Project ID: 649

Competitive Research Grant

Sub-Project Completion Report

on

Economics of Adoption of Bio-security Measures for Controlling Avian Influenza in Bangladesh`s Poultry Farms

Project Duration

May 2017 to September 2018

Department of Agricultural Economics
Bangladesh Agricultural University
Mymensingh 2202

Submitted to
Project Implementation Unit-BARC, NATP 2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

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Project Implementation Unit
National Agricultural Technology Program-Phase II Project (NATP-2)
Bangladesh Agricultural Research Council (BARC)
New Airport Road, Farmgate, Dhaka – 1215
Bangladesh

Acknowledgement

The execution of CRG sub-project entitled "Economics of adoption of bio-security measures for controlling Avian Influenza in Bangladesh`s poultry farms" has successfully been completed by the Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh using the research grant of USAID Trust Fund and GoB through Ministry of Agriculture. We would like to thank World Bank for arranging the grant support and supervising the CRGs by BARC. We highly appreciate the cooperation and quick responses of PIU-BARC, NATP 2, in respect of field implementation of the sub-project in different districts. We gratefully acknowledge the help and cooperation of the respondent poultry farmers in the study area who gave their time and valuable information regarding the bio-security practices in poultry production. Without the help of poultry farmers, stakeholders and a number of data enumerators, the preparation of this document could not be made possible. All of them, who made it possible, deserve thanks. Our thanks are also due to the Director PIU-BARC, NATP 2 and his team who have given their whole hearted support to prepare this document. We believe and hope that the information on the adoption of bio-security measures we generated through the study and published in the report would be very helpful to the agricultural scientists who are working in the poultry sector for designing their future research projects in order to reduce poultry disease through practicing bio-security measures in the farm which ultimately increase profitability of poultry production and productivity for sustainable food and nutrition security in Bangladesh. It would also help the policy makers of the agriculture sub-sector that is livestock sector for setting their future research direction.

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Acronyms

AI	: Avian Influenza
BCR	: Benefit-Cost Ratio
BKB	: Bangladesh Krishi Bank
BLRI	: Bangladesh Livestock Research Institute.
BRAC	: Bangladesh Rural Advancement Committee
DAE	: Department of Agricultural Extension
DOC	: Day Old Chick
DLS	: Department of Livestock Services
FAO	: Food and Agriculture Organization
FGD	: Focus Group Discussion
GDP	: Gross Domestic Product
g h^{-1} day^{-1}	: Gram per hour per day
h^{-1} $year^{-1}$	: per hour per year
HPAI	: like Highly Pathogenic Avian Influenza (HPAI)
KII	: Key Informant Interviews
IRR	: Internal Rate of Return
MMT	: Million Metric Tonne
NGO	: Non-Government Organization
No.	: Number
NPV	: Net Present Value
SAARC	: South Asian Association for Regional Cooperation
Tk	: Taka
US$	: US Dollar
@	: At the rate of

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Executive Summary

Poultry disease such as Highly Pathogenic Avian Influenza (HPAI), greatly threatens developing countries including Bangladesh. The financial loss from first outbreak in 2007 was estimated to be 38580 million Taka and since then, Bangladesh has experienced HPAI spread up to 2015 in every year with terrific financial loss. Bio-security is the key pillar for controlling spread of HPAI and other infectious diseases. The adoption of bio-security measures in poultry farms is one of the key measures to save the poultry farms against entry of disease such as HPAI. Various research efforts, since the first outbreak of HPAI, have concentrated only to the biological issues, however not much is known about economics of adoption of bio-security measures including the management practices in poultry farms. Therefore, this study was undertaken to unfold the adoption rate of bio-security measures, estimating the costs and returns and factors associated with adoption of bio-security measures at different farm levels in Bangladesh. The study was conducted in seven districts i.e., Kishoreganj, Gazipur, Narsingdi, Tangail, Rangpur, Bogura and Mymensingh. A total of 630 poultry farms (broiler and layer) were selected on the basis of purposive sampling technique. FGD, KII and observation study were done for collection of information. However, comparing the level of bio-security knowledge and practices, it was found that layer farms were more bio-secured (72.5 percent) than broiler farms (65.6 percent). Prohibition of dogs and cats, secured sources of water, exclusion of backyard poultry in the vicinity of farms were practiced in 100 percent by broiler and layer farms. Whereas, sharing comprehensive bio-security plan and warning signs were less exercised in broiler farms compared to layer farms. From economic analysis, it was found that estimated total cost of broiler production was lower (Tk. 565388.40) than layer (Tk. 1359808) and gross returns per farm were higher for layer farms compared to broiler farms. Net returns were also higher for layer farms compared to broiler farms. NPV value was positive both for the broiler and layer farms and it was found to be higher in layer farms (Tk. 1409367.34) in comparison to broiler farms (Tk. 193820.58). According to BCR, layer farms were economically more viable than broiler farms. IRR was greater than the discount rate both for the broiler and layer farms representing that both farms were financially viable. The result of sensitivity analysis was that investment on bio-security measurement (incurred 15 to 20 percent of total cost) in broiler and layer farming was not sensitive to net returns on the basis of NPV, BCR and IRR. The analysis of logit equation expressed that farmer's age, education, experience as a poultry farmer, access to bio-security knowledge and access to market and total return had positive effect; and poultry shades, attitude to risk, price of day old chick had negative effect on the farmer's adoption of bio-security measures in the poultry farm. The findings of the study will lead to make appropriate measures and policies for the development of poultry sector. This would also help the policy makers to formulate optimum policies to control poultry diseases. The Department of Livestock Services (DLS) could also use this information to design better farmers-extension linkages and hence explore the huge potentialilty of the sector in terms of income, employment and meeting-up the nutritional requirement of the Bangladeshi populace at all level and all time.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project**:
   Economics of adoption of bio-security measures for controlling Avian Influenza in Bangladesh`s poultry farms

2. **Implementing organization**:

   Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh 2202, Bangladesh

3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s)**:

   Principal Investigator:
   Dr. Ismat Ara Begum
   Professor, Department of Agricultural Economics
   Bangladesh Agricultural University
   Mymensingh-2202
   Cell: 01718528456, E-mail: ishameen@yahoo.com

   Co-Principal Investigator:
   Dr. Mohammad Jahangir Alam
   Professor, Department of Agribusiness and Marketing
   Bangladesh Agricultural University
   Cell: 01799763274, E-mail: alambau2003@yahoo.com

4. **Sub-project budget (Tk):**

   4.1 Total: Tk. 24,99,015
   4.2 Revised (if any):

5. **Duration of the sub-project**:
   5.1 Start date (based on LoA signed) : 9 May 2017
   5.2 End date : 30 September 2018

6. **Justification of undertaking the sub-project:**

Poultry disease such as highly pathogenic avian influenza (HPAI), called as bird-flu, greatly threatens developing countries including Bangladesh. The financial loss from first outbreak in 2007 was estimated to be 38580 million Taka. However, since then, the virus has spread to 49 out of 64 districts and become the highest reported number of HPAI outbreaks' country worldwide (WHO, 2015). Bangladesh has experienced HPAI spread from 2007 to 2015 in every year, thus, the poultry industry obviously has faced a terrific financial loss.

As of 2017 there was an estimated 150,000 poultry farms in Bangladesh and about 300 billion Taka was invested in the poultry industry. However, since 2007, Bangladesh has experienced HPAI spread until 2015 in every year. Bio-security is the key pillar for controlling spread of HPAI and other infectious diseases. Bio-security is composed of preventive measures which are organized to reduce transmission of infectious diseases in livestock. It is the key pillar for controlling spread of HPAI. Studies found a lower prevalence of infection is associated with higher levels of bio-security (WHO, 2015). The adoption of bio-security measures could reduce the diffusion of infectious diseases throughout the poultry industry. That means, adoption of bio-security measures in poultry farms will

be a key measure to save the poultry farms against entry of diseases including HPAI. HPAI has emerged as a big global concern for its socio-economic and public health impact due to devastating infection in poultry and human cases. At national and international levels various research efforts have concentrated on biological issues, but there has been few attempts to assess the bio-security measures in detail which could control the poultry diseases such as HPAI. However, In Bangladesh no benchmark information is available on the level of adoption of bio-security measures, private and social costs and returns from complying the bio-security measures and what are the factors associated with the adoption of bio-security measures. Saleque (2007) mentioned that the rapid growth of the commercial sector has brought a number of diseases with it and that in general bio-security ought to be improved. Dolberg (2008) concluded that there is a strong need to improve bio-security in commercial poultry farms in Bangladesh. Roland-Holst *et al*. (2007) estimated that the poor household`s income loss was about 10 percent due to avain influenza. Yalcin *et al.* (2006) also concluded that the avian outbreak decreases in price and demand substantially in Turkey. SA PPLPP (2010) highligted how bio-security measures, tailored to various categories of poultry farmers, can help preventing and controling future outbreaks of avian infulenza as well as other poultry diseases in Bangladesh. Sarker *et al.* (2011) concluded that an effort is required to enhance knolwedge and behaviour regarding bio-security measures among those most at risk in low income country such as Bangladesh. Ali *et al.* (2014) studied the productive performance and profitability of broiler farming that carried out with and without bio-security management in Bangladesh. The authors found that no significant difference among farm sizes with respect to body weight, feed consumption and survivability but raising broilers had smaller profit under non-bio-security managed intervention than the bio-security managed intervention and concluded that profitability could be improved if bio-security is maintained. Kawsar *et al.* (2013) studied the productive performance and profitability of small-scale broiler farming at rural households that carried out with or without management intervention and Similar to Ali *et al.* (2014), Kawser *et al*. (2013) concluded that raising broiler was a losing concern without management intervention/bio-security practices but profitability of such farms could be ensured if intervention in terms of scientific knowledge on management aspect is disseminated to the poultry farmers. Ibrahim *et al.* (2015) have found that in general, the small holder poultry farmers were less aware on the common infection sources such as sick poultry, cages, wild animals, etc. The authors also found that the poultry farmers were not aware about the strict bio-security process such as segregation of sick birds, cleaning and disinfection of premises to prevent poultry diseases. Current governments` poultry disease control policies and strategies in Bangladesh are based on epidemiological aspects of disease control by massive culling but not based on information of the level of adoption of the bio-security mesures that control the highly devastating poultry disease such as HPAI. Since bio-security measures mean the scientific practices and management to control the diseases, the adoption of such measures can not only save the losses from the sector but also could save to transmit the diseases to human. So far few studies (Begum, 2008; Rahman and Sabur, 2005;and Alam *et al.,* 2008) have estimated the economic loss from HPAI but did not address the bio-security measures. Begum (2008) showed that the livestock sub-sector including poultry provides full time employment to about 20 percent of total population and about 50 percent people are associated with this sub-sector as part time workers. The author found that besides direct employment opportunity the broiler industry generated indirect jobs within the industry, in terms of production (i.e., hatcheries, breeder farms, broiler farms, maize farms) processing (i.e., feed mills, dressing, processing, cold storage) marketing (including veterinary and extension services) and consumption (e.g. fast-food outlets, restaurants). Therefore, the bio-

security as a means of controling bird-flu should take into serious consideration at all levels by the poultry farmers, the traders and the policy makers. However, no study has tried to investigate the level of adoption of bio-security measures, the costs and returns from complying bio-security measures and factors associated with the level of adoption of bio-security measures in Bangladesh. The main objectives of this study was therefore, to unfold the adoption rate of bio-security measures, estimating private and social costs and returns of adoption of those measures and factors associated with adoption of bio-security measures at different farm levels in Bangladesh. This would help the policy makers to formulate optimum policies to control poultry disease and how Department of Livestock Services (DLS) of the government of Bangladesh could design better farmers-extension linkages and hence explore the huge potentialilty of the sector in terms of income, employment and meeting-up the nutritional requirement of the Bangladeshi population at all level and all time.

7. **Sub-project goal**: To improve the level of adoption of bio-security measures for controlling avian influenza or other diseases in Bangladesh`s poultry farms.

8. **Sub-project objective (s)**:
   i) To examine the level of adoption of bio-security measures by different categories of poultry farms;
   ii) To estimate the private costs and returns from complying bio-security measures by the poultry farms; and
   iii) To examine the driving factors associated with the adoption of bio-security measures by poultry farms.

9. **Implementing location (s)**:
   Kishoreganj, Gazipur, Narsingdi, Tangail, Rangpur, Bogura and Mymensingh District

10. **Methodology in brief:**

10.1. Examining the level of adoption of bio-security measures by different categories of poultry farms:

Selection of the study areas

The research required collection of primary data which was involved selection of an area that would deal with a scope to accomplish the objectives of the study. Keeping in view the objectives, the study was conducted in seven major poultry farm concentrated districts (Gazipur, Narsingdi, Kishoreganj, Tangail, Rangpur, Bogura and Mymensingh) covering four different divisions (Dhaka, Rangpur, Rajshahi, and Mymensingh) in Bangladesh. The divisions and regions were selected on the basis of highest number of poultry farms. Considering the objectives of the study and limitations of the research with respect to time, manpower and other facilities, fourteen (14) sub-districts (Upazilas) from seven (7) districts, was purposively selected for the study. However, two Upazilas (Kaliakoir and Sreepur) in Gazipur district, two Upazilas (Roypura and Manohardi) in Narsingdi district, two Upazilas (Bajitpur and Kuliarchar) in Kishoreganj district, two Upazilas (Modhupur and Sadar) in Tangail district, two Upazilas (Sadar and Pirganj) in Rangpur district, two Upazilas (Sadar and Gabtali) in Bogura district and two Upazilas (Bhaluka and Trishal) in Mymensingh district were selected for the

study. In total, 14 Upazilas were selected from 70 Upazilas from selected seven districts. The main considerations in selecting the study districts were as follows:

a) Availability of a large number of poultry farms
b) Resemblance to the objectives of the study
c) It was expected that the co-operation from the broiler farmers in these areas would be high so that the reliable data required for the study could be obtained
d) Well communicated which would help data collection easier for the researcher and
e) Occasional outbreaks of avian influenza, or other poultry diseases.

