initiation on MS + 0.5 mg L^{-1} BA + 0.5 mg L^{-1} Kin after 1 month of culture, (c) multiple shoot formation in the same medium after 3 months of culture, (d) healthy shoot formation and shoot elongation in the same medium after 3 months of culture, (e) root induction on half strength MS + 1.0 mg L^{-1} indole-3-butyric acid after 1 month of culture, (f) in vitro raised plant resumed new growth in the polybag, (g) 4 months old in vitro raised plant at flowering state.

Poor performances for rooting were observed on media containing IAA and NAA. This might be due to the fact that IAA and NAA is toxic for rooting tissue or incompetent media type that inhibited root induction of pink color Gladiolus cv. Neelima. The superiority of IBA for in vitro rooting over other auxins has been reported by others (Jaiswal and Amin, 1987; Amin et al., 1992; Amin and Akhter, 1993; Grewal et al., 1994).

Comparatively, healthy rooted shoots were taken out from the culture vessels and washed gently under running tap water to get rid of agar. The *in vitro* rooted plantlets were then transferred into polybags containing a mixture of soil and compost (2:1) and covered with transparent polythene to maintain high humidity and after 1 week the polythene was removed. About 80% of the plantlets were resumed new growth within 30 days of acclimatization period. A total number of 40 plantlets were survived in the field out of 50 *in vitro* regenerants. Gladiolus is a good consumer preference cut flower due to its attractive, colorful and showy florets. Therefore, the development of efficient tissue culture protocol is necessary for commercial cultivation, conservation, the creation of new variants, mutation breeding, and genetic improvement of this flowering plant. Thus, the protocol described in this study is repeatable, long-term *in vitro* regeneration and future genetic improvement of this plant using cormel-sprout as explants and also useful for other crop variety.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 05

Status of Dairy Cattle Rearing In Char Land Areas As Enterprise at Two Upazilas of Bogura.

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ABSTRACT

The aim of the study is to explore the participation of char people in dairy enterprise in relation to their socio-economic characteristics in the selected areas of Bogura district. The study was carried out at two Upazilas (Sariakandi and Sonatola) of Bogura District of Bangladesh. From each area 40 families were selected purposively for the study and data were collected from them by direct interview. A total of 30% and 52.5% respondents were engaged in agriculture sector who had one or more dairy cattle. About 10% and 15% char people were illiterate while 35% and 42.5% of them can sign only and 55% and 42.5% were found literate. In the study areas people milked their cows twice daily and and get on an average 4.23 L and 5.75 L milk per cow daily. Maximum lactation period in both areas were 7.5 and 7.3 months. majority of the farmers had cross breed (59.44%) at Sariakandi and 51.24 % at Sonatola. About 57.5% and 55% farmers were inseminated their cows with artificial insemination method. None of the respondent used their cattle's waste product for biogas and 52.5% and 15% used for fertilizer and rest of them used for fuel at Sariakandhi and Sonatola respectively. Health care activities such as use of vaccines, treated their diseased cow with veterinary surgeon were 55% and 17.5% at Sariakandhi and 52.5% and 10% at Sonatola respectively. There were 39.16% and 53.73% milking cows among 40 respondents in each upazilas respectively. Large farmers reared the highest number of crossbreed cattle and small farmers were the highest of indigenous cattle rearers. Many problems were faced by the respondents for cattle rearing and establishing dairy enterprises in the study area (100% of the respondent in both areas stated tthat high feed price is the main problem and secondly 75% abd 82.5% stated lower milk price). The result suggested that improved feeding technology, proper hygienic and sanitation program, proper treatment, sound breeding policy should be taken and more participation in management practices are necessary for increasing the milk production as well as establishing dairy enterprises in the study areas.

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INTRODUCTION

Dairy enterprise is considered a "treasure" of the economy of Bangladesh, particularly for rural system. The sector involves millions of resource-poor farmers for whom animal ownership ensures critical livelihood, sustainable farming, and economic stability. Livestock's share in agricultural income increased from 7.6% in 1973-74 to 12.9% in 1998-99 and is projected to reaches to 19.9% in 2020 (Hossain and Bose, 2000). Livestock provides cash income with a small amount of investment and creates employment opportunity for the landless rural people, unemployed youths and destitute women. In addition to supplying drought power required for land cultivation, threshing, crushing and transport; it supplies meat, milk for human consumption, manure for crop and fuel for household purposes. Therefore, development of this sub-sector may be considered as an important strategy for poverty alleviation which is a major objective of the Government of Bangladesh (MoF, 2013; BBS, 2012).

Many of the rural people of our country maintain their livelihood by depending on the cattle rearing. Dairy cattle rearing is considered a profitable business in Bangladesh. Many researchers have agred that the dairy industry of Bangladesh holds great potential for sustainable development of the country.

In the char areas of Bangladesh, people are rearing cattle. They use cattle for milk, meat and drought purpose. Maximum cattle are indigenous breed. These animals are kept mainly in the stall with limited grazing. Husbandry practices and health care of these animals are poor. The average milk production is very low. But poor people living in char areas are alleviating their poverty through flourishing diary sector even after facing many hurdles. To the best of the researchers knowledge no specific study on the issue of dairy sector's 'status of dairy cattle rearing and existing condition of cattle rearing in Char areas' is conducted in Bangladesh. So, the aim of the present study is to evaluate the impact of dairy farming on income generation, poverty reduction and livelihood patterns of the dairy farmers.

For this reason the present study was undertaken with the following objectives.

Objectives

i) To observe the existing condition of cattle rearing in selected char areas.
ii) To assess the prospects of cattle rearing in char areas.

Justification of the Study

Bangladesh is one of the least developed countries in the world in terms of per capita income and literacy rate. Bangladesh accounts for a significant portion of the world's poor with nearly 25% people living below the poverty line. Hence, the eradication of poverty occupies the foremost place and priorities in Bangladesh's development programmers. Review of documents and experience over the last three decades both explicit and implicit shows that different strategies and actions were taken in the past to combat poverty in the country. Despite all these efforts and implementation of various programs, poverty still continues to be pervasive and overwhelming.

However, there is sufficient evidences to believe that the existing poverty cycle can be broken if the poor are allowed to have access to resources and justice. Keeping these facts in mind the research has been undertaken to evaluate the status of the poor char peoples.

MATERIALS AND METHODS

Study area

Two upazilas namely Sariakandi and Sonatola of Bogura district of Bangladesh were purposively selected as study areas.

Baseline Survey

A baseline survey was be conducted with structured questionnaires. A total of 80 farmers were interviewed and data were collected using a well-structured and pre tested interview schedule by covering all the dimensions i.e. housing, feeding, breeding, health care, marketing of cattle product and income from them. Data were interpreted by using frequency and percentage analysis of the existing situation of dairy cattle rearing.

RESULTS AND DISCUSSION

Demographic feature of the study areas

The study areas namely Sariakandi and Sonatola in which 40 respondents in each upazila were separately selected for the study. The total sample respondent was 80 (Figure 1) Represents the socio-demographic information of the respondents incorporating gender, age, education, family member and occupation. Out of 40 respondents 42.5% were male and 57.5% female at Sariakandi and in Sonatola majority of the respondents were male 85%. The maximum respondents belong to 31-40 years of age at Sariakandi (30%) and 41-50 years at Sonatola (32.5%).Total population of the two upazilas among 40 families are 198 and 178 at Sariakandi and Sonatola respectively. The occupations of maximum respondents were found as housewife 52.5% at Sariakandi and farmers 52.5% at Sonatola.

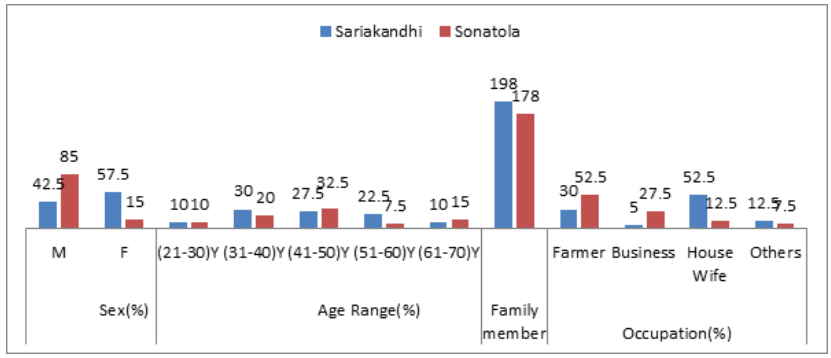

Figure 1: General information of the respondents in the study areas

Educational Status

The majority of the respondents found their educational level was can sign only in both areas 35% and 42.5% at Sariakandi and Sonatola followed by up to class VIII 17.5% and 16% respectively. Only 2.5% at Sariakandi and 5% at Sonatola had graduation/masters degree and illiteracy rate was not also negligible 10% and 15% at both areas. (Table-1)

Table-1: Educational level of the sample respondents

Study Area	Illiterate (%)	Sign Only (%)	Up to Class V (%)	Up to Class VIII(%)	SSC (%)	HSC (%)	Honors/ Masters (%)
Sariakandi	10	35	15	17.5	12.5	7.5	2.5
Sonatola	15	42.5	7.5	16	7.5	7.5	5

Cattle population

The total cattle population was 143 and 201 at Saiakandhi and Sonatola among 80 respondents in both areas. Among them at Saiakandhi among 143 cattle 16.08% male calf, 13.29% female calf, 9.1% heifer, 39.16% milking cow, 14.48% dry cow, and 7.7% bull and at Sonatola among 201 cattle 12.44% male calf, 10.94% female calf, 8.96% heifer, 53.73% milking cow, 11.44% dry cow and 2.49% bull. (Table-2) The total cattle population of Bangladesh is 22.87 million of which 3.79 million is dairy cows (Rokonuzzaman, 2009).

Table 2: Cattle population of the respondents in the study areas

Study Area	M calf (%)	F calf (%)	Heifer (%)	Milking cow (%)	Dry cow (%)	Bull (%)	Total
Sariakanhi	16.08	13.29	9.1	39.16	14.68	7.7	143
Sonatola	12.44	10.94	8.96	53.73	11.44	2.49	201

Breed of cattle

At Sariakandi 40 families have total 143 cattle and among them 40.46% are local breed and 59.44% is cross breed. And at Sonatola among 201 cattle 48.76% is local and 51.24% is cross breed cattle. (Figure 2)

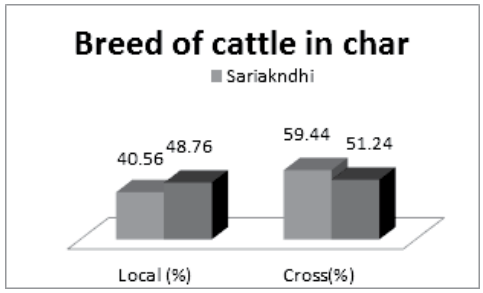

Figure 2: Breed of cattle in char land Areas

Extensive reports on production performance of local and crossbred cattle in these two upazilas of Bogura district are not adequate (Alam and Ghosh, 1988; Nahar *et al*. 1989; Shamsuddin *et al.*, 1988, 1995; Khan *et al.*, 2001; Sarder, 2004; Rahman and Rahman, 2006). For upgrading these cattle, it is essential to know the existing condition of dairy farm and its production in char area.

Milk production

At Sariakandi Upazila, there are 56 milking cows producing about 237 liter milk per day and on an average 4.23 lit per day per cow. On the other hand, at Sonatola 108 milking cows produce about 621 liter milk and per cow produce on average 5.75 liter milk per day. But during flood time milk production decreases to 3.03 lit and 4.78 lit per cow at Sariakandi and Sonatola respectively. (Table-3).

Table-3: Milk production performances of cattle

Study Area	Normally		During Flood	
	Total Lit	Average Lit	Total Lit	Average Lit
Sariakandi	237	4.23	170	3.03
Sonatola	621	5.75	516	4.78

The results are similar with those of Sultana *et al*. (2001) where daily milk production of indigenous and cross breed cows were an average2.6 and 4.9 liters daily, respectively. Our results partially agree with those of Ahmed and Islam (1987); Uddin *et al*. (2004); Rahman and Rahman (2006); Sarder (2001;2006).

Lactation Period

First three months are the peak milk production period found in both Sariakandi and Sonatola Upazilas. And average milk production length is 7.5 months at Sariakandi and 7.3 months at Sonatola. (Table-4)

Table-4: Milk production performances at different stages

Study Area	Average Peak Milk production (Months)	Average milk production time (Months)
Sariakandi	3	7.5
Sonatola	3	7.3

The average milk production of the present study is partially in agreement with the results of Halim (1992) where the lactation period for indigenous and cross breed dairy cows were 7.6 and 8.6 months, respectively. Khan (1990) reported that the average lactation period of cross breed cows were 6.6, 8.3 months respectively; the result is almost similar with the present finding.

