Bangladesh Development Studies
Vol. XXXVIII, March 2015, No. 1

Economic Impacts of Oilseed Research and Development in Bangladesh

M. A. MONAYEM MIAH*
S. M. A. SHIBLEE*
M. A. RASHID**

This paper estimates the economic impacts of oilseed research and development (R&D) in Bangladesh. For the purpose, a total of 1,980 oilseed growing farmers are randomly selected from 11 oilseed growing districts in the country for gathering primary data using pre-tested interview schedules during 2011-12. An *ex-post* evaluation method using economic surplus model under both closed and small-open market economy situations has been adopted to estimate the rate of returns of investment in oilseeds R&D. The adoption of improved mustard, groundnut, sesame and soybean varieties at the farm level creates an additional employment of 12.7, 11.6, 15.4, and 6.1 man-days/ha for the respondent farmers respectively. The livelihood status of the adopting households is much better than that of non-adopting households. *Ex-post* evaluation of the past investment on oilseeds R&D reveals an IRR of 24 per cent, which ranges from 22 per cent to 26 per cent under different assumptions. The amounts of NPV and foreign exchange savings due to R&D of oilseeds during 1998-2012 are Tk. 4,769.04 million and US$ 97.11 million respectively.

Keywords: Oilseeds, Economic Surplus Model, Research and Development, IRR, NPV, BCR, Foreign Exchange Savings

JEL Classification: Q16

I. INTRODUCTION

Edible oil or fat is the most important nutrient of human foods. It plays a vital role in our national economy as well as in human nutrition for meeting calorie requirement. But, in Bangladesh, the per capita consumption of oil and fat remained far below its recommended intake. According to the Bangladesh

*Senior Scientific Officer, Agricultural Economics Division, Bangladesh Agricultural Research Institute (BARI), Bangladesh.
**Principal Scientific Officer, Agricultural Economics Division, Bangladesh Agricultural Research Institute (BARI), Bangladesh.

Institute of Research & Training on Applied Nutrition (BIRTAN), in 2007, per capita per day requirement of edible oil was 40 gram. BIRDEM, with the support of National Food Policy Capacity Strengthening Programme, suggested a desirable dietary intake of oil 30 gm/capita/day after the evaluation of previous works and current consumption patterns in the country (http://www.hortex.org) whereas at the national level the per capita consumption of edible oil is only 20.5 gm (BBS 2011). The level of edible oil consumption for the poor and non-poor is 14.20 and 23.41 gm/capita/day respectively (Miah *et al.* 2013). The major sources of visible oils are mustard, soybean, groundnut, sesame and sunflower, whereas the main sources of invisible oils are fish, meat, milk, egg, vegetables, etc.

Acute shortage of edible oil has been prevailing in Bangladesh during the last several decades. This shortage inherited from the past has been met through imports, using a huge amount of foreign exchange every year. The values of imported oilseeds and edible oils were Tk 14,200 million and Tk 130,510 million in 2012, which were 285 per cent and 519 per cent higher compared to the values of 2003 (Bangladesh Bank 2012). Besides, the area under oilseeds cultivation is decreasing over the years due to various economic and technical reasons (Miah *et al.* 2014). Realising the importance and demand of oilseeds, Bangladesh government has given emphasis on R&D of oilseed crops and invested a lot of money for attaining their self-sufficiency in the country. Bangladesh Agricultural Research Institute (BARI), Bangladesh Institute of Neuclear Agriculture (BINA), and Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU) have started conducting research on oilseeds and they released a good number of high yielding varieties and improved management technologies of different oilseeds. The Department of Agricultural Extension (DAE) has also been involved in developmental programmes for the technology transfer of oilseed crops through its countrywide networks. All these initiatives have raised the productivity growth of oilseeds to a great extent. Again, the released technologies have been found to be suitable for farmers and the potential adoption of these improved varieties generated employment and additional income for the oilseed farmers and saved valuable foreign exchange by producing more of these crops utilising fallow and under used land in the country. This impressive development indicates the immediate need of strengthening the current efforts of improved variety adoption at farm level.

The main concern of this paper is to quantify the contribution in economic term. In order to measure such type of benefit, different researchers estimated returns to investment (e.g. IRR, NPV, BCR, etc.) using economic surplus method for different crops in different periods (Evenson and Flores 1978, Siddiqui 1985, Echeverría *et al.* 1989, Dey and Evenson 1991, Morris *et al.* 1994, Deb and Mustafi 1999, Hossain *et al.* 2002, Miah and Hossain 2003, Karim *et al.* 2003, Hossain *et al.* 2003, Hasan and Miah 2003, Hossain *et al.* 2004, Miah *et al.* 2005, Miah *et al.* 2009). But no researches as yet estimated returns to investment in oilseed research and development (R&D) in Bangladesh. However, the economic impacts of farm level adoption of these technologies need to be evaluated properly to understand the output of R&D of oilseed. This information could be useful for both government and donor agencies in investing more on oilseeds improvement programmes in Bangladesh. Therefore, an attempt has been made to estimate the economic impacts and returns to investment in oilseed R&D in Bangladesh.

The specific objectives of this paper are to:

1. identify the level of adoption of improved oilseed varieties;
2. estimate the yield advantage and profitability of improved oilseed varieties cultivation; and
3. estimate the rate of return of investment in oilseed research and development in Bangladesh.

II. METHODOLOGY

2.1 Sampling Design

The Oilseed Research Centre (ORC) deals with six oilseed crops, namely mustard, sesame, groundnut, soybean, linseed and sunflower. Among these oilseed crops, the first four major oilseed crops were considered for socio-economic evaluation. Based on the area coverage of individual oilseed crop during 2008-2009, three districts, consisting high (covered ≤10 per cent of the total area), medium (covered >10 per cent area), and low (covered >5 per cent area) growing districts, were purposively chosen for studying each type of oilseed crop.[1] The selected districts were Manikgonj, Faridpur, Tangail, Mymensingh, Rajshahi, Pabna, Dinajpur, Noakhali, Laxmipur, Comilla and Jessore. Again, three suitable (in terms of data availability, ease of data collection, accessibility and logistic supports) *Upazilas* from each district were purposively selected in consultation with DAE personnel for collecting primary

[1]In the case of mustard and groundnut, the numbers of districts under high, medium and low growing areas were 3, 3, and 16 respectively, while the respective numbers were 3, 6, and 14 for sesame. In the case of soybean, about 96 per cent areas were under two districts (Noakhali and Laxmipur) and 3 per cent under Comilla district.

data from oilseed growers. Finally, a total of 540 households (3 districts × 3*Upazilas* × 3 Agri. blocks × 20 HHs) for each type of crop were selected for interview using simple random sampling technique to collect primary data. Thus, a total of 2,160 (540 HHs × 4 crops) oilseeds cultivating farmers were interviewed for the study. But the actual sample size was 1,980, as no data could be found from other areas. Selected oilseed crops and study areas are shown in Table I.

Primary data were collected by interviewing oilseed farmers using a structured pre-tested interview schedule during October 2011 to October 2012. Farm level primary data and information were collected by different project personnel, such as Principle Investigator, Co-Investigator, Scientific Officer, and trained Scientific Assistants. In order to cross check the information collected from the farm survey, a number of focus group discussions (FGDs) were conducted with oil scientists of BARI and the extension personnel of DAE of different districts.

TABLE I

NAME OF SELECTED OILSEED CROPS AND STUDY AREAS

Oilseed crops	Study areas		
	High growing areas	Medium growing areas	Low growing areas
Mustard	Manikgonj	Rajshahi	Dinajpur
Groundnut	Noakhali	Pabna	Tangail
Sesame	Jessore	Faridpur	Comilla
Soybean	Noakhali	Luxmipur	--

2.2 Estimating Returns to Investment in R&D

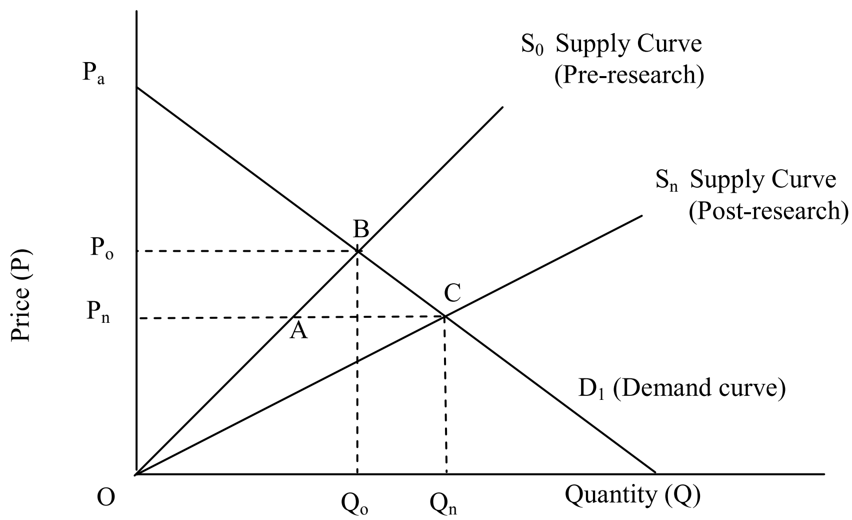
An *ex-post* evaluation with the help of economic surplus model was adopted in this study to estimate the benefit-cost ratio BCR, internal rate of return (IRR) and net present value (NPV) of the investment on oilseeds R&D in Bangladesh. Economic surplus approach estimates the benefits to agricultural research by measuring the change in consumers' surplus and producers' surplus from a rightward shift in the supply curve that is brought about through technological change. Aggregate consumers' surplus, producers' surplus and total surplus are usually calculated by summing up corresponding surpluses of all commodities rather than summing up from the areas of the model. In order to calculate the net benefits of research and extension, expenditures are subtracted from total surplus. All these estimates of benefits were expressed in real terms by using the price of