In order to fairly spread the sample farms over the entire study population at first, a list of all poultry farms were prepared with the help of Upazilla Livestock Officers. In the second stage, the farms were categorized according to their bird sizes and types of farms. As per the DLS definition, the bird size categories were defined as follows: (i) small scale poultry farm (101 to 1200 birds per cycle), (ii) medium scale poultry farm (1200 to 2000 birds per cycle) and (iii) large scale poultry farm (above 2000 birds per cycle).

Target population and sampling

A sample of 630 broiler and layer farms were selected from seven districts on the basis of stratified random sampling (Table 1). In brief, the steps in sampling procedure that was followed are as follows. These are (i) collection of lists of poultry farmers in different Upazilas from DLS, (ii) selection of unions within each Upazila, (iii) selection of villages/mouzas within each Union, & (iv) selection of poultry farmers in each mouzas/villages.

The sampling process and survey administration included the following steps:

- Random selection of 28 Unions in 14 Upazilas with probability proportional to size sampling
- Listing all villages/mouzas in the selected Unions
- Random selection of all 70 villages/mouzas from the selected 28 Unions
- Collection of list of poultry farmers
- Random selection of 9 samples from each mouza/village and conduct interviews

Table 1: Plan of sample collection

Divisions	Districts	No. of Upazilas	No. of Unions	No. of broiler farm	No. of layer farm	No. of Samples
Dhaka	Kishoreganj	2	4	45	45	90
	Gazipur	2	4	45	45	90
	Narsingdi	2	4	45	45	90
	Tangail	2	4	45	45	90
Rangpur	Rangpur	2	4	45	45	90
Rajshahi	Bogura	2	4	45	45	90
Mymensingh	Mymensingh	2	4	45	45	90
	Total	**14**	**28**	**315**	**315**	**630**

Quantitative and qualitative research approaches being employed in accomplishing the research. Quantitative approach included field survey using semi-structured interview schedule and collecting secondary data from different published & unpublished secondary sources, as needed. The primary data were collected by semi-structured interview schedule in the study areas. Secondary data were

collected from DLS, DAE, Livestock research institutions such as BLRI, national and international journals, published and unpublished articles etc. Qualitative approaches included FGD, KII and observations. Number of FGD, KII and observation were 14, 30 and 14 respectively. A total of 14 FGDs were conducted in the selected Upazilas from the selected districts. However, as standard, 6-10 poultry farmers were selected in each FGD, as participants. Both broiler and layer farms were categorized into three groups i.e. small, medium and large farms. The average number of chicks per small, medium and large farms was 731, 1489 and 2325, respectively for broiler farms and number of chicks per small, medium and large farms were 635, 1209 and 4402, respectively for layer farms.

Preparation of interview schedule

Preparation of the survey schedule is crucially important in any survey. The first step in this direction was the development of a good survey questionnaire / interview schedule with suitably arranged questions. The interview schedule was designed in a way so that the objectives of the study are met. At first, a draft interview schedule was pre-tested on few respondents. In the pre-test, attention was given to identify any information that was not included in the previous draft interview schedule. Then some parts of the survey questionnaire were improved, rearranged and modified. Finally, the schedule was developed in a simple manner to avoid misunderstanding in order to get solicit information.

The final interview schedule contained the following information:

i. Identification and general information of the poultry farm owner;
ii. Socioeconomic characteristics of poultry farmer;
iii. Items of cost and returns of rearing poultry;
iv. General bio-security practices by the poultry farmers.
v. Qualitative information regarding bio-security practices such as awareness, knowledge, exposure, farmers' opinions and suggestions, etc.
vi. Problems of poultry farming faced by the farmer and suggestions for improving those problems.

Focus Group Discussion (FGD)

The research conducted FGDs with the poultry farmers (layer farms and broiler farms). This was done to collect the qualitative information such as awareness, knowledge, exposure, farmer's opinions, suggestions, etc. The checklists were developed, pre-tested and finalized before doing the FGDs. Prior to the commencement of the FGDs, a discussion guide was worked out. The guide set the general format of the discussions and the techniques that used in order to elicit responses. It was noted that the discussion guide was merely a guide, which was flexible and subject to variation and alteration in the field.

Key Informant Interview (KII)

The key informants were included but not necessarily limited to the key resource persons in the experts, professionals, lead farmers, local representative, Stakeholders, etc. A total of 30 KII was conducted.

Observation

In addition to FGD and KII, at least 14 observations were conducted in the selected Upazilas under the selected districts. This was done to observe the bio-security measures being practiced by the poultry farmers.

Data entry and Data management plan

The collected data were coded, cleaned and entered in MS Excel first and then was exported to the STATA data file. The study team did data entry, cleaning, and finally data analysis. Data collection and entry was done by Master Fellow along with other data enumerators under the guidance of PI and Co-PI of the sub-project. In order to ensure efficient data entry and cleaning, the sub-project team (under the leadership of Co-PI) developed a customized data-entry form, which included controls for legal values, out of range values, logical checks, and cross consistencies. It was able to produce reports on missing data. Listing and grouping of open-ended responses was done based on the first few days of field work. The open-ended list was updated regularly with new listing of responses.

Monitoring, Evaluation and Quality assurance plan

Quality assurance plan

Quality of data collection was ensured through stringent quality control mechanism through multiple steps as follows:

Stringent Recruitment and Training procedure

Thorough recruitment and training of procedure was followed. This was done to recruit the experienced and quality data enumerators who understand the works` responsibilities and deliver his/her assigned work in timely fashion.

Back-checks and scrutiny

- Application of sampling plan : 15%
- Sample verification : 15%
- Scrutiny : 100%

Corrective actions were taken as gaps or deviation was found.

Documentation

The sub-project team (PI & Co-PI and others) understood that proper documentation at all the stages of work is a pre-condition of monitoring and evaluation plan. Therefore, the sub-project team ensured mandatory documentation of work checklist and responsibilities was performed by the assigned persons concerned at different stages.

Quality auditing

The PI with the help of Co-PI randomly spot checked at least 15 percent of field work of data enumerators, in addition to the measures mentioned above. As problems and/or errors were found, the corrective measures were taken so that the quality data are collected.

Field Log Sheet

Data enumerators always carried a field log sheet in which they recorded relevant information on what happened in the field, such as contact and call-back details. The data enumerator logs supplied enough information for an independent observer to locate the selected poultry farmers and to identify the respondent interviewed.

Field progress monitoring

Field progress report was prepared for each location every day based on the performance. The progress report was communicated to PI which contained number of completed interviews. This facilitated early detection and solution of problems of implementation. Besides, the team held discussion meetings regularly on quality and field related issues. Appropriate corrective actions were taken immediately as gaps or deviation was found.

Data analyses/Statistical methods/Econometric models

All the collected quantitative and qualitative data was analyzed in accordance with the project objectives so as to answer the issues involved in the study. The data were analyzed using STATA software. The analytical methods/statistical techniques as per the study objectives are presented below. Data were analyzed by descriptive statistics. Comparisons of the results of broiler and layer farms were made in terms of profitability. Binary Logistic model was also used to identify the factors influencing the adoption of bio-security activities on poultry farms.

A summary of the objective wise data collection methods and data collection instruments are shown in Figure 1.

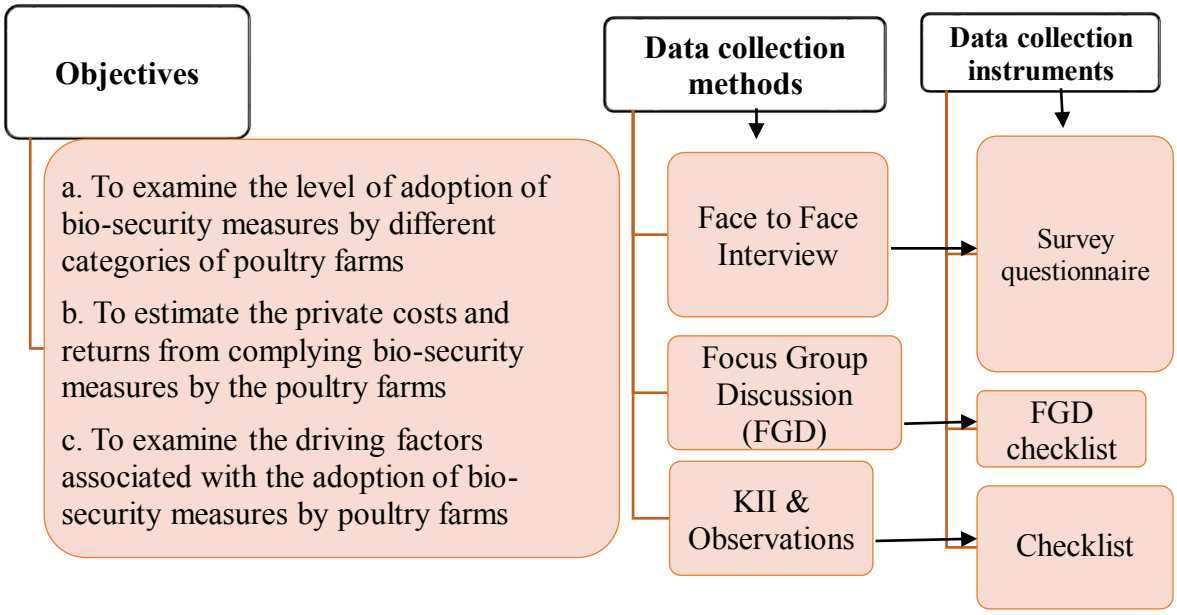

Figure 1: Objective wise data collection method and data collection instruments

Bio-security score

The level of adoption of bio-security measures was examined by constructing the revealed bio-security control score (Susilowati *et al.,* 2011) which measured farmers` implementation of a range of bio-security activities. Since bio-security is defined as management to keep diseases out of the flock through designing a combination of systems and practices to prevent the adverse effects of disease (FAO, 2008), the sub-project collected data on different bio-security measures such as, broadly, the contacts with other animals (i.e., no contacts between poultry and other animals, stored feed was not accessible to rodents, etc.), water related issues (surface water was not used for drinking, used/cleaning water was not drained outside, surface water was not used for cleaning, wild birds had no access to stored fresh litter, etc.), hygienic infrastructure (i.e., regular cleaning and disinfection, disposals of dead birds, sanitary transition zones present, fence present around the farm yard perimeter, etc.), hygienic persons (visitor no access to poultry compartments, good hygiene of supply teams, good hygiene of discharge teams, good hygiene of professionals, etc.), hygienic transport/traffic onto farm (i.e., transport vehicles do not visit more than one farm per day, transport vehicles were not used for double purposes, etc.), vector status of farm inputs, bio-security at farm boundary, bio-security between farm boundary and shed, bio-security at the shed door, etc. (Steen winkel *et al.,* 2011). The adoption level of the respondents was measured by making use of adoption index (Karthikeyan, 1994 and Rahman, 2007).

Adoption index = (Respondent total score/ Total possible score) x 100

Depending upon the extent of adoption of bio-security measures the respondents were categorized as follows: (1) Low adopters (up to 33 percent); (2) Partial adopters (34-66 percent) and (3) High adopters (67-100 percent).

10.2. Estimation of the costs and returns from complying bio-security measures by the poultry farms:

The accounting method was employed to estimate the costs and returns. The depreciation was charged 13 percent per annum both on the value of buildings and equipment. The interest on fixed capital and working capital was charged 13 percent per annum. The term working capital included investment on feed, labour, medicines and miscellaneous costs. For analysis, descriptive statistics like, simple averages and percentages were used. For studying the financial viability of poultry enterprise, net present value, benefit cost ratio and internal rate of return were calculated using standard procedures. Once the cost and returns were estimated, profitability was analyzed as it is one of the major criteria for the determination of acceptance of an enterprise. Gross return, gross margin, net return and BCR were calculated and analyzed to estimate the profitability of broiler and layer production. The expenses incurred per unit of production of an enterprise are the cost of production. The cost items were divided between fixed and variable cost.

