Cumulative Environmental Effects Assessment of BRAC's Agriculture, Fisheries and Poultry Program

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1. Introduction

Concerns on the environmental impact of various development programs in Bangladesh is a new phenomenon. However, it is increasingly realized that it is necessary to conduct environmental examination of development programs that are potentially chemical input intensive and uses natural resources, such as land and water. Promotion of modern technology in agriculture, fisheries and poultry sector involves use of chemical inputs in its various phases and, therefore, deserves an environmental examination, given the scale and extent of spread of these BRAC programs nationwide. Given this backdrop, the present study attempts to conduct an initial assessment of cumulative environmental effects of BRAC's agriculture, fisheries and poultry programs.

Investigation of environmental impacts of all BRAC programs is a huge task. BRAC's attention to environmental issues and its link with poverty was initiated in early 1990s when few studies (e.g., Rahman, 1994) explored the overall poverty-environment relationship of BRAC programs and goals. Since then, attempts were made to initiate systematic investigation on the effect of BRAC's sectoral development programs on environment and how environmental management strategies may affect BRAC program goals. Thus far, environmental examination of BRAC's prawn/carp culture program (Chicoine, 1996), dairy and food project (Jakariya and Akter, 1997), medical waste disposal system of BRAC health centres (Akter et al., 1997), sericulture program and Ayesha Abed Foundation (Akter and Rahman, 1998), and poultry farm and feed mills (Tareq and Akter, 1998) has been conducted. Though these studies differ with respect to scope and methods of investigation, they tended to address a common issue: whether and how BRAC's development programs affect the environment and also attempted to infer on potential health hazards to BRAC beneficiaries who participates in these programs? Recommendations from these studies, were then delegated to BRAC management for action and modification of program implementation strategies if and when desired.

1.1 Rationale

The focus of BRAC's agriculture, fisheries and poultry development Program is on promoting modern technologies that are land augmenting as well as cost saving. As these technologies are highly chemical input intensive, knowledge on their sensitivity to the environment becomes important. It is possible that direct and indirect contact of these chemicals used during production and processing may pose risk on health of the participants. Improper disposal of these chemicals may have adverse effect on environment. They may also have an effect on the biodiversity. Knowing the ways of use and precautionary measures followed by the beneficiaries and composition of these chemicals, waste management system and the maximum residue limit of those chemicals for human or environment can provide with suggestions to improve the condition of these programs.

The present study differs from others in scope and nature of investigation. All previous studies conducted environmental investigation of programs in selected sample sites and reported on the range of inputs, particularly, chemical input use levels specific to those sample units only. In such cases, the magnitude and dimension of the issue seems negligible as farm specific chemical use levels looks minimal. Since, BRAC operates its programs on a very large scale nationwide, knowledge on the overall scenario of chemical use is essential. Thus far, none has attempted to provide such information based on their studies. The present study is an attempt in this line. Initially, based on selected sample sites/farms, the farm-specific chemical use levels are determined. Also, the recommended use rates of these chemicals by BRAC program implementation staff for such activities are noted. Thereafter, a cumulative chemical input use scenario is built based on BRAC's target and achievement of these development programs. Such cumulative picture can effectively provide knowledge on the magnitude and dimension of environmental effect, which might be deemed insignificant when only few sample sites are considered.

1.2 Objectives

The broad objective of the study is to conduct an assessment of cumulative environmental effects of BRAC's agriculture, fisheries and poultry programs. The specific objectives are:

- identify activities in agriculture, fisheries and poultry programs that are environmentally sensitive
- determine chemicals used in agriculture, fisheries and poultry programs
- investigate waste disposal system in agriculture, fisheries and poultry programs
- build cumulative chemical use scenario in agriculture, fisheries and poultry programs
- infer on the risk of these chemicals on program participants' health

2. BRAC programs under study

Thus far, the programs are broadly categorized into agriculture, fisheries and poultry, which in turn are composed of a number of components. Also, in recent years, large-scale projects (e.g., seed production and processing farms, poultry project, prawn and fish hatchery, etc.) managed and operated by BRAC, are introduced within these programs whose environmental sensitiveness worth investigation. Prior to the analysis, a brief description of the programs as well as the specific components of the programs covered under the present study is provided.

2.1 Agriculture program

The agricultural development program of BRAC is a new venture aimed at promoting and diffusing an estimated 81 types of modern and/or hybrid varieties of field crops (rice, wheat, maize, vegetables, spices and oilseeds) to its beneficiaries as well as marginal and small farmers. In early years of BRAC's involvement with agriculture was in provision of credit only as its emphasis was in upgrading the livelihoods of landless poor. However, in this conventional approach of rural development, the functionally landless, marginal and small farmers remain outside of the purview of any development intervention. Realizing this BRAC initiated a program to involve landless marginal and small farmers by undertaking a comprehensive agricultural developmental program in 1998. The main objectives of the agricultural program are to (RDP, 1999):

- create employment opportunities for the landless farmers
- create per capita income through cultivation
- increase agriculture production using modern scientific technology
- increase vegetable consumption for upliftment of nutritional status
- mobilize properly the rural agricultural land and labor

The focus of BRAC's agricultural development program is to promote crop diversification through cultivation of rice, wheat, maize, sunflower, spices and, particularly, vegetables. The supporting activities include seed production and processing, promotion of land augmenting and cost saving technologies, research and development of different crops and vegetable export. BRAC's vegetable export started in 1997 and in 1998/99 exported 35 MT of French beans and 7 MT of other experimental crops such as green chilly, baby pineapple, okra and bitter gourd. In 1998, about 5,550 farmers produced vegetables in 6,397 acres of land. The program covers some 25,000 villages in its vegetable extension network.

2.1.1 Seed production, processing and marketing program

Shortage of high quality seed is believed to be one of the major constraints in raising crop productivity in Bangladesh. Only 4.5% of the seed available to farmers are produced under controlled conditions to ensure high quality (RDP, 1999). In order to provide high quality seed, BRAC has set up eight seed farms (three rice seed, two vegetable seed, two maize seed and a wheat seed farm) to produce a wide variety of certified, high quality seeds. The main objectives of the seed production program are to:

- provide high quality seeds to group members and small farmers
- increase agricultural productivity

BRAC obtains parent seeds from Bangladesh Agricultural Development Corporation (BADC) and is used to produce foundation seeds. These are then processed and distributed to farmers (known as seed contract growers) selected by BRAC to produce certified seeds. These certified seeds are then harvested by contract growers and brought to BRAC's two seed processing centres (Sherpur of Bogra for cereals and Sripur of Gazipur for vegetables and spices). These certified seeds are then distributed to agricultural extension workers in area offices who then sell them to farmers for cultivation. BRAC also maintains two seed production farm that serves as research stations for developing and testing new varieties as well as experimenting with new techniques (RDP, 1999).

BRAC produces about 22 types of vegetable seeds, maize, HYV (high yielding variety) and hybrid rice, cotton and various spices. In 1999, 133.47 MT of vegetable seeds, 700 MT of rice seed, 50 MT of wheat seed and 227 MT of maize seed were distributed (RDP, 1999). In 1998, about 26,000 acres of land is brought under hybrid rice cultivation and 3,300 acres under improved wheat cultivation (RDP, 1998). BRAC's agricultural extension covers about 61 districts.