Different feeding practices of the respondents

Although there was lack of pasture land 62.5% and 67.5% respondents graze their cattle at the road side, fallow lands, arable land after harvesting and 100% people supply green grass in both areas, only 5% and 7.5% people use Urea treated Straw (UTS). Majority (87.5%) and (82.5%) of the people supplies chopped straw and 20% farmer supplies concentrate mixture to their calves. Kokate and Tyagi (1991) observed that 22% of respondents supplied concentrate feeds.

All the (100%) farmers fed colostrums of their new born calves in both areas and none of the respondents fed milk replacer to the calf in both areas. About 85% and 80% rural farmers supply concentrate mixture to their cows for increase milk production and reproductive efficiency in the study areas (Table-5). Kokate and Tyagi (1991) observed that only 23% of respondents supply concentrates mixture. From Table 3 it was stated that among the feeding practices only 30% and 22.5% farmer cultivates improved fodder for their dairy cattle. Natraju and Channegowda (1985) stated that 22.70% people cultivate improved fodder. (Table-5)

Table-5: Feeding system of cattle population in the study areas.

Feeding activities	No. of respondents		Percentage	
	Sariakandi	Sonatola	Sariakandi	Sonatola
Grazing of dairy cattle	25	27	62.5	67.5
Feeding of green grass to the dairy cattle	40	40	100	100
Feeding of UMS/urea treated straw	2	3	5	7.5
Chopping of straw	35	33	87.5	82.5
Feeding of concentrate mixture to the calf	34	32	85	80
Feeding of colostrums to new born calf	40	40	100	100
Feeding of milk replacer to the calf	0	0	0	0
Feeding of concentrate mixture to the dairy cattle	34	32	85	80
Cultivation of improved fodder	12	9	30	22.5

Breeding procedure of cows

Among 40 respondents 57.5% artificial insemination and 42.5% followed natural services using their own or neighbors bull at Sariakandi and at Sonatola 55% and 45% of the respondents through AI and bull respectively. Islam (1987) stated that insemination of cow by natural Service was 74.0% and artificial was 26.0% (Figure 3)

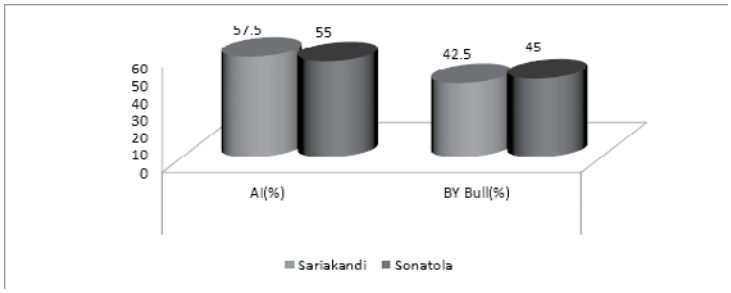

Figure 3: Insemination procedures of the study areas

Diseases infestation

In both areas majority of respondents (92.5% and 95%) stated that their cattle suffer from Foot and Mouth Disease and 55 % mentioned about Mastitis, 5% Anthrax, 2% BQ, 57% EF, 57.5% HS and 37.5% parasitic disease at Sariakandi and at Sonatola 32.5% Mastitis, 2.5% Anthrax, 10% BQ, 52.5% EF, 67.5% HS and 25% - parasitic disease respectively. (Figure 4)

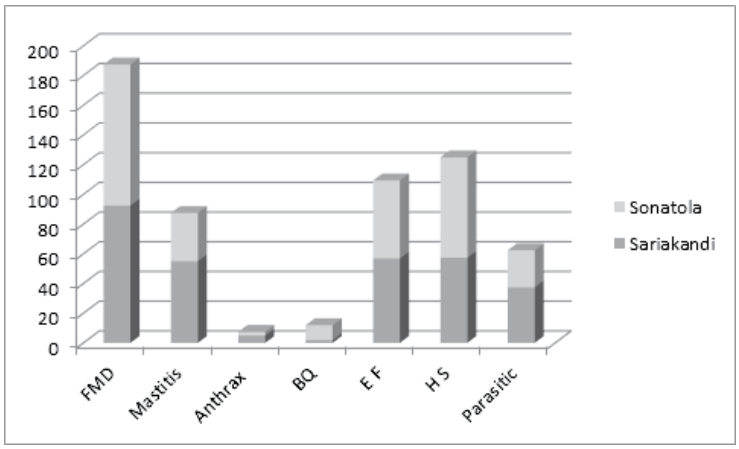

Figure 4: Livestock suffers different diseases of the respondents

The respondents pointed out that their cattle suffers in various diseases in different periods of the year. The farm owners claimed that veterinary services are not available in the study area. On the other hand, the supply of medicines and vaccines from the Thana Livestock Office were not sufficient.(Rabbani, 2004).

Source of treatment of cattle

Majority of the respondents(77.5%) at Sariakandi and 90% at Sonatola receive treatment for their cattle from Livestock Service Provider (LSP). About 17.5% and 10% respondents go to Upazila VS and 12.5% and 5% go to quack. It is noticed that none of them in both areas received treatment from other source. (Fig-5) 22% farmers vaccinated their cattle regularly but 90 percent farmer treated their diseased animals by quacks (Rabbani, 2004). Rabbani, 2004 stated that only 29% farmers were treated their dairy cows by registered Govt. Veterinary Surgeon, 57% farmers were treated their sick animals by Quack and 4% people treated their animals by indigenous herbal plant resources in the study area. Hossain et al. (1996) observed that 59% farmers have not taken curative measures for the disease cattle.

In case of curative measures, only 27% and 14% of farmers as a whole treated their diseased cattle by doctors and quacks respectively.

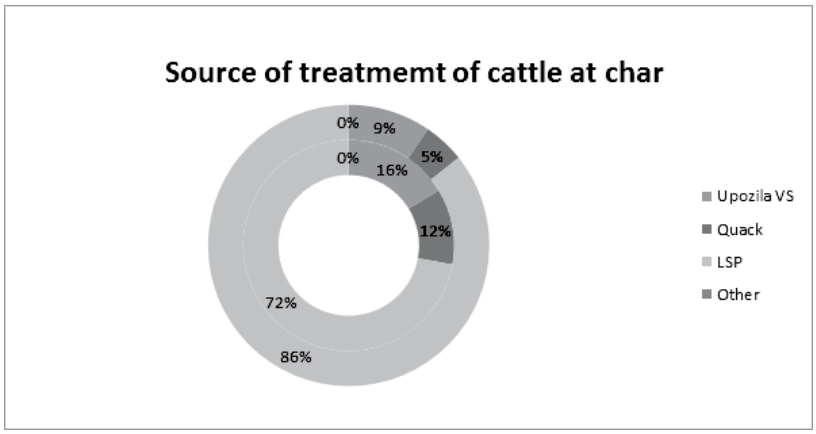

Fig-5: Source of treatment received by the owner of cattle

Vaccination done by the owner

At Sariakandi 20%, 17.5%, 7.5%, 15% owner done FMD, Anthrax, BQ, HS and 45% no vaccination respectively and at Sonatola 42.5% for FMD, 17.5% for Anthrax, 15% for BQ, 27.5% for HS and 47.5% owner do not vaccinate their cattle. (Table-6) Twenty two percent farmers vaccinated their cattle regularly but 90 percent farmer treated their diseased animals by quacks (Rabbani, 2004)

Table-6: Vaccination for cattle done by the respondents.

Study Area	FMD (%)	Anthrax (%)	B Q (%)	H S (%)	No Vaccination (%)
Sariakandi	20	17.5	7.5	15	45
Sonatola	42.5	17.5	15	27.5	47.5

Use of waste products of cattle

It was found that among 80 respondents in both areas none of them use their cattle's waste products for biogas. However, 47.5% and 85% used as fuel and 52.5% and 15% as fertilizer at Sariakandi and Sonatola respectively.

Baset (1996) found that 87.63% of total manure used as organic fertilizer and rest 6.91, 1.72 and 3.74% of the total manure use as fuel, plastering and others respectively. (Figure 6)

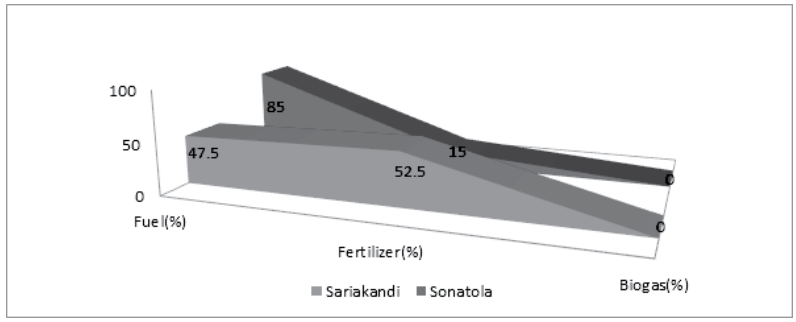

Fig-6: Respondents using of waste products for different purposes.

Problems of cattle rearing

Centpercent (100%) of the respondents at both areas stated that high feed price is the main problem. So that, they could hardly afford to buy commercially available cattle feed. Respondents cannot supply concentrate mixture to the calves due to high price. This is why calves are fully dependent on her mother's milk, which is mostly extracted by the milkman. This reduces health condition of calves. Rahman (1996) found that 100 of dairy cow owners reporting high price of concentrate feed. Most of them (82.5%) and (75%) mentioned about the problem of lower milk price. Lower price which is economically unsatisfactory. About (32.5%) and (37.5%) stated about lack of grass and (52.5%) and (67.5%) stated about less production at both areas (Sariakandi and Sonatola). The productivity of cattle is low because of poor genetics, nutrition, herd health and management. Khan et al. (1999) (Figure 7)

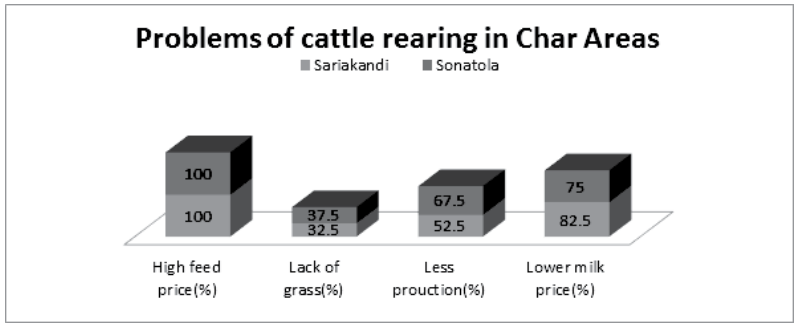

Figure 7: Problems faced by the respondents during cattle rearing

CONCLUSION AND RECOMMENDATIONS

Cattle are important source of protein both milk and meat. Livestock farmers at char land areas used to rear cattle however it is still inadequate to meet the national demand of milk and meat because as majority of the cattle is crossbreed but the farmer have no knowledge about the proper management of cattle, their feeding requirement (balanced ratio), have no knowledge about fodder production, don't use quality semen for reproduction. Small scale dairy farming contributes significantly to household income, food security and overall welfare of livelihood of the poor dairy farmers. Overall livelihood status of the Char dwellers ranged between low to medium. This is attributable to poor communication and transportation facilities, geographical and climatic hazard, low annual income, poor support from GOs and NGOs. Livelihood status can be improved and can create dairy entrepreneur by the support of GOs and NGOs through arranging practical training on livestock management, feeding, breeding, AI etc. Cattle population can increase and improved breed by supplying quality semen and can ensure livestock health by providing the service of LSP (Trained about livestock) From the above discussion, it can conclude that char land people of the study area could not be successfully participated in dairy management practice due to lack of capital, shortage of feed, high price of concentrated feed, illiteracy and ignorance about improve technology, low milk cost, insufficient extension services and disorganized marketing system. The credit facilities should be given at lower interest as well as distribution of credit must be strengthened. Different training program on dairy cattle rearing technology in the study area should be offered from GO\NGOs and other private sector. Vaccination schedule, proper hygienic and sanitation program, suitable breeding policy can also be taken and motivate the farmers to cultivate high yielding fodder such as pakchug, Napier etc. More participation is needed in the dairy enterprise for establishing sustainable dairy business.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 06

Design and Fabrication of Electronic Yogurt Incubator, and Comparison of Qualities of Yogurt Made by Electronic and Traditional Incubation System

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Md. Ferdous Hossain Khan[3]

ABSTRACT

This study developed an electronic yogurt incubator for maintaining required temperature for yogurt production as well as the comparison carried out for qualities of yogurt to traditional incubation system, i.e. the performance evaluation of incubator was carried out. The main heating elements were four sets of 1200W heating coil used to provide the required temperature in the incubator. The system was powered by 220 volts electricity. The developed incubation system was tested and plotted temperature reading on hourly base. The graph obtained shows that the incubator was performed its desired function of incubation of yogurt effectively. The temperature of the electronic incubator was maintained ranged 41^{0}C –43^{0}C with the error ±0.5^{0}C, on the other side the error of temperature by traditional incubation system was ±10^{0}C. The consumption of electricity was 5KW/hr for electronic incubator. The quality parameters of the yogurt made by traditional and electronic incubation methods were analyzed and plotted in the graph. The result showed that the electronic incubated yogurt is better quality in case of consumer sensory attributes as well as the forms of microbial count, acid values and self-life of yogurt compared to the yogurt made in traditional system.