Investment in broiler farming was evaluated as a project to study the financial viability of investments to maintain bio-security in broiler farming. The financial soundness, i.e., profitability of broiler farming as a project was examined by analyzing the cash flow during the assumed life of the investment. Net present value (NPV), benefit-cost ratio (BCR), and internal rate of return (IRR) were worked out to see the financial viability of investment in broiler farming in this chapter. However,

since it is difficult to generate cash flow for the entire life span of the project in the absence of observed temporal information on costs and benefits, the following assumptions were made for the financial analysis:

i. **Economic life**: It was assumed to be 10 years.

ii. **Construction period**: The construction of broiler sheds and buildings was assumed to be completed before started the poultry business and the arrival of first batch of day-old chicks after the shed prepared.

iii. **Economic life of buildings and equipment**: The economic life of sheds and other buildings was assumed to be 20 years and that of equipment was assumed to be 3 to 5 years. Accordingly, replacement of equipment has been provided for. The salvage/terminal value was assumed at 13 percent of the capital cost in respect of both the sheds and buildings and poultry equipment.

iv. **Inflation:** The data related to costs and returns were assumed to be uniform and 5 percent increased each year over the project life.

v. **Discount rate:** Discount rate was taken as 13 percent because the opportunity cost of capital i.e., rate at which capital was available was also 13 percent. The lending rate of nationalized commercial bank such as Bangladesh Krishi Bank was 13 percent for poultry loan purpose.

10.3. Factors affecting in adoption of bio-security practices:

Logistic Regression Analysis

The logistic regression model (Gujarati, 2003) was used to examine the driving factors associated with the adoption of bio-security measures by poultry farms. To test for significant differences among the binary choice responses to the reference question, several regression equations namely linear, log-linear and probit regression analysis and logistic regression analysis were tried. On the basis of results of the parameter, its sign and magnitude, Logit model (logistic regression analysis) one of the mentioned types has been considered to be closer to reality. The dependent and independent variables are described in below:

$$K_i = \ln [P_i \div (1 - P_i)] = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + E_i$$

Where,

P_i is the probability of adoption of bio-security measures (P_i = 1 indicates adoption and P_i = 0 indicates non- adoption;

K_i = Dependent variable= Probability of adoption of bio-security measures;

X_1 to X_{10} =Independent variables (age, education, experience, attitude to risk, farm category (layer and broiler), capacity to rear poultry, day old chick price, poultry shades, access to knowledge, access to market and total return)

β_0 = Intercept; β_1 to β_{11} = Regression coefficients of the independent variables; and E_i = Error term.

11. Results and Discussion:

11.1. Examining the level of adoption of bio-security measures by different categories of poultry farms:

Bio-security practices in the study areas

Bio-security practices and farm hygiene are implemented on poultry farms to reduce the risk of disease agents moving on to farms from outside sources, the movement of disease agents between sheds on the same farm, carryover of disease agents from one batch to the next in the shed environment, and carryover of disease agents from breeding flocks to their progeny via the egg. Bio security in poultry farms is designed for the protection of the animals against the outbreak of a number of diseases. It is achieved by making use of several strategies and practices that the minimum levels of contagious organisms are able to farming settings. It is a fact that bio security is indeed the cheapest of all the methods which can be used for the prevention of any disease. There are three different components through which bio security in poultry production can be understood. These include:

i) **Isolation:** keeping the poultry birds isolated from common sources of pathogens.

ii) **Traffic control:** limiting who and what comes on to the farm or has contact with the birds.

iii) **Sanitation:** ensuring that anything that comes into contact with the birds or their environment is clean (people, vehicles, equipment, etc.).

Development of a Bio-security Scoring System

The prioritization and weighing of the various bio-security measures and sub-categories has been done by expert opinions and existing literature. Table 2 describes the level of bio-security knowledge and practices exercised in broiler and layer farm. Bio-security knowledge and practices were mainly categorized into two broad categories such as external and internal bio-security which were executed by four sub-categories like farm places, equipment and vehicles, personnel and visitors at the farm.

Table 2: Bio-security scoring system in broiler and layer farms

External Bio-security		Score (%)	
		Layer	**Broiler**
Bio-security practices taken in farm places	Water drawn from secured sources	100	100
	Prohibition of dogs and cats in the farm	100	100
	Prohibition of backyard poultry from other households	100	100
	Houses bird-proofed against wild or free-flying birds	100	90
	External entrances to broiler houses kept locked during non-business hours	55	40
	warning signs for people to enter the farm	35	5
	Sharing bio-security plan with family members	60	20
Bio-security practices for visitors	Availability of suits, boots, etc.	5	0
	Visitors entrance permission	40	5
Sub-total of External Bio-security		595	460
Average score		66%	51%
Internal Bio-security			
Bio-security practices for equipment and vehicles	Manure collecting van for single farm	10	5
	Cleaned equipment under conditions	10	5
	Cleaning and disinfecting transport equipment prior to use	10	5
	Cleaning farm equipment and tools prior to use	70	40
	Availability of hand washing stations	88	71
	Footbath uses to collect dirt, egg contents or manure	90	70
	Footwear uses to enter farm	85	70
Bio-security practices for personnel	Prohibition of another farm's equipment	40	30
	Avoiding contact with other birds not owned by the family members	45	40
	Ownership of other birds	65	70
	Bio-security training	25	20
	Wash/sanitize hands before entering and after leaving farms	75	40
	Footwear covers prior to entering farm	80	45
Sub-total of Internal Bio-security		693	511
Average score		53%	39%

In this study, bio-security practices in four sectors such as farm places management, equipment and vehicles management, personnel management and visitor management were considered for the purpose of providing a better environment to the animals for their growth and protection. Analysis of the adoption of bio-security measures has been described by using the following four figures (Figures 2-5), where Figure 2 shows that, at farm places 100 percent broiler and layer farmers adopted the practices of the prohibition of backyard poultry from other households, prohibition of dogs and cats in the farm and water drawn from secured sources. About 100 percent layer farmers had houses which were bird-proofed against wild or free-flying birds. On the contrary, 90 percent broiler farmers had houses which were bird-proofed against wild or free-flying birds. About 60 percent layer farmer shared bio-security plan with family members. On the other hand, only 20 percent broiler farmers shared bio-security plan with family members. Hence, the layer farmers adopted more bio-security practices than the broiler farmers at farm places. Figure 3 shows that, for equipment and vehicles 88 percent layer farmers adopted the practice of having hand washing stations. On the other hand, 71 percent broiler farmers had hand washing stations. About 70 percent

broiler farmers adopted both the practices of using footwear to enter farm and footbath to collect dirt, egg contents, manure. The practices of using footwear to enter farm and footbath to collect dirt, egg contents, manure adopted by 85 and 90 percent layer farmers, respectively. About 40 percent broiler farmers adopted the practice of cleaning farm equipment and tools prior to use. On the contrary, 70 percent layer farmers adopted the practice of cleaning farm equipment and tools prior to use. Only 5 percent broiler farmers adopted the practices of cleaning and disinfecting transport equipment prior to use, cleaned equipment under conditions that prevent exposure to wild birds, and use manure collecting van/vehicle only for single farm. On the other hand, 10 percent layer farmers adopted the practices of cleaning and disinfecting transport equipment prior to use, cleaned equipment under conditions that prevent exposure to wild birds, and use manure collecting van only for single farm. Hence, the overall bio-security condition on layer was in better condition than the broiler farms for the equipment and vehicles. Figure 4 shows that for personnel level management, 80 percent layer farmers adopted the practice of using footwear prior to entering farms. On the contrary, 45 percent broiler farmers adopted the practice of using footwear prior to entering farm. About 75 percent layer farmers adopted the practice of washing hands before entering and after leaving farms. Whereas, 40 percent broiler farmers adopted the practice of washing hands before entering and after leaving farms. Only 20 percent broiler farmers had access to get bio- security training. On the other hand, 25 percent layer farmers had access to get bio-security training. So, the layer farmers adopted more bio-security practices than the broiler farmers for bio-security management at personnel level. Finally, Figure 5 shows that, 5 percent broiler farmers did not allow visitors entrance permission to the farms unless absolutely necessary. On the other hand, 40 percent layer farmers did not allow visitors unless absolutely necessary. None of the broiler farmers adopted the practice of making available of disposable suits, disinfected boots and hairnets that are required for visitors. On contrary, only 5 percent layer farmers adopted the practice of making available of disposable suits, disinfected boots, and hairnets that are required for visitors. The above mentioned facts indicates that the overall bio-security condition for the visitors in layer farms was better than in the broiler farms which is summarized in Figure 6.