From the aforementioned discussion, it is clear that the most important component in BRAC's agricultural program is the modern seed production. Specifically, production of "foundation seeds" of cereals and vegetables by BRAC seed production farms and "certified seeds" of the same by contract growers which are then distributed to farmers through BRAC's agricultural extension network and marketing channels. Also, BRAC is operating a research station where "varietal trials" of hybrid and modern varieties of vegetables and spices are conducted. Therefore, given the importance of these components, the present study decided to conduct a detailed investigation on the production activities and input – output levels for seed production by BRAC seed production farms, BRAC agricultural research station as well as contract seed growers in selected regions. In addition, activities and chemical use levels of BRAC seed processing centres are investigated.

2.2 Fisheries program

BRAC's fisheries program started in its early years when 16 derelict ponds were re-excavated in Mangikganj, Jamalpur and Sulla in Sylhet district in1976 and soon evolved into a large sector program. The fisheries program is implemented independently as well as jointly with government, international donor and research institutes. The focus of this program is to promote pond aquaculture development and extension as well as culture fisheries in semi-closed large water bodies (e.g., oxbow lakes). The main objectives of BRAC's fisheries program are to (RDP, 1999):

- increase income and employment opportunities through proper utilization of water bodies
- promote fish culture activities by re-excavating and re-constructing derelict ponds
- ensure timely spawn and fingerling supply

- develop aquaculture management skills of rural fisherman
- increase protein intake of rural people

By the end of 1998, BRAC's fisheries program covered 114, 024 participants with only 5% in baor (oxbow lake) fisheries. The total area under pond aquaculture is 8,712 hectares and baor fisheries in 1,473 hectares, respectively. In order to timely distribute spawn and fish fry, BRAC has set up six prawn and fish hatcheries in Jessore, Pabna, Faridpur, Comilla, Rajendrapur and Bogra.

Two major facets of BRAC's fisheries program are the fingerling nursery and pond fish culture. Therefore, in the present study detailed investigation on the activities and input use in fish nurseries and culture ponds are conducted in selected regions. Also, information on input use in BRAC fish/prawn hatcheries is collected.

2.3 Poultry program

BRAC's poultry program is the largest sector program initiated in 1983, in collaboration with the government of Bangladesh, as an integrated package of support to rural women. In addition to independent implementation, BRAC also runs this program with other agencies. The main objectives of the poultry program are to (RDP, 1999):

- develop women as poultry rearers to enable them to earn Tk. 200 – 250 per month
- reduce poultry mortality from 40 – 45% to 15%
- increase the population of poultry birds
- introduce cross breeding of birds for increasing the production of eggs and meat
- improve the protein intake level of rural people

By 1998, about 1.24 million women were involved in the poultry sector wherein 8.7 million day-old chicks were being reared (BRAC 1998). The purpose is to increase income by promoting poultry production in the country. The components of poultry program includes breed development, supply of feed, health care, supply of input, technical service, vaccination and financial support (BRAC 1998). By the end of the year 1998, 43,446 group members are trained in poultry vaccination skills. In order to provide good quality day-old chicks, BRAC established a large-scale poultry hatchery complex in Mirzapur thana of Bogra district in 1998.

Chick rearing forms a major component of BRAC's poultry development program, which is relatively conducted at a large scale given the economic circumstances of its group members. Therefore, in the present study, detail information on activities and use of input by chick rearers in selected regions is collected. Also, activities and input use levels of the single large-scale BRAC poultry project is collected.

3. Research design and methodology

The research is based on primary data as well as secondary data generated by the program implementation bodies. Structured questionnaire, checklist and field observation was utilized for data collection.

3.1 Study area

Although BRAC operates its program throughout Bangladesh, BRAC's large-scale projects, i.e., poultry project, seed farms, seed processing centres and fish/prawn hatcheries are located in specific regions of the country. Therefore, in order to cover selections of these large-scale projects as well as for manageability and logistic considerations, selective samples of contact seed growers, chick rearers and fish producers were collected from 21 villages of 10 thanas in 4 agro-ecological regions.

3.2 Data collection

Data collection is conducted for a period of two weeks during March 27 – April 10, 2000. Both field observation and interviews with farmers and relevant program personnel involved were conducted.

3.3 Questionnaire design

The questionnaire for contract seed growers focussed largely on the environmental aspects of the program activities. It also intended to explore the level of knowledge on various adversities of chemical use as well as promotion and diffusion of modern agricultural technologies. The questionnaire is designed according to the level of respondents' understanding. Also a checklist for field observation was prepared which included information on:

- kinds of chemicals used
- internal environmental condition of the projects
- condition of the working environment
- biodiversity in the production, processing and cultivation areas
- machines used
- energy used
- public nuisance

3.4 Sample size

Decision on optimal sample size varied largely depending on the importance of the program components as well magnitude and dimension of its sensitivity to the environment. Also, for program components where the activities are uniform across beneficiaries, few samples were taken. In all cases, random sampling procedure is adopted. Following sample sizes for specific program components are used in the study (sample summary appears in Table 1):

(a) Sample size for components of agriculture program

- 81 contract agricultural seed growers from 29 villages in 6 thanas of 2 regions
- 1 (out of a total of 8) BRAC seed production farm
- 1 BRAC agricultural research farm
- 2 BRAC seed processing centre
    - 1 vegetable seed processing centre
    - 1 cereal (rice, wheat and maize) seed processing centre

(b) Sample size for components of fisheries program

- 5 fish fingerling producers (nursery) in 3 regions (few samples are selected as the input use levels are uniform)
- 5 fish producers (culture) in 3 regions (few samples are selected as the input use levels are uniform)
- 1 (out of a total of 3) BRAC fish/prawn hatchery
- 1 (out of a total of 3) BRAC prawn hatchery

(c) Sample size for components of poultry program

- 1 BRAC poultry project
- 3 chick rearers in 3 regions (few samples are selected as the input use levels are uniform)

Usefulness of the study

The study is expected to contribute to limited knowledge on the environmental impacts of technological innovations in general and BRAC's agriculture, fisheries and poultry development program in particulars. It is expected that such study will help devise more environmental friendly rural development interventions.

4. Assessment of chemical use levels of BRAC seed production centres, crop research farm and seed processing centres

The purpose of BRAC's agriculture development program is to increase agricultural production through promotion of modern technology that are land augmenting as well as cost saving (?). Also, this drive in modernizing agricultural production through crop diversification is considered as a vehicle to uplift life standard of the rural poor including marginal and small farmers.

However, in recent years, there is a worldwide realization that these "high payoff input intensive modern agricultural technology" though increased production dramatically, its production potential is tapering off in many developing countries and is also associated with adverse socio-economic and environmental impacts. For example, Shiva (1991) in her analysis of agricultural transformation in Indian Punjab concluded that "Green Revolution" produced scarcity not abundance (by reducing the availability of fertile land and genetic diversity of crops), though it was believed to be the superior substitute of nature and a source of abundance. Redclift (1989) examining the issues of environmental degradation in rural areas of Latin America noted that it is closely linked to agricultural modernization. Rahman and Thapa (1999) noted that "decline in soil fertility" featured at the top of the list of adverse environmental impacts of technological change and/or "Green Revolution" in Bangladesh according to farmers' perception followed by "health effects" and "decline in fish catch".

Also, production of modern varieties of rice is estimated to contribute 29 percent to total existing income inequality in rural Bangladesh and varies directly in relation to the rate of adoption (Rahman, 1999).

In terms of gender equity in employment, women lose out in comparison with male counterparts in the hired labor market in modern rice production in Bangladesh (Rahman and Routray, 1998). However, in case of vegetables and other non-cereals, involvement of hired rural women is comparatively higher (Rahman, 2000). Therefore, BRAC's drive in promoting vegetables and other non-cereal production can be seen as a positive drive in promoting rural women's employment as agricultural labor.