Keywords: Yogurt; Fabrication; Traditional incubator; Electronic incubator; Sensory attributes; Shelf-life

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INTRODUCTION

Yogurt is a very popular fermented milk product; especially the yogurt of Bogura district in Bangladesh is familiar as *Bograr Doi*. Mainly two types of yogurt are available in the local markets named sweetened yogurt (sugar added) and sour yogurt; both are prepared by a traditional method using previously made yogurt as starter (S. Dey *et al.*2011).

The current methodology of yogurt preparation involves tedious boiling of fresh milk and cool down to specified temperatures that accommodate survival of active cultures, addition and subsequent mixing of the culture in milk, compartmentalization of the milk into sterilized containers and incubation of these containers at 38°C-42°C for 8 hours. The yogurt is incubated by local made *Chhata* (umbrella) type incubator (made by bamboo and papers) and jute sacks are used as insulator. The main source of temperature is the burnt woods. So, when the yogurt keeping in this traditional incubator chamber, usually happened that at the beginning of incubation temperature of the incubator is higher and after time interval it's being lower. For yogurt incubation it needs to continue the same temperature all along to get good quality yogurt. Yogurt denatures if time and temperature settings are not set at optimal conditions. Since the incubation environment of the incubation chamber does not present at optimal conditions for the growth of lactobacillus bacteria, so undesired bacteria grow which make the bad quality of yogurt (Hossain M. N. *et al.* 2014).

In Bangladesh, there is no usual electronic yogurt incubator manufacturer for small scale yogurt production. Usually the large yogurt manufacturing industries import yogurt incubator from China or India. In that study the fabricated incubation system consists of two parts; the mechanical and electronic part. The mechanical part consists of a rack like a box tray to keep yogurt using a small wheel, the heater, fan; and the electronic part is comprised of the sensor and control board including timer. The incubator can be operated manually and automatically.

The small scale producers of Bangladesh produce yogurt by traditional methods, especially using the traditional incubation system. The producers believe that yogurt cannot be produced by modern electronic incubator. The major objectives of this research were to design and fabricate low cost electronic incubator for preparing yogurt especially for the small scale producer.

The specific objectives were to:

II. Formulate the operational procedure;
II. Produce *Bograr Doi* in fabricated incubator and compare its quality with traditional incubated *Bograr Doi* by expert panels in terms of consumer acceptability, self life, taste, etc.;

MATERIAL AND METHODS

Raw milk, sugar as well as starter were available in the local markets of Bogura district and all others equipments (like *suspan*, spoon, etc) were available in the Agro Processing, Preservation and Marketing (APM) unit of Rural Development Academy (RDA), Bogura, Bangladesh. For

microbiological analysis, all the chemicals were used from the ready stock of quality control lab of APM unit of RDA with at least 98% of purity. On the contrary, traditional incubator was made using locally available materials i.e. Bamboo, sacks, etc.

The materials that were used in the development of this electronic incubator were divided into two parts, namely electrical and non-electrical materials. The electrical materials include the microcontroller, bi-directional AC motor (with high torque), DHT temperature sensor, limit switch sensor, relays, low-speed axial fans, high density cables, LCD display, current driver, electric bulb, and electronic switches. The non-electric components include the materials like aluminum sheet, good heat insulation material for lining the inside of the incubator to prevent heat loss, SS crates, basket, and metal frames. For electronic incubator, all the raw materials needed were collected locally from Bogura town except sensors and control board. Sensor and control board were imported from China. The incubator was designed by autoCAD (AutoCAD Civil 3D 2018, AutoCAD Electrical 2018) software and fabricated at APM unit of RDA by the expert technicians for egg fertilization or producing chicks. The operational procedure was recorded and described by trial and error methods. The trial production of *Bogurar Doi* was done according to traditional method except incubation by the electronic incubator. The temperature distribution of the whole incubation chamber was measured by manual thermometer putting at the same distance in different places to prove any variation in temperature distribution.

To compare the produced yogurt by traditional and fabricated electronic incubator, qualities of yogurt analysis by sensory evaluation, five expert panels were used to evaluate the organoloptic qualities. The organoleptic evaluation was based on a five-point-scale to determine the characteristics in terms of texture (5- firm; 1-very soft); colour (5-no discoloration; 1-extreme discoloration); odour (5-extremely desirable; 1- extremely unacceptable/ off-odours); tastes (5-extremely desirable; 1-extremely unacceptable/off-odours) and overall acceptability (5-extremely desirable; 1-extremely unacceptable) of the samples (Yasir A. A., *et.al* 2014).

For shelf life comparison of yogurt in both of the traditional and electronic incubation the total microbial load (viable count) was done according to Tarkhasi A. *et al*. 2016 and pH value was determined by the automatic pH meter-215 (made in China).

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows, SPSS Inc., Chicago, IL, USA, 2013).

RESULT AND DISCUSSION

In this section the experimental result is demonstrated with relevant information and data for the design and fabrication of electronic yogurt incubator, and comparison of qualities of yogurt made by electronic and traditional incubation system.

Fabrication of traditional incubator (*chhata*)

Traditional incubator named *chhata* (umbrella) made by bamboo and other local material like sacks, carton, etc. is shown in figure 3.1. for 3D design and 3.2 for pictorial views. The heating

source for keeping temperature inside was burnt woods (usually tamarind woods) that could not be regulated or maintained. So, it was difficult to produce good quality yogurt. A total of 50-60 soras (local container made by mud for *Bograr Doi* inclined which contains a total of 800 g yogurt) or 150 cups (usually each cup contains 150-300gm) of yogurt per batch was produced by incubator. Through this traditional process it's also difficult to maintain Good Manufacturing Practice (GMP) for producing yogurt.

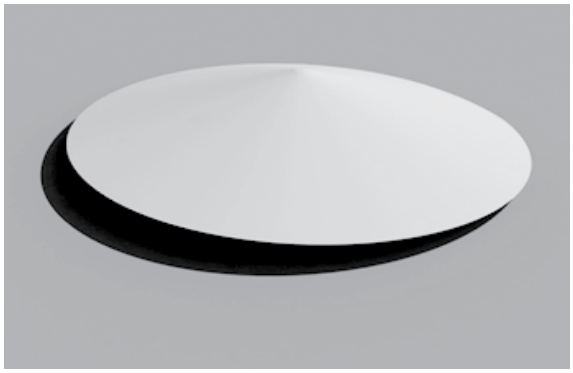

Fig. : 3.1 3D design of inclined

Fig. : 3.2 Pictorial view of inclined

Design & fabrication of electronic incubator

The electronic yogurt incubator developed had slight modifications in comparison to the industrial incubator. The incubators had aluminum frames with gas fiber insulation. The gas fiber insulation was for heat retention which increases the efficiency and reduces the electricity consumption. The incubator had two chambers with six removable shelves in each chamber. Four bulbs (heaters) were installed at the base of the incubator to supply required heat. The front side of the incubator was covered with glass so that it was observed by expert visually at the time of maturing stage of yogurt and when it was ready to be taken out. The schematic diagram, the 3D view, and the pictorial view of the electronic incubator are shown in the figures 3.2.1, 3.2.2, and 3.2.3 respectively.

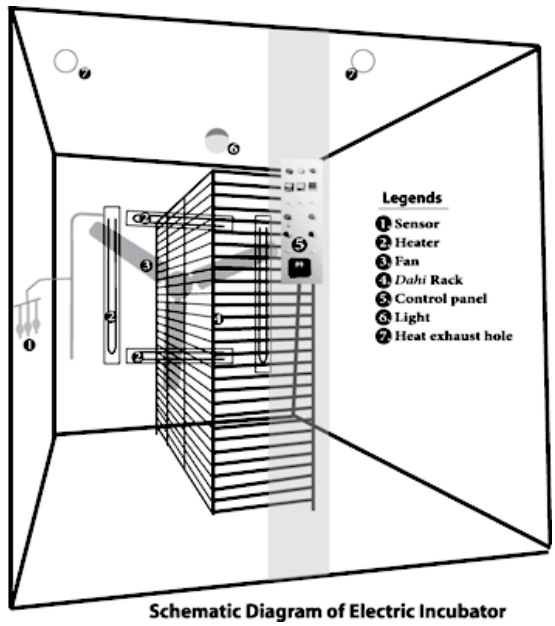

Fig. 3.2.1 Schematic diagram of Electronic incubator

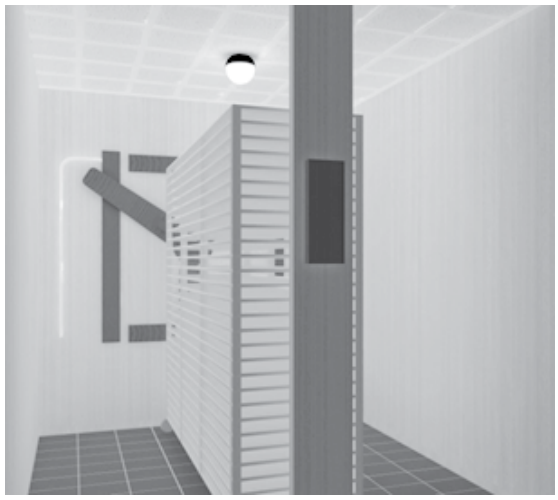

Fig. 3.2.2 3D view of electronic incubator

Fig. 3.2.3 Pictorial view of electronic incubator

This developed electronic incubator was operated into two ways e.g., automatic and manual operating system. In the automatic version, the thermostat turns off-on when the required temperature was reached at 41^0C and did not need to be monitored. In the manual operation, the internal chamber was sterilized easily by setting the thermostat at 100^0C. This allowed the production process to be more hygienic by removing any unwanted bacteria that could spoil the yogurt or alter its taste.

The Figure 3.2.4 below is demonstrated the automatic temperature controlling system. The setting temperature on the control board wad maintained according to the sensor temperature. If the sensor gets the setting temperature, the heater automatically off according to explanation by Shittu S.*et al*. 2017.

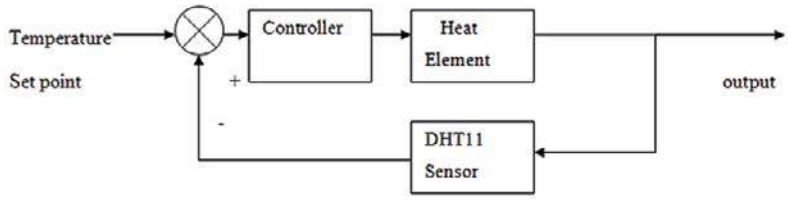

Fig. : 3.2.4 Temperature control system

The manual and automatic operating system including the circuit diagram and power supply of the fabricated incubator is shown in figure 3.2.5. In this figure shows that when the incubator was operated manually there is no connection with the thermostat. The 220 volts AC supply coming from the convenience outlet was converted into 12 and 5 volts DC. These voltages were required for the different circuits to operate properly. The 12 volts DC was used by the relay, while the 5 volts was used by the microcontroller and the alarm circuit. The step down transformer was connected directly to the 220 volts AC power supply. The transformer used in this project was 750 mA 12 volts.

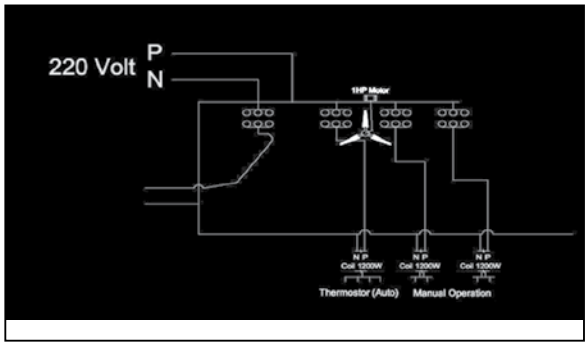

Fig. 3.2.3 Fictional diagram of Heaters

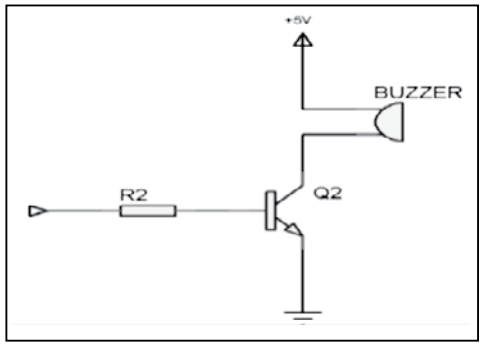

Fig. 3.2.4 DC supply circuit diagram

A small buzzer with a 5 volts DC supply was used in the project as shown in Figure 3.2.4. The buzzer was used to produce a sound to alert the user that the yogurt is ready to be removed from the incubator. This was done to prevent excessive fermentation of yogurt. The general purpose of the transistor use in the circuit is to drive the buzzer. The buzzer operates at a maximum current of 100 mA. The component used in the circuit is the same as the relay driver since less amount of current is required in the buzzer according to Rogelio B. P *et al*. 2016.