2011-2012 as the base year. The rate of returns and net benefit are then discounted using 10 per cent interest rate for obtaining the efficiency of investment. Due to multiple oilseed crops under study, the present analysis was done under both closed and small open-economy market[2] situations. Hasan and Miah (2003) also analysed returns to investment in rapeseed and mustard R&D under small open-economy market condition. Theoretical and empirical concepts of the economic surplus model are discussed below.

2.2.1 Theoretical Concept of Economic Surplus Model

The concept of economic surplus has been used to measure the economic welfare and the changes in economic welfare from policy and other interventions (Alston *et al.* 1995, Currie *et al.* 1971). In general, the economic surplus concept is adopted to estimate the social benefits from the adoption of improved varieties. The components of economic surplus are consumer surplus and producer surplus resulting from a shift in the supply curve, caused by an increase in productivity. This outward shift in the supply function results from an upward shift in the aggregate production function resulting from the adoption of improved varieties.

Figure 1: Economic Surplus Model under Closed Economy Market Situation



[2]Bangladesh produces oilseeds domestically, but imports oilseeds from world market. A commodity is produced domestically and traded internationally in an open economy market. Open economy markets are characterised as being either small or large. A small economy market is one, where the amounts of exports and imports are small relative to total world trade of the commodity.

This relation is shown in Figure1 in which D_1 and S_o represent the actual market demand and pre-research supply curve, whereas S_n represents the post-research supply curve that would have existed due to adoption of improved varieties.

Distribution of Economic Benefits:

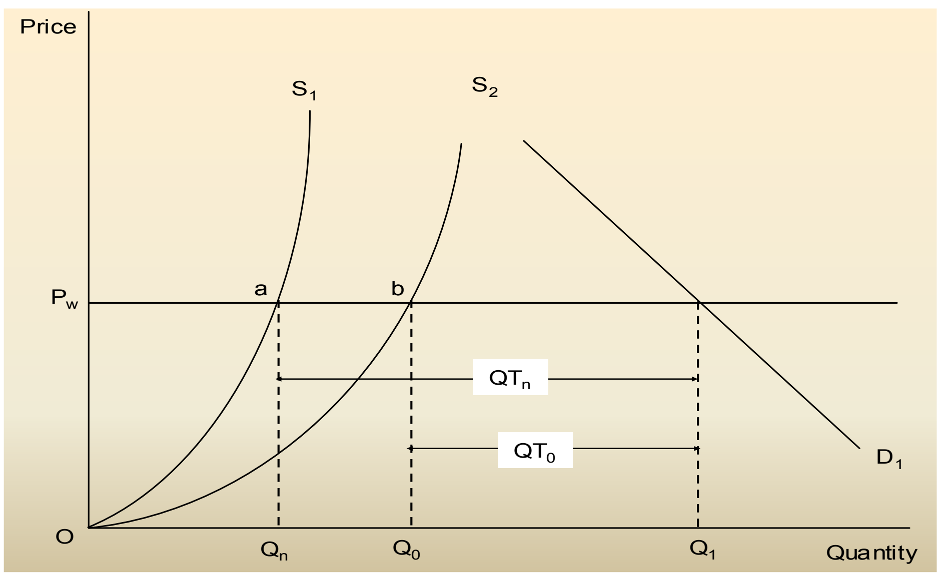
Change in consumer surplus/benefit	=	Area ABC + Area P_oBAP_n
Change in producer surplus/benefit	=	Area AOC - Area P_oBAP_n
Change in total economic surplus/benefit	=	Area ABC + Area AOC

Given a shift in the supply curve from S_o to $S_{n,}$ the change in consumer surplus is depicted in Figure 1 as Area ABC+Area P_oBAP_n, the producer surplus as Area AOC-Area P_oBAP_n, and the total social benefit or economic surplus as Area ABC + Area AOC. The shift in the supply curve has decreased the price that made consumers better off. The change in consumers' surplus (benefits) can be measured as a monetary value. Besides, area AOC represents the decrease in the cost of production (i.e. benefits of the farmers) for the same unit of commodity due to the adoption of improved variety and can also be measured and quantified in monetary terms. The adoption of improved variety, however, has increased the quantity produced, thereby decreasing the price of the commodity (from P_0 to P_n in Fig-1) which is a loss to farmers' income. Farmers can recover some of this loss since they can sell excess quantity (Q_n to Q_0 in Fig-1) of the commodity. Farmers will be benefited from the adoption of improved technology intervention if Area AOC is greater than Area P_oBAP_n. In the present case, the Area AOC is less than the Area P_oBAP_n. The size of the two areas depends on the elasticities of supply and demand curves and the size of the supply curve shift. The total social benefit (i.e. economic surplus) from the adoption of an improved variety is the summation of the change in consumer surplus plus the change in producer surplus (Area ABC + Area AOC). For a closed economy model, the estimated price elasticity of demand is used in the above formulae.

Small open economy model, where the elasticity of demand is perfectly elastic, uses a sufficiently large number of η (Nagy and Alam 2000). In a small open economy market, there is little or no effect on the world price of the commodity (the small country assumption). In this situation, the price of commodity does not change with the shift in the supply curve. For this study, the oilseed market of Bangladesh is modelled as a small open economy market.

The change in economic surplus for a small open-economy that is domestically produced, but allows imports to cover shortfall, is depicted in Figure 2. The world price P_w and quantity demanded by Bangladeshi consumers Q_1 defines the initial equilibrium. At price P_w, producers supply Q_n amount of oilseed, when faced by the pre-research supply curve S_1. Oilseed imports are equal to QT_n, when faced by the research induced supply curve S_2 (the supply curves that exist because farmers have adopted new high yielding varieties). Oilseed producers increased production to quantity Q_n and increase Q_nQ_0. Oilseed imports are decreased by the same amount as the increase in production Q_nQ_0 and are now at QT_0. Since P_w does not change (small economy assumption), there is no change in consumer surplus- consumers are neither better off nor worse off. The entire change in economic surplus from the adoption of new oilseed varieties is thus a change in producer surplus only and is identified by area Oab in Fig-2 (corresponds to area OAC in Fig-1). The amount of foreign exchange saved by the adoption of improved varieties is equal to P_w x (Q_nQ_0).

Figure 2: Small Open Economy Importer Economic Surplus Model



2.2.2 The Empirical Model

The Akino and Hayami (1975) approximation formula for calculating changes to producer and consumer economic surplus was used in this study. The approximation formula for calculating the change in economic surplus for a closed-economy situation (Figure 1) is as follows:

Area ABC = $((½ P_nQ_n)((k(1+\lambda))^2/(\lambda+\eta)))$ (1)

Area AOC = (kP_nQ_n) (2)

Area P_oBAP_n=$((P_nQ_nk(1+\lambda))/(\lambda+\eta))x((1-(½ k((1+\lambda)\eta))/(\lambda+\eta))$ - $(½ k(1+\lambda)))$ (3)

where

P_o = Output price (Tk/ton) that would exist in absence of research (existing market price)

Q_o = Quantity of output (ton) produced that would exist in absence of research

P_n = Actual output price (existing market price)

Q_n = Actual quantity of output (existing production)

k = Horizontal supply shifter

λ = Price elasticity of output supply

η = Absolute price elasticity of the demand for the output.

For a closed-economy model, the estimated η is used in the above formulas. For a small open-economy model where the η is perfectly elastic, use a sufficiently large number for η .

2.2.3 Limitations of the Economic Surplus Model

Economic surplus model as presented above only measures benefits from a supply shift (in the case of open economy model) due to research and development (R&D). However, this supply shift is not fixed over time. This means that with changes in the rate of adoption of new varieties, the shift of supply curve could be different in different years. Therefore, estimates of supply shifts over time shall be estimated before employing the model. Moreover, elasticities of supply might vary over years. Unfortunately, no time series data on supply shifts exists. Furthermore, expenditure on research by crops is also not readily available over time.