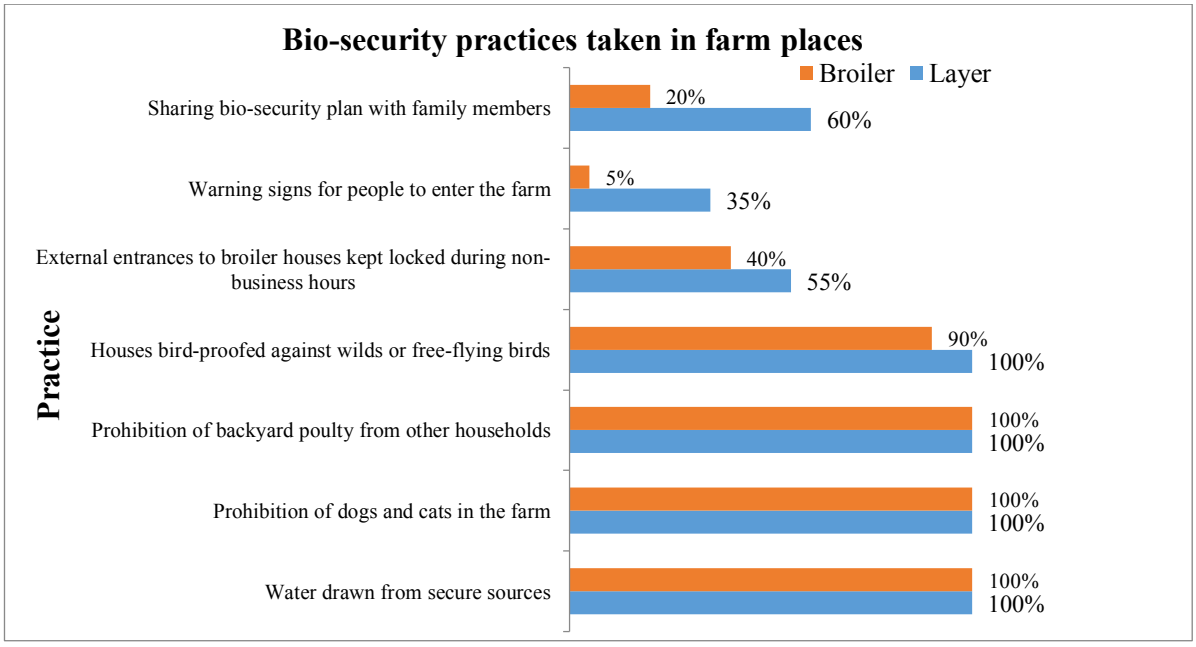

Figure 2: Bio-security practices taken in farm places

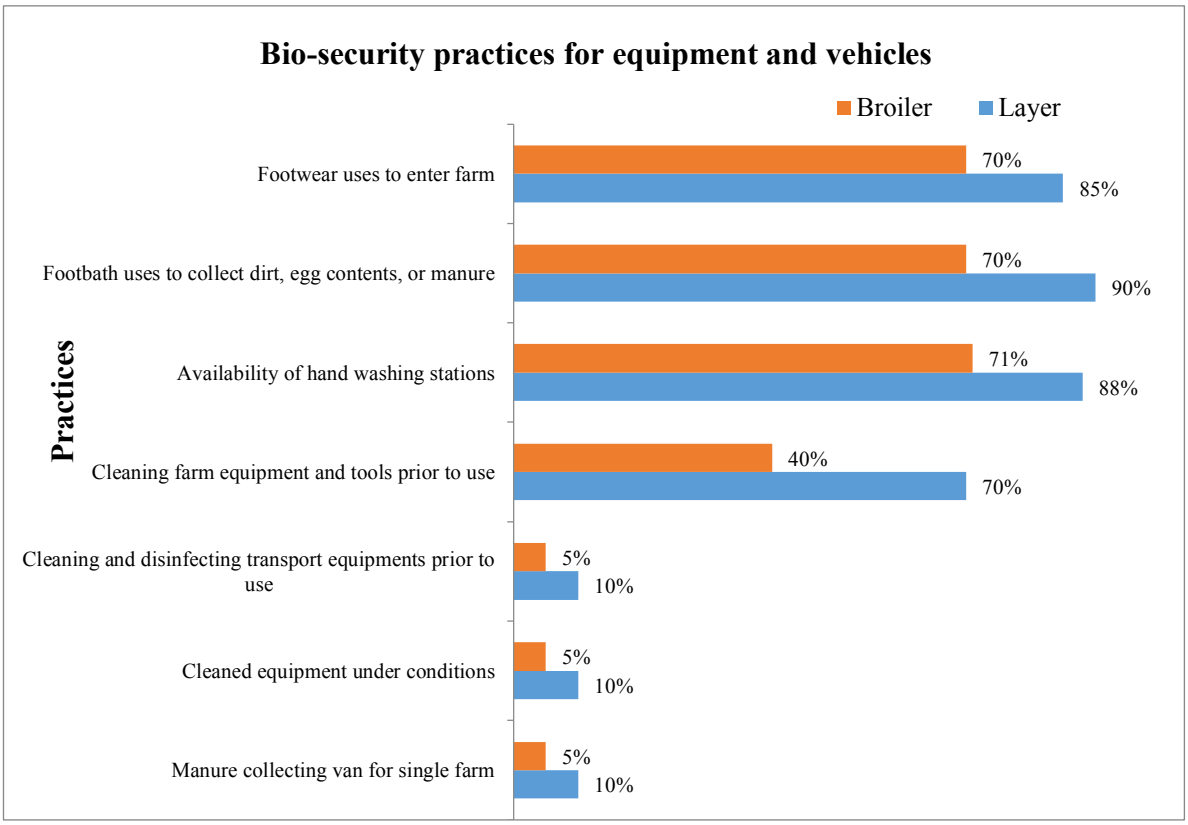

Figure 3: Bio-security practices for equipment and vehicles

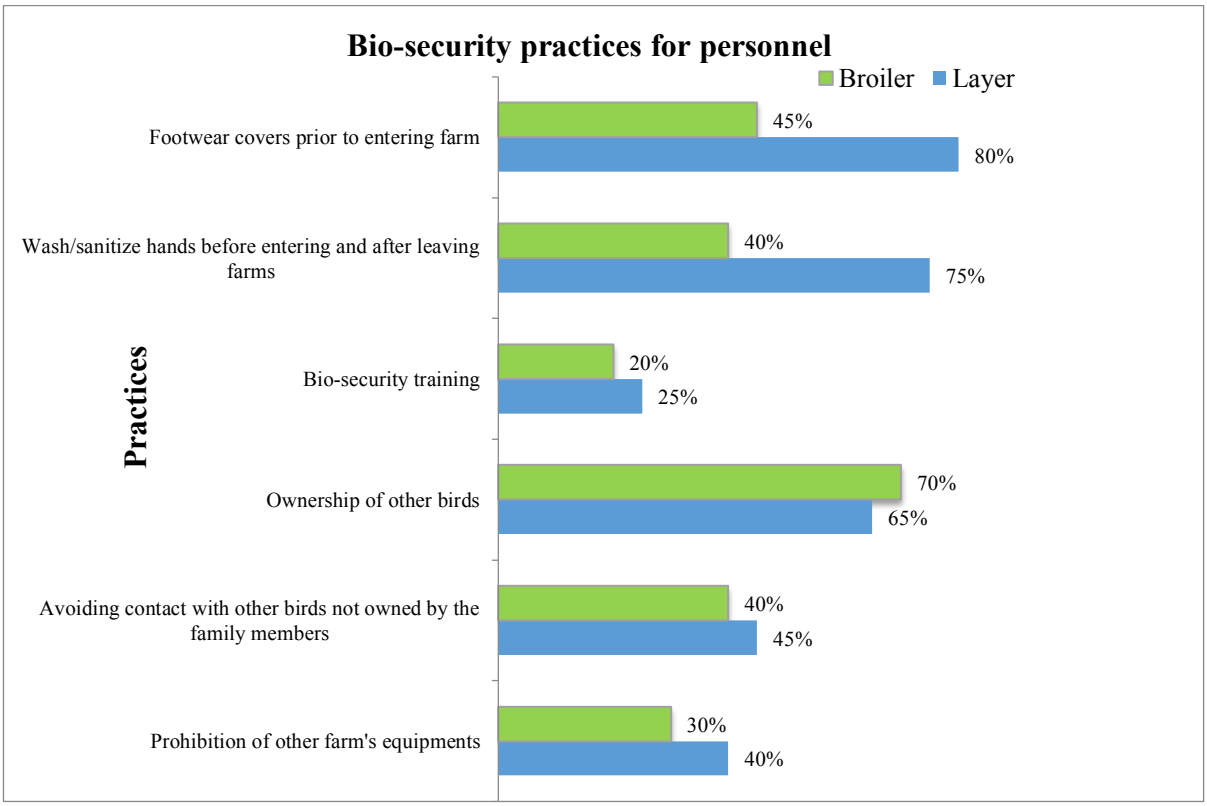

Figure 4: Bio-security practices for personnel

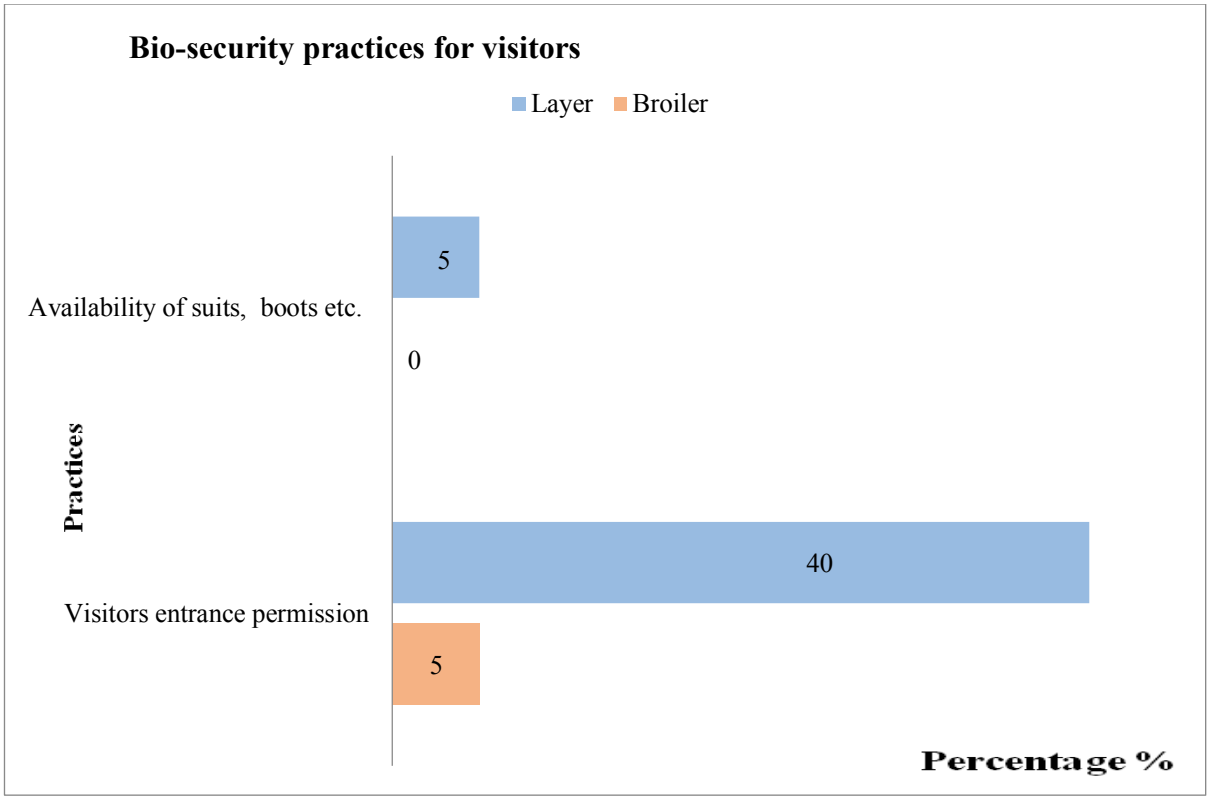

Figure 5: Bio-security practices for visitors

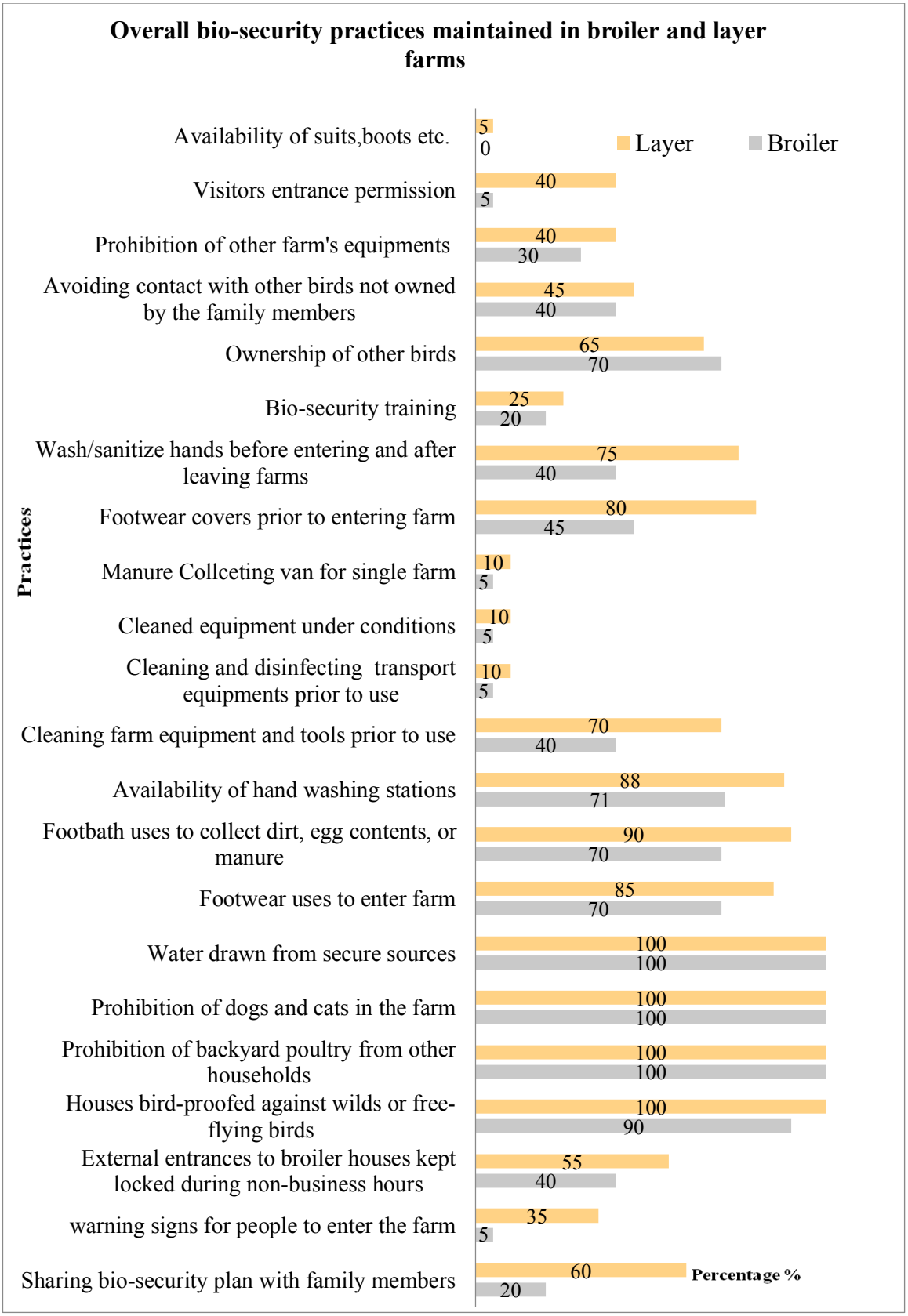

Figure 6: Overall bio-security practices maintained in broiler and layer farms

Quantification of the bio-security level

In this procedure, a total amount of 100 weight points was given which had to be distributed over the different subcategories in function of their relative importance. Subsequently, the experts had to give a weight, ranging from 0 to 10, to each preventive measure within the associated subcategory. For each question related to a bio-security measure different answers were possible and for each answer a score can be obtained ranging from 0 to 10. All results of the experts were combined afterward and the averages were calculated and translated into weights of subcategories as well as questions. By doing so, the scoring system was risk-based and weights were included both at the level of the subcategories as well as at the level of the individual questions. Based upon the different weights given by the expert panel to each bio-security measure and sub-category a final weight and risk-based score was calculated. To obtain this score, each answer to a specific question received an individual score between 0 (= total absence of preventive measure or full presence of risk) and 1 (= full presence of preventive measure or total absence of the risk). This score was subsequently multiplied by the weight of the specific question to obtain the relative result of the question. Next, all the results of the individual questions within a subcategory were summed up and divided by the maximum score that could be obtained in the subcategory. This proportional result of the subcategory was then multiplied by the weight of the subcategory to obtain the subcategory score. The final score of the internal and external bio-security is the sum of the different subcategory scores. The overall bio-security score is the sum of the external and internal bio-security score. Due to the different relative weight, the external bio-security score counted for 60 percent and the internal counted for 40 percent in the total bio-security score in case of broiler farms (Table 3) and it was 55 percent and 45 percent respectively for layer production (Table 4). In addition, to illustrate this scoring system, under the external bio-security, bio-security practices taken in farm places subcategory was selected. This subcategory had a relative weight of 40 within the 60 points allocated to the external bio-security in case of broiler farms. Within the subcategory there were 7 questions. Some of these only have a yes/no answer translated into 1 or 0 points, whereas other questions (e.g., number 2, distance to nearest poultry farm) had more potential answers resulting in intermediate scores such as 0.5. Then this was translated into a score of (7*1) + (5*0) + (5*1) + (5*0.5) + (6*1) + (7*0.3) + (5*0) = 22.6 out of a possible maximum score of 40, which was 0.57 or 57 percent. This score was then multiplied by the subcategory weight (0.57*40 = 22.8) to obtain the final share of this specific subcategory in the total bio-security score.