Parameters		**Specifications**
Size	:	Length-8 feet, Width-8 feet, Height -8 feet
Body	:	Structure by MS Box pipe
Insulator	:	Gas fiber insulator covered with 2.75 mm fiber sheet
Controlling	:	Auto
Electricity capacity	:	220V, 5KW
Motor	:	220 V, 1HP
Trolley	:	Body by GPI Sheet, Rack made by SS
Heating system	:	Tube heater 4 no. each capacity 1200 W.
Capacity	:	500 pieces sora or 1500 pieces cup can produce in one batch

Temperature distribution

Data obtained in the process of testing the incubation system with yogurt are illustrated in the figure 3.2.2.1. This system maintained ambient temperature in the chamber in the range of 41^0C-43^0C. Different thermometers were set at the same distances inside the incubator for both traditional and electronic incubator. Mean data was obtained for 8 hours period and the graph (Fig. 3.2.2.1) is drawn based on the hours of incubation and temperature. The graph (Fig. 3.2.2.1) is shown that temperatures of the traditional incubator were not stable, which reached from higher to lower level. On the contrary, electronic incubator's temperatures almost were at the constant level.

Data suggested that temperature error was $\pm 0.5^0$C for electric incubator, where as that was $\pm 10^0$C error for traditional incubator.

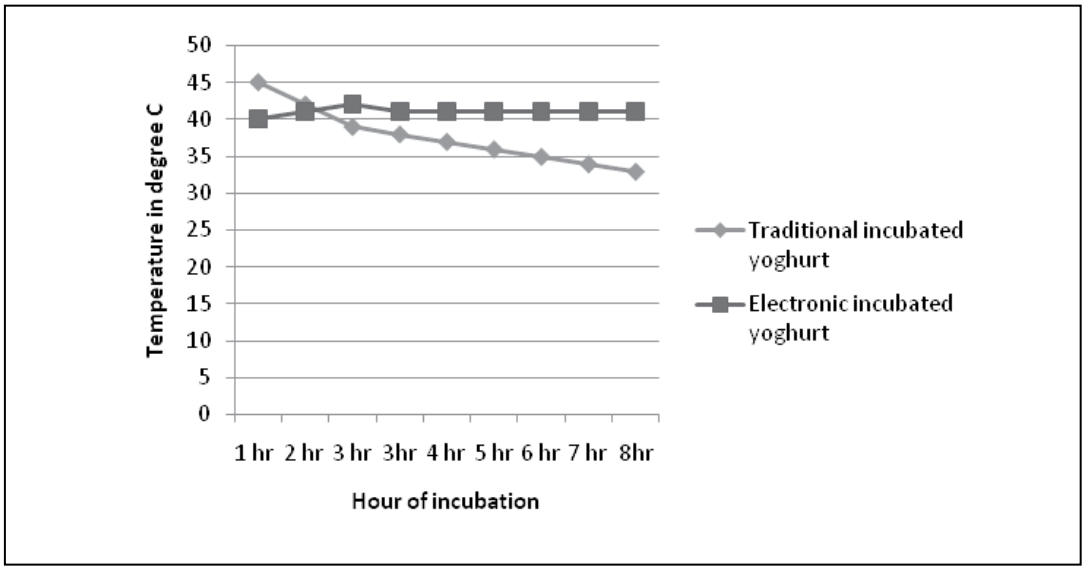

Fig. 3.2.2.1 Temperature distribution diagram

Operational procedure

It was found that the fabricated incubator was operated both manually and automatically. In case of manual operation, before incubation the incubator's time was set up according to needed heating at high temperature, at that time of manual operation heater-1 and heater-2 were needed to be on. On the other hand, in case of automatic operation, time was set up by the timer and temperature was set up by the thermostat that was continued for incubation period. The control panel board is shown in figure 3.3.1.

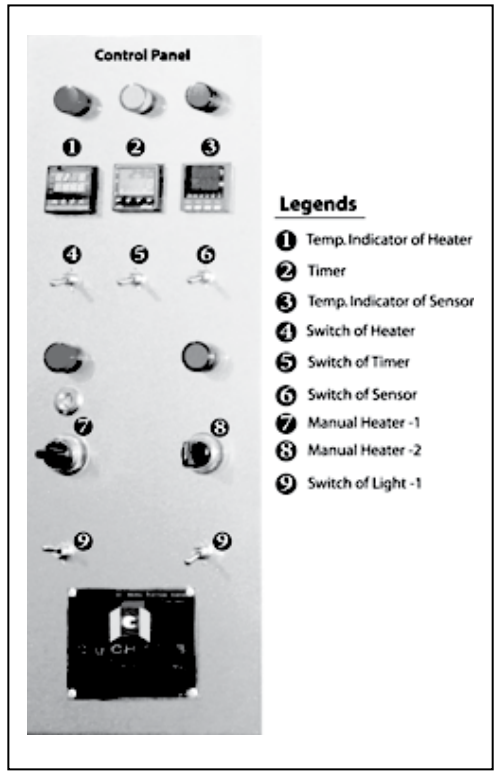

Fig. 3.3.1 Control panel

Comparison of products qualities by sensory parameters

Sensory evaluation of food was defined as "a scientific method used to evoke, measure, analyze and interpret responses to products as perceived through the senses of sight, touch, smell, taste, and hearing". It was an important tool to assess the quality and consumers' acceptability of a food product. The sensory

parameters had significant effect on the traditional incubated and electronic incubated yogurt had better sensory characteristics as traditional incubated yogurt. The result is shown in the graph in the figure 3.4.1. The result is based on the mean values of the panels test. The graph shows that the electronic incubated yogurt is of better quality than that of the traditional incubated yogurt by color, taste, flavor, texture and overall acceptability.

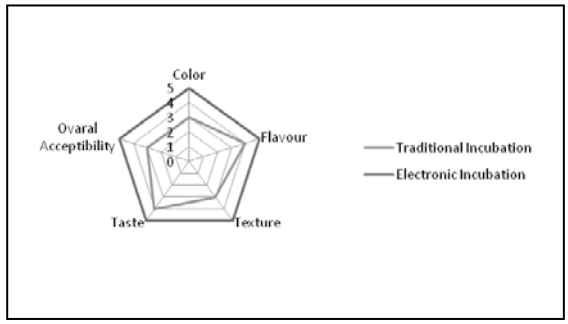

Fig. 3.4.1 Sensory evaluation demonstration

Shelf life of yogurt

Total viable count (TVC) was done for both traditional and electronic incubated yogurt at the days of 1st, 5th and 7th after production. The both types of yogurt were kept at room temperature. Experiment was done triplicate and the result was based on mean value. The result is illustrated in figure 3.5.1. This figure states clearly that the value of TVC in log10 CFU/g of traditionally incubated yogurt is more than that of electrically incubated yoghurt. For pH value it is observed same in the figure 3.5.2. The pH value is lower with the traditional incubated yogurt than the electrical incubated yogurt at the interval of time. It indicates that the electronic incubated yogurt had more shelf life than that of the traditional incubated yogurt. This result is supported by Kumer A. D. *et al*. 2017. The picture 3.5.3 is shown for the *Bograr Doi*.

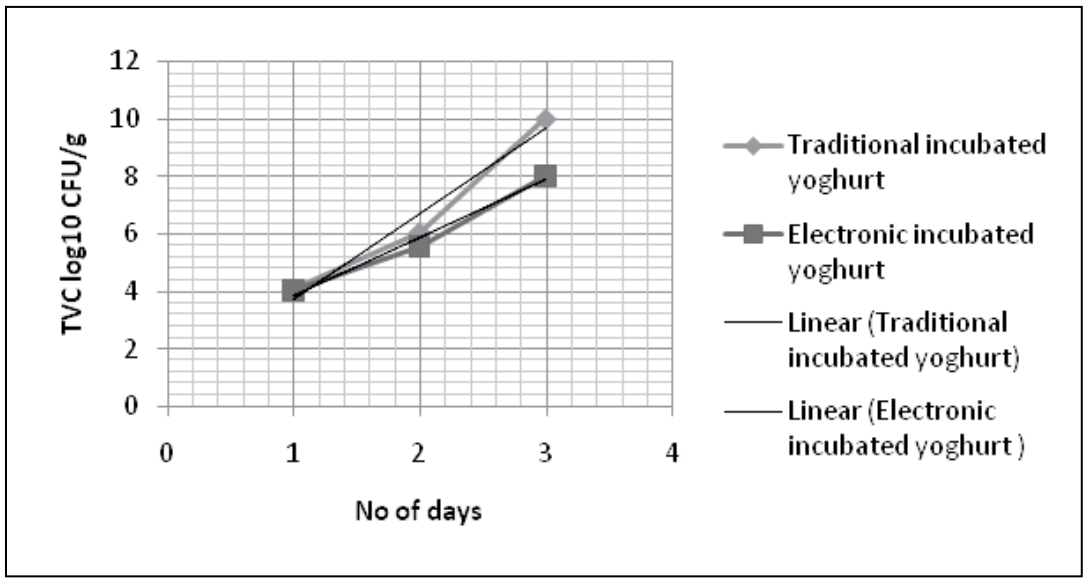

Fig.: 3.5.1 Total viable count in contrast of days

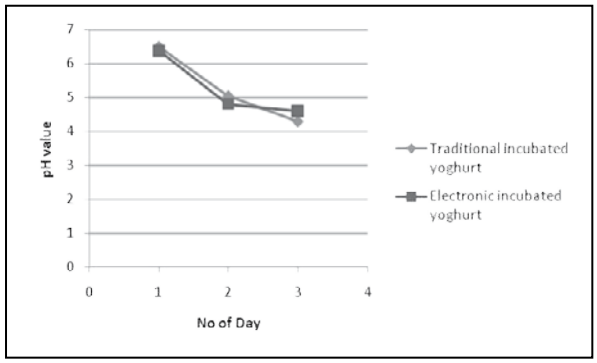

Fig.: 3.5.2 pH value in contrast of days

Fig. 3.5.3 Pictorial view of texture of *Bogurar Doi*

CONCLUSION AND RECOMMENDATIONS

This study has been able to successfully develop an incubator that can accommodate about 500 pieces *Sora* at a time. In consideration of quality attributes of yogurt, it is revealed that shelf life and GMP of *Bogurar Doi* by electronic incubation system is better than traditional incubation system. The hypothesis was addressed through this research that the electronic incubator is better compared to traditional incubator by technically in case of the product qualities. Further action research can be undertaken on the basis of these research findings to spread out this technology throughout country. Thus, the indigenous technology of *Bogurar Doi* by this incubation technology will be flourished in Bangladesh and post harvest losses of milk will be reduced as well. Entrepreneurs may be encouraged setting up this type of small scale yogurt industries and it will help to create employment opportunities. As a result, food safety and food security will be ensured with enrichment of nutrition and maintain food hygiene in rural Bangladesh.

FUTURE RESEARCH

1. Project feasibility study for small scale yogurt enterprises.
2. Close comparison study for both traditional incubation as well as electronic incubator incubation in terms of qualities.
3. Development of technical protocol for *Bogurar doi* to spread throughout the country.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 07

Effects of Seasonal Flood on Primary Education in Char Area (River Island) of Bogura District

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ABSTRACT

Char areas are river islands cut off from the mainland and are vulnerable to floods, drought and river erosion. Ensuring education for children is one of the challenging issues in the char areas of Bangladesh. Flooding is a regular disastrous event in Bangladesh and has a negative impact on char education. To determine the impact of flood on primary education in the char area, the study was conducted in Sariakandi upazila of Bogura district from September to December 2017 by using questionnaire survey; focus-group discussion and observations through transect walks. This study was conducted in two schools in Char Benipur village of Sariakandi upazila as these areas were mostly flood-prone in Bogura. This study mainly used qualitative data. The students, surveyed in the study, lived with families having an average size of 4.5. The highest numbers (45%) of guardians of school going-children were engaged in small-scale agricultural farming and the lowest (5%) were involved in fishing. The enrollment rates of the children were 96% and 97% in Char Dighapara Government Primary School (CDGPS) and Char Benipur Government Primary School (CCBGPS) respectively; where, the completion rates of primary education were found 91% and 89% correspondingly. The male and female student ratios were 0.95 and 0.89 in CBGPS and CDGPS respectively. In this study result shows that, factors attributed to the flood increased the dropout rate and lower contact hour of the students. The study suggested different adaptation measure to reduce the dropout rate and ensure quality education for the students of the char.