Therefore, time series data on these were estimated using the following heuristic assumptions.

a) The elasticity estimates for demand and supply used in this study were considered constant over time.

b) The percentages of areas planted to different improved varieties of oilseeds used for the period 1997 to 2008 were estimated using expert opinions from field offices.

c) The calculation of yield advantages of an improved oilseed variety over traditional one for different years was based on a single year (2011-12) observation and hence remained constant over time.

d) In this study, R&D expenditures on oilseeds incurred by different organisations were estimated using the composition of R&D in oilseeds for the year 2011-12.

Literature on supply shifts due to research often points out that such shifts are not constant and often follows a quadratic time path (Haque *et al.* 1989). This means supply shifts gradually increase initially and then decline with release of newer varieties. Therefore, it is likely that the benefits estimation remains somewhat biased despite our sincere effort to estimate it more accurately.

2.2.4 Estimation of Supply Shifter (k)

The overall yield advantage of improved technology over the traditional varieties weighed by the proportion of the total production saved due to improved technology adoption is called the supply shifter (k). In Akino and Hayami (1975) approximation formulae, k is the horizontal shift from the equilibrium price P_n given S_1 to the equilibrium price Po given S_2, which corresponds to a distance equal to Q_nQ_o in Fig-1 (Gardiner *et al.* 1986, Nagy and Furtan 1978). In estimating yield advantage, the yields of selected crops (both improved and old variety) were collected through household survey. The supply shifter k is calculated as follows:

$$k_t = \sum_{i=1}^{n} [1 - \frac{Y_t}{Y_{it}})] \times A_{it} \tag{4}$$

where

Y_{it} = Yield of improved variety in year t

Y_t = Yield of traditional variety in year t

A_{it} = Proportion of the total production saved due to improved variety adoption in year t

n = Number of farms (Sample respondents).

2.2.5 Estimation of Rates of Return

The internal rate of return (IRR) is calculated by taking the total social benefit (TSB) minus total expenditure for research and development (C) in each year. The IRR is the discount rate that results in a zero net present value (NPV) of the benefits. The IRR is calculated as (Equation 5):

$$O = \left[\sum_{t=1}^{n} (TSB_t - C_t)(1 + IRR)^{-t} \right] \tag{5}$$

The formal mathematical statements of benefit cost ratio (BCR) and NPV are as follows:

$$BCR = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+i)^t}} \tag{6}$$

$$NPV = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+i)^t} \tag{7}$$

where

B_t = Benefit in time t

C_t = Expenditure in time t

i = Interest (discount) rate

n = Number of years

t = 1,2,3 ………, n.

2.2.6 Type and Sources of Data for the Model

Both primary and secondary data were used to run the economic surplus model. The procedure of collecting primary data has been discussed in section 2.1. Three years (2009-20011) data on area and production of the selected four oilseeds and per cent adoption of the improved varieties were collected from 64 district level offices of the Directorate of Agricultural Extension (DAE). Consumer price index (CPI) and time series data (1989-2012) on area and production of selected oilseeds were collected from various issues of the Bangladesh Bureau of Statistics (BBS). In addition, the demand and supply elasticity estimates used by Norton (1993) for oilseeds were considered in this study. The costs incurred in the past years for oilseed research were collected from the Finance and Accounts section of BARI and BINA. Extension and promotional activities were conducted by DAE and the related costs were obtained from this organisation. The administrative costs were gathered from the apex body of agricultural research, the Bangladesh Agricultural Research Council (BARC). Primary and secondary data collected from different sources are Table II.

TABLE II

TYPE AND SOURCES OF DATA USED IN ECONOMIC SURPLUS MODEL

Data type	Sources of data
Year-wise district level area, production and yield	BBS and DAE
Local level area, production and yield	Field survey
Adoption profile of oilseed varieties	DAE & expert opinion
Retail prices of oilseeds	DAM
Consumer price index (CPI)	BBS
Supply and demand elasticity	Norton, 1993
Oilseeds research and extension costs	ORC-BARI, BINA, DAE, BARC
Year-wise quantity and price of imported oilseeds	FAOstat
f.o.b price of oilseeds	FAOstat

2.2.7 Research and Development Expenditure

The total expenditures incurred for the development of improved technologies of oilseeds, and the dissemination of these improved technologies at farm levels included the costs incused by different institutes, such as ORC of BARI, BINA, BARC and DAE. Different agricultural universities, namely BAU, SAU and BSMRAU conducted some research on oilseeds for their M.S. and Ph.D. levels which have little or no impact at farm level. Therefore, oilseed research costs at university levels were not taken into consideration in this study. For the analysis, the current total expenditures were converted to 2011-12 constant prices (inflated price) using the national CPI Index.

The costs incurred for oilseeds research were collected from the Finance and Accounts section of BARI and BINA. The costs of these two research institutes included capital, revenue and foreign exchange costs. The ORC of BARI mainly works on six oilseed crops, but the present study deals with four crops. Hence, based on the assumptions and suggestions of ORC scientists, about 66.7 per cent of the total ORC costs were taken for this analysis and was assumed constant throughout the study period. Again, 5 per cent of the total costs of BINA were considered as the costs for oilseeds development programme. BARC is the apex body of National Agricultural Research System (NARS) of Bangladesh. Currently, major ten research institutes belong to the BARC. Therefore, the administrative costs were also gathered from BARC. It was assumed that BARC administrative expenditure for BARI was about 10 per cent of total BARC expenditures. Again, BARI conducts researches on both crops and non-crops enterprises. However, 0.50 per cent of the total BARC cost was taken for the analysis and was assumed constant throughout the study period. Finally, extension and promotional activities were conducted by DAE and the related costs were obtained from this organisation. The expenditures of DAE for the dissemination of improved technologies of oilseeds were calculated based on the percentage of oilseeds cropped area relative to total cropped area. On average, 0.483 per cent of the land was planted to four oilseed varieties and 1.81 per cent of total DAE cost was incurred for oilseeds extension.

2.3 Estimation of Employment Generation

The amount of additional employment generated due to the adoption of improved varieties of oilseeds and production practices was estimated using the following formula. This equation (8) was also used by Miah *et al.* (2009).

$$TEG = \sum_{t=1}^{16} (LABI_{ti} - LABT_{ti})(AREA_{ti} \times ADOP_{ti}) \qquad (8)$$

where

TEG = Total additional employment generation (man-day) due to improved oilseed adoption

LABI = No. of labour (man-day/ha) required for improved i^{th} oilseed cultivation in the t^{th} year

LABT = No. of labour (man-day/ha) required for old i^{th} oilseed crop cultivation in the t^{th} year

AREA= Total area (ha) cultivated to i^{th} oilseed crop in the t^{th} year

ADOP = Adoption rate of improved i^{th} oilseed crop in the t^{th} year

i = 1, 2, 3, 4 (*1= Mustard, 2= Groundnut, 3 = Sesame, 4= Soybean*)

2.4 Assessing Livelihood Development

The livelihood development due to cultivating improved oilseed varieties was measured by analysing data and information regarding livelihood improved indicators under the *"with improved variety*" and *"without improved variety."*

III. RESULTS AND DISCUSSION

The farm level adoption of improved oilseed varieties has created employment and additional income for the farmers, and saved foreign exchange for the country by producing more of these crops. The estimated impacts of R&D on oilseeds in Bangladesh are discussed in the following sections.

3.1 Development of Improved Varieties

A good number of high yielding varieties of different oilseeds along with their management technologies have been developed and released by BARI and BINA for farm level use. It is revealed that BARI has developed 16 rapeseed and mustard, 10 groundnut, 4 sesame and 6 soybean varieties since 1976. On the other hand, BINA has developed 8 rapeseed and mustard, 6 groundnut, 3 sesame, and 4 soybean varieties for farm level use.

3.2 Adoption Status and Area under Improved Variety

The DAE has been involved in disseminating modern technologies to the farmers through its countrywide networks. It is important to state that the rate of adoption of BINA variety oilseeds was found very low compared to BARI released oilseeds variety. It was revealed that the farm level adoption of improved mustard, groundnut, sesame and soybean varieties was reported to be 40.2, 17.6, 21.5 and 15.5 per cent respectively (Miah *et al.* 2014).

The adoption of improved varieties is an important factor by which the volume of change in economic surplus is determined. The more is the adoption of improved varieties over traditional ones, the higher will be the change in surplus. Apart from this, it gives us feedback as to why and how well an improved variety is being accepted by the farmers. The adoption rates of improved varieties of mustard, groundnut, sesame and soybean for three years (2009-2011) were estimated using primary data from 64 districts. The adoption rates of the remaining years were estimated by taking expert opinions (Table III).