The focus of the present study is in assessing the intensity of chemical inputs used in seed production both by contract seed farmers as well as BRAC seed farms which also rely on the use hired agricultural labor to accomplish the tasks.

As a starting point of the analysis, frequency and levels of various pesticides used by BRAC "foundation" seed production farm is examined. Also, levels of fertilizers, bio-fertilizers, irrigation, as well as any other environment friendly techniques, such as "integrated pest management (IPM)", is enumerated. Similarly, the frequency and levels of pesticides used by BRAC crop research farm is examined where mainly most suited crop variety is screened through varietal trials using same doses of inputs.

4.1 Chemical use levels in BRAC seed farm

BRAC seed farm concentrates in producing vegetable seeds that are grown either in rabi (winter) or in kharif (summer) season. In the year 1999, BRAC seed farm produced "foundation seeds" of

18 types of summer and winter vegetables. These are, beans, yardlong bean, mungbean (a pulse crop), bottle gourd, bitter gourd, ridge gourd, pumpkin, chalkumra, cucumber, kangkong, chinasak, red amaranth, amaranth, tomato, radish, eggplant, okra, and cauliflower. Most of these vegetable seeds are grown within a production cycle of 1 – 3 months either in winter or summer seasons. The farm itself is located within the enclave of Dinajpur Regional Office. As the purpose is to produce high quality "foundation seeds" from the "parent seeds" obtained from BADC, it is very likely that the input use intensity will be much higher than the contract farmers producing "certified seeds" from these "foundation seeds". Nevertheless, these use rates are in turn recommended to contract seed growers to obtain best results. Therefore, assessing the potential hazards of such intensive chemical use can shed light on the scenario that will emerge once BRAC goes to scale-up its operation in the usual manner.

Frequency of the use of various pesticides and artificial vitamins and/or hormones to boost "foundation seed" production in BRAC seed farm is presented in Table 4.1. The net sown area devoted to seed production is estimated at around 600 decimals in rabi and 500 decimals in kharif season, respectively. The dominant vegetable seed sown in rabi season is tomato (330 decimals of land) and in kharif season is okra (366 decimals of land). It is alarming to note that all these 18 crops receive about 4 – 10 doses of pesticides within its 20 – 90 days production cycle starting from land preparation to final seed harvest. Fourteen types of pesticides and two types of hormones were used in the year 1999. Among these diverse range of pesticides, some fall within the enlisted "dirty dozen" and other pesticides that are banned in most of the northern countries as well as in Bangladesh. These banned pesticides include DDT, HCH, Diazinon, Basudin, Dimecron, Endosulfan, Kumulous, DF, Santar, Pirikks, Hinoson, Kupravit, Golteer, Thilovic, Rovral, Regent, Melathion, Sumodi, Darsban, Ekalas, Ronstar, Nucrovin, Maltok, Segkos, Takgar, Azanal, Butakular, Hilaton, Gamakcine, Sumithion, Nogos, Shankuan, and 90G (Motin, 2000).

It is clear from Table 4.1 that, among the banned pesticides, Takgar in 7 crops, Melathion in 2 crops, Dimecron in 6 crops, Rovral in 3 crops, Nogos in 5 crops, and Darsban in 5 crops. Some of the vegetables, such as pumpkin and chalkumra uses three types of banned pesticides simultaneously.

Given the uniform dose rates for all types of pesticides, frequency of use and land area cultivated, the total level of pesticide use in the BRAC seed farm is calculated and presented in Table 4.2. If cropping intensity are taken into account, as same plot is used for more than one crops (i.e., in rabi as well as in kharif season), then the total pesticide use on same piece of land would increase dramatically. Table 4.2 reveals the hidden danger in the use of pesticides to boost vegetable production using modern technology. The minimal pesticide use rate of 4 ml and or 4 gm per decimal of land area, coupled with frequency of its use leads to substantially high accumulated dose in a given piece of land area in one year. Although, it will not be wise to add up the individual use levels of pesticides, the bottom line of Table 4.2 clearly reveals the potential danger of pesticide accumulation within this estimated 600 decimals of soil, crops, as well as the surrounding environment as a whole. Assuming, this intensity of pesticide use to continue each year, one can readily foresee the potential hazard in the pursuit of modern agricultural technology to boost crop production.

Apart from the use of pesticides, chemical use in the seed farm is also very high. The chemical fertilizer use levels of BRAC seed farm is based on the recommendation made by Bangladesh Agricultural Development Corporation (BADC) in the early 1980s. Even by that standard, the cumulated use levels of Urea, MP, and TSP in 600 decimals of land per year is substantially high (Table 4.3). It is at least encouraging to note that cowdung as well as gypsum, zinc, borax and magnesium is also used to supplement organic matter and micro-nutrient deficiency in soils.

Based on the actual use of various pesticides and fertilizers in producing 18 types of vegetable seeds in the year 1999 in this seed farm, mean use rates per decimal of net sown area is estimated and presented in Table 4.4. It is alarming to note that out of 14 pestcides, the mean use rate of 7 pesticides are above the reported use rate of 4 ml/gm per decimal of land. More disturbingly, 5 of these pesticides are among the banned pesticides. Dimecron, a banned pesticide, is used at a mean use rate of 9.21 ml/dec, which is twice the reported use rate.

4.2 Chemical use levels in BRAC research farm

The BRAC research farm is located in Cherag Ali, Tongi of Gazipur district. In an estimated 400 decimals of land, a wide range of vegetables including spice is grown. The main purpose of BRAC research farm is to screen suitable varieties of vegetable and spice crops by conducting varietal trials using same set of input levels. In the year 1999, BRAC research farm produced 11 types of vegetables including one spice crop. A total of 51 varieties of these 11 crops are grown to screen out the most suitable vegetables for mass recommendation (Table 4.5).

As with the of BRAC seed production farm, the frequency of pesticide use level is similarly high in BRAC research farm. The frequency of pesticide use is alarmingly high (16 times) in tomato, the dominant crop grown in 384 decimals of land (Table 4.5).

Given the uniform dose rates for all types of pesticides, frequency of use and land area cultivated, the total level of pesticide use in the BRAC research farm is also calculated and presented in Table 4.6. The last row of Table 4.6 again reveals the potential danger of pesticide accumulation in limited piece of land, crops as well as in the surrounding environment every year.

An innovative measure in fertilization of the BRAC research farm is the use of poultry litter solution which lead to relatively less use of chemical fertilizers such as Urea, TSP and MP as compared to BRAC seed production farm (Table 4.7). Nevertheless, the total level of chemical input use remains a matter of concern, if BRAC wishes to continue to pursue variety screening trials with such intensity in future.

4.3 Chemical use levels in BRAC seed processing centres

Automated seed processing centre in Bangladesh are rear. BRAC has taken initiative in establishing seed processing centres that are capable of processing either vegetable seeds or cereal seeds. Investigation on the seed processing centre confined in examining the chemical use levels (if any) in the various stages of seed processing. Both of the BRAC seed processing centre, Sreepur and Sherpur centres, were visited for this purpose and interviews were taken using a checklist. Although a number of steps are involved in processing of seeds, chemical use remains confined in only one stage and is applied when vegetable seeds are processed. In other words, cereal seed processing does not involve chemical usage at any stage. A brief activity profile of a typical seed processing centre is explained in Box. 4.1.