Table 3: Total farm bio-security status score (FBSS) for broiler

Broad category	Sub-category	Possible maximum scores	Bio-security scores	Final share of this specific sub-category in the total bio-security scores
External bio-security (60)	Bio-security practices taken in farm places	40	22.6 (57%)	22.8
	Bio-security practices for visitors	20	15 (75%)	15
Internal bio-security (40)	Bio-security practices for equipment & vehicles	20	16 (80%)	16
	Bio-security practices for personnel	20	12 (60%)	12
Overall bio-security score				**65.6**

Table 4: Total farm bio-security status score (FBSS) for layer

Broad category	Sub-category	Possible maximum score	Bio-security score	Final share of this specific subcategory in the total bio-security score
External bio-security (55)	Bio-security practices taken in farm places	40	26 (65%)	0.65*40=26
	Bio-security practices for visitors	15	12 (80%)	0.80*15 =12
Internal bio-security (45)	Bio-security practices for equipment and vehicles	25	21 (84%)	0.84*25=21
	Bio-security practices for personnel	20	13.5 (68%)	0.68*20=13.6
Overall bio-security score				**72.5**

From the above two tables (Table 3 and 4) it can be summarized in a way that poultry farmers are still lagging behind a good bio-security for 34.4 percent (100-65.6) in case of broiler and 27.5 percent (100-72.5) in case of layer. This comparison would help motivating poultry farmers to implement better bio-security measures through voluntary adoption of different bio-security practices.

Adoption level of total bio-security

The adoption level of the respondents was measured by making use of adoption index. Depending upon the extent of adoption of bio-security measures the respondents were categorized as (1) Low adopters (who adopted up to 33 percent of bio-security practices); (2) Partial adopters (who adopted 34-66 percent of bio-security practices) and (3) High adopters (who adopted 67-100 percent of bio-security practices).

Table 5 and 6 show that for all risk stages majority of layer (85.71 percent) and broiler farmers (74.60 percent) achieved a partial level of bio-security adoption. Most of the broiler and layer farms of Bangladesh adopted partial level of bio-security. So, the overall bio-security condition is not so good. The mean of adoption index which showed the total level of bio-security measures was 44.15 on broiler farms and 52.02 on layer farms. This indicated that layer farms overall bio-security adoption is in better position than the broiler farms.

Table 5: Level of adoption of total bio-security measures on broiler farms

Level of adoption	Number of respondents	Percentage	Mean of adoption index
Low adopter	61	19.37	44.15
Partial adopter	235	74.60	
High adopter	19	6.03	
Total	315	100.00	

Table 6: Level of adoption of total bio-security measures on layer farms

Level of adoption	Number of respondents	Percentage	Mean of adoption index
Low adopter	16	5.08	52.02
Partial adopter	270	85.71	
High adopter	29	9.21	
Total	**315**	**100.00**	

Conclusion

Protecting poultry birds from the different contagious and infectious diseases is an extremely important component of commercial poultry production environment. The introduction of a highly pathogenic, contagious disease organism into poultry flocks could result in serious economic consequences for producers. The effectiveness of a bio-security program can be optimized by regional participation. Practicing sound bio-security procedures every day as part of a best management program would help to reduce contracting a disease like avian influenza and spread of other diseases.

11.2. Estimation of the costs and returns from complying bio-security measures by the poultry farms:

The focus of this section is to estimate the costs, returns and finally profitability of broiler and layer farming so that comparison can be made in respect to the bio-security measures being adopted in the poultry farms. In calculating the costs and returns, the current market prices received by the poultry farmers for their poultry products and costs incurred for the production and marketing of the poultry products were estimated. The study also categorized poultry farms (both broiler and layer) according to farm sizes. The farm sizes were as follows: (i) small scale poultry farm (101 to 1200 birds per cycle), (ii) medium scale poultry farm (1200 to 2000 birds per cycle) and (iii) large scale poultry farm (above 2000 birds per cycle). In the present study, total costs per farm per year were worked out where variable cost and fixed cost were separately calculated.

Profitability analysis of broiler production

The major cost items of the broiler enterprise are estimated and analyzed below:

Variable cost

The variable costs are the cost which varies according to the changes of the level of output. Variable costs increase or decrease depends on a farm's production volume; they rise as production increases and fall as production decreases. For broiler farm variable costs include: day old chick cost, feed cost**,** hired labor cost, litter cost, electricity cost, veterinary cost, additives cost, transportation cost, repairing cost of housing, miscellaneous cost and cost for interest on operating capital. Variable costs on an average for all broiler farms and by farm sizes are presented in the Table 7.

Day Old Chick cost

Broiler production starts with buying day old chicks. Thus, it is an important cost item for broiler farm owners. Table 7 shows that the overall average day-old chick cost was Tk. 157141.5 per farm per year which covers 32.93 percent of total variable cost. The Table also shows that average day-old chick cost for small, medium and large farm were Tk. 106216.14, Tk. 235079.20 and Tk. 452454.2 respectively. However, overall average birds/year was 5079.58 and overall average batch per year

were 6. Average birds per year were 3609, 7726 and 12612.5 for small, medium and large farms and average batch per year were 5, 5 and 5.5 for small, medium and large farms respectively.

Feed cost

Feed cost is the major cost item for broiler production and it was accounted for 40.30 percent of the total variable cost. The broiler farm owner used ready-made feed. The feed cost was calculated by multiplying average quantity of the feed intake by broiler birds to the average per kg price of the feed. In the period of data collection average price of the feed per bag containing 50 kg feed was Tk. 2250, so per kg feed was Tk. 45. Overall feed cost was estimated to be Tk. 219867.5 and feed cost for small, medium and large farm were Tk. 139183.8, Tk. 380376.7 and Tk. 595174.2 respectively.

Hired labor cost

In the study area, the average number of batch reared was 6 per year by the broiler farm owner. And the average time per batch was 28-35 days. So, it could be said that most of the farmer were engaged in broiler production all the year round. Labor was mainly used for feeding and watering, cleaning of farm, medical care, purchasing inputs and selling birds. In calculating human labor cost, family labor and hired labor were taken into consideration. Table 7 presents the labor cost per farm per year which was Tk. 20867.88 that coved 4.37 percent of the total variable cost. The hired labor cost for small, medium and large farms were Tk. 14130.31, Tk. 35612.37 and Tk. 48855.81 respectively.

Litter cost

Litter cost includes the cost of rice bran, lime and cement which is an important cost for broiler production. It is evident from Table 7 that the overall average litter cost was Tk. 1569.93 per farm per year which covered 0.33 percent of the total variable cost. The litter cost for small, medium and large farms were Tk. 1075.39, Tk. 1390.75 and Tk. 6777.91 respectively.

Electricity cost

Electricity was very essential for broiler farms for maintaining temperature in the broiler house. In the study area, represented by Table 7 overall average electricity cost per farm per year was Tk. 2698.22 which shared 0.57 percent of the total variable cost. The electricity cost for small, medium and large farms were Tk. 927.42, Tk. 6195.91 and Tk. 10997.92 respectively.

Veterinary cost

Medicine and doctors' fees were the main components of veterinary cost. Large and medium broiler owners were more careful about the possibility of diseases than the small farmers. Table 7 presents the vaccination cost per farm which was Tk. 7173.52. Veterinary costs for small, medium and large farm were Tk. 5742.16, Tk. 9838.16 and Tk. 14288.67 respectively.

Additives cost

Broiler farmers purchase additives for the broiler production. Here, additives mean feed supplement for broiler which is mixed in the feed so that the broiler birds can get enough nutrients from regular meals. The additives provided by the farmers included vitamins, amino acids, fatty acids, minerals, feed energy, antioxidants, acidifier, antimicrobial and growth promoting factors. The overall average additive cost per farm per year was Tk. 1984.69 which accounts for 0.42 percent of total variable cost and Tk. 1.26. Additives cost for small, medium and large farm were Tk. 1238.07, Tk. 3714.75 and Tk. 4845.83 respectively.

Transportation cost

The farmers transport their purchasing input such as feed, day old chicks and litter by the means of easy bike, rickshaw, van and pulling curt from feed mill or local market to their farms. Table 7 shows that the average transportation cost per farm per year was estimated at Tk. 4523.91 that shared 0.95 percent of the total variable cost. Transportation cost for small medium and large farms were Tk. 119.47, Tk. 3675 and Tk. 20163.83 respectively.

Repairing cost of housing

Due to maintain the congenial environment inside the house, the farm owner has to repair the broiler houses which include some cost named as repairing cost. The average per farm per year repairing cost was estimated at Tk. 1939.56. The average cost of repairing covers 0.41 percent for per farm per year of the total variable cost. Repairing cost of housing for small, medium and large farms were Tk. 1871.45, Tk. 2285.84 and Tk. 2671.32 respectively.

Miscellaneous cost

Miscellaneous cost included costs of some minor items like ropes, mosquito coil, net, etc. Miscellaneous cost per farm per year was Tk. 4225.74 that shared 0.29 percent of total variable cost (Table 7).

Table 7: Variable cost of different categories of broiler farms (per farm) (Tk. /year)

Cost items	Small	Medium	Large	All
Day old chick cost	106216.15 (34.65)	235079.20 (30.79)	452454.2 (35.15)	157141.52 (32.93)
Feed cost	139183.80 (45.40)	380376.70 (49.82)	595174.2 (46.24)	219867.50 (46.07)
Hired labor cost	14130.31 (4.61)	35612.37 (4.66)	48855.81 (3.80)	20867.88 (4.37)
Litter cost	1075.39 (0.35)	1390.75 (0.18)	6777.91 (0.53)	1569.93 (0.33)
Electricity cost	927.42 (0.30)	6195.91 (0.81)	10997.92 (0.85)	2698.22 (0.57)
Veterinary cost	5742.16 (1.87)	9838.16 (1.29)	14288.67 (1.11)	7173.52 (1.50)
Additives cost	1238.07 (0.40)	3714.75 (0.49)	4845.83 (0.38)	1984.69 (0.42)
Transportation cost	3119.47 (1.02)	3675 (0.48)	20163.83 (1.57)	4523.91 (0.95)
Repairing cost	1871.45 (0.61)	2286.84 (0.30)	1671.32 (0.13)	1939.56 (0.41)
Miscellaneous cost	3182.27 (1.04)	4993.75 (0.65)	4892.08 (0.38)	4225.74
Interest on operating capital	35270.56 (11.50)	87838.54 (11.50)	148081.40 (11.50)	54902.56 (11.50)
Total variable cost (TVC)	306582.50	763519.59	1287169.08	477229.95 (100.00)

Note: Value in parenthesis indicates percentage of Total variable cost (TVC)

Interest on operating capital

Interest on operating capital includes variable costs in the broiler production which was calculated for one year period such as feed cost, DOC cost, labor cost, veterinary cost, etc. Interest rate of 13 percent per annum was considered for calculation as the lending rate of BKB was 13 percent for poultry purpose. It was assumed that if the owner of the broiler farm borrowed money from any financial institution, he would have paid interest at the above-mentioned rate. The interest rate on operating capital was Tk. 54902.56 for per farm per year and that for small, medium and large farm were Tk. 35270.56, Tk. 87838.54 and Tk. 148081.40 respectively.

Fixed cost

Fixed costs are those costs which do not change in magnitude as the amount of output changes and are incurred even when production is not undertaken. In this study, fixed cost included depreciation on housing cost, depreciation on tools and equipment cost and family labour. These costs are analyzed and described below:

Housing cost

Housing cost is an essential part of the cost of boiler birds rearing. A well-structured housing can protect the broiler birds from sunshine, rainfall, storm, cold weather and wild animal. Farmers were found to keep their birds in tin shade, mud cum pucca floor and fenced by iron net in the study areas. The cost of housing was calculated by taking into account the depreciation cost. The amount of depreciation to be charged during a year was measured by the following formula:

$$\text{Depreciation cost} = \frac{\text{Original value} - \text{Salvage value}}{\text{Life span}}$$

Overall average cost of housing per farm per year was calculated to be Tk. 48334.02 which covered 54.83 percent of the total cost. Depreciation cost of housing for small, medium and large farms were Tk. 55065.04, Tk. 41818.16 and Tk. 30119.69 respectively (Table 8).

Tools and equipment cost

Broiler farms generally used feeder, drinker, brooder, fan, bulb, khunti, tube well, etc. The cost of tools and equipment was estimated by applying the same depreciation method as stated before. The overall average tools and equipment cost covers 5 percent of total cost for per farm per year. Depreciation cost on tools and equipment for small, medium and large farms were Tk. 3313.87, Tk. 6807.81and Tk. 7647.66 respectively (Table 8).

Family labor cost

In the study area, the average number of batches reared and the average time per batch was 6 per year and 28-35 days respectively for broiler farms. Therefore, most of the farmers were engaged in broiler production all the year round. Labor was mainly used for feeding and watering, cleaning of farm, medical care, purchasing inputs and selling birds. In calculating human labor cost, family labor and hired labor were taken into consideration. Table 8 presents the family labor cost per farm per year which was Tk. 35514.80 that covers 40.29 percent of the total fixed cost. The family labor cost for small, medium and large farms were Tk. 32970.72, Tk. 4526.23 and Tk. 39972.94 respectively.