The first improved varieties of mustard, groundnut, sesame and soybean were released for farm level use in 1994-95, 1998-99, 2001-02, and 2002-03 respectively. For the adoption of any new variety to a certain level requires at least three years. The area covered by improved varieties of mustard was 6 per cent during 1997-98 and then gradually increased to 35 per cent in 2011-12. The annual rate of adoption of improved variety mustard was 13.09 per cent, but due to less area planted to mustard throughout the country during 2010/11-2011/12, the annual growth rate became negative. The reasons of sharp declining of mustard area were might be the rise in prices of competitive crops, rise in cultivation of maize, and variability in weather variables. Again, 5, 5, and 8 per cent of the total groundnut, sesame and soybeans areas were planted with improved varieties during 2001-02, 2004-05 and 2005-06 respectively. Then the adoptions of these varieties gradually increased to 12, 13, and 30 per cent in 2011-12. The annual rates of adoption of improved varieties of groundnut, sesame and soybean were 6.7, 11.9, and 24.8 per cent respectively (Table III).

TABLE III

ADOPTION STATUS AND AREAS UNDER IMPROVED VARIETIES OF OILSEEDS IN BANGLADESH

Year	% of area replaced by improved varieties over old ones				Area coverage (ha) of improved varieties replacing old ones			
	Mustard	Groundnut	Sesame	Soybean	Mustard	Groundnut	Sesame	Soybean
1997-98	6.0	-	-	-	20,626	-	-	-
1998-99	6.0	-	-	-	20,648	-	-	-
1999-00	8.0	-	-	-	26,313	-	-	-
2000-01	8.0	-	-	-	25,416	-	-	-
2001-02	10.0	5.0	-	-	30,306	1,424	-	-
2002-03	12.0	7.0	-	-	35,707	1,867	-	-
2003-04	15.0	7.0	-	-	41,885	1,823	-	-
2004-05	18.0	8.0	5.0	-	43,478	2,308	1,946	-
2005-06	20.0	8.00	7.0	8.0	43,363	2,354	2,147	3,249
2006-07	21.0	9.0	8.0	10.0	44,214	3,030	2,883	3,923
2007-08	22.0	9.0	9.0	12.0	51,414	2,798	1,051	4,727
2008-09	23.9	8.9	6.4	14.5	55,931	2,802	2,109	5,828
2009-10	29.4	12.2	12.5	50.9	51,357	4,093	4,446	20,716
2010-11	30.0	**9.1**	11.2	**21.6**	**6,920**	2,875	3,891	8,955
2011-12	35.0	12.0	13.0	30.0	**6,666**	3,606	2,850	12,630
GR (%)	13.1***	6.7***	11.9***	24.8**	-2.1	8.5***	9.1	25.7**

Note: Adoption rates for three years (2009-2011) were estimated using 64 districts DAE data. Adoption rates of the remaining years were estimated through expert opinions.
*** and ** represent significant at 1% and 5% levels respectively.

3.3 Yield Advantage of Improved Varieties over Old Varieties

This is an important factor to determine the economic surplus. The higher yield advantage always ensures higher level of economic surplus. Farm level difference in yields is generally considered as actual yield difference. So, the study used farm level difference of yields between old and improved varieties of oilseeds to calculate yield gaps and yield advantage. The farmers' level yields of the improved varieties of mustard, groundnut, sesame, and soybean were much higher compared to their corresponding farmers' level BARI old varieties. The farm level yield data revealed that the adopters of improved mustard, groundnut, sesame, and soybean received on an average 46.39, 48.73, 27.78, and 5.20 per cent higher yield than that of non-adopters (Table IV).

TABLE IV

YIELD ADVANTAGES OF IMPROVED VARIETIES OF OILSEEDS OVER OLD ONES

Oilseed crops	Yield of old variety (t/ha)	Yield of improved variety (t/ha)	Yield difference (t/ha)	Yield advantage (%)
Mustard	1.121	1.641	0.520	46.39
Groundnut	1.613	2.399	0.786	48.73
Sesame	1.141	1.458	0.317	27.78
Soybean	1.519	1.598	0.079	5.20

Source: Field Survey, 2011-12.

3.4 Growth of Oilseed Area, Production and Yield

Three improved mustard varieties (i.e., BARI Mustard 6, 7 and 8) were first released in 1994 and the rest eight varieties were released between 2000 and 2009 for farm level use. Besides, BINA released eight improved mustard varieties between 1991 and 2011 for farm level use. However, a 3-year period was considered for the successful farm level adoption of an improved mustard variety.[3] Table V reveals that the productivity and production of mustard were significantly increased at national level due to the adoption of improved mustard varieties and improved cultural management practices, whereas the area under mustard decreased during post-adoption period (1998-2011).

[3]The concerned scientists of BARI opined that an improved variety needs at least three years for its successful farm level adoption.

The coefficients of variations for area and production were also lower in the post-adoption period than that of pre-adoption period (1981-1997). It indicates that the area and production were more stable in the post-adoption period than that of pre-adoption period. The results of chow test also show that highly significant structural breaks occurred in the area, production, and yield of mustard between pre- and post-adoption periods.

BARI released ten improved groundnut varieties between 1976 and 2010, among these varieties, Dhaka No.1 and 4 are very old and low yielders. The first improved groundnut variety (DG-2) was released in 1979 and the rest were released between 1987 and 2010. BINA also released six improved groundnut varieties between 2000 and 2011 for farm level use. The results of chow test, as shown in Table VI, reveal that highly significant structural breaks occurred in the production and yield of groundnut between pre- (1981-2001) and post-adoption periods (2002-2011).

TABLE V

GROWTH RATES AND STRUCTURAL BREAK OF AREA, PRODUCTION AND YIELD OF MUSTARD BETWEEN TWO PERIODS

Period	Mean	Std. Dev	CV (%)	GR (%)	Structural break		
					Intercept	Slope	Total
A. Area (ha)							
1981-1997	283,135	74,084	26.17	4.25***	25.14***	40.42***	21.95***
1998-2011	269,858	53,925	19.98	-4.31***			
B. Production (t)							
1981-1997	189,041	50,510	26.71	4.33**	25.79***	41.84***	22.84***
1998-2011	217,592	30,925	14.21	2.16**			
C. Yield (t/ha)							
1981-1997	0.683	0.072	10.67	0.08**	5.57**	6.43**	3.22**
1998-2011	0.822	0.087	10.62	2.15***			

Note: *** and ** indicate significant at 1% and 5% levels respectively.

Like mustard, the productivity and production of groundnut were significantly increased at national level during 2002-2011 due to the adoption of improved groundnut varieties and improved cultural management practices, whereas groundnut area decreased during post-adoption period. The coefficients of variations for area and production were also lower in the post-adoption period compared to pre-adoption period (Table VI). It indicated that the area and production of groundnut were more stable in the post-adoption period than that of pre-adoption period.

TABLE VI

GROWTH RATES AND STRUCTURAL BREAK OF AREA, PRODUCTION AND YIELD OF GROUNDNUT BETWEEN TWO PERIODS

Period	Mean	Std. Dev	CV (%)	GR (%)	Structural break		
					Intercept	Slope	Total
A. Area (ha)							
1981-2001	31,157	7,533	24.17	2.83***	0.55	0.01	6.95**
2002-2011	30,089	2,649	8.80	2.35***			
B. Production (t)							
1981-2001	34,999	9,084	25.96	3.15***	8.42***	5.79**	6.05***
2002-2011	41,885	8,201	19.57	6.38***			
C. Yield (t/ha)							
1981-2001	1.12	0.063	5.62	0.31	38.97***	50.98***	30.69***
2002-2011	1.38	0.178	12.91	4.03***			

Note: *** and ** indicate significant at 1% and 5% levels respectively.

BARI has released two improved sesame varieties in 2001 and one variety in 2009 for farm level use. BINA has also released three improved varieties between 2004 and 2013. The adoption impact was not significant for sesame. The growth rates of area, production and yield were negative during post-adoption period (2005-2011), whereas these were positive during pre-adoption period (1981-2004). A significant structural break was found only in the case of yield of sesame during post-adoption period. However, the productivity increased mainly due to adoption of improved sesame varieties (Table VII).

TABLE VII

GROWTH RATES AND STRUCTURAL BREAK OF AREA, PRODUCTION AND YIELD OF SESAME BETWEEN TWO PERIODS

Period	Mean	Std. Dev	CV (%)	GR (%)	Structural break		
					Intercept	Slope	Total
A. Area (ha)							
1981-2004	58,742	24,872	42.34	1.42	0.00	0.06	1.88
2005-2011	33,719	4,289	12.71	-2.40			
B. Production (t)							
1981-2004	34,629	15,050	43.46	2.12	0.31	0.43	0.50
2005-2011	31,501	4,834	15.34	-4.08			
C. Yield (t/ha)							
1981-2004	0.237	0.014	6.23	0.704***	4.31**	1.98	17.72***
2005-2011	0.383	0.072	19.05	-1.680			

Note: *** and ** indicate significant at 1% and 5% levels, respectively.