Keywords: Char area, Primary Education, Flood, Factor

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INTRODUCTION

Char areas are one of the most isolated, deprived and backward regions in Bangladesh. The char dwellers, particularly the extreme poor, are highly vulnerable to natural disasters. Deprivation from all the basic needs such as food security, agricultural development, health, education, habitation and empowerment almost ceases their ability to rise above the poverty line. Their little earning and scarce employment opportunities are exacerbated by natural disasters. Geographical isolation and poor governance thus contribute to making the chars extreme poverty pockets in the country (Siddiki, et al. 2014).

Chars in the river basins of the Padma, the Jamuna and the Brahmaputra have become deprivation traps due to their geographical isolation and vulnerability to natural disasters. Approximately 6 million people live on these islands. Inadequate government and NGO services in sectors like education, healthcare and livelihood hinder their socio-economic progress.

Chars are largely excluded from the global trends of technological and social advancements because of scarcity of resources like electricity, road and rail communication, healthcare facilities and education system. Char dwellers are constantly fighting against the shocks and threats of natural disasters and man-made problems such as floods, river erosion, and the exclusion of the extreme poor in local governance structures (Kabir, 2006).

Education has a pivotal role in the creation of not only human capital, but also social changes, especially the making of a progressive and democratic society that values sustainable development, economic growth and poverty reduction. Investment in education results in returns in other sectors, such as health, agriculture etc. (El-Ghonemy, 2006).

More than one-third of Bangladesh was intensely flooded by the heavy rain in August-September 2017. The flood affected 32 districts in the northern, northern-eastern and central parts of the country, affecting more than eight million people (HCTT, 2017). The flood had a huge impact on education in all over the country; and, an estimated 3 million children were in the need of education in emergencies in Bangladesh (HCTT, 2017).

Justification

Hazards can turn into disasters, and can distress the health and economic condition of school-going children and their families. They also may result in poor attendance, lower learning and higher dropouts of school children; and this, in the long run, will negatively influence economic development (Metzler, 2008). Considering the fact that developing countries, with lower means of protection and insurance against natural hazard events, are geographically more vulnerable to extreme weather events than the developed countries; and climate change will produce more frequent and severe hazards that may adversely affect educational outcomes and long-term human capital formation in the developing countries (Turvey, 2007). Flood is the most devastating natural disaster that occurs every year in Bangladesh. Each year, char areas were flooded and the socio economic well-being of the char dwellers was also affected (Rahman & Siddik, 2018). As a consequence, the school-going children of the area do not go to their educational institutions. Some students migrate to the mainland to avoid further disruption in their education.

Objectives

This study was intended to explore the impact of the 2017 flood immediately after the flood on the education of the char children. Specific objectives of this study were-

1. To get an overview of the education status of the selected char
2. To identify the factors affecting children's education during the flood
3. To recommend some measures to diminish the detrimental effect of flood on the education in the char areas

METHODOLOGY

Duration and the study area

Data were collected from September to December 2017 in the selected char. The following two schools were selected to fulfil the aim of the study (Table-1). Char areas of Sariakandi upazila are the most flood-prone in Bogura district. So, Char Benipur of Sariakandi was selected for the study purposively.

Table 1: Study areas

Schools	Char/ Village	Upazila	District
1) Char Dighapara Government Primary School (CDGPS)	Char Benipur	Sariakandi	Bogura
2) Char Benipur Government Primary School (CBGPS)			

Data collection

Qualitative data were collected by using questionnaires; focus group discussions (FGD), and observations through transect walks for this study. A total of 90 school children (45 boys and 45 girls), from two schools were interviewed through a structured questionnaire. Four FGDs were held; two at each school, one with the students and another with the guardians. Each focus group consisted of 10 pupils (5 boys and 5 girls) and another one consisted of 3 male and 3 female guardians. In all, 6 key informal interviews were conducted: two with the school head teachers, one with a union parishad member of the area, and three with assistant teachers of the schools. Field observations and transect walks were undertaken with the guardians to assess the nature and level of damages that were caused by the flood. The researchers also visited some of the areas to assess the type of roads that were used by the school-going children.

Data analysis

The collected data were transcribed and analyzed based on their content. Entries in the transcripts were classified into themes or categories. The entries were organized and synthesized depending on their relevance to the study. Descriptive statistics, frequency of responses, percentages and means were used to describe the data obtained from the survey by using Excel 2007.

RESULT AND DISCUSSION

The children of the chars are depriving from quality education due to their socio-economic condition and different factors. The livelihood scenario of pupil parents, educational status and different factors that affect the quality education in the char with recommendation were presented in this study.

Livelihood status

In the study areas, the average family size was 4.5; while, the largest was 12, and the smallest was 3 (Table 2).

Table 2: Family size of the school-going children

Title	Mean	Minimum	Maximum
Family size	4.5	3	12

The highest number (45%) of guardians of the school-going children was engaged in small-scale agricultural farming and lowest (5%) were involved in fishing. Subsequently, 28%, 15% and 7% guardians of the school-going students were day laborer, boatmen and small businessmen like grocery store owners respectively (Figure 1).

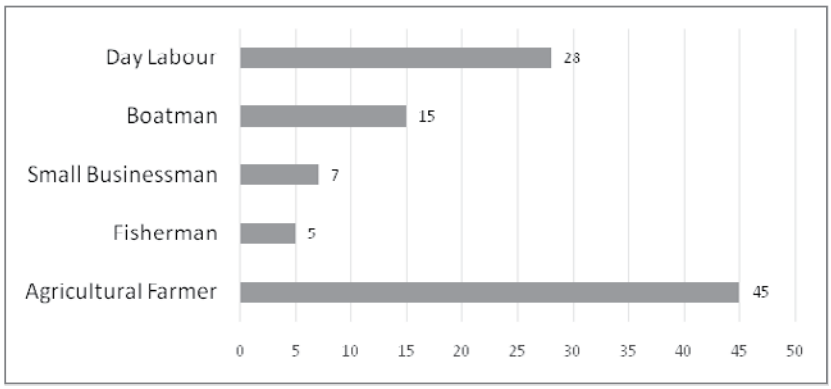

Figure 1: Scenario of occupation of the guardians of the respondent

Education status of the selected char

Two government primary schools were found on char Benipur i.e. Char Dighapara Government Primary School and Char Benipur Government Primary School. In the study area, there was no other higher educational institution. As a result, the students who completed their primary education had to migrate to the mainland to continue their studies.

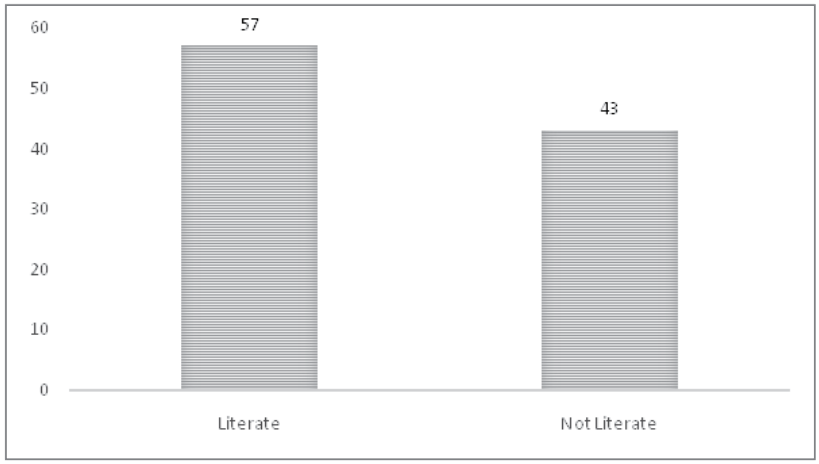

Figure 2: Educational status of the char dwellers

The literacy rate was 57% among about 1200 people living on char Benipur (Figure 2). Due to extreme poverty and malnutrition, the literacy rate in the study area was found low compared to the average national literacy rate of 73.9% (Alamgir, 2020; 1st char convention, 2015).

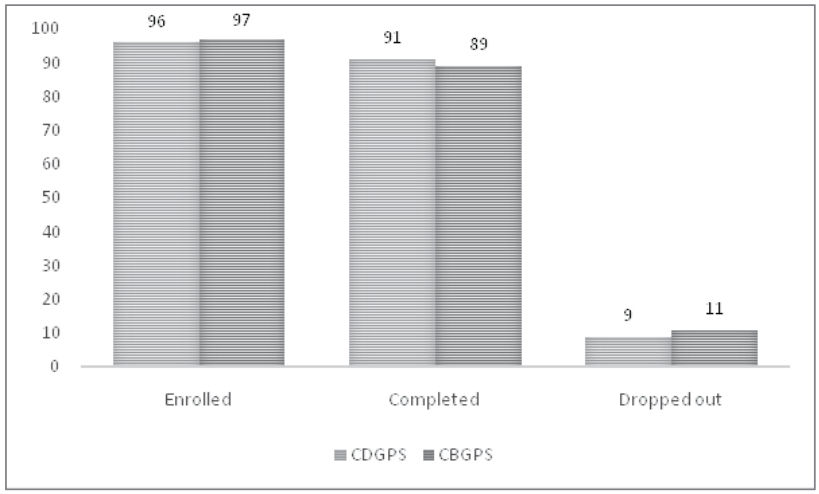

Figure 3: Enrolment, completion and dropout status

The enrolment rate of the children were 96% and 97% in CDGPS and CBGPS respectively; whereas, the completion rate of primary level were 91% and 89% correspondingly (Figure 3). The enrolment rates of both the study areas were lowered than the national enrolment rate of 97.85% (CRI, 2019). Different adverse factors such as poverty, malnutrition, illiteracy and disaster-prone environment might be associated to the dropout rates in the area.

In Char Benipur Government Primary School (CBGPS), the total number of students was 86, of whom 42 were boys and 44 were girls. The total number of students was 87 in Char Dighapara Government Primary School (CDGPS), of whom 41 were boys and 46 were girls. The male and female student ratios were 0.95 and 0.89 in CDGPS and CBGPS respectively (Table 3).

Table 3: Total number of students and their ratios in both the schools

	CDGPS	**CBGPS**
Total students	87	86
Male	41	42
Female	46	44
Ratio	0.89	0.95

* **CDGPS** = Char Dighapara Government Primary School
CBGPS = Benipur Government Primary School

The male and female primary-school enrollment ratio in 2018 in Bangladesh was reported 1.07 (Gender Statistics of Bangladesh, 2018).

The number of the teacher posts in both school was 5 (five) but only 4 (four) and 3 (three) were found occupied in CDGPS and CBGPS respectively. Among the 4 (four) teachers in CDGPS,2 (two) were male and 2 (two) were female. In contrast, 2 (two) teachers were male and 1 (one) was female in CBGPS. In addition, all the teachers used to go to the schools from the mainland and none of them was from the char areas (Table 4).

Table 4: Number of teachers in the surveyed school

Name of school	**Post**	**Occupied posts**	**Male**	**Female**	**From char**
CDGPS	5	4	2	2	-
CBGPS	5	3	2	1	-

* **CDGPS**= Char Dighapara Government Primary School
CBGPS = Benipur Government Primary School

Factors affecting education during the flood

During the study period, a number of factors were identified that affected the quality of education in the char areas.

Poverty

In Bangladesh, about 130.20 million people live in flood plains and deltas of three major rivers i.e. the Brahmaputra/Jamuna, the Ganges/Padma and the Meghna (Kabir, 2006). Thus, poverty and floods are two big inter-related socio-economic problems in char of Bangladesh. Floods impede development in rural communities of char through erosion of river, human relocation, and destruction of crops, shelter and livestock. It also affects the human resource by causing injuries to char dwellers. The primary-level enrolment rates in the study area were lower particularly among the children from poor families. Most of the time, school-going children missed their schools as they were busy assisting their parents to secure food for the family members. Furthermore, the direct and indirect costs of education were another disincentive for the extreme poor households and hampered the progress of the children's education (ILO, 2008). These issues forced the children to be employed as field labours instead of attending schools.