Table 8: Fixed cost and total cost of different broiler farms by farm size (Tk. /farm)

Cost item	Small	Medium	Large	All
Depreciation on buildings	55065.04 (60.28)	41818.16 (45.38)	30119.69 (38.74)	48334.02 (54.83)
Depreciation on equipment	3313.85 (3.63)	6807.81 (7.38)	7647.66 (9.84)	4309.58 (4.89)
Family labour	32970.72 (36.09)	43526.23 (47.23)	39972.94 (51.42)	35514.80 (40.29)
Total fixed cost (TFC)	91349.63	92152.22	77740.30	88158.40
Total variable cost (TVC)	306582.50	763519.60	1287169.00	477229.95
Total cost (TC)	397932.10	855671.80	1364909.00	565388.35

Note: Value in parenthesis indicates percentage of Total Fixed Cost (TFC)

Return from broiler production

In this section, gross return, gross margin and net return from broiler production were calculated and analyzed.

Gross Return

In the present study, gross return from broiler production was calculated by adding values of live weight broiler birds and used litter and bag. Table 9 presents the overall average gross return of broiler production per farm per year and for different farm sizes. The overall average gross return from per farm per year was estimated to be Tk. 682091.72. The gross return of large farm Tk. 1670971 was higher than the gross return from medium and small farm which were Tk. 1025420 and Tk. 490173.5 respectively.

Table 9: Gross returns (Tk.) from different broiler farm-sizes (per farm)

Particulars	Small	Medium	Large	All
Broiler meat	485370.80	1019938.00	1661941.00	676836.70
Used litter	2946.88	2903.33	2916.66	2936.28
Used feed bags	1855.78	2578.16	6113.04	2317.74
Gross returns	490173.50	1025420.00	1670971.00	682091.72

Gross margin is the gross return over variable cost. Gross margin is obtained by deducting total variable cost from gross return. Table 10 shows gross margin of broiler farming per farm per year for different farm sizes. The overall average gross margin of a broiler farm was Tk. 204860.76 per year. The gross margin of large farm was Tk. 383801.88 which was higher than the gross margin of medium and small farms (Tk. 261900.3 and Tk. 183591 respectively).

Net Return

Net return is a very useful tool to analyze or compute performance of enterprises. It is calculated by subtracting total cost from total return. Overall average net returns of broiler production per farm per year were estimated to be Tk. 116702.36. The net return from large farm was Tk. 306061.58 which was greater than the net return of medium and small farms (Tk. 169748.10 and Tk. 92241.36 respectively). This result indicates that large farms are more profitable than small and medium farms. The details of the results are presented in Table 10 and Figure 7.

Benefit Cost Ratio (BCR)

Benefit cost ratio was calculated by dividing the gross return/ gross cost. It is a relative measure, used to compare benefit per unit of cost. Here benefit cost ratio (undiscounted) was used to see the profitability of production. Overall average benefit cost ratio per broiler farm per year was 1.20 (Table 10). Other studies (Begum, 2008; Alam *et al.,* 2008; Saha 2015; Nipa 2015 and Mirza, 2017) related to broiler farming in Bangladesh revealed also nearly the same result of benefit cost ratio. BCR for small, medium and large farm were 1.21, 1.19 and 1.23 respectively indicating that broiler farming is profitable.

Table 10: Net returns (Tk.) from different broiler farm-sizes (per farm)

Particulars	Small	Medium	Large	Overall
Gross return	490173.50	1025420.00	1670971.00	682090.70
Total cost	307932.10	855671.80	1364909.00	565388.40
Net return	92241.36	169748.10	306061.58	116702.36
Gross margin	183591.00	261900.30	383801.88	204860.76
BCR	**1.21**	**1.19**	**1.23**	**1.20**

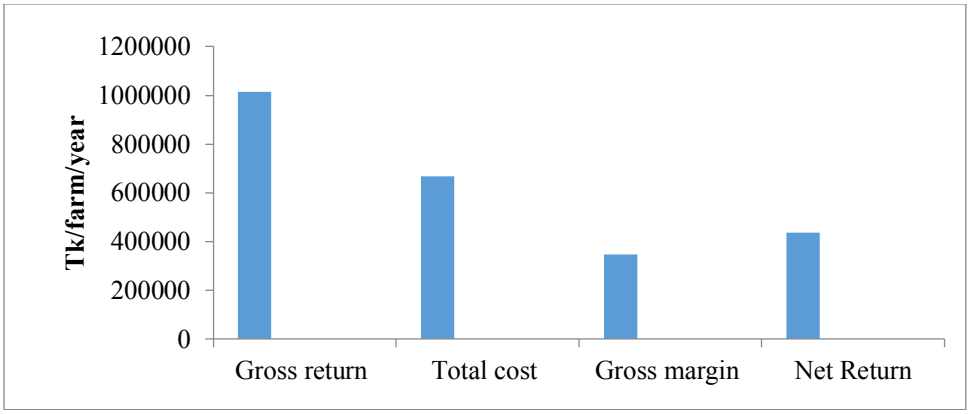

Figure 7: Gross return, total cost, gross margin and net return of broiler production per farm per year

Financial analysis

The data on net present value, benefit-cost ratio and internal rate of returns of investments in broiler farms in different situations are presented in Table 11.

Net Present Value (NPV)

The NPV is an absolute measure which estimates the project's net present value by taking into accounts the costs and returns. The NPV at present situation was found to be Tk. 193820.58 for all farms (Table 11). As it is positive, the farms returns are greater than the cost incurred which is the evidence of viability of the farms.

Discounted Benefit Cost Ratio (BCR)

The BCR is a relative measure, which is used to compare benefits per unit of cost. The BCR estimated as a ratio of gross returns and gross costs. BCR for all farms was estimated to be 1.05 at the present situation (Table 11), which is greater than one. Thus, farms were found financially viable.

Internal Rate of Return (IRR)

The IRR is defined as the average earning power of an investment over the project life. IRR is that rate for which NPV equals to zero. The IRR was 42 percent (Table 11) considering all farms at the present situation which was greater than the discount rate (13 percent) representing the opportunity cost of capital, thus the farms is financially viable.

Sensitivity analysis of broiler farms

Sensitivity analysis is a method for predicting the scenario if a situation turns out to be different compared to the key predictions. Thus, sensitivity analysis is also referred to as "what-if" or simulation analysis. It helps in identifying the key variables that have major influence in the cost and benefits of the project. A sensitivity analysis was performed to understand the financial scenario of the farms while adopting bio-security measures increases the cost and returns.

Bio-security measures and its importance

In situation I, sensitivity analysis was done assuming 20 percent increase of total cost due to practicing bio-security measures. From FGD and field survey the study came to know that to maintain bio-security in the farm total cost had to increase by at least 15 percent to 20 percent. Thus, 20 percent increase was considered. In situation II, it is considered that total costs increased by 20 percent as well as total return increased by 10 percent. As the assumed increased cost was due to the maintaining bio-security which is definitely positive thing for any farm thus a follow up increased return is also expected from that farm. Farmers are expected to get premium price from the customers for ensuring safe poultry meat. In this regard researcher came to know that from poultry rearing and selling company “safe broiler” that for adopting bio-security measures, with increased costs return also increases more or less 10 percent. Thus, it seems justified to consider 10 percent increased return. From the sensitivity analysis it was found that when the cost increased by 20 percent (situation -I), the NPV on an average of all farms became 23182.74, BCR became 1.01 and IRR became 15 percent, i.e. higher than the discount rate of 13 percent. Hence, the farming was found to be feasible with 20 percent increase in costs but due to one-way increase of cost, all net present value, BCR and IRR have decreased than the present situation. When along with increased total costs by 20 percent, total return also increased by 10 percent (situation-II) the NPV on an average of all farms became Tk. 459604.75, BCR became 1.11 and IRR became 36 percent that is higher than the discount rate of 13 percent. So, in this case farm will be again financially viable. As return has also increased due to getting premium price for adopting bio-security measures in this case NPV, BCR and IRR will be even higher than the present situation.

Table 11: Sensitivity analysis of broiler farms (Discount rate 13% per annum)

Situation	All farms		
	NPV (Tk.)	BCR	IRR (%)
Present situation	125548.66	1.03	21
Situation I	23182.74	1.01	15
Situation II	459604.75	1.11	36

Situation I: *Total cost increased by 20 percent;* ***Situation II:*** *Total costs increased by 20 percent and total return increased by 10 percent;* ***Note:*** *NPV- Net present value, BCR- Benefit-cost ratio, IRR- Internal rate of returns.*

Conclusion

From the above discussion it may be concluded that investment in broiler farming is financially viable on all categories of broiler farms. The average total cost of small, medium and large farms was Tk. 307932.10, Tk. 855671.80 and Tk. 1364909 respectively. Average gross returns from small, medium and large farms were Tk. 490173.50, Tk. 1025420 and Tk. 1670971 respectively. Average net returns from small, medium and large farms were Tk. 92241, Tk. 169748 and Tk. 306062 respectively. The BCR (undiscounted) of small, medium and large farms was 1.21, 1.19 and 1.23 respectively and discounted BCR for small, medium and large farms were 1.03, 1.01 and 1.11 respectively. But the small broiler farms were highly sensitive to increase in costs and decrease in net returns followed by medium and large farms. On the basis of NPV, BCR and IRR, investment in broiler farming was found to be most profitable in large farms, followed by medium and small farms.

Profitability of layer production

Variable cost

For layer production variable costs include: pullet cost, feed cost, labor cost (hired), litter cost, electricity cost, veterinary cost, additives cost, transportation cost, repairing cost of housing, miscellaneous cost, interest on operating capital. Variable costs on an average for all farms and by farm sizes are presented in the Table 12.

Pullet cost

Pullet cost is an important cost item for layer farm owners. From Table 12 it can be seen that the overall pullet cost was Tk. 39037.65 per farm per year which covers 3.23 percent of the total variable cost. The average pullet cost for small, medium and large farms were Tk. 25394.68, Tk. 48396.1 and Tk. 176108.3 respectively.

Feed cost

The layer farm owners were found to use ready-made feed. The feed cost was calculated by multiplying average quantity of the feed intake by layer birds to the average per kg price of the feed. In the present study, overall feed cost was Tk. 827321.7 which accounted for 68.52 percent of total variable cost. The feed cost for small, medium and large farms were Tk. 770461.5, Tk. 877087.8 and Tk. 1343438 respectively (Table 12).

Hired labor cost

There are broadly two kinds of labor for poultry farm. Such as hired labor and family labor. Here for the calculation of variable cost only hired labor was considered. Labor was mainly used for feeding and watering, cleaning of farm, medical care, purchasing inputs and selling eggs and birds. Table 12 presents the hired labor cost per farm per year which was Tk. 104341.2 covering the 8.64 percent of the total variable cost. The hired labor cost for small, medium and large farms were Tk. 97273.32, Tk107174.1 and Tk. 185680.3 respectively.

Litter cost

Litter cost includes the cost of rice bran, lime and cement which is an important cost for layer production. It was found that the overall average litter cost was Tk. 2833.79 per farm per year which covers 0.23 percent (Table 12) of the total variable cost. The litter cost for small, medium and large farms were Tk. 2858.433, Tk. 2785.061 and Tk. 2749.375 respectively.

Electricity cost

The overall average electricity cost per farm per year was calculated to be Tk. 15040.44 which was 1.25 percent of the total variable cost. The electricity cost for small, medium and large farms were Tk. 15033.78, Tk. 15201.95 and Tk. 14303.13 respectively (Table 12).

Veterinary cost

Medicine and doctors' fees were the main components of veterinary cost. Large and medium layer owners were found to be more careful about the prevention and control of diseases in their farms compared to the small farmers. In this study the veterinary cost per farm was calculated to be Tk. 53014 which covered 4.39 percent of the total variable cost and per bird cost was calculated to be Tk. 1.94. Veterinary costs for small, medium and large farms were Tk. 49879.31, Tk. 57217.07 and Tk. 73987.5 respectively (Table 12).

Additives cost

The overall average additive cost per farm per year was Tk. 14050.79 which accounts for 1.16 percent of total variable cost. Additives cost for small, medium and large farms were Tk. 11341.01, Tk. 19451.22 and Tk. 23125 respectively (Table 12).

Transportation cost

The average transportation cost per farm per year was Tk. 1224.85 that was accounted for 0.10 percent of the total variable cost. Transportation cost for small medium and large farms were Tk. 1287.74, Tk. 1121.52 and Tk. 901.56 respectively (Table 12).

Repairing cost of housing

The average per farm per year repairing cost was estimated to be Tk. 56815. The average cost of repairing covers 0.29 percent per farm per year of the total variable cost. Repairing cost of housing for small, medium and large farms were Tk. 616.46, Tk. 482.62 and Tk. 351.25 respectively (Table 12).

Miscellaneous cost

Miscellaneous cost per farm per year was Tk. 13411.51 that shared 1.11 percent of total variable cost. Miscellaneous costs for small, medium and large farm were Tk. 11752.86, Tk.16952.63 and Tk. 17758.75 respectively (Tables 12).

Interest on Operating Capital (IOC)

Interest on operating capital includes variable costs in the layer production which was calculated for one-year period such as feed cost, pullet cost, labor cost, veterinary cost, etc. Interest on operating capital was calculated using the following formula:

$$\text{Interest on operating capital} = \frac{\text{Operating cost x rate of interest x study period}}{2}$$

The IOC was Tk136609.7 for per farm per year which was 11.31 percent of the total variable cost. The IOC for small, medium and large farms was Tk. 125566.9, Tk. 146363.1 and Tk. 236392.4 respectively (Table 12).