Box. 4.1 Activities of BRAC seed processing centres

Steps of seed processing in a processing centre are as follows:
(1) Drying: *Seeds are needed to be dried to an minimum moisture content so that it could be preserved properly. Drying is done in the open sun. Minimum moisture content is maintained in seeds according to the categories of seeds. In case of vegetable seeds moisture is reduced to 8% and in rice it is 12%.*
(2) Cleaning: *Seeds are cleaned from dust particles by an air cleaning machine.*
(3) Gravity separator: *Vegetable and rice seeds are separated by a separator on the basis of different parameters of seeds like weigh, size, and even color, etc.*
(4) Indenting cylinder: *Seeds are separated from dust, gravels by crushing these unwanted substances.*
(5) Grader: *Seeds are categorized in to different grades like large, small and medium.*
(6) Chemical inputs: *To protect seeds from any kind of fungal, bacterial or any kind of diseases different chemicals are used in seeds. For* ***Rice****, no chemicals were used. However for* ***Vegetables*** *some antifungals are used.*
(7) Weighing: *Then seeds are then weighed to keep them in different quantity..*
(8) Packaging: *The final stage of seed processing is packaging.*

No proper system of waste management has been developed yet in either of the centres. Polythene bags, sometimes, were found burnt and/or dumped. Glass vials were also found broken and dumped. As the seed processing project is going to expand, proper waste management system should be established.

5. Assessment of chemical use levels, chemical handling practices and environmental awareness of contract seed growers/farmers

Examining the levels of chemical input use by contract seed growers and their awareness on adverse environmental effects of chemical use forms the core of this study. As such, major thrust has been placed in conducting in-depth farm-level survey of contract seed growers surrounding the BRAC foundation seed farm in Dinajpur district as well as BRAC cereal processing centre at Sherpur, Bogra. The distribution of population of contract seed growers from where samples are selected is presented in Table 5.1.

A total of 81 contract seed growers were interviewed (64 in Dinajpur and 17 in Bogra) from 29 villages (22 in Dinajpur and 7 in Bogra) of 6 upazila (5 in Dinajpur and 1 in Bogra). In terms of crops produced, the total number of observation stands at 128 (111 in Dinajpur and 17 in Bogra). The distribution of sampled contract seed growers by broad crop group is presented in Table 5.2. Vegetables include radish (16), okra (10), yardlong bean (9), bean (6), ridgegourd (4), pumpkin (3), tomato (1), eggplant (1), cucumber (1), and bottlegourd (1). The leafy vegetables include red amaranth (18), kangkong (14), palangsak (8), amaranth (3), chinasak (2) and spinach (1). Among these 81 contract seed growers, about 30 of them are also hybrid/HYV cereal producers (14 hybrid maize, 6 hybrid wheat and 10 HYV rice). The concentration of the cereal producers is in Bogra district in the neighborhood of BRAC cereal seed processing farm in Sherpur, Bogra.

Average area under seed production, yield rate and gross value of output per acre (100 decimals of land) is estimated and presented in Table 5.3. The dominance of cereal based farming in Bangladesh is clear from the table even in case of seed production. Also, it is true that growing vegetables requires less land and input intensive and relatively costly. In terms of gross value of output, it seems that producing vegetable seeds provides relatively high return (Tk. 14,246 per acre). On the other hand, production of maize seeds (Tk. 13,426 per acre) fair relatively close followed by leafy vegetable seeds (Tk. 10,818 per acre). There is virtually no difference in gross return from producing hybrid wheat or HYV rice (Table 5.3). As, the objective of this study is not to estimate profitability of modern agricultural technology, detailed cost and return is not estimated. Also, these modern technologies are expected to be costly. Therefore, the net rate of return could provide a different scenario.

A series of questions were asked to the contract seed growers to examine their chemical input use level, chemical (pesticides and fertilizers) handling practices as well as environmental awareness. As open questions are placed in eliciting reasons and contexts, multiple responses were recorded. Based on these responses to various inter-related questions, it is expected that the levels of farmers' environmental awareness and their chemical handling practices can be assessed which will assist in drawing inference on possible environmental effects of modern agricultural technology adoption.

5.1 Assessment of farmers' chemical use levels:

Growing modern/hybrid vegetable seeds as well as cereal seeds require intensive use of chemicals (fertilizers as well as pesticides/fungicides). As the main purpose of these seed farmers is to sell these "certified seeds" to BRAC who in turn distributes these to farmers willing to produce modern/hybrid vegetables and/or cereals, assessment of the actual level and varieties of chemicals is essential.

5.1.1 Fertilizer application

BRAC staff involved in extension program recommends certain standard doses of fertilizers for vegetables as well as cereals. In principle, 6 types of fertilizers: Urea, TSP, MP, Gypsum, Zinc and Borax are recommended. The recommended doses for various crops is presented in Table 5.4.

Almost all farmers seem to use Urea, TSP, and Gypsum fertilizers. About 88 percent use MP while 43 percent use Borax and only 13 percent use Magnesium, respectively (Table 5.5). Zinc, Borax and Magnesium is not used for rice and Magnesium is not used for wheat as well. The highest level of fertilizer use (N, P, K, Gypsum, Zn, and Mg combined) is in hybrid maize seed production (381.4 kg/acre) followed by leafy vegetables (223.7 kg/acre0 and vegetables (210.9 kg/acre), respectively (Table 5.6). Application rate is lowest for rice (117.7 kg/acre) while wheat uses substantially high amount (202.6 kg/acre) which is not quite expected. This has led to high fertilizer cost for maize (3,364.6 Tk/acre). The fertilizer application rate for vegetables, leafy vegetables and wheat seems to be very close to the recommended rate. For maize, the application rate is relatively high and for rice it is quite lower than the recommended rate.

5.1.2 Pesticide application

Wide variety pesticides/fungicides are used by farmers some of which are banned in Bangladesh, as indicated earlier. Given the variety of names, it is quite difficult to broadly group them in typical hazard categories. However, an attempt is made to group some of the selective pesticides while the remaining appeared in its own brand names (Table 5.7). It is evident from Table 5.7 that Darsban is used by 41 percent farmer followed by synthetic pyrithroids (28 percent) and organophosphorus compounds (27 percent) that contains most of the banned pesticides. Azodrine, also a banned pesticide is used by 6 percent farmers.

As pesticides are used with greater frequency, that is, as and when required, even the minimal doses eventually add upto a large rate of application. For example, even though the standard recommended rate by BRAC staff (in verbis) is 4 ml and/or gm per decimal of land for each time, the average level of pesticide application by farmers seems alarming (Table 5.8). Surprisingly, the application rate is extraordinarily high for rice production 28 ml or gm/dec followed by vegetable 14 ml or gm/dec and maize 13 ml or gm/dec. However, in terms of cost, the costly pesticides are applied to vegetables, leafy vegetables and maize. It is encouraging to note that wheat production required minimal use of pesticides (only 1 ml or gm/dec.).

5.1.3 Vitamin or growth hormone application

Vegetables require additional vitamins and/or growth hormones for quality, quantity as well as taste (?). Although few farmers used vitamins for vegetables and rice, the mean application rate is highly fluctuating (Table 5.9). Surprisingly, vitamin is applied in large quantities in rice production as compared to vegetables.

5.1.4 Bio-fertilizer application

It is encouraging to note that in addition to chemical fertilizers, farmers are also using bio-fertilizers, particularly cowdung. About 88 percent of farmers reported to use cowdung while negligible proportion tried ash, compost, poultry litter as well as oilcake (Table 5.10). As with the case of pesticides and fertilizers, bio-fertilizers are also used in maize seed production at highest rate (5.4 tons/acre) followed by vegetables (3.1 tons/acre), respectively, (Table 5.11). As opposed to earlier assumptions, bio-fertilizers, particularly, cowdung is sold in the market as indicated by substantial amount of cost involved in using them (Table 5.11).