Poor learning environment at school

Conducive school environment is a vital element in effective learning and has a strong positive impact on the quality of education. Student-oriented environment also helps to ensure high attendance of students and effective classroom interactions. Ideally, classrooms should be attractive, spacious, soundproofed (proper doors, windows etc.), well-lit, well-ventilated and provided with enough benches, tables, blackboards, dusters, fans and other necessary equipment (1st char convention, 2015).

Though schools were located along unmaintained roads; during the flood, they were badly hit by the flood and became unusable for the children to reach their schools. As a result, some children chose to be absent from school; whilst others ended up being dropouts. The children reported that floods damaged school infrastructure and property such as furniture, books, classrooms and toilets every year and every time they experienced floods, some classroom walls and toilets collapsed with roof tops blown off.

Loss of learning hour

Every year, during the rainy season almost the entire char goes under water and the schools remain closed during that time. The recent 2017 flood inundated the ground floors of the school buildings water, and so educational activities were suspended for a couple of months. For that long closure, it was very difficult for the teachers and students to cover the school syllabus within the particular time period. As a result, they could not achieve their desired examinations results compared to the other pupils whose learning was never interrupted. The children highlighted that, during the rainy season, most of the rivers overflowed. Consequently, they could not attend their schools and lost valuable learning hours. This is a common scenario of almost every year. During the flood or water logging times, the families struggle to find food and shelter; and thus, educational activities become an unaffordable luxury for the char dwellers.

Losing books and other learning material

In the study area, most of the children lived in traditional houses with grass-thatched roofs. Such houses were highly prone to damage by flood and rain. It was observed that 90% of the households had lost at least a hut during the recent 2017 flood. Their homes were as vulnerable as the schools which compounded the effects of floods on the school children. The students lost their books and other instruments or learning materials. As a result, some children whose houses were badly affected by the flood dropped out of school. Whilst some others who stayed at home for a long period to recover from the disaster impacts also added to the increase number of dropouts in the char area; and thus, failed to access the right to education for all.

Teacher and student absenteeism

During any flood, the educational activities of the char schools usually stop. Most of the char areas are highly vulnerable to land erosion due to the river current and flood. As a result, teachers from the mainland have a kind of apathy to teach in the char schools. In both the schools, all the posts for the teachers were not fulfilled due to the adverse environment during flood time and lack of road communication with the mainland. The students and guardians also reported that it was very hard to find any well-qualified teacher in the disaster prone char areas. The teachers who were serving in char schools also had the affinity for getting transferred to the mainland schools, and deliberately remained absent in the existing schools. Often, the newly transferred teachers in the char schools caused discontinuity of learning assessments that also hampered learning environment of the schools. Most of the time, the schools had to without the full staff of teachers. At the same time, majority of the poor students remained absent in school after the flood as they were assisting their families to recover from damages caused by the flood. Lack of teachers and absence of students hampered the learning environment of the char schools resulting in a low standard of education.

Poor communication system with the mainland

Respondents highlighted that the children at lower levels of the schools were normally compelled to stay at home because they could not cross the overflowed rivers, which again affected their academic progress. Children always faced extra challenges to access schools during the rainy season because of the damaged roads and travelling across rivers. Rivers and streams created barriers to children who needed to cross them to get to their respective schools; and, these were also mentioned as a contributing factor to the poor learning environment of the schools. It was indicated that children who crossed rivers to reach their schools normally got wet which made them uncomfortable to learn with others; and so, they often ended up dropping out or staying at home.

Social obstacles for female students

Although the ratio of male and female students in study areas was near the national level but floods and heavy rain created more problems for the female students. Flood damaged the communication facilities in the char areas. River erosion, loss of houses and property, no work facilities in the monsoon period, and lack of socioeconomic safety created extra loads on families that led to the early marriage of school-going female students. Lack of usable communication

facilities, sense of insecurity, and early marriage of girls are three main reasons for dropping out from the schools.

Migration/ Displacement of families

River erosion caused by flood is a major threat to Bangladesh as it causes the migration of the river island dwellers and ravages approximately 10,000 hectares of land every year (Government of Bangladesh, 2010). The losses caused by erosion are usually slow and gradual. However, they are more destructive in the long run than other sudden and devastating calamities. This situation is even more worrying considering that about one million people are affected by the erosion of riverbanks each year (IOM, 2009). Migration to another char means the beginning of a new fight for survival. Fragile economic condition and adaptation to the new environment due to the flood made more difficulties for the children who tried to continue of their studies in the middle/eleventh hour of the academic year.

Lack of local-community teachers in the char

One critical hindrance to the expansion of secondary or higher level education in char areas is unavailability of qualified teachers from the local communities. In the study area, all the teachers came from the mainland; and, only by boat they could reach the schools. The flood damaged or destroyed the road and other communication structures. Fluctuation of timing of the boats, unpredictable weather, and unreliable communication system created barrier for the teachers from the mainland to reach school on time. As a consequence, valuable contact hours were lost and the learning environment was negatively affected as well.

RECOMMENDATIONS AND CONCLUSION

The 2017 flood badly affected the education service delivery and the schooling of the children living in the char areas. Disruption or cancellation of classes, infrastructure damages, poor learning environment, poor communication system caused by the flood inserted adverse effects on both the students and teachers of the schools; and created huge problems in the delivery of quality education services. This study shows that significant inequalities exist in education in char areas, which must be addressed immediately if Bangladesh is to attain the SDGs. As such, it is vital that the government of Bangladesh and the national and international education actors/stakeholders concentrate on improving the quality of char education and removing the barriers that hinder education for the char children. Government can take massive program on asset transfer to reduce the poverty in flood affected char by identifying the poor people. It is very urgent to develop a digital mechanism to collect the loss and damage of the flood affected schools that helpful to make necessary plans to develop the learning environment within a short periods. In addition, online teaching can be arranged during the flood time, and trainings for the teachers can be ensuring to improve their skills to ensure online teaching-learning. To reduce the dropout rates, particularly of female students, it is important to run awareness campaigns involving the local key persons and guardians of the students, opinion builders like the imams and local political leaders. Mobilization and engagement of local education officials, parents and school

communities are need to ensure that all children resume their education immediately after flood. Besides, the authority can plan to reschedule primary-school-level examinations to ensure that all the students are examination ready by providing catch-up classes and increasing the teacher-student class hours. In preparation of the next academic year, development of an additional educational calendar based on geographical hazards such as floods and river bank erosion is recommended to mitigate the potential loss of class hours of the students.

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ISSN 1019-9624
Bangladesh Rural Development Studies Vol. XXIII; No.1 (2020)

Article 08

Impact of Groundwater Fluctuation in the Selected Upazilas of Bogura District, Bangladesh

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ABSTRACT

Groundwater fluctuation affects domestic, agricultural, and industrial prospects of a region. Bogura district, Bangladesh, is located on the Pleistocene terrace of the Bengal Basin, where the aquifer of medium-to-coarse sand is located at a depth of 4.66–42.68 m. The water table (WT) time series data for 2007–2019 in Sadar, Kahaloo, Dupchachia and Adamdighi Upazilas of Bogura district was examined for forecasting and characterizing present and future groundwater resources using recognized empirical equations. The maximum WT of two Upazilas Dupchachia, and Adamdighi of the four Upazilas in the district were 11.52, and 10.47 m, respectively; shallow tube wells (STWs) in these Upazilas were inoperable for irrigation via suction mode by exerting a pressure of 1.03 kg/cm^2. The annual groundwater storage and annual groundwater discharge were 639.76 Mm^3 and 375.52 Mm^3, respectively. The annual reserve of groundwater was 264.24 Mm^3 (41.30%) in the study area. Annual groundwater recharge was found 234.69 mm in the study area. Considering uniform areal distributions of boreholes, the extant spacing between deep tube wells (DTWs) and STWs were 786 and 393 m, respectively. Currently, DTW spacing ranges 786–800 m, but STW spacing of 250–393 m is inadequate. Hence, further installation of STWs in the study area should be strictly disallowed. WT declined by 1.28 m in the last 13 years, i.e., 0.09 m decline rate per annum, causing water scarcity in thestudy area; especially in the Dupchachia and and Adamdighi Upazilas of the district during the peak period in the dry season due to failure of suction mode, thus affecting irrigation and limiting agricultural production.

Keywords: Groundwater Monitoring, Discharge, Storage, Water Table Decline, Peak Period.

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INTRODUCTION

Groundwater is the most significant source of water in Bangladesh. Owing to the inadequate availability of surface water during dry seasons, it acts as the vital, safe, and reliable source of water for irrigation and domestic use, as well as for industrial purposes, during the dry period (Matin et al. 2000). In fact, it contributes more of 70% of the water for irrigation and 90% of the drinking water in the country (Matin et al. 2000). Groundwater is obtained using various types of lifting equipment, such as hand tube wells, shallow tube wells (STWs), deep tube well (DTWs), deep set shallow tube wells, and force mode tube wells. Moreover, the main sources of surface water are the Canal and rivers of Nagar, Bengali, Ichamoti, Karatoa, Bhadrabati, Jamuna, Tulshiganga, etc. in the study area, where low lift pumps (LLPs) are mainly used for contributing surface water. Further, alluvial aquifers are the proven sources of groundwater in Bangladesh. Groundwater is annually replenished via rainfall and flooding as well as through the systematic recycling of water nationwide, except in Dhaka Megacity where there is an imbalance between the asymmetrical recharge and discharge (BADC 2008). Therefore, the groundwater shortage occurs primarily in the dry season and affects the amount of water available for irrigation. From an earlier study which showed that the northwestern districts in Bangladesh face a groundwater shortage of 42% annually (Shahid and Hazarika, 2010).

LITERATURE REVIEW OF THE STUDY

Groundwater hydrology is a very complex process and is not limited to merely understanding the groundwater situation, zoning maps, areas, climate, weather, temperature, humidity, rainfall, and aquifer properties because of the difficulty in characterizing an area through only a few studies. Groundwater hydrology is the continuous process of providing solutions when studying a problem for a specific area. From the presently available geological subsurface information, most of the aquifers appear to occur between depths of 30 to 130 m and the aquifer systems across the country are heterogeneous (Zahid and Ahmed 2006). Barind/drought prone area in Bangladesh has a typical dry climate and high temperature in the winter season beginning from mid-June to October whereas the rainfall and temperature ranges vary from about 1500 mm to 2000 mm and 4^0C to 44^0C, respectively, in the region (www.bmda.gov.bd). The depth of the water table (WT) and rainfall penetration depth are slowly declining in most of the wells, and in the present trends of decline of the WT in Bogura district suggest that the WT depth may double by year 2060 in some cases (Hasanuzzaman et al. 2017). Groundwater scarcity is becoming severe because of the uncontrolled and unplanned extraction for irrigation; STWs are inoperable during the dry season. As a result, groundwater recharge is less (330 mm) than the annual water excess (594 mm) realized through managed aquifer recharge (Rahman et al. 2018). The WT is decreasing at an alarming rate due to over-exploitation in the northwestern districts of Bangladesh. The reductions rates varies from 0.00 to 0.03 m/yr, considering the mean depth of phreatic surface and from 0.012 to 0.15 m/yr for the maximum depth of phreatic surface in the southern and western upazilas or sub-units of Bogura district (Abdullah et al. 2019). However, the aquifer in Bogura district is in a poor condition—during the dry season, water is insufficient to meet the demands for both irrigation and human consumption; hence, efforts to improve the availability

of groundwater resources are essential. Some research on groundwater resources has been performed by Barind Multipurpose Development Authority (BMDA) and other organizations, focusing on the areas in the Barind Tract, such as Naogaon, Rajshahi, Chapai Nababganj, and the greater Rajshahi and Rangpur divisions. However, research on groundwater in the selected Upazilas of Bogura district is few and not detailed; most deal with groundwater assessments.

OBJECTIVES OF THE STUDY

The main objective of the study was to assess the WT for forecasting present and future groundwater resources. The specific objectives were as follows:

- prepare a lithological inventory of boreholes and identify the type of soil formation;
- estimate the available groundwater storage using groundwater recharge and discharge;
- determine well spacing; and
- determine if the groundwater is rising or falling.

SIGNIFICANCE OF THE STUDY

The results of this study are of significance to planners, policy makers and researchers involved in irrigation and water management, and groundwater planning are applicable to not only the study area, but also on a nationwide or global level.

LIMITATIONS OF THE STUDY

As this study area is confined in the selected Upazils of northwest region Bogura, Bangladesh due to scarce water in dry period and consideration and investigation of groundwater resources, especially on groundwater fluctuations according to environmental monitoring and assessment, the literature review recommends that there is a wide range of concerns that might have some impacts on environmental degradation due to groundwater fluctuation. Also, environmental, political, legal and cultural issues are likely exogenous factors due to raise the various unconditional situation for the study. To keep the study with suitable scopes for laborious investigation ungenerousness, only environmental impacts were scrutinized, especially on practical aspects of groundwater but there is a wide scope to determine the hypothetical models that's are recommended for the future study. In addition, this study specifically explore only the impacts on groundwater fluctuations like groundwater storage, recharge, discharge, and pressure etc. for considering the present and future environmental deprivation due to resources and time constraints, but there is a lot of opportunity to further study copping up climate change.