3.5 Farmer's Income from Oilseed Production

The adoption of improved oilseed varieties made a lucrative impact on farmers' income in the study areas. The farmers who cultivated improved varieties of oilseed received higher financial benefits in most of the cases. Table VIII shows that improved mustard variety cultivating farmers' got 53.8 per cent and 290.4 per cent higher gross and net incomes respectively. Almost similar benefits were also received by improved groundnut and sesame varieties cultivating farmers. The gross income received from improved soybean cultivation was slightly higher, but net income was 12.8 per cent lower than that of income from BARI old variety cultivation. Less adoption of improved varieties and overall good performance of BARI old varieties were the main reasons for achieving good financial benefit.

TABLE VIII

INCOME FROM THE PRODUCTION OF DIFFERENT OILSEED VARIETIES

Oilseed crop	Variety	Gross income (Tk/ha)	Total cost (Tk/ha)	Net income (Tk/ha)
Mustard	Improved	80,105 (53.3)***	51,245 (14.3)***	28,860 (290.4)***
	BARI old	52,241	44,848	7,393
Groundnut	Improved	146,248 (102.6)***	62,048 (17.9)***	84,200 (330.2)***
	BARI old	72,190	52,616	19,574
Sesame	Improved	56,796 (28.8)***	42,918 (7.1)***	13,878 (245.0)***
	BARI old	44,089	40,066	4,023
Soybean	Improved	48,171(3.4)	44,410 (5.0)	3,761(-12.8)
	BARI old	46,605	42,294	4,311

Source: Field survey, 2011-12.
Note: *** indicates mean difference is significant at 1% level.
Figures in the parentheses are per cent higher than corresponding varieties.

3.6 Returns to Investment in Oilseed R&D

Bangladesh government has invested a lot on the R&D of oilseeds through the Oilseed Research Centre of BARI and BINA since independence for increasing oilseed production. BARI and BINA have released a good number of improved varieties of oilseeds and some of them are being cultivated in the farmers' fields. DAE has contributed to disseminate these improved varieties among farmers. Therefore, an attempt has been made to estimate the output of R&D of oilseeds in Bangladesh using the economic surplus model.

3.6.1 Supply Shifter and Additional Oilseed Production

The supply shifter (k) identifies the amount of production that can be attributed to the varietal improvement research in each year (i.e., the shift in the supply curve). The more the value of supply shifter, the more is the shift in the supply curve, resulting higher benefits to society. The supply shifter is the outcome of the simultaneous force of the percentage of improved variety adoption and its yield advantage. It was calculated using the formula discussed in section 2.2. It was found that the rate of shift gradually increased. The shifter accounted for the yield advantage of improved oilseed varieties over the BARI old and local oilseeds varieties. The supply shifter of mustard was found to be 0.019 for the year 1997-98, suggesting that about 2 per cent more mustard production was achieved during 1997-98 because of farmers' adoption of improved varieties of mustard. Due to the adoption of improved varieties, the total amount of additional production of mustard, groundnut, sesame and soybean was estimated at 140.53, 14.36, 4.95, and 4.81 thousand metric tons respectively (Table IX).

TABLE IX

SUPPLY SHIFTER (K) AND AMOUNT OF ADDITIONAL OILSEED PRODUCTION IN DIFFERENT YEARS DUE TO IMPROVED VARIETY ADOPTION

Year	Supply shifter (k)				Additional production (ton)			
	Mustard	Groundnut	Sesame	Soybean	Mustard	Groundnut	Sesame	Soybean
1997-98	0.019	-	-	-	4,819	-	-	-
1998-99	0.019	-	-	-	4,798	-	-	-
1999-00	0.025	-	-	-	6,227	-	-	-
2000-01	0.025	-	-	-	5,942	-	-	-
2001-02	0.032	0.016	-	-	7,448	477	-	-
2002-03	0.038	0.023	-	-	8,283	788	-	-
2003-04	0.048	0.023	-	-	10,107	784	-	-
2004-05	0.057	0.026	0.011	-	10,908	1,011	410	-
2005-06	0.063	0.026	0.015	0.004	11,558	987	588	246
2006-07	0.067	0.029	0.017	0.005	12,655	1,331	496	289
2007-08	0.070	0.029	0.020	0.006	15.955	1,284	541	355
2008-09	0.076	0.029	0.014	0.007	15,406	1,349	398	416
2009-10	0.093	0.040	0.027	0.025	14,066	2,139	872	1,738
2010-11	0.095	0.030	0.024	0.011	5,982	1,742	753	725
2011-12	0.111	0.039	0.028	0.015	6,376	2,468	891	1,039
Total	-	-	-	-	140,530	14,360	4,949	4,808

3.6.2 Research and Extension Expenditure

Total expenditures of the development of improved oilseed varieties, and the extension of these improved varieties to the farmers' fields included the costs incurred by different institutes, such as ORC of BARI, BINA, BARC and DAE (Table X). These institutional costs included infrastructure, salaries and wages, vehicles, repair and maintenance, research and development, training, higher education, etc. DAE expenditure for the dissemination of oilseed technologies was estimated based on the percentage of oilseeds cropped area relative to total cropped area (for detailed information, see methodology section). For the analysis, the current total expenditures were converted to 2011-12 constant prices (inflated price) using the national CPI Index. The total cost for R&D of oilseeds was estimated at Tk 2,461.7 million during 1992-93 to 2011-12. The highest share of the total cost was for DAE (84.1 per cent), followed by BARI (14.3 per cent).

TABLE X

EXPENDITURES FOR OILSEED RESEARCH AND DEVELOPMENT IN BANGLADESH

(Figures in Taka)

Year	ORC, BARI (current price)	BINA (current price)	BARC (current price)	DAE (current price)	Total Expenditure (current price)	Total Expenditure (Base:2011-12=100)
1992-93	7754625	15973	1434943	34267234	43472775	154707384
1993-94	7745999	4510	851361	38831330	47433200	163958521
1994-95	8045249	3428	240383	35030542	43319602	137043980
1995-96	7464001	5225	182712	40213301	47865239	141529388
1996-97	8028000	13517	278493	43429552	51749562	147602858
1997-98	10082250	23635	720456	45620889	56447230	145745494
1998-99	2253155	24310	756480	43792928	46826873	110623371
1999-00	2312010	31443	794302	43346580	46484335	106958893
2000-01	4992431	40668	834017	43569283	49436399	112176989
2001-02	2064001	52600	875719	44225560	47217880	105420585
2002-03	4427325	68033	919503	45746164	51161025	110427423
2003-04	2414250	87993	965480	45523078	48990801	98891403
2004-05	4178250	113810	1013755	43334319	48640134	90984164
2005-06	6042375	119501	1064440	47903479	55129795	95694836
2006-07	6489000	125476	1117665	50640587	58372728	93711235
2007-08	15924150	131750	1173548	52019342	69248790	99025869
2008-09	19874624	138338	1099270	125976012	147088244	196222311
2009-10	26031056	146637	1119445	123593820	150890958	185483661
2010-11	13840326	158368	1338033	66862097	82198824	88547694
2011-12	22034353	171038	1228739	53498774	76932904	76932904
Total	**181,997,430**	**1,476,253**	**18,008,744**	**106,742,4871**	**1,268,907,298**	**2,461,688,961**
% share	14.34	0.12	1.42	84.12	100.0	

Source: Estimated using field data.

3.6.3 Economic Returns to Oilseeds R&D

The efficiency of resource allocation to R&D for oilseeds improvements was assessed through NPV, BCR and IRR under both closed and small open-economy market conditions. The return to investment in R&D of sesame was estimated under closed economy market situation, since no international trade was present for sesame during the study period. Small open-economy market situation was considered for mustard, groundnut and soybean. Under small open-economy, the producers' benefits were found much higher compared to consumers' benefits, since the elasticity of demand for oilseeds was very high. The opposite scenario was found in the case of closed-economy situation, because the elasticity of demand for oilseeds was low. In estimating economic benefits, related costs incurred by different organisations (Table X) were taken into consideration.

The total changes in consumers' and producers' surplus were estimated at Tk 281.8 million and Tk 6,704.9 million respectively from oilseeds R&D during 1997-98 to 2011-12. Producers' surplus was about 2279.3 per cent higher than that of consumers' surplus, because the elasticity of demand for oilseeds was very high under small-open economy market. The estimated total surpluss ranged from Tk 246.1 million in 1997-98 to Tk 491.0 million in 2011-12, and the total surplus accrued as Tk 6,986.7 million from the oilseeds R&D in Bangladesh. Besides, the total net benefit (NPV) obtained from oilseeds R&D was Tk 4,769.0 million for the period 1992-93 to 2011-12. The NPV indicates the total social benefit for a country, and it was found negative up to 1996-97 and then it was positive. It suggests that the country did not receive any benefit from oilseeds R&D up to that period. After that the country as a whole benefited a lot and found increasing trend up to 2011-12. Using the base parameters, the IRR of the oilseeds R&D was estimated to be 24 per cent, implying one Taka invested in R&D gave returns on an average Taka 1.2 annually from the date of investment until 2011-12. The benefit-cost ratio (BCR) is estimated at 3.15, implying that one taka investment generated 3.15 taka over the period (Table XI).