5.1.5 Irrigation application

About 89.8 percent farmers used mechanical irrigation with timing varying between 1 – 16 times in a cropping season. The major source of irrigation is the groundwater drawn by Shallow Tube Wells (STW). The main source of energy used in irrigation is diesel (88.3 percent) which is based on non-renewable fossil fuel stock.

5.2 Assessing farmers' chemical handling practices

In order to assess farmers' chemical handling practices a series of inter-related questions were asked, such as "whether they use gloves in handling pesticides", "whether they use of masks or any other protective emasure while applying pesticides", "where do they store pesticides and chemicals", "what they do with the empty cans", and "whether they received any knowledge on precautionery measures in handling chemicals", etc. Multiple response were recorded as these questions contained open-end for eliciting reasons and sources of information.

Only 7 percent of farmers uses gloves while handling fertilizers and/or pesticides which is very striking. When asked for reason, 42 percent responded that this is due to lazyness, while 32 percent though it is not necessary. About 16 percent informed that they are not aware of such practice. Only one farmer said that mask should be used but cannot purchase due to lack of money.

However, it is encouraging to note that, about 44 percent farmers use some kind of mask while spraying chemicals (particularly pesticide). When asked reason for not using mask, 30 percent responded that they do not consider it necessary. Fourteen percent cited lazyness as reason. Only 5 percent informed that they do not know about taking precaution while only one farmer cited monetary reason.

Timing of pesticide application have some bearing on effect on farmers health. On the question of the timing of pesticide application, 68 percent responded that they apply pesticides mainly during afternoon, followed by late morning after breakfast (51 percent), and before breakfast (21 percent). Only few (6 percent) apply pesticide during evening time. Application of pesticide in late morning or afternoon reflects that they do it after having meals.

About 24 percent farmers responded that they feel sick after handling chemicals with some common symptoms (Table 5.12). Seventeen percent reported that they feel tired and weak after spraying pesticide in the crop field. Vomiting tendency and/or headache as well as burning sensation in eyes/chest/lower knee were also reported.

It is highly encouraging to note that almost all farmers (98) responded that they use soap and/or ashes to wash hands after using chemicals. Also, about 88 percent informed that they know of that precautionary measure should be followed while handling pesticides. BRAC staff is the main sources of disseminating knowledge on handling chemicals (43 percent) (Table 5.13). Further, written instruction in the bottle or leaflet served as an important source (27 percent). Also neighbors serve as another major source (16 percent). Contribution of government agricultural officials are not very dominant in disseminating information on safety measures in handling chemicals indicating the ever-existing sluggish and non-functional agricultural extension system in Bangladesh.

When asked about what precautions are taken during pesticide/fungicide application, 87 percent farmers reported that they cover the face with cloth or mask while few (13 percent) mentioned use of caps/helmet (Table 5.14). Only 13 percent of farmers did not use any pesticides. It seems that farmers are increasingly realizing that some precautions are necessary while applying pesticides which is encouraging.

It is encouraging to note that about most of the farmers (93 percent) store chemicals with some degree of caution (Table 5.15). About 49 percent reported that they keep it in a safe place or specific location at home. About 25 percent emphasized that they keep it out of the reach of children. Only 7 percent informed that they do not know about it or did not use pesticide at all.

When asked about "what you do with empty chemical cans", about 53 percent of farmers bury the empty chemical cans after use (Table 5.16). Eleven percent informed that they clean it and re-use it for domestic purpose. Also, some (11 percent) keep it anywhere at home indicating not taking any caution in strict sense. Few responded that they throw these in river/water body (5 percent) and in the woods (5 percent).

5.2 Assessment of farmers' environmental awareness

The starting point of such assessment is opened by asking the farmers "what they do with the residue left in the crop field" for which multiple responses were received. About 70 percent mentioned that they uses it as fuel, 50 percent responded that they leave it in the field, 18 percent uses these to feed animals, and 13 percent uses it as compost. This response pattern reveals that the dominant tendency is to utilize the crop residue as fuel and feeding animals. Crop residues that cannot be used for fuel and animal feed is left in the field and is made compost to some extent as explained by farmers. In other words, the need for replenishing soil fertility by recycling crop residues seems to be not very strong.

Later, to assess the intensity of input use and farmers' tendency in this respect they were asked to opine on their current fertilizer use rates in growing vegetable seeds as well as hybrid/HYV cereals. It is encouraging to note that large majority (89 percent) responded that they use sufficient amount of fertilizers. Although, the actual use level is already quite high, they are at least not looking forward to increase the application rate, which would have lead to further adversity in the environment. However, among the remaining 11 percent, contrasting responses were received. About 8 percent feel that they should have applied more of potassium and phosphate fertilizers. The range of increase varies between 10 - 20 percent of present application rate. On the other hand, 3 percent opined that they should have reduced phosphate fertilizers substantially. It is interesting to find that none mentioned about increasing the use of Urea that supplies nitrogen to the soil. Historically, Bangladeshi farmers were very fond of applying more of Urea only as it shows vigorous vegetative growth but contributes less to grain/fruit development. Such unbalanced use of fertilizers by farmers is also considered as a contributory factor in rapidly declining soil fertility status in Bangladesh over the past two decades. In vegetable seed production, use of potassium and phosphate is of crucial importance. Concern on increasing the use of these fertilizers, as revealed from farmers' responses, indicate that they are becoming well aware of its importance which is a good sign in promoting use of balanced fertilization.

Similarly, on the question of their existing pesticide use rate, about 77 percent farmers responded that they use enough pesticides. Among the remaining 23 percent, 5 percent feels that they should use more (upto 50 percent than the existing rate) while 18 percent did not respond.

Almost all farmers (95 percent) consider that pesticide use has good (?) effects. The range of such good effects is elaborated in Table 5.17. Majority (85 percent) farmers think that pesticide use increases production. About one-third (31 percent) considers that it prevents insect and pest attack. Some 15 percent responded that pesticide use increases quality of output. Only 3 percent farmers opined that there are no good effects of pesticide use.

At the same time, when farmers are asked to opine on the harmful effects of pesticides use, 37 percent of them provided a long list which is elaborated in Table 5.18. It is surprising that 49 percent of farmers considers there is no harmful effect in pesticide use. About 9 percent did not give any thought on whether pesticides has harmful effects, implying 58 percent being naive about any harmful effects of pesticides which is alarming. Among the harmful effects, 10 percent thinks pesticides also kills useful insects and animals, such as, earthworm, honey-bee and frogs, that are good for crop production. Adverse effect on human health (9 percent) emerged as second important harmful effect of pesticide use. Damages to crop (8 percent) as well as reduction of soil fertility (7 percent) appeared among the adverse effects. About 5 percent opined that pesticide also kills bird, which comes in contact with the crops.

When asked "after how many days you harvest your crops after using chemicals", only 4.9 percent responded that they harvest it within 5 days while majority (95.1 percent) harvest it from 7 days onward.

When asked about whether local villagers tend to consume vegetables and/or fruits immediately after using chemicals, only 18.5 percent responded in the affirmative. Remaining 81.5 percent informed that they do not consume immediately. The dominant number of days allowed to consume vegetables and fruit after spraying pesticides came out to be 7 days (28.4 percent) followed by 10 days (17.3 percent) and 15 days (8.6 percent), respectively. When asked whether villagers drink water from pond/canal/waterbody/river, none responded in the affirmative except one farmer who reported to drink water from the pond.