MATERIALS AND METHODS

Study Location

The target area of this study was the selected Upazilas of Bogura district in northwest Bangladesh. Geographically, Bogura district lies between 89^0, 21 min, 0 sec east longitudes, and 24^0, 46 min to 48^0 north latitudes. It is called the gateway to north Bangladesh. It is approximately 200 km from the north of Dhaka, the capital of the nation.

Sample Size

Lithologies for 145 boreholes were analyzed for preparing a groundwater lithological inventory to identify the soil formation types. In addition, 11 monitoring wells were selected (one from each upazila) and the time series primary data of the WT were collected for the last 13 years from 2007 to 2019 from the Bogura office of the Bangladesh Agricultural Development Corporation (BADC). The location of the selected monitoring wells is listed in **Table-1**.

Table-1: Locations of the groundwater Monitoring Wells

Sl. No	District	Upazila	Union	Mouza
1.	Bogura	Sadar	Madla	Helancha para
2.	Bogura	Kahaloo	Moral	Valta
3.	Bogura	Dupchachia	Zianagar	Zianagar
4.	Bogura	Adamdighi	Chhatianagram	Boroakhra

Estimation of Annual Groundwater Storage

Groundwater refers to the water present in the pore spaces of soil. That part of the rock or unconsolidated deposit formation is called an aquifer when it can harness an effective quantity of water. Groundwater storage is the product of the area of the aquifer, depth of fluctuation of the WT and specific yield (Raghunath 1987):

$$\text{Groundwater storage} = \text{Area of aquifer (A)} \times \text{Thickness or Depth of fluctuation of WT (ØH)} \times \text{Specific yield (Sy)} \quad (1)$$

Where, A is the area of aquifer in the study area (m^2); ØH, the depth of fluctuation of the WT (m); and Sy, the specific yield (%). The depth of the WT fluctuation is the difference between its maximum and minimum levels in the WT throughout the year in the given region. The Eqn can easily assess groundwater discharge by comparing storage, shortage, or steadiness of groundwater in a region. Moreover, the Eqn assessed the basin or district wise evaluation by considering static groundwater resources carefully and cautiously for sustainable groundwater development (Ministry of Water Resources, India 2009).

Groundwater Recharge

Groundwater recharge is a hydrological process where water passes downward from the surface deeper into the ground. It is the amount of water that enters the saturated zone, i.e., the enduring WT in an aquifer. The main source of recharge is rainfall, which may enter the soil directly to reach the groundwater zone. Aquifer recharge refers to the amount of water that may be available in the long term for extraction. Groundwater recharge, also referred to as deep drainage or deep percolation, is calculated for areas that receive abundant rainfall. The data of groundwater recharge is then used for calculating the well spacing in the study. Annual groundwater recharge estimated using the following formula (Rao 2016):

A. Bhattacharya's formula (1954), $P = 3.47 (R - 38)^{0.4}$ (2)
   Where, P is the rainfall penetrated/recharge (cm), and R is the annual rainfall (cm).

B. Chaturvedi's formula (1973), $W = 13.93 (P - 381)^{0.4}$ (3)
   Where, W is the groundwater recharge (mm), and P is the annual rainfall (mm).

C. Sehgal's formula (1973), $W = 12.6 (P - 406.4)^{0.5}$ (4)
   Where, W is the groundwater recharge (mm), and P is the annual rainfall (mm).

D. Radhakrishna's formula (1974), $G = (P \times 10)/100$ (5)
   Where, G is the groundwater recharge (mm), and P is the annual rainfall (mm).

E. Datta et al.'s formula (1980), $Re = 0.11 (P - 41.8)$ (6)
   Where, Re is the groundwater recharge (cm), and P is the annual rainfall (cm).

Groundwater Discharge

Groundwater discharge is the term used to describe the movement of groundwater from the subsurface to the surface. Annual discharge can be easily determined to ascertain the number of wells (DTWs and STWs), average pumping capacity, and time period of operation. The annual discharge of groundwater for irrigation in the study area is estimated using the following equation (Asaduzzaman 1987):

$$Va = N \times Q \times t$$

Where Va is the annual groundwater discharge (Mm^3); N, number of tube wells operated in the area; Q, the capacity of pumping a well (m^3/h); and T, the operation period (h/yr).

Well Spacing

It is generally defined as the maximum area of the resource basin that can be drained efficiently and economically by a well. The prevailing spacing between wells was determined for the study area by considering a uniform areal distribution of wells and entire utilization of the safe yield of the groundwater basin on the basis of the available groundwater recharge. Safe yield is defined as the amount of water that can be withdrawn from the groundwater basin without producing an undesired effect. The annual recharge must not exceed the total groundwater extracted. The well spacing clearly indicates the distribution of water lifting devices installed in an irrigation field.

The relation of well spacing to recharge, discharge, and pumping period is described by the following equation (Chowdhury and Wardlaw 1978):

$$R = 60 \sqrt{(QtN / Rg)} \quad (8)$$

Where, R is the well spacing (mm); Q, the well discharge in L/s; t, the pumping period in days/yr; Rg, the groundwater recharge in mm/yr; and N, the number of operating h/day.

Direct Field Supervision

Some data was collected through direct field supervision with consent from end users, beneficiaries as well as managers handling groundwater resources in the study area.

RESULTS AND DISCUSSION

Lithology

Borehole inventory is plotted in **Fig. 1** using both the borehole and aquifer thickness of 145 lithologies. From this figure, the maximum, minimum, and average borehole thickness were found as 72, 27, and 44.54 m, respectively. In addition, the maximum, minimum, and average aquifer thickness were 42.68, 4.66, and 19.48 m, respectively. The aquifer in the study area was composed of medium sand (MS) to coarse sand (CS).

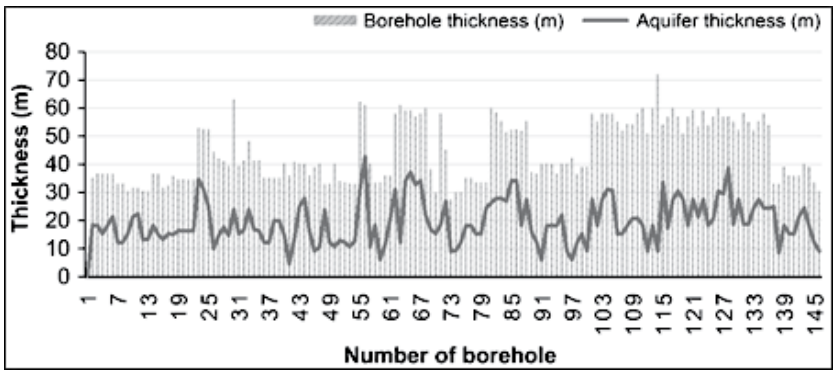

Fig. 1: Borehole Inventory of the Study Area

Hydrograph

A hydrograph is a graph showing the rate of flow past a specific point such as a river, channel, or conduit. In this study, the hydrographs obtained through monthly rainfall and groundwater table (GWT) data from 2007 to 2019 are designated as hydrograph **(Fig. 2)**. The x-axis denotes the month–year, and the y-axis represents monthly rainfall and groundwater table that is reflected in the hydrographs as well in the two recognized limbs, particularly seen in the one-year water curve of Bogura Sadar Upazila. The two limbs of the hydrograph show groundwater level fluctuations,

one, the rising limb or crest or peaks representing the recharge phenomena, whereas the other, the recession limb or trough representing the discharge phenomena. The hydrographs are compared and classified with groups of identical classes. The form of the annual hydrograph in a specific well remains nearly unchanged over consequent years in spite of the deviations in its magnitude with the variation of the annual recharge or discharge to the aquifer.

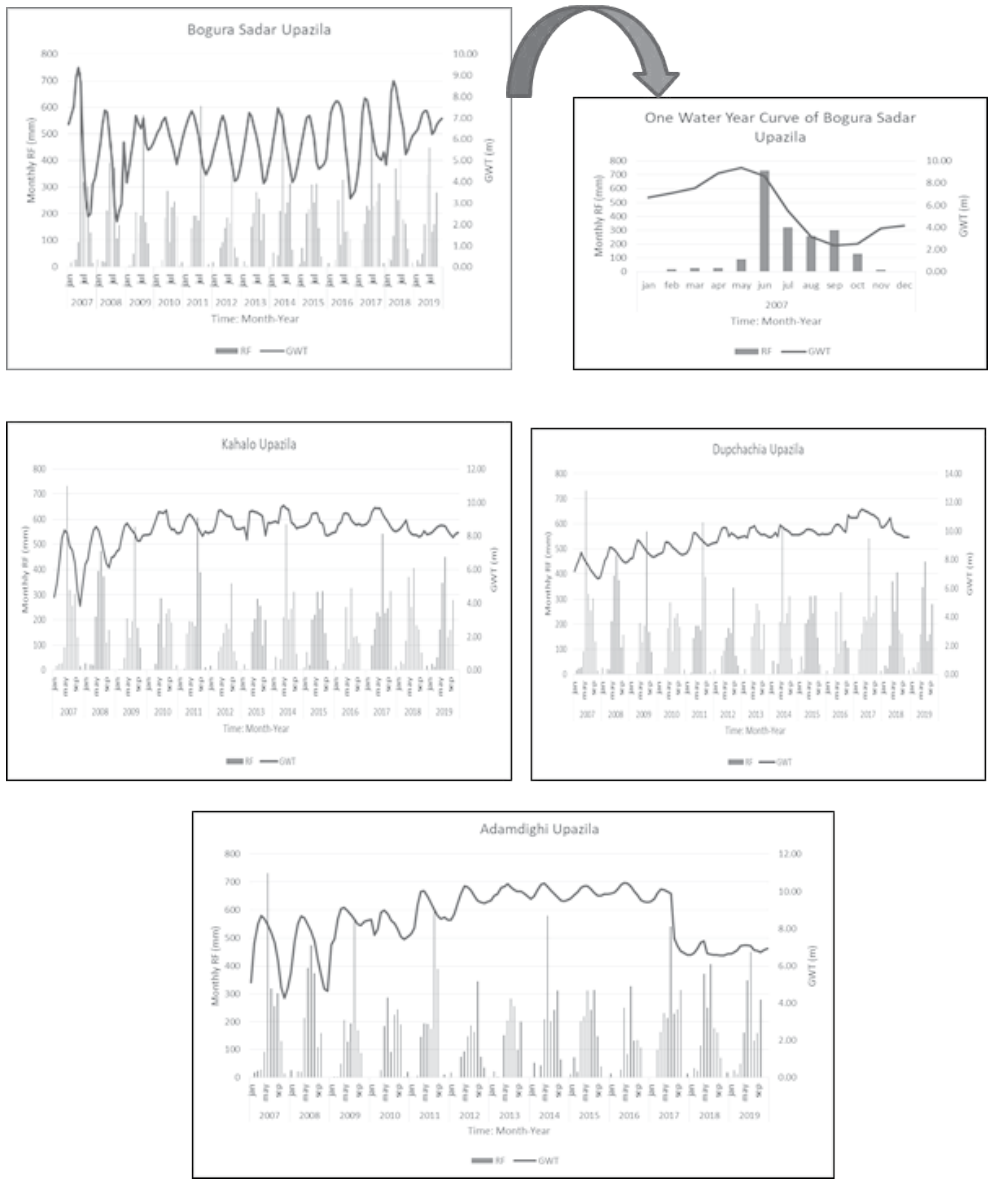

Fig. 2: Typical Hydrograph from Monthly Rainfall and Water Table along with Time Series Data during 2007 to 2019 in Wells from the Study Area.

Groundwater Fluctuations

Groundwater fluctuations shown in **Fig. 3** are plotted using monthly GWT data for the last 13 years (from 2007 to 2019). From these figures, the maximum, minimum, and average GWT, groundwater fluctuation, and standard deviations values are obtained as listed in **Table-2**.