A sensitivity analysis was undertaken under various assumptions on the adoption of improved varieties of oilseeds and the R&D expenditures (Table XII). The estimated NPV, BCR and IRR of the oilseeds development programme ranged from Tk 4,070.01 to Tk 5,468.15 million, 22 to 26 per cent, and 2.8 to 3.5 respectively. However, it is apparent that the investment in oilseed R&D was a good effort.

TABLE XI

DISTRIBUTION OF FINANCIAL BENEFITS AND COSTS OF OILSEEDS R&D IN BANGLADESH

(Base: 2011-12 = 100 Tk)

Year	Change in consumer surplus (Taka)	Change in producer surplus (Taka)	Change in total surplus (Taka)	Research and extension costs (Taka)	Net benefit (Taka)
A	*B*	*C*	*D = B+C*	*E*	*F = D-E*
1992-93	0	0	0	105,763,671	-105,763,671
1993-94	0	0	0	116,155,185	-116,155,185
1994-95	0	0	0	94,982,205	-94,982,205
1995-96	0	0	0	101,045,204	-101,045,204
1996-97	0	0	0	120,365,890	-120,365,890
1997-98	0	246,103,789	246,103,789	118,935,701	127,168,088
1998-99	0	216,467,424	216,467,424	99,915,862	116,551,562
1999-00	0	269,006,357	269,006,357	106,958,893	162,047,464
2000-01	0	222,677,183	222,677,183	112,176,988	110,500,195
2001-02	0	285,145,190	285,145,190	105,420,584	179,724,606
2002-03	0	326,470,137	326,470,137	110,427,421	216,042,716
2003-04	0	459,611,115	459,611,115	98,891,403	360,719,712
2004-05	20,891,610	409,238,855	430,130,466	90,984,163	339,146,303
2005-06	28,941,516	437,854,633	466,796,149	95,694,837	371,101,312
2006-07	28,935,240	579,083,343	608,018,583	93,711,236	514,307,347
2007-08	39,256,718	966,459,852	1,005,716,570	99,025,870	906,690,700
2008-09	18,796,987	774,613,705	793,410,692	196,222,309	597,188,383
2009-10	49,378,061	750,606,866	799,984,927	185,483,663	614,501,264
2010-11	39,369,829	326,741,349	366,111,178	88,547,694	277,563,484
2011-12	56,227,322	434,800,366	491,027,688	76,932,902	414,094,786
Total	**281,797,284**	**6,704,880,163**	**6,986,677,447**	**2,217,641,681**	**4,769,035,766**

Results: Net present value (NPV) = Tk. 4769.0 Million; Benefit-cost ratio (BCR) = 3.15; Internal rate of return (IRR) = 24 per cent

Note: See also Appendix Table A.1.

TABLE XII

SENSITIVITY ANALYSIS ON THE BENEFITS OF OILSEED R&D IN BANGLADESH

Scenarios	NPV (Million taka)	BCR	IRR (%)
Base parameters	4769.0	3.2	24.0
Adoption increased by 10%	5468.1	3.5	26.0
Adoption decreased by 10%	4070.0	2.8	22.0
Expenditure increased by 10%	4547.3	2.9	22.0
Expenditure decreased by 10%	4990.8	3.5	26.0

3.6.4 Foreign Exchange Savings

A considerable amount of oilseeds are imported in Bangladesh every year to meet the internal demand of its increasing population. According to Bangladesh Bank (2012), in 2011-12, the value of total imports of oilseeds and edible oils was Tk 14,200 million (US$182.05 million) and Tk 130,510 million (US$1,673.21 million) respectively. Thus, the increased production attributed to adoption of improved varieties of oilseeds saved foreign exchange amounting to US$ 97.1 million during 1997-98 to 2011-12 (Table XIII).

TABLE XIII
FOREIGN EXCHANGE SAVINGS DUE TO ADOPTION OF IMPROVED VARIETIES OF OILSEEDS IN BANGLADESH

Year	Mustard *(Base: 2011-12 =100)*		Groundnut *(Base: 2011-12 =100)*		Soybean *(Base: 2011-12 =100)*		Total Savings ($)
	Price ($/ton)	Savings ($)	Price ($/ton)	Savings ($)	Price ($/ton)	Savings ($)	
1997-98	683.19	3,292,299	--	--	--	--	3,292,299
1998-99	546.40	2,621,615	--	--	--	--	2,621,615
1999-00	534.22	3,326,559	--	--	--	--	3,326,559
2000-01	481.78	2,862,731	--	--	--	--	2,862,731
2001-02	554.97	4,133,399	1,232.8	588,023	--	--	4,721,422
2002-03	555.00	4,597,038	1,002.1	789,684	--	--	5,386,722
2003-04	505.25	5,106,545	1,386.0	1,086,617	--	--	6,193,162
2004-05	581.78	6,346,065	1,419.5	1,435,125	--	--	7,781,190
2005-06	616.75	7,128,403	1,190.0	1,174,549	477.0	117,346	8,420,298
2006-07	506.34	6,407,749	802.7	1,068,390	446.2	128,948	7,605,087
2007-08	571.79	9,122,847	1,072.5	1,377,091	440.5	156,372	10,656,310
2008-09	642.10	9,892,231	1,334.1	1,799,627	461.2	191,873	11,883,731
2009-10	534.73	7,521,463	1,075.6	2,300,706	401.9	698,618	10,520,787
2010-11	652.81	3,905,087	1,010.5	1,760,202	361.9	262,415	5,927,704
2011-12	521.00	3,321,896	907.0	2,238,476	332.0	344,948	5,905,320
Total		**79,585,927**		**15,618,490**		**1,900,520**	**97,104,937**

Note: Import prices of oilseeds are taken from FAOstat. See also Appendix Table A.2.

3.7 Impact on Employment Generation

The adoption of improved oilseed varieties at farm level has created a lot of additional employments for the farmers as well as for the society. It was found that the per hectare cultivation of an improved mustard, groundnut, sesame and soybean variety created an additional employment of 12.7, 11.6, 15.4 and 6.1 man-days for the respondent farmers, respectively (Miah *et al.* 2014). The additional labour is mainly required for harvesting and threshing the increased production of oilseeds. The national level employments created due to improved variety adoption were estimated based on the above estimates and varietal adoption rates (Table XIV). During 2011-12, a total of 1.414 million man-days of additional farm labour valuing Taka 353.56 million were generated due to cultivation of improved varieties of oilseed. The number of additional employment created by improved mustard was much higher compared to that of other oilseeds, which was due to higher area coverage and adoption.

TABLE XIV
ADDITIONAL EMPLOYMENT CREATED AT NATIONAL LEVEL DUE TO IMPROVED VARIETY ADOPTION

(Man-days)

Year	Mustard	Groundnut	Sesame	Soybean	All oilseeds
1998	261,952	--	--	--	261,952
1999	262,228	--	--	--	262,228
2000	334,171	--	--	--	334,171
2001	322,788	--	--	--	322,788
2002	384,887	16,514	--	--	401,401
2003	453,473	21,654	--	--	475,128
2004	531,942	21,142	--	--	553,084
2005	552,171	26,775	29,971	--	608,916
2006	550,707	27,305	33,071	19,821	630,904
2007	561,522	35,147	44,404	23,931	665,005
2008	652,956	32,455	16,185	28,833	730,429
2009	710,319	32,506	32,473	35,553	810,850
2010	652,234	47,476	68,466	126,367	894,543
2011	961,437	39,988	59,921	54,554	1,115,901
2012	1,227,309	43,394	66,466	77,080	1,414,249
Total	**8,420,098**	**344,356**	**350,958**	**366,138**	**9,481,549**

Source: Estimated using field data.

3.8 Impact on Livelihood Development

A livelihood is a means of making a living. It encompasses people's capabilities, assets, income, and activities required to secure the necessities of life (http://www.ifrc.org). In other words, livelihood is defined as a set of activities involving securing water, food, fodder, medicine, shelter, clothing, and the capacity to acquire above necessities working either individually or as a group by using endowments for meeting the requirements of a household (http://en.wikipedia.org/wiki/Livelihood). Livelihood development is a broad issue which generally depends on the wider economic development of the society. In this section, the scenario of livelihood development through adopting improved oilseed varieties gives a glimpse of the livelihood development of a respondent household.