5.4 Farmers' perception on environmental impacts of modern agricultural technology

To understand farmers' perception on the environmental impacts of technological change, an elaborate procedure is adopted. First, open questions are placed on whether they are aware of any adverse environmental impacts of technological change in agriculture. If they said yes, then they are asked to provide examples of such impacts. If they disagree, then they are also asked to provide reasons for such disagreements. This was done to set the stage for asking question that will enable to assess farmers' perception on environmental impacts of modern agricultural technology.

About 39.5 percent farmers responded that they are aware of the adverse environmental impacts associated with modern agricultural adoption. The examples of adverse environmental impacts are elaborated in Table 5.19. "Decrease in the population of beneficial insects" is seen as the important example of adverse environmental impacts of modern agricultural technology adoption reported by 16.1 percent of farmers. This is followed by "increasing disease in human" (8.6 percent) and "decline in earthworms" (7.4 percent). Also, "reduction in fish catch" (4.9 percent) and "reduction in soil fertility" (4.9 percent) are cited as examples of adverse effects.

Reasons cited in favor of modern agricultural technology adoption by remaining 59.5 percent farmers includes "increase in crop production than before" (27.2 percent), "insects cannot damage crops" (11.1 percent) and "no damage is occurring to the environment" (27.2 percent).

After receiving a notion of farmers' awareness, their perceptions are elicited in two steps. First, a set of 12 specific environmental impacts was read to the respondents. The identification and selection of these indicators were based on a similar study recently undertaken by Rahman and Thapa, (1999). In the questionnaires farmers were asked to reveal their opinion on these impacts, and to weight them on a five-point scale. Zero weighting was given where there was disagreement. It is believed that using these elaborate three steps, first farmers' own awareness level, and then a two-step procedure to elicit farmers' perception helped to avoid leading statements and loaded responses. The results of these questions are presented below.

"Decline in fish catch" featured at the top of the list of adverse environmental impacts of modern agricultural technology adoption (Table 5.20). This are then followed by "increase in pest/insect attack", "reduction in soil fertility", "effect of human health" and "increase in crop disease". The results are strikingly similar with Rahman and Thapa (1999) where "Green Revolution" farmers were asked to reveal their perception on adverse environmental impacts of technological change in agriculture in three agro-ecological regions of Bangladesh. From the index values, it is clear that farmers' perception is stronger for visible impacts, whereas perception on the intangible impacts, particularly on water resources, is very weak. For example, "contamination of soil and water body" is poor as indicated by very low index values for these impacts (Table 5.20).

6. Assessment of chemical use levels in BRAC fisheries program

BRAC fisheries program is one of the largest income generating program and is expanding quite rapidly over the years. It is assumed that the potential beneficial impacts of fisheries program possibly outweigh the negative environmental impacts caused by use of poisons and chemicals for fertilization. However, detail investigation might shed better light on the existing situation and will provide rooms for further reduction of any negative environmental consequences to promote fish farming which serves as one of the major source of protein for Bangladeshi people.

In this survey, 7 nursery and culture pond and 3 BRAC operated culture ponds were investigated that spread in 5 districts of Bangladesh. In addition, out of six pond hatcheries operated by BRAC, two were investigated of which one is fish/prawn hatchery and the other only prawn hatchery. Information concentrated mainly on types of poison used and chemicals used for fertilization.

6.1 Chemical use in pond nursery and culture

Three types of poisons are mainly used in Bangladesh to kill competitor and predator fish. These are carbamates, such as Rotenone, organophosphates such as Phostoxin and organochlorine such as Aldrin and Dieldrin (Chicoine, 1996). Although, Phostoxin are largely used in BRAC ponds earlier, currently only Rotenone (a relatively less hazardous poison in WHO standard) is being recommended for killing competitor and predator fish.

Two sets of recommended dose for pond fish culture: one by BRAC Fisheries program and one practiced by Bangladesh Fisheries Research Institute is presented in Table 6.1. There are quite large discrepancy in types and doses of poisons and fertilizers recommended for pond aquaculture by two institutes. However, it seems that recommendation provided by BRAC is more diverse and specific to pond conditions and contains less harmful poisons.

Out of 10 ponds investigated Phostoxin is used by only one farmer who started pond culture in 1996 (Table 6.2). Also, Sumithion, a banned pesticide, is used by two nursery farmers who started operation in 1999. It should be mentioned that BRAC recommends judicious use of Sumithion in nursery ponds. It is encouraging to note that the actual doses of poisons applied by farmers are largely less than the amount recommended by BRAC. One nursery farmer adopted de-watering and drying of pond before operation that avoided the use of any poison, which is highly encouraging as an attempt. Also, BRAC hatcheries in Jessore adopted Lime treatment in pond preparation instead of poisoning to culture Pangas fish, also an encouraging phenomenon.

Detail of amount of chemicals used for pond fertilization is presented in Table 6.3. Also, a comparison is made between actual use and recommended requirement to see the degree of discrepancy. The general impression drawn from examination of Table 6.3 reveals that pond farmer under-use the amount of chemicals. However, they seem to overuse cowdung than the recommended requirement. In providing continuous feed, none seem to be quite specific about it and failed to provide any detail information in this respect. Only BRAC hatchery operators stick to official recommendations in all respect.

6.2 Chemical use in BRAC fish/prawn and prawn hatcheries

The objective of hatchery is to produce post-larvae fish/prawn from the semen of brood stock. After eggs are hatched, larvae are kept in rearing tanks containing fresh water for carp fish and brackish water for prawn. As hatchery is a very sensitive operation in overall fish production activity, various chemicals are in different stages of the process in order to safeguard from any danger. The following Box 6.1 contains the details of chemicals used in different stages in BRAC fish/prawn hatchery activities.

Box. 6.1. Chemicals used in different stages in BRAC fish/prawn and prawn hatchery.

Chemicals	*Dose*	*Purpose*
Rotenone	*4 ppm*	*Initial disinfection for carp pond*
Bleaching powder	*10 ppm, 20kg*	*Disinfection*
Formalin	*200 – 250 ppm, 40 litre*	*Disinfection for prawn hatchery*
Oxy tetracycline (OTC)	*3 – 5 ppm*	*Disinfection*
Methylene blue	*300 gm*	*Disinfection for carp hatchery*
EDTA	*800 gm*	*Disinfection for prawn hatchery*
Sodium thiosulphate	*10 ppm, 5kg*	*To dilute and inactivate chlorine*
Sodium carbonate	*60 – 100 gm*	*Decapsulation*
Agar	*2gm/100gm cluster*	*Fish feed*

In each hatchery, at least two persons are directly involved in handling chemicals used in hatchery activities. However, no visible precautionary measures were taken by them to safeguard from health effects while handling chemicals. When asked about any health incidents, they reported burning sensation in eyes when applying bleaching powder. Also, palms and footsoles seem to be affected as lesions are observed in footsoles. The disposal system of washing water passes through a 3-chamber tank where various filtering systems is installed.

7. Assessment of chemical use levels in BRAC poultry program

Poultry program is the largest in employment and income generation activities of BRAC that involves 1.24 million women member in various capacities. It may also be considered as one of the environment friendly programs as level of chemical use *per se* is negligible. However, since only exotic varieties of poultry that is suited to Bangladesh condition is produced and distributed, the diversity in poultry breed gets affected and the traditional varieties might go extinct in foreseeable future.