Table 12: Average variable cost of layer production by farm sizes (Tk. /year)

Variable	Small	Medium	Large	All
Pullet cost	25394.68	48396.1	176108.30	39037.65 (3.23)
Feed cost	770461.50	877087.8	1343438.00	827321.70 (68.52)
Additives cost	11341.01	19451.22	23125.00	14050.79 (1.16)
Veterinary cost	49879.31	57217.07	73987.50	53014.00 (4.39)
Electricity cost	15033.78	15201.95	14303.13	15040.44(1.25)
Litter cost	2858.43	2785.06	2749.38	2833.80(0.23)
Hired labour	97273.32	107174.10	185680.30	104341.20(8.64)
Transportation cost	1287.74	1121.52	901.56	1224.86(0.10)
Repairing cost of housing	616.47	482.62	351.25	568.16(0.05)
Miscellaneous cost	11752.86	16952.63	17758.75	13411.51(1.11)
Interest on operating capital	125566.90	146363.10	236392.40	136609.70(11.31)
Total variable cost	1111466.00	1292233.00	2074796.00	1207453.80(100.0)

Note: Value in parenthesis indicates percentage of Total variable cost (TVC)

Fixed cost

Fixed costs are those costs which do not change in magnitude as the amount of output changes and are incurred even when production is not undertaken. In this study, fixed cost includes family labor, housing cost, tools and equipment cost, interest on fixed capital or fixed investment. These costs are analyzed and described below with the results (Table 13):

Family labor

Opportunity cost was considered for family labor. Overall average cost of family labor per year was calculated to be Tk. 40577.12 which was 2.98 percent of the total cost. The family labor cost for small, medium and large farms were Tk. 37828.51, Tk. 41678.82 and Tk. 72208.99 respectively (Table 13).

Housing cost

Housing is very important for raising commercial layer birds. A good housing system keeps the layer birds safe, healthy and highly productive. Adequate temperature management system is also a very important factor for layer poultry housing as the birds are very sensitive to temperature and egg production. Poultry producers were found to keep their birds in cages under tin shade in the study areas. Cage system is suitable for commercial production purpose. The cost of housing was calculated by taking into account the depreciation cost. The amount of depreciation to be charged during a year was measured by the following formula:

$$\text{Depreciation cost} = \frac{\text{Original value} - \text{Salvage value}}{\text{Life span}}$$

Overall average cost of housing per farm per year was calculated to be Tk. 100818.1 which covered around 7.41 percent of the total cost. Depreciation cost of housing for small, medium and large farms were Tk. 99559.49, Tk. 104673.3 and Tk. 98130.28 respectively (Table 13).

Tools and Equipment cost

Layer farms generally used feeder, drinker, brooder, fan, bulb, hunt, tube well, etc. The overall average tools and equipment cost was Tk. 10958.56 which was 0.81 percent of the total cost for per farm per year. Depreciation cost of tools and equipment for small, medium and large farms were Tk. 10506.23, Tk. 11310.17 and Tk. 15291.37 respectively (Table 13).

Table 13: Average fixed cost and total cost of layer production by farm sizes (Tk.)

Cost item	Small	Medium	Large	All
Depreciation on housing	99559.49	104673.30	98130.28	100818.1 (7.41)
Depreciation on tools & equipment	10506.23	11310.17	15291.37	10958.56 (0.81)
Family labor	37828.51	41678.82	72208.99	40577.12 (2.98)
Total fixed cost (TFC)	147894.20	157662.30	185630.60	152353.80 (11.20)
Total variable cost (TVC)	1111466.00	1292233.00	2074796.00	1207454.0 (88.80)
Total cost (TC)	1259360.00	1449895.00	2260426.00	1359808.0 (100.00)

Note: Value in parenthesis indicates percentage of Total Fixed Cost (TFC)

Return from layer production

The gross return, gross margin and net return were calculated and analyzed. The results are presented in Table 14, Table 15 and Figure 8.

Gross Return

The gross return from layer production was calculated by adding values of eggs, culled birds, used litter and bags. Table 14 presents the average gross returns per year from different sizes of layer farms. The overall average gross return per year was estimated to be Tk. 1831158. The gross return of large farm was Tk. 2866172 which was higher than the gross return of medium and small farms which were Tk. 1970130 and Tk. 1702329 respectively. So, the large farms were found to be the most profitable farms.

Table 14: Average gross returns from different sizes of layer farms (Tk.)

Particulars	Small	Medium	Large	All
Egg	1187352	1350782	1690480	1255451.00 (68.56)
Culled	501255.9	603598	1153557	561030.10 (30.64)
Litter	3309.677	3897.561	3981.25	3496.83 (0.19)
Bags	10411.64	11852.54	18154.57	11180.02 (0.61)
Gross return	1702329	1970130	2866172	1831158.00 (100.00)

Note: Value in parenthesis indicates percentage of Gross Returns (GR)

Gross Margin

Analysis of the results of gross margin is presented in Table 15. The overall average gross margin of a layer farm was Tk. 623704.3 per year. The gross margin of large farm (Tk. 791376.70) was greater than the medium farm (Tk. 677897.00) and small farm (Tk. 590863).

Net Return

Net return is calculated by subtracting total cost from total return. The results are presented in Table 15. Overall average net returns of layer production per year were estimated to be Tk. 471350.5. The

net return from large farm (Tk. 605746) was greater than the medium (Tk. 520234.7) and small (Tk. 442968.8) farms.

Benefit Cost Ratio

Benefit cost ratio was calculated by dividing the gross return with gross cost (Table 15). Here benefit cost ratio (undiscounted) was used to see the profitability of production. Overall average benefit cost ratio per layer farm per year was 1.40. BCR for small, medium and large farms were 1.39, 1.42 and 1.42 respectively. So, layer farming was profitable.

Table 15: Average net returns from different sizes of layer farms (Tk.)

Particulars	Small	Medium	Large	All
Gross return	1702329.00	1970130.00	2866172.00	1831158
Total cost	1259360.00	1449895.00	2260426.00	1359808
Net return	442968.80	520234.70	605746.00	471350.5
Gross margin	590863.00	677897.00	791376.70	623704.3
BCR	1.39	1.42	1.42	1.4

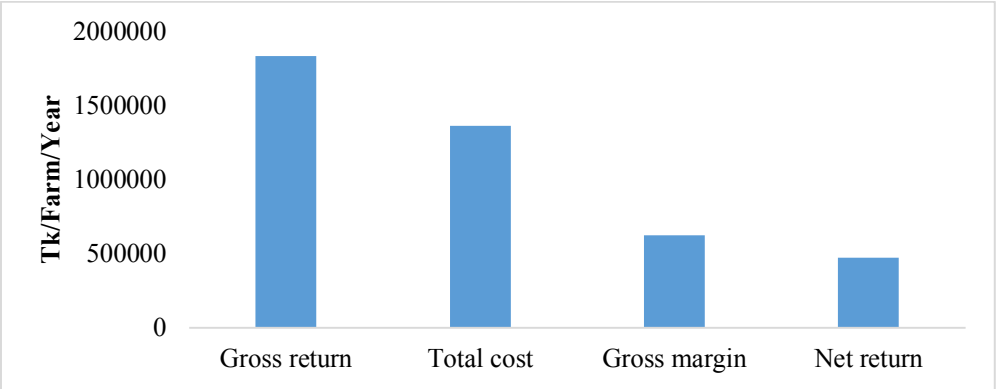

Figure 8: Gross return, total cost, gross margin and net return of layer production per farm per year

Financial Analysis

The data on net present value, benefit-cost ratio and internal rate of returns of investments in layer farms in different situations are presented in Table 16.

Net Present Value (NPV)

The NPV at present situation was found Tk. 1409367.34 for all farms (Table 16). As it is positive, the returns from layer farms are greater than the cost incurred which is the evidence of viability of the farms.

Discounted Benefit Cost Ratio (BCR)

BCR for all farms was estimated 1.09 at the present situation (Table 16), which is greater than one. Thus, the layer farms were found financially viable.

Internal Rate of Return (IRR)

The IRR was 32 percent (Table 16) considering all sizes of layer farms at the present situation which is greater than the discount rate (13 percent) representing the opportunity cost of capital, thus the farms were financially viable.

Sensitivity Analysis of layer farm

Sensitivity analysis is a method for predicting the scenario if a situation turns out to be different compared to the key predictions. Thus, sensitivity analysis is also referred to as "what-if" or simulation analysis. It helps in identifying the key variables that are major influencer in the cost and benefits of the project.

In this study along with the present observed situation two other situations was assumed to gain a clear picture of how exposed the farm's position is to risk. In situation I, sensitivity analysis was done assuming 20 percent increase of total cost. From FGD and field survey the researcher came to know that to maintain bio-security in the layer farms total cost had to increase by 10 percent to 20 percent at least. Thus, in the study for a valid reason 20 percent was considered. In situation II, it is considered that total costs increased by 20 percent as well as total return increased by 10 percent. As the assumed increased cost was due to the maintaining bio-security which is definitely positive thing for any farm thus a follow up increased return is also expected from that farm. Farmers are expected to get premium price from the customers for ensuring safe food. In this regard researcher came to know from poultry rearing and selling company "safe eggs" that for adopting bio-security measures, with increased costs, return also increases more or less 10 percent. Thus, it seems justified to consider 10 percent increased return in the present study. From the sensitivity analysis it was found that when the cost is increased by 20 percent (situation -I), the NPV on an average of all farms became 630940.62, benefit-cost ratio became 1.04 and IRR became 19 percent, i.e. higher than the discount rate of 13 percent. Hence, the farms are feasible with 20 percent increase in costs but due to one-way increase of cost, all net present value, BCR and IRR have decreased than present situation.

When along with increased total costs by 20 percent, total return also increases by 10 percent (situation-II) the NPV on an average of all farms became Tk. 2294822.04, BCR became 1.14 and IRR became 36 percent that is higher than the discount rate of 13 percent. So, in this case farm will be again financially viable. As return has also increased due to getting premium price for adopting bio-security measures in this case NPV, BCR and IRR will be even higher than the present situation.

Table16: Sensitivity analysis of layer farm (Discount rate 13% per annum)

Situation	**All farms**		
	NPV (Tk)	**BCR**	**IRR (%)**
Present situation	1409367.34	1.09	32
Situation I	630940.62	1.04	19
Situation II	2294822.04	1.14	36

Situation I: *Total cost increased by 20 percent;* ***Situation II:*** *Total costs increased by 20 percent and total return increased by 10 percent; Note: NPV- Net present value, BCR- Benefit-cost ratio, IRR- Internal rate of returns.*

Conclusion

From the above discussion it may be concluded that investment in layer farming is financially viable on all categories of layer farms. The average total cost of small, medium and large farms was Tk. 1259360, Tk. 1449895 and Tk. 2260426 respectively. Average gross returns from small, medium and large farms were Tk. 1702329, Tk. 1970130 and Tk. 2866172 respectively. Average net returns from small, medium and large farms were Tk. 442968.8, Tk. 520234.7 and Tk. 605746 respectively. The BCR (undiscounted) of small, medium and large farms was 1.39, 1.42 and 1.42 respectively and discounted BCR for all farms were 1.09. Thus, it could be concluded that investment in layer farming is financially viable on all categories of layer farms. But the small layer farms were highly sensitive to increase in costs and returns followed by medium farms. On the basis of NPV, BCR and IRR, investment in layer farming was found to be most profitable in large farms, followed by medium and small farms.

11.3. Factors affecting in adoption of bio-security practices

The poultry farms both broiler and layer were categorized into two types i.e. bio-security adopted farm and bio-security non-adopted farm. This was classified on the level of adoption which the farmers were practicing in the farm at the time of study. The farms where the level of bio-security practice was more than 50 percent was considered as bio-security adopted farms and where the level of bio-security practice was lower than 50 percent was considered as bio-security non-adopted farm.

Logit model was used to identify the factors influencing farmers to adopt bio-security measures in the poultry farm. Eleven independent variables related to bio-security measures were included in the model. They were classified into three categories i.e. a) farmer's socio-economic condition, b) characteristics of the poultry farm and c) external factors. The independent variables were farmers' age, education, experience as a poultry farmer, attitude to risk, return from poultry production, capacity of birds, type of poultry farm, price of day-old chicken, poultry shades, access to bio-security knowledge and access to market (Table 17).