A total of 13 socio-economic indicators were used to measure the impact of improved oilseed variety adoption on the livelihood of adopting households. The results depicted that the livelihood status of the adopting households was better to some extent than that of non-adopting households (Table XV). Among thirteen indicators, the highest percentage of the adopting households owned assets and had social standard much higher compared to that of non-adopting households. Obviously, there were some positive impacts of cultivating improved oilseeds on the livelihoods of its adopters.

TABLE XV

LIVELIHOOD STATUS OF ADOPTER AND NON-ADOPTER HOUSEHOLDS IN THE STUDY AREAS

(Figures in per cent)

Particulars	Mustard		Groundnut		Sesame		Soybean	
	Adopter (n=197)	N-adopter (n=343)	Adopter (n=95)	N-adopter (n=445)	Adopter (n=116)	N-adopter (n=424)	Adopter (n=56)	N-adopter (n=304)
1. Housing status								
Concrete building	3.6	7.9	5.3	1.4	10.3	4.5	--	1.3
Brick wall-tin roof	58.9	45.5	26.3	7.0	26.7	17.0	3.6	5.3
Tin wall-tin roof	11.2	11.1	60.0	81.8	35.3	62.0	75.0	80.9
Earthen wall-tin roof	21.3	16.9	--	0.5	16.4	10.9	--	--
Bamboo wall-tin roof	1.0	1.8	8.4	7.9	3.5	3.3	19.6	11.2
Katcha (straw roof)	6.6	19.5	--	1.6	7.8	2.4	1.8	1.3
2. Motorcycle	23.4	18.4	20.0	9.2	6.9	5.7	32.1	5.9
3. Bicycle	74.6	70.3	69.5	57.1	58.6	45.1	69.6	37.2
4. Hand tubewell	93.9	93.6	90.5	85.2	98.3	94.8	91.1	75.7
5. Water pump	12.2	6.1	10.5	5.4	6.0	4.0	5.4	1.0
6. Electricity	81.2	78.4	71.6	42.5	75.9	75.2	62.5	29.9
7. Television	71.1	62.1	53.7	27.4	58.6	46.0	53.6	18.8
8. Gas	1.0	0.9	2.1	0.5	1.7	1.4	--	--
9. Land phone	3.1	1.2	1.1	0.5	2.6	--	--	0.7
10. Mobile phone	85.3	77.6	73.7	70.6	66.4	65.1	83.9	60.9

(Cont. Table XV)

Particulars	Mustard		Groundnut		Sesame		Soybean	
	Adopter (n=197)	N-adopter (n=343)	Adopter (n=95)	N-adopter (n=445)	Adopter (n=116)	N-adopter (n=424)	Adopter (n=56)	N-adopter (n=304)
11. Sanitation status	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Flush toilet	2.6	3.8	2.1	1.6	2.6	1.9	--	0.7
Sanitary toilet	75.6	74.6	62.1	54.8	75.8	66.5	62.5	87.8
Temporary toilet	21.8	21.6	35.8	43.6	21.6	31.6	37.5	11.5
12. Expenditure (Tk/month)	**9118**	**8516**	**11175**	**10371**	**9200**	**9480**	**12193**	**10669**
Food	6153	5850	6953	7019	6451	6667	8446	7271
Education	1295	1180	2159	1398	926	909	1214	1148
Transportation	829	697	981	875	772	841	1120	942
Treatment	841	789	1083	1078	1051	1063	1413	1308
13. Doctor's visit								
Specialist	4.1	7.0	1.1	0.2	1.7	--	1.8	1.3
MBBS	54.8	56.0	42.1	58.7	80.2	77.1	62.5	71.7
Village doctor	70.1	74.9	90.5	93.5	98.3	97.9	96.4	99.3
Quack	--	1.2	2.1	2.5	--	0.5	--	--

Source: Field Survey, 2011-12.

IV. CONCLUSIONS

This paper provided an in-depth account of the economic impacts of oilseeds R&D in Bangladesh. It has been observed that the current level of adoption of improved oilseed technologies has created a variety of economic impacts in the country. The adoption of improved oilseed technologies has ensured higher production, higher income, created employments and improved livelihood of the farmers to some extent. Ex-post evaluation of the past investment in oilseed R&D revealed an IRR of 24 per cent, which seemed to be low due to lower adoption of improved oilseed varieties. Under various assumptions, the IRR ranged from 22 per cent to 26 per cent and BCR from 2.84 to 3.5. Moreover, the increased production of oilseeds has saved a huge amount of foreign exchange through producing additional oilseed crops and thus contributed to the national economy of Bangladesh. The estimated NPV and foreign exchange savings due to R&D of oilseeds for the period 1998 to 2012 are Tk 4,769.04 million and US$ 97.11 million respectively. Therefore, the investment in R&D of oilseeds is found to be encouraging in Bangladesh.

Based on the findings of the study, the following steps and measures could be taken to enhance oilseed production throughout the country.

a) In order to generate employment opportunity and to save foreign exchange, the rate of adoption of improved oilseed varieties must be increased manifold and for doing so the following steps must be taken by the concerned authority:

    - The seeds of available improved and short duration oilseed varieties should be disseminated to the farmers;
    - Mustard seed is sown after harvesting of *T. Aman* rice and before transplanting *Boro* rice. Therefore, short-duration varieties of these two crops are also important and should be disseminated to the farmers.
    - Potential areas should be brought under improved oilseed cultivation;
    - Extension services should be strengthened;
    - Regular training programme for oilseed farmers and extension personnel should be conducted; and
    - Private sectors should be involved in oilseed production and value addition.

b) The Government should increase oilseed R&D expenditures in such a varietal research programme so that more improved oilseed varieties could be released in the near future. Strengthening of international collaboration must be considered in this regard.

c) Undertaking good quality impact assessment requires good data, especially on adoption. Adoption information is important not only for rate of return studies but also for information feedback to researchers and research managers about how well a technology is being accepted, the determinants of adoption (who is adopting or not adopting and why), and the distribution of adopted varieties. These are issues that need to be brought to the attention of researchers, research managers, extension agents and policy makers.

REFERENCES

Akino, M. and Y. Hayami. 1975. "Efficiency and Equity in Public Research: Rice Breeding in Japan's Economic Development." *American Journal of Agricultural Economics,* 57:1-10.

Alston, J. M., G. W. Norton and P. G. Pardey. 1995. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting.* Ithaca: Cornell University Press, pp.237.

Bangladesh Bank. 2012. *Monthly Economic Trends.* Dhaka, Bangladesh: Statistics Department, Bangladesh Bank.

BBS. 2012. *Statistical Yearbook of Bangladesh*. Dhaka: Bangladesh Bureau of Statistics.

——2011. *Report of the Household Income and Expenditure Survey 2010*. Dhaka: Bangladesh Bureau of Statistics.

BNNC. 1984. *Nutrition Policy and Programme for Bangladesh.* Dhaka: Bangladesh National Nutrition Council, pp.70-79.

Currie, J. M., J. A. Murphy and A. Schmitz. 1971. "The Concept of Economic Surplus and its Use in Economic Analysis." *Economic Journal,* 18:741-798.

Deb, U. K. and B. A. A Mustafi. 1999. "Social Returns to Rice Research in Bangladesh." *Bangladesh Journal of Agricultural Economics*, XX (2): 21-41.

Dey, M. M. and R. E. Evenson. 1991. "The Economic Impact of Rice Research in Bangladesh." Mimeo, Bangladesh Rice Research Institute, Gazipur, BRAC, Dhaka and International Rice Research Institute, Philippines.

Echeverría, R. G., G. Ferreira and M. Dabezies. 1989. "Returns to Investment in the Generation and Transfer of rice Technology in Uruguay." *ISNAR Working Paper No. 30,* International Service for National Agricultural Research (ISNAR), The Hague.

Evenson, R. E. and P. Flores. 1978. "Social Returns to Rice Research." In: *Economic Consequences of the New Rice Technology*, pp. 243–265. Los Baños, Philippines: International Rice Research Institute.

Gardiner, J. C., J. H. Sanders and T. G. Barker. 1986. "An Economic Evaluation of the Purdue Soft Red Winter Wheat Program." Department of Agricultural Economics, Agricultural Experimental Station, Purdue University, West Lafayette, Pakistan.

Haque, A. K. E., G. C. Fox and G. Brinkman. 1989. "Product Market Distortions and the Returns to Federal Laying-hen Research in Canada." *Canadian Journal of Agricultural Economics*, 13 (1): 29-46.

Hassan, M. K. and M. A. M. Miah. 2003. "Impact of Rapeseed & Mustard Research and Extension in Bangladesh." *Bangladesh Journal of Agricultural Research,* 28 (1): 15-31.