As with the other components of the study, information on poultry program concentrated mainly of levels of chemicals used (if any) in chick and poultry rearing activities. As poultry rearing activity involves waste nuisance, information on their waste management practice is collected. Very few samples for poultry program is taken because BRAC operates this program in a uniform set up with variation only in the size of each farm, such as from 500 – 1,500 chicks or birds to be reared while the program package remains strikingly uniform irrespective of area and region. In addition, details of chemical use and waste management system of the lone BRAC poultry project located in Mirzapur, Bogra is collected as its operation size is very large.

7.1 Chemical use and waste management in poultry program

The 3 case studies of poultry program: 2 chick rearers and 1 poultry rearer is summarized in Box 7.1. The interview focussed on how the farmers manage poultry waster ('litter'), the vials of vaccines and containers of vitamins used to feed chicks.

Box 7.1. Case studies of poultry rearers.

	Farm1: Chick rearing	*Farm2: Chick rearing*	*Farm3: Layer rearing*
Farm size	*300*	*400*	*300*
Year started	*1999*	*1996*	*1996*
Rearing	*Reared for 2 months*	*Reared for 2 months*	*Reared for 68 weeks*
Vaccination	*BCRDV, Gambura, RDV and Fowl pox*	*BCRDV, Gambura, RDV and Fowl pox*	*BCRDV, Gambura, RDV and Fowl pox*
Hygiene maintenance during rearing	*Use potash water to wash hands and feet before entering shed*	*Use potash water to wash hands and feet before entering shed*	*Use potash water to wash hands and feet before entering shed*
Hygiene during cleaning shed	*No precautions*	*Cover face while cleaning litter*	*No precautions*
Frequency of cleaning litter	*Weekly*	*Weekly*	*Weekly*
Maintenance of vaccine vials	*Empty vials kept out of children reach*	*Empty vials kept out of children reach*	*Empty vials kept out of children reach*
Maintenance of vitamin containers	*Reuse for domestic purpose*	*Not known*	*Not known*

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"poultry litter" which causes some foul smell is used for dual purpose: (a) as fertilizer, and/or (b) as fish feed. The poultry rearers reported that they sell it to local vegetable, betel leaf and banana grower, which fetches upto Tk. 100 – 150 for a single unit where chicks are raised for two months.

7.2 Chemical use in BRAC poultry project

The BRAC poultry project is a large scale farm with modern equipment and contains a series of operations ranging from poultry hatching, rearing and egg production. In its modern incubation facilities, incubations are undertaken at a daily rate of 19,200 eggs. Day old chicks hatched from this facility are distributed nationwide to BRAC chick rearing units. In addition, live chickens whose egg producing capacity declines are sold in addition to sterilized eggs.

As this facility is quite big, the scale of waste management needs to be well planned and implemented. The level of chemical used and the waste management system of this project is summarized in Box 7.2.

Box 7.2. Chemical use and waste management system in BRAC poultry project

Chemicals	*Dose*	*Purpose*
Losan	*10 cc/litre*	*Disinfection of litter, cleaning*
Potash	*20 gm*	*Disinfection through fumigation*
Formalin (40 % concentration)	*30 ml*	*Disinfection through fumigation*
Supercept	-	*Cleaning*
Antec	-	*Day old chick carrying case washing*
Bleaching powder	-	*Day old chick carrying case washing*
Washing soap	-	*Day old chick carrying case washing*
Waste management system		
Empty vials of vaccine	*375 per month*	*Plastic vials – burnt,* *Glass vials – dumped/buried*
Dead birds	-	*Burned in fixed disposal site*
Egg shells	-	*Dumped/buried in fixed disposal site*
Poultry litter	-	*Sold as fish feed and fertilizers*
Dirty water from washing area	-	*Drained directly to crop field*

Although the waste management system for this poultry project is well planned, its implementation did not seem satisfactory. As, the area where dead birds are burnt, it was found that certain portions are not burnt properly and scavengers (dogs, crows etc.) scatter these remains in the nearby crop field. Also, foul stench of burnt bodies of dead birds is felt while visiting the dumping/disposal site. The scale at which vaccine vials are used, soon new dumping sites will be required and the soil quality of this specific location will be seriously hampered. The draining of dirty washing water directly in the field seems to be not satisfactory as it contains bleaching powder, chemicals and detergents in greater quantities. Dumping sites of egg-shell will also run out very quickly. The current burying practice also does not seem to be very carefully managed as scavengers take turns in scattering them in the nearby areas.

Proper waste management system is thus required for this modern extra-large facility since the potential hazard from such projects are also expected to be large in equal proportion if not handled properly.

8. Building cumulative environmental effect scenario of BRAC agriculture, fisheries and poultry program

The aforementioned sections elaborated on the existing level of chemical use, waste disposal and management system of the various components of BRAC agricultural, fisheries and poultry program. Although we can obtain a clear picture on the magnitude of chemicals used by individual beneficiaries for his/her own activities, but from the aforementioned analysis we miss out in identifying the overall level of chemical uses and the consequent cumulative environmental implications when such uses persists overtime. The present section, therefore, attempts to provide a picture of cumulative environmental effect by building scenarios of total estimated chemicals used by various components under study.

The assumption is that, the actual use, as observed from the sample survey, represents the use level of all beneficiaries of BRAC undertaking the same activities. In such case, based on the information available in BRAC reports on the targets and achievement of selective indicators of these programs, the overall level of chemical use for the past few years (1992 – 1999) is estimated including its cumulative amount over time. Thereafter, based on such cumulative use level of chemical, a three-year projection is attempted assuming the target of the year 1999 remains constant and reached every year from 2000 to 2002. Although such analysis will not provide a concrete result of the specific environmental effect due to these programs, it will provide an indication on the magnitude of the chemicals used to pursue BRAC's dual objective of "poverty alleviation" and "empowerment of the poor" and potential trade-off between environmental consequences and socio-economic welfare.

As a starting point of the analysis, the past achievements of selected indicators of BRAC program components under study is presented in Table 8.1, 8.2 and 8.3, respectively. As the promotion of modern/hybrid vegetable seeds is a recent phenomenon, information is available only for the year 1999 (Table 8.1). On the other hand, for the BRAC fisheries program, information is available from 1993 – 1999 as well as the cumulative achievement since its inception which is presented in Table 8.2. Similarly, information on BRAC poultry program for the years 1993 – 1999 including cumulative achievement since its inception is provided in Table 8.3. It is clear from Tables 8.1, 8.2 and 8.3 that BRAC programs expand continuously with few exceptions. For example, areas under vegetable cultivation upto year 1999 stands at 40,377 acres followed by rice area 10,368 acres. Similarly, total pond area for fish farming (including culture, nursery and extension ponds) is estimated at 25,181 acres. Also, the numbers of women involved in poultry rearing (including chick and key rearers) is estimated at 1,164,138.

Given these estimates of cumulative achievements from Table 8.1 and the use rates of chemicals appearing in Tables 4.4, 5.6, 5.8, 5.9 and 5.11, a cumulative chemical use level in agricultural program is estimated and is presented in Tables 8.4 and 8.5, respectively.

It is clear from Table 8.4 that based on the actual use level of chemicals for the year 1999, the 3- year and 5-year projection of BRAC seed production farm at Dinajpur seem quite worrying. The same amount of soil, an estimated 6-acre farm, is going to receive such huge levels of chemicals of various kinds in 3 to 5 years time even assuming that there is no increase in the use rates and/or intensity of cropping. Obviously, there will be no ambiguity in realizing the magnitude of the potential adverse environmental effect, particularly, the chemical accumulation in soils, in this small patch of land even if all precautionary measures are undertaken which are currently absent. Also, the surrounding environment, particularly, water and air quality is expected to be deterrent if such activities continue at its present scale. With respect to waste disposal, the current practice of dumping/burying of vials and containers within the farm location will ultimately create further toxicity in soils including excessive proportion of glass, metals and other debris.