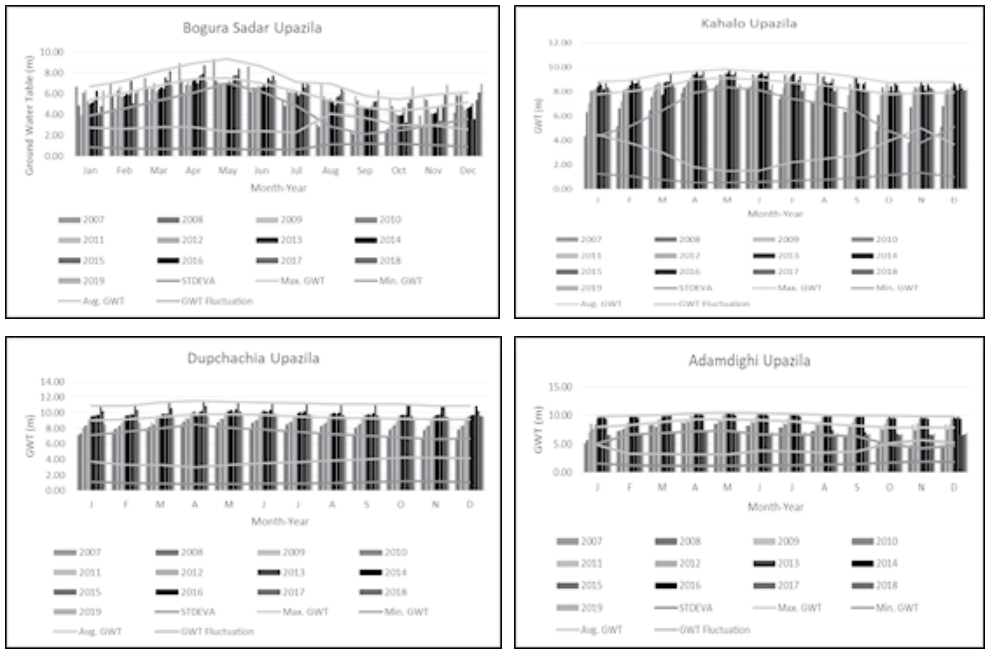

Fig. 3: Maximum, Minimum, and Average Values of the Water Table, Water Table Fluctuations, and Standard Deviation in the Study Area.

Table-2: Maximum, Minimum, and Average of the Water Table, Groundwater Fluctuations, and Standard Deviation for the Period 2007–2019

Sl. No.	Name of Upazila	Water Table (meter)			Groundwater Fluctuations (meter)			Standard Deviation (meter)		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
1	Bogura Sadar	9.38	2.15	5.76	4.1	2.3	2.94	1.19	0.63	0.89
2	Kahaloo	9.83	3.83	8.36	4.98	1.48	3.04	1.32	0.52	0.88
3	Dupchachia	11.52	6.67	9.4	4.27	3.03	3.66	1.19	0.81	0.99
4	Adamdighi	10.47	4.27	8.53	5.62	3.12	4.05	1.89	1.14	1.44
Average		10.30	4.23	8.01	4.74	2.48	3.42	1.40	0.78	1.05

From the data in **Table-2**, the maximum, minimum, and average WT are 10.30, 4.23, and 8.01 m, respectively; the maximum, minimum, and average groundwater fluctuations are 4.74, 2.48, and 3.42 m, respectively; the maximum, minimum, and average standard deviation are 1.40, 0.78,

and 1.05 m, respectively. Finally, the average WT and groundwater fluctuation are 8.01 and 3.42 m, respectively, in the study area.

Groundwater Pressure

Generally, the suction mode of centrifugal pumps (a shallow aquifer) is employed in the case of STWs, and the force mode of submergible pumps (a deep aquifer) is employed in the case of DTWs. Using the suction mode, water can be lifted by not more than 10.33 m at sea level by exerting a pressure of 1.03 kg/cm^2 if perfect vacuum occurs in the pump (Mahmud 2012). The maximum WT in Dupchachia, and Adamdhigi Upazilas (Table-2) are 11.52 and 10.47 m; these values exceed the limit 10.33 m, beyond which the suction mode is inoperable. In other words, the centrifugal pumps of STWs fail in the dry seasons. The remaining two upazilas (Bogura Sadar and Kahalo) are safe zones for pumping up groundwater throughout the year because the WTs in these Upazilas are within 10.33 m.

Annual Groundwater Storage

Analysis of the lithology and aquifer type in Bogura district revealed the presence of MS-to-CS. The specific yield (Sy) for MS and CS was 15%–30% and 20%–35%, respectively, for this soil formation (Walton 1996). The aquifer area of Bogura Sadar (176.58 km^2), Kahaloo (240.42 km^2), Dupchachia (162.44 km^2) and Adamdighi (168.83 km^2) A, is 748.27 km^2; average depth of the WT fluctuation, ØH, is 3.42 m (From Table-1). These values were substituted in Eqn (1). Then, for a specific yield, Sy, of 22.5% (average for MS), the groundwater storage was estimated as 748.27 km^2 × 3.42 m × 0.225 or −575.79 Mm^3. Now, for a specific yield of 27.5% (average for CS), the same equation yielded an estimate of 748.27 km^2 × 3.42 m × 0.275 or −703.74 Mm^3 as the groundwater storage. The annual groundwater storage was taken as the average of these two values, i.e., 639.76Mm^3.

Groundwater Recharge

Groundwater recharge was calculated using Eqn (2) to Eqn (6) as listed in **Table-3**.

Table-3: Annual Groundwater Recharge

Sl. No.	Formula		Average rainfall during 2007–2019 (mm)	Annual recharge (mm)
	Name	Rainfall unit		
1.	Bhattacharya's (1954) $P = 3.47 (R - 38)^{0.4}$	R = cm	1549.62	233.10
2.	Chaturvedi's (1973) $W = 13.93 (P - 381)^{0.4}$	P = mm		234.97
3.	Sehgal's formula (1973) W = 12.6 (P − 406.4)0.5	P = mm		426.02
4.	Radhakrishna's (1974) G = (P × 10)/100	P = mm		154.90
5.	Datta et al.'s formula (1980 Re = 0.11 (P − 41.8)	P = cm		124.47
Average				**234.69**

The average groundwater recharge in Table 3 is 234.69 mm. This is close to the values of 233.10 and 234.97 mm calculated using the formulas given by Bhattacharya (1954) and Chaturvedi (1973), respectively. Hence, in this study, the groundwater recharge is considered as 234.69 mm.

Groundwater Discharge

The annual discharge and surface water contribution are calculated from the total number of DTWs, STWs, and LLPs with their average pumping capacity and operating period. The study area has 1384 DTWs (Sadar 179 Nos., Kahaloo 581 nos., Dupchachia 340 nos. and Adamdighi 284 Nos.) and 4816 STWs (Sadar 2546 Nos., Kahaloo 850 nos., Dupchachia 570 nos. and Adamdighi 850 Nos. (BADC 2019) with discharge capacities of 56 L/s (or 201.6 m^3/h), and14 L/s (or 50.4 m^3/h), respectively (Singha et al. 2014). Considering pump design, the actual pumping efficiency of each DTWs, and STWs were regarded approximately 25% less than the discharge capacity. Presently, the average irrigation period was considered as 960 h/yr for DTWs, and STWs (entire irrigation depends on the Rabi season, but supplementary irrigation is performed for the seasons of Aus and Aman cultivation, i.e., July–August and December–January, respectively, if needed). The irrigation periods have decreased because of cultivation of modern varieties, as well as the adoption of modern irrigation techniques, with average yearly operating periods of 1223 h for DTWs and 1216 h for STWs (Mondal and Saleh 2002). From Eqn (7), the number of wells, average pumping capacity, time period of operation, annual discharge, and surface water contribution are obtained as listed in **Table 4**.

Table-4: Annual Groundwater Discharge

Sl. No.	Name of Devices	Total Numbers in Operation, Nos	Pumping Capacity, Q (m^3/hr)	Irrigation Period (16 hr/day × 60 day/yr), T (hr/yr)	Annual Discharge, Va = N × Q × T (Mm^3)
1	2	3	4	5	6 = (3 × 4 × 5)
1.	DTW	1384	151.2	960	200.89
2.	STW	4816	37.8	960	174.83
Total Discharge					375.72

The annual groundwater storage and annual groundwater discharge were 639.76 Mm^3 and 375.52 Mm^3, respectively. The annual storage of groundwater was 264.24 Mm^3 (41.30%) of the total storage in the study area.

Well Spacing

To calculate the well spacing, the following parameters were considered: The pumping capacity of DTWs, Q, was 151.2 m^3/h or 42 L/s; pumping period, t, was 60 d/yr; operating hours, N, was 16 h/d; and groundwater recharge, Rg, was 234.69 mm/yr (Table-3). Then, using Eqn (8), the

well spacing of the existing DTWs was calculated as 786 m. Further, for the pumping capacity of STWs, Q, 37.8 m^3/h or 10.5 L/s and all other parameters identical to those for the DTWs, the well spacing of existing STWs was calculated as 393 m using the same equation. However, the recommended spacing for DTWs (a well with a discharge capacity of 201.60 m^3/h or 2.01 cusec) and STWs (a well with a discharge capacity of 50.4 m^3/h or 0.50 cusec) are 800 and 250 m, respectively, for the study area (Ministry of Agriculture, Bangladesh 2019). Thus, the results showed although the spacing of DTWs is appropriate, that for STWs is inappropriate. Hence, further installation of STWs should be strictly disallowed in the study area, and all STWs should be operated very carefully in the dry season to ensure they do not over lift groundwater. Further, the installation of DTWs is preferable for the proper management of groundwater in future.

Period toward to Groundwater Fluctuations

The list in Table-5 shows that the average WT fell by 1.28 m over the last 13 years from 2007 to 20019 in the study area. Meanwhile, the WT rose from April to June, but fell during the nine months from July to March. This result is in agreement with the results of a previous study that showed, the WT suffers a yearly fall of 1.20 m in some northern parts of Bangladesh due to excessive withdrawal through tube wells along with low recharge, poor management, and land use changes (Khan and Islam. 2015).

Table-5: Monthly Rising (-) or Falling (+) in the Groundwater Table during the Period 2007 to 2019 (in meters)

Sl. No.	Upazila	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg.
1.	Bogura Sadar	-0.37	-0.63	-0.75	-1.70	-2.04	-1.34	1.39	3.09	4.01	4.18	2.93	2.80	0.96
2.	Kahalo	3.78	3.07	1.93	0.65	0.28	0.46	1.21	1.16	1.71	3.18	4.30	3.09	2.07
3.	Dupchachia	1.35	1.16	1.38	1.06	1.69	1.95	2.15	2.27	2.40	2.49	2.81	2.82	1.96
4.	Adamdighi	1.54	-0.47	-1.42	-1.63	-1.42	-1.12	-0.75	-0.39	0.51	1.87	2.59	2.14	0.12
Average		**1.57**	**0.78**	**0.28**	**-0.40**	**-0.37**	**-0.01**	**1.00**	**1.53**	**2.16**	**2.93**	**3.16**	**2.71**	**1.28**

CONCLUSIONS

In this study, the borehole lithologies, groundwater storage, groundwater discharge and recharge, and prevailing well spacing of DTWs and STWs and fluctuations of the WT and its trends were analyzed intensively using some recognized empirical equations. The borehole thickness, aquifer thickness, and soil formation can be easily grasped from the borehole inventory of the entire Bogura district. The amount of groundwater shortage/excess can be determined from the calculated groundwater storage and discharge in any region or area. Measuring the WT

fluctuations is an effective way to estimate groundwater recharge in both shallow and deep aquifers. It is also useful for describing the temporal variation in recharge in previous years. The trends of the fluctuations can be used to predict future WT and fluctuations.

The results are significant for policy makers, planners, and researchers involved in initiating the planning and policy for groundwater development. Future action plan will be taken for installing DTWs and STWs by comparing the prevailing well spacing. In addition, the overall knowledge on groundwater gained from this study will be helpful for those involved in irrigation and water management not only in Bogura district in Bangladesh, but also elsewhere in the world. In the case of STWs, the possibility of operating the suction mode can be determined. Groundwater conditions (reserve, shortage, or steady) can be easily known from the estimation of groundwater storage and discharge. The actual need of further installation of groundwater-lifting devices such as DTWs and STWs can be easily identified by assessing the existing well spacing. Overall, the study findings may play be significant for the policy makers, planners, and researchers to initiate planning and policy for groundwater development with a broad outlook.

Recommendations

The following recommendations can be made on the basis of the results of this study:

- If groundwater fluctuations are known, a new borehole design can be accomplished to optimize the pump capacity and pump lifting head.
- Crop planting seasons, most notably for rice, can be alternated taking into account in future, if the groundwater reserve (41.30%) in the study area.
- Water-saving technologies for rice production, such as the use of alternating wetting and drying methods and the raised bed crop technology approach, can be applied.
- The current well spacing for DTWs are appropriate (800 m > 786 m); however, that for STWs is inappropriate (250 m < 393 m), and further installation of STWs should be strictly disallowed in the study area.
- Future groundwater plans should be prepared to ensure the balance between groundwater recharge and discharge.
- The mathematical, statistical, and theoretical modeling of groundwater resources in this area will require further research.

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