Hossain, M. I., M A.M. Miah and M. A. Akbar. 2002. "Impact of Maize Research and Extension in Bangladesh. *Bangladesh Journal of Agricultural Economics*, XXV (1): 17-33.

Hossain, M. I., M. A. Sattar, M. A. M. Miah, S. N. Begum and M. S. K. Khan. 2003. "Impact of Mungbean Research and Extension in Bangladesh." *Pakistan Journal of Biological Sciences,* 6 (20): 1733-1740.

Hossain, M. I., M. A. M. Miah and M. S. Rahman. 2004. "Impact Analysis of Guava Variety Kazi Peyara in Bangladesh." *Bangladesh Journal of Agricultural Research,* 29 (2): 237-250.

Karim, M. R., M. I. Hossain, and M. S. Hussain. 2003. "Research Costs and Social Returns: the Case of Okra Research in Bangladesh." *Bangladesh Journal of Agricultural Research, 28 (1): 53-62.*

Miah, M. A. M., A. K. E. Haque, T. M. B. Hossaim, S. Hossain and M. S. Rahman. 2013. "Policy Options for Supporting Agricultural Diversification in Bangladesh." National Food Policy Capacity Strengthening Programme (NFPCSP), Food Planning and Monitoring Unit (FPMU), Ministry of Food, FAO_Bangladesh.

Miah, M. A. M and M. I. Hossain. 2003. "Returns to Investment on Varietal Research and Extension: A Case of Uttara Brinjal Technology. *Bangladesh Journal of Agricultural Research,* 28 (2): 159-178.

Miah, M. A. M., M. K. Hasan, M. I. Hossain and M. A. Quddus 2005. "Impact of Winter Tomato Research and Extension in Bangladesh." *Bangladesh Journal of Agricultural Research*, 30 (4): 545-562.

Miah, M. A. M., M. A. Rashid and S. A. M. Shiblee. 2014. *Assessment of Socioeconomic Impacts of Oilseed Research and Development in Bangladesh.* SPGR sub-project completion report, Project Implementation Unit (PIU), Bangladesh Agricultural Research Council (BARC), Dhaka.

Miah, M. A. M., Q. M. Alam, A. Sarker and M. S. Aktar. 2009. "Socio-economic Impact of Pulse Research in Some Selected Areas of Bangladesh." *Asia Pacific Journal of Rural Development,* 19(2):115-141.

Morris, L. M., H. J. Dubin and T. Pokhrel, 1994. "Returns to Wheat Breeding Research in Nepal." *Agricultural Economics,* 10: 269-282.

Nagy, J. G. and W. H. Furtan. 1978. "Economic Costs and Returns from Crop Development Research: The Case of Rapeseed Breeding in Canada." *Canadian Journal of Agricultural Economics,* 26 (1): 1-14.

Nagy, J. G, and M. F. Alam. 2000. *The Impact of Agricultural Research in Bangladesh: Estimating Returns to Agricultural Research*. Project Report submitted to BARC, Dhaka and International Fertilizer Development Centre, Muscle Shoals, Alabama.

Norton, G. 1993. "Analysis of Agricultural Research Priorities in Bangladesh." Discussion Paper No. 93-07, ISNAR, The Hague.

Siddiqui, M. R. 1985. "Social Returns to Rice Research in Bangladesh." Unpublished MS thesis submitted to the Faculty of Economic Studies, University of New England, Armidale, NSW, Australia.

APPENDIX TABLES

Table A.1
Model for the Economic Impact Analysis of Oilseed Research & Development in Bangladesh

Year	Mustard &mustard			Groundnut			Sesame			Soybean		
	Supply Shifter (k)	Inflated price (Base: 2011-12 =100 Tk/ha)	Quantity production (Metric ton)	Supply Shifter (k)	Inflated price (Base: 2011-12 =100 Tk/ha)	Quantity production (Metric ton)	Supply Shifter (k)	Inflated price (Base: 2011-12 =100 Tk/ha)	Quantity production (Metric ton)	Supply Shifter (k)	Inflated price (Base: 2011-12 =100 Tk/ha)	Quantity production (Metric ton)
1992-93	0.000	50,260	218000	-	-	-	-	-	-	-	-	-
1993-94	0.000	51,403	239080	-	-	-	-	-	-	-	-	-
1994-95	0.000	48,181	218725	-	-	-	-	-	-	-	-	-
1995-96	0.000	46,730	245885	-	-	-	-	-	-	-	-	-
1996-97	0.000	47,353	249355	0.000	46,463	39525	-	-	-	-	-	-
1997-98	0.019	50,991	253640	0.000	44,454	39540	-	-	-	-	-	-
1998-99	0.019	45,051	252515	0.000	40,161	38755	-	-	-	-	-	-
1999-00	0.025	42,568	249080	0.000	37,690	42210	0.000	39,231	22005	-	-	-
2000-01	0.025	36,930	237660	0.000	43,749	31835	0.000	32,857	22120	-	-	-
2001-02	0.032	35,655	232740	0.016	44,988	29835	0.000	32,284	22180	-	-	-
2002-03	0.038	35,159	217980	0.023	44,362	34240	0.000	31,835	24440	-	-	-
2003-04	0.048	42,874	210570	0.023	38,595	34075	0.000	33,912	25485	-	-	-
2004-05	0.057	34,699	191375	0.026	37,262	38880	0.011	31,781	37260	0.003	35,141	510
2005-06	0.063	34,456	183465	0.026	39,958	37980	0.015	29,925	39225	0.004	32,020	61485
2006-07	0.067	41,804	188880	0.029	40,649	45910	0.017	35,222	29180	0.005	30,809	57715
2007-08	0.070	57,686	227930	0.029	40,440	44268	0.020	45,874	27043	0.006	30,215	59158
2008-09	0.076	46,091	202717	0.029	43,797	46533	0.014	29,282	28461	0.007	31,757	59395
2009-10	0.093	44,954	151251	0.040	39,939	53467	0.027	34,886	32306	0.025	27,810	69522
2010-11	0.095	38,974	62970	0.030	50,803	58068	0.024	31,940	31363	0.011	28,232	65883
2011-12	0.111	45,630	57445	0.039	55,130	63293	0.028	38,780	31835	0.015	25,896	69296

Source: Using production and price data from various issues of BBS.
Note: The estimates of price elasticities of supply and demand for sesame were 0.30 and 0.50 respectively under closed-economy market situation. The price elasticity of supply and demand for other oilseed crops were 0.30 and 10000000000 respectively, to make consumer surplus zero as small open-economy market situation.

Table A.2

Foreign Exchange Savings due to Adoption of Improved Varieties of Oilseeds in Bangladesh

Year	Rapeseed & Mustard			Groundnut			Soybean			National CPI	Total savings
	Current price ($/ton)	Inflated price ($/ton)	Savings ($)	Current price ($/ton)	Inflated price ($/ton)	Savings ($)	Current price ($/ton)	Inflated price ($/ton)	Savings ($)		
1997-98	264.60	683.19	3,292,299	--	--	--	--	--	--	38.73	3,292,299
1998-99	231.29	546.40	2,621,615	--	--	--	--	--	--	42.33	2,621,615
1999-00	232.17	534.22	3,326,559	--	--	--	--	--	--	43.46	3,326,559
2000-01	212.32	481.78	2,862,731	--	--	--	--	--	--	44.07	2,862,731
2001-02	248.57	554.97	4,133,399	552.15	1232.75	588023	--	--	--	44.79	4,721,422
2002-03	257.13	555.00	4,597,038	464.29	1002.14	789684	--	--	--	46.33	5,386,722
2003-04	250.30	505.25	5,106,545	686.62	1385.99	1086617	--	--	--	49.54	6,193,162
2004-05	311.02	581.78	6,346,065	758.87	1419.51	1435125	--	--	--	53.46	7,781,190
2005-06	355.31	616.75	7,128,403	685.57	1190.02	1174549	274.81	477.02	117346	57.61	8,420,298
2006-07	315.40	506.34	6,407,749	500.00	802.70	1068390	277.93	446.19	128948	62.29	7,605,087
2007-08	399.85	571.79	9,122,847	750.00	1072.50	1377091	308.03	440.48	156372	69.93	10,656,310
2008-09	481.32	642.10	9,892,231	1000.0	1334.05	1799627	345.74	461.23	191873	74.96	11,883,731
2009-10	435.00	534.73	7,521,463	875.00	1075.60	2300706	327.00	401.97	698618	81.35	10,520,787
2010-11	606.00	652.81	3,905,087	938.00	1010.45	1760202	336.00	361.95	262415	92.83	5,927,704
2011-12	521.00	521.00	3,321,896	907.00	907.00	2238476	332.00	332.00	344948	100.00	5,905,320
Total			**79,585,927**			**15,618,490**			**1,900,520**		**97,104,937**

Source: Using import price data from FAOstat.
Note: For inflated price, Base: 2011-12 =100 $/ton.