Table 17: Factors determining adoption of bio-security measures in the poultry farms

Category	Variable	Type	Description of the variable
Farmer's socio-economic condition	Farmers' age	Continuous	Years
	Education	Continuous	Years of schooling
	Experience as a poultry farmer	Continuous	years
	Attitude to risk	Dummy	1= Risk taker, 0 = otherwise
Characteristics of poultry farms	Type of poultry farm	Dummy	1=Layer, 0= Broiler
	Capacity of birds	Continuous	No.
	Return from poultry production	Continuous	Tk.
	Price of day-old chicken	Continuous	Tk.
External factors	Access to bio-security knowledge	Dummy	1= usually available, 0 = otherwise
	Access to market	Dummy	1= usually available, 0 = otherwise

The estimated coefficients are not easily interpreted quantitatively due to the nature of Logistic regression model. Table 18 shows the regression results for adoption of bio-security measures by poultry farms. The logit equation expresses that farmer's age, education, experience as a poultry farmer, capacity of birds, access to bio-security knowledge, access to market and total return had positive effect. Likewise, price of day-old chicken, attitude to risk, poultry shades had negative effect on the farmer's adoption of bio-security measures (Table 18). The results also show that farmer's age, farm's category and total return had a significant effect on adoption of bio-security measures at 5 percent level of significance whereas, experience as a poultry farmer, price of day-old chicken had significant effect at 10 percent level of significance. First, poultry farmer's age has a positive and insignificant effect on adoption of bio-security measures which means that older people are more likely to adopt bio-security measures for their poultry farms due to their experience and the regression coefficient for age is 0.009 which means that holding other variable constant if there is an increase of one year in the age of poultry farmers their interest to adopt bio-security measures increased by 0.0094. The regression coefficient of education was estimated at 0.127 which means that the coefficient is positive and significant. It can be explained in a way that educated farmers were adopting bio-security measures more than the illiterate farmers. The coefficient of experience was estimated at 0.164 which is positive and significant. It means that older farmers in this business are more likely to adopt bio-security measures.

Attitude to risk had negative value of 6.954 (significant at 1 percent level). This indicates that if farmer's attitude to risk was increased by 1, farmers' probability of adopting bio-security measures in the poultry farm will be decreased by 6.954 times.

The coefficient for type of poultry farm had positive value of 0.002. This indicates that if poultry farm is layer, farmers' probability of adopting bio-security measures in the poultry farm will be increased by 0.002 times. The category of poultry farm considered as dummy variable. The significant negative coefficient (0.002) of the dummy variable (D) indicates that bio-security scores can be decreased if the farm is broiler, that is, the dummy variable presents the bio-security scores less if they enter into broiler farming system compared to layer farming system.
The coefficient for price of day-old chicken was estimated at -0.235 which means that keeping other variables constant if price of day-old chicken has increased by 1 Tk. the farmers' probability of adopting bio-security measures in the poultry farm will be decreased by -0.235.

The coefficient for return from poultry production had positive and significant effect on adoption of bio-security measures. This indicates that if farm's return from poultry production were increased by 1 Tk. keeping other variables constant, farmers' probability of adopting bio-security measures in the poultry farm will increase but at a very minimum level.

Table 18: Estimates of the coefficients and marginal effects

Variables	Coef.	Std. Err.	z	P>z
Constant	9.798	4.814	2.04	0.042
Age	0.009	0.016	0.57	0.566
Education	0.127**	0.054	2.35	0.019
Experience	0.164*	0.095	1.73	0.084
Attitude to risk	-6.954	1.812	-3.84	0
Farm category *(layer =1, broiler=0)*	5.320**	1.720	3.09	0.002
Capacity to rear poultry	0.0001	0.0003	0.43	0.666
Day-old-chicks price	-0.235*	0.142	-1.65	0.098
Poultry shades	-4.807	0.956	-5.02	0
Access to knowledge	6.894	1.576	4.37	0
Access to market	7.906	1.389	5.69	0
Total return	8.13E-07**	4.12E-07	1.97	0.049
Number of observations = 630				
LR chi^2 (11) = 656.67				
Prob > chi^2= 0.0000				
Log likelihood = -100.0557				
Pseudo R^2=0.7664				

Note: ***significant at 5% level and *significant at 10% level*

Conclusion

Poultry is one of the significant livestock sectors which contribute largely to the economy of Bangladesh through livelihood generation and meeting protein requirement of its large population. For enhancing poultry sector, it is crucial to control bird-flu with the help of adopting bio-security measures in poultry farm which was the focus of the study. The result of the study shows that most of the poultry farm whether it was broiler or layer was not 100 percent bio-secured. Layer farms were more bio-secured than broiler farms on the basis of different bio-security level. Hence, benefit cost ratio was higher for layer farms than broiler farms. Farmer's education, attitude to risk, experience with poultry disease including HPAI and farm location were found to be the significant factors that determined farmer's adoption of bio-security measures for both broiler and layer or poultry sector in general. The present status of bio-security is not satisfactory for prevention of diseases. Therefore, collective and coordinated efforts should be taken to further develop and improve the existing management practices for the better interest of this sector.

12. Research Highlights/Findings

- Comparing the level of bio-security knowledge and practices for both the broiler and layer farms, it was found that layer farms were more bio-secured than broiler farms. However, prohibition of dogs and cats including backyard poultry in the farm premises and secured sources of water were practised in 100 percent of the broiler and layer farms.
- The net return of small, medium and large broiler farms was Tk. 92241.36, Tk. 169748.00 and Tk. 306062.00 respectively. However, layer farms were more profitable than broiler farms. Overall average net returns of layer farms per year were estimated at Tk. 471351.00. The net return from large layer farms (Tk. 605746) were greater than the net return from medium (Tk. 520235.00) and small (Tk. 442969.00) farms.

- Investment in poultry farming was found to be financially viable for all categories of broiler and layer farms. The BCR (undiscounted) of small, medium and large broiler farms was 1.21, 1.19 and 1.23 respectively. However, overall average BCR of layer farm was 1.40 which is higher than broiler farm. BCR for small, medium and large layer farms were 1.39, 1.42 and 1.42 respectively.
- The results from sensitivity analysis show that if the total cost is increased by 20 percent due to practicing bio-security measurements the net present value on an average of all farms becomes Tk. 23183.00 and the benefit-cost ratio become 1.01. Hence, it could be concluded that broiler farming is feasible with practicing bio-security. In case of layer farm, it was also found that when the cost is increased by 20 percent, the net present value on an average of all farms become Tk. 630941.00, benefit-cost ratio become 1.04 and internal rate of return become higher than the opportunity cost. When along with the increased total costs by 20 percent, total return also increased by 10 percent, the net present value on an average of all farms become Tk. 2294822.00, and benefit-cost ratio become 1.14. Therefore, the results show investment in layer farming is financially viable, as return has also increased due to getting premium price for adopting bio-security measures.
- IRR was also greater than the opportunity cost for both broiler and layer farms, if total cost is increased by 20 percent due to practicing bio-security measurements representing that both the broiler and layer farming is financially viable.
- The result of sensitivity analysis showed that investment in broiler and layer farming is not sensitive to increase in costs (due to bio-security practices) and increase in net returns (premium price due to safe poultry meat & eggs) on the basis of NPV, BCR and IRR.
- The analysis of logit equation expressed that farmers' age, farmer's education, experience as a poultry farmer, farm income, farm types, access to bio-security knowledge and access to market had positive effect; and attitude to risk, day old chick price and number of poultry shed had negative effect on the farmer's adoption of bio-security measures in the poultry farm.

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP target		Achievement		Remarks
	Phy (#)	Fin (Tk.)	Phy (#)	Fin (Tk.)	
(a) Office equipment	Laptop computer- 02	120000	Laptop computer- 02	120000	
	Desktop computer - 01	60000	Desktop computer - 01	60000	
	Printer- 01	20000	Printer- 01	20000	
	Scanner- 01	10000	Scanner- 01	10000	
	Digital camera-01	25000	Digital camera- 01	24000	
(b) Lab.& field equipment	-	-	-	-	
(c) Other capital items	Chair- 02	20000	Chair- 02	20000	
	Desk/Table- 01	20000	Desk/Table- 01	20000	
	Steel Almirah- 01	24000	Steel Almirah- 01	24000	
	File Cabinet - 01	20000	File Cabinet - 01	20000	
	Computer Table – 01	5000	Computer Table – 01	5000	
	Computer Chair – 01	3500	Computer Chair – 01	3300	
	Total	327500	**Total**	327200	

2. Establishment/Renovation Facilities: None

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	

3. Training/Study Tour/ Seminar/Workshop/Conference Organized: Not Applicable

Description	Number of participants			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training	-	-	-	-	
(b) Workshop	-	-	-	-	-

C. Financial and Physical Progress

Fig in Tk.

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation*
A. Contractual Staff Salary	407035	407035	407035	0	100	
B. Field Research / Lab expenses and supplies	1082000	1082000	1082000	0	100	
C. Operating Expenses	298500	280915	204662.64	76252.36[1]	73	Less operating expenses
D. Vehicle Hire and Fuel, Oil & Maintenance	199980	199000	199000	0	100	
E. Training/ Workshop/Seminar, etc.	0	0	0	0	-	
F. Publications and printing	124000	15000	15000	0	100	
G. Miscellaneous/ Contingencies	60000	60000	60000	0	100	
H. Capital Expenses	327500	327200	327200	0	100	
Total	**2499015**	**2371150**	**2294897.64**	**76252.36**	100	

[1]*The unspent amount BDT 76252.36 was returned to NATP on 12-02-2019 (Ref. 47040796712)*

D. Achievement of Sub-project by Objectives: (Tangible Form)

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output (i.e. product obtained, visible, measurable)	Outcome (short term effect of the research)
i) To examine the level of adoption of bio-security measures by different categories of poultry farms	• Personal observation • FGD • Key Informant Interview • Survey Research	• Layer farms were found more bio-secured than broiler farms	Updated knowledge of the cost of bio-security compliances and driving factors associated with the adoption of bio-security measures by poultry farms will help policy makers in planning policies for bio-security adoption by the farms.
ii) To estimate the investment and returns from complying bio-security measures by the poultry farms	• Personal observation • Interview • Survey Research	• Investment in poultry farming was found to be financially viable for all categories of broiler and layer farms. The BCR (undiscounted) of small, medium and large broiler farms was 1.21, 1.19 and 1.23 respectively. However, overall average BCR of layer farm was 1.40 which is higher than broiler farm. BCR for small, medium and large layer farms were 1.39, 1.42 and 1.42 respectively. • Investment in broiler and layer farming was found not to be sensitive to increase in costs due to maintaining bio-security • The net return of small, medium and large broiler farms was Tk. 92241.36, Tk. 169748.00 and Tk. 306062.00 respectively. However, layer farms were more profitable than broiler farms.	
iii) To examine the driving factors associated with the adoption of bio-security measures by poultry farms.	• Personal observation • FGD • Key Informant Interview • Survey Research	• Farmers' age, farmer's education, experience as a poultry farmer, farm income, farm types, access to bio-security knowledge and access to market had positive effect on the adoption of bio-security measures by the poultry farmers.	

E. Materials Development/Publication Made under the Sub-project:

Publication	Number of publications		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication		To be submitted	
Information development			
Other publications, if any			Proceedings of Annual Workshop on BAU Research Progress (2017-18) *
MS Thesis		Factors Influencing the Adoption of Bio-security Activities on Broiler Farms in Some Selected Areas of Gazipur District	Department of Agricultural Economics, BAU, Mymensingh

**The presentation made in the workshop has been awarded as the BEST Presentation.*

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity & Non-commodity)

N/A

ii. **Generation of new knowledge that help in developing more technology in future**

a) An updated fact on what extent bio-security measures are being practised by different categories of poultry farmers
b) An updated information on cost & return from adopting and non-adopting bio-security measures
c) Knowledge regarding the factors affecting adoption of bio-security measures

iii. Policy Support

- Bio-security adoption policy should include farmer's training to maintain proper bio-security practices. For this Government and NGO's can come forward.
- Government should establish new and modern veterinary centers in every remote area across the country to provide better extension services.
- Public media like Television, Radio, and Newspaper can play an active role against the rumors regarding bird-flu and know-how of bio-security practices.

G. Information Regarding Desk and Field Monitoring

i) Desk Monitoring (description & output of consultation meeting, monitoring workshops/seminars etc.):

A workshop on " Progress Review of CRG Sub-Projects, PIU-BARC, NATP-2 Project under AERS Division, BARC, was held on 5 March, 2018 at the conference room 1 of Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka. Dr. Paresh Chandra Golder, Member Director (P & E) BARC and Dr. Mian Syeed Hassan, Director (PIU-BARC), NATP-2 project was present as Chief Guest and Special guest, respectively in the inaugural session of the workshop. Dr. A. S. M. Anwarul Huq, Member Director (AERS), BARC presided over the inaugural session. A total of 75 participants including principal and co-principal investigators (PI & Co-PIs) of sub-projects, research management experts of PIU-BARC, scientists, and delegates attended the workshop. Two technical sessions were presided over by Professor Dr. Rezaul Karim Talukder, Advisor, MUCH, FAO and Dr. Jahangir Alam Khan, Former Director General, BLRI, Dhaka. In discussion session the learned participants were participated actively by providing valuable comments/ suggestions for further improvement. However, desk monitoring was done by BARC team and the report was satisfactory.

ii) Field Monitoring (Time & No. of visit, Team visit and output): Not applicable.

H. Lesson Learned (if any):

i. The project needed to allocate more time.

I. Challenges (if any)

i. Most of the poultry farmers thought that the investigator was an agent of the government authority and therefore, they initially did not want to cooperate with the researcher regarding bio-security practices.
ii. In many cases, they hesitated to answer some questions relating to income and asset.
iii. Researcher had to depend solely on the memory of the respondents for collecting necessary information because most of them did not keep written records. Therefore, the collected information might not be free from errors.

Signature of the Principal Investigator

Begum

Date ……
Seal

Counter signature of the Head of the organization/authorized representative

Begum

Date …….
Seal

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