However, the practice undertaken in BRAC Research farm at Tongi seem to be less fertilizer intensive as a unique mulching system and poultry litter solution is used (Table 4.7), although the use rate of pesticide remains high (Table 4.6). Therefore, if similar cumulative chemical use scenario is built for this research farm, the picture will not be any better from BRAC seed production farm, and therefore, not reported.

BRAC has undertaken a very ambitious program of diffusing modern agricultural technology, particularly, modern/hybrid varieties of vegetables, maize, wheat and rice in recent years. As such, huge targets are set for the year 1999, which however not reached satisfactory achievement levels. Particularly, achievement was very weak for maize, rice and wheat acerage (Table 8.1). However, as BRAC strategy is quite keen on pursuing its targets and in most case achievements surpasses the target usually set for each program, we assumed that the target for modern technology diffusion set for the year 1999 will be achieved steady from year 2000 to 2002. And as such, a 3-year chemical use scenario is built and the cumulative use level upto year 2002 is presented in Table 8.5.

The picture of chemical uses, particularly fertilizers and pesticides, are astonishingly high. The fertilizer use runs into thousands of tons while pesticides amounts to thousands of kilograms. It should be reminded that the mean use rates are actual farm-level applications estimated from the survey results which are usually lower than the recommended rates set by BRAC program staff. Although this huge use of chemicals is for the nation as a whole, still its potential adverse environmental consequence is not expected to be encouraging by any means.

Fisheries program of BRAC was initiated since 1976 which however, was scaled up in the mid 1980s. The cumulative total area under pond aquaculture is estimated at 25,181 acres operated by 116,354 beneficiaries. As with the case of agricultural program, similar projection of chemical use level in ponds for nursery and culture is estimated based on the actual use level of pond operators estimated from the survey. The mean use rate of chemicals, such as Urea, TSP, MP and lime for the year 1999 is presented in Table 8.6. Also, the use level of poisons for killing competitor and predator fish is estimated. In addition, estimate of organic fertilizer (cowdung) and fish feed (oilcake) is estimated. Then, based on the mean use rates, the cumulative use levels of chemicals, organic fertilizers and fish feed upto the year 1999 since the inception of program is estimated and presented in Table 8.6. The figures that appears from this estimation by no means looks encouraging as substantial amount of chemicals went into pond waters for clearing competitor and predator fish and concentrated on introducing only few varieties of fish, thereby, affecting natural bio-diversity.

As mentioned earlier, since BRAC is very keen on meeting program targets, a 3 year projection is attempted assuming that the target set for the year 1999 is met each year from 2000 to 2002. It is worth mentioning that the target set for 1999 was surpassed in the same year by a large margin. However, to maintain consistency of the analysis, we stick to use the target for the year 1999 as benchmark for any projection. The last column of Table 8.6 provides the final cumulative chemical use scenario for the fisheries program since its inception upto the year 2002. The figures are quite worrying as all these chemicals went into limited amount of pond waters whose average area is around 12 - 15 decimals and depth is around 4 - 5 feet. Although it is claimed that the poisons used in pond waters loses its toxicity in 48 hours (in verbis), no concrete research in validating such claims exists till date.

In case of BRAC poultry program, since no chemicals is used except for potash water to clean hands and feet, building cumulative chemical use scenario is not necessary. The only point of concern is the use of vaccines and management of its disposal. Also the introduction of few exotic varieties will have effect on the diversity of traditional poultry breeds. Heavy concentration of poultry farms in limited area may cause nuisance in the form of foul smell and ambient air pollution.

9. Discussion, conclusion and policy implication

In land scarce country like Bangladesh where land-person ratio is one of the lowest in the world (about 0.2 ha per person) which is coupled with food insecurity and widespread hunger, pursuing rapid technological progress remains the most lucrative option to promote agricultural production. However, as with the case of other developing countries where rapid technological progress, particularly, "Green Revolution" resulted in unexpected adverse socio-economic and environmental consequences, Bangladesh is also facing similar challenges. Land productivity is now on decline (Ali et al, 1997) as well as Total Factor Productivity in agriculture (Rahman and Coelli, 2000). "Decline in soil fertility" due to technological change in agriculture is also claimed by Bangladeshi farmers (Rahman and Thapa, 1999), which are revealed in this study as well.

Among the income generating and employment activities, BRAC's most recent initiative is to promote crop diversification via the route of diffusion of modern and hybrid seed technologies to marginal and small farmers. Although raising land productivity in land scarce country like Bangladesh is the most viable option, infusion of modern/hybrid technology need to be carefully scrutinized as it is coupled with intensive use of chemicals, particularly, inorganic fertilizers, pesticides and growth hormones/vitamins. Also, the technology itself is quite delicate and demanding, which often results in failure and crop loss if not met with proper timing and application of inputs and micro-climatic circumstances.

The present study revealed that contract seed growers use substantial amount of fertilizers, pesticides as well as vitamins for boosting their vegetable and cereal seed production. In certain cases, the actual application rate of these chemicals passes the recommended dose, for example, the case of hybrid maize. Also, frequency of use of pesticides in particular is alarming in both BRAC seed production and research farms as well as in the fields of contract seed growers. On the other hand, although farmers seem to be aware of health hazards associated with chemicals, they unscrupulously uses banned pesticides as these are the only one available and are probably cheaper and show visible results. The belief is that pesticides have more good effects rather than harmful effects, which needs to be properly evaluated. As this perception will boost chemical application whenever their crops are infested with insect/pest and/or disease.

It is encouraging to note that use of bio-fertilizers, particularly, cowdung is also quite common among the contract seed growers and BRAC farms. But introduction of more environment friendly techniques for pest control such as IPM (integrated pest management) is completely absent in BRAC agricultural extension system. Also, investigation reveals that even if BRAC wishes to introduce IPM, the current set-up will not be able to provide this service, as there is no capacity for such venture.

In this drive for crop diversification through modern/hybrid technology, there remains a danger of losing biodiversity and traditional varieties, which are not always necessarily associated with low productivity. Particularly, the sustainability of these modern/hybrid technologies are uncertain which largely depends on modern inputs that are import based and quite demanding on natural resources such as minerals and fossil fuels.

In case of fisheries program, chemicals are used to eliminate competitor and predator fish and use limited exotic varieties, which has direct bearing on reducing natural fish diversity as well as potential water toxification. Although its income generating potential is quite high, the trade-off against environmental effect and sustainability demands careful scrutiny.

The poultry program seems to be quite well suited and is associated with least adverse environmental hazards although it is also promoting exotic birds at the expense of traditional breeds.

In summary, it can be stated that the main route that BRAC chose to pursue income and employment generating activities for its beneficiaries' welfare is through modernization of agriculture, fisheries and poultry production. Although, such modern technologies initially boosts production, but at the later years its production potential reaches an upper limit and begins to taper off towards a saturation point. Also, these technologies are heavily dependent on modern inputs and chemicals, which are largely import-based and/or creates excess demand on natural resources for its supply. Therefore, BRAC should carefully evaluate each of its program components in light of its income generating potential, employment generating potential, demand on chemicals, its consequent impacts on selected components of environment such as soil fertility, water quality, biodiversity, and human health hazard. Current experience suggests that, thus far, BRAC concentrated on only the first two components: income and employment generating potential, without proper attention to other issues as noted above.

Based on the findings from Sections 4 – 8, following recommendations worth consideration:

- promote crop diversification through a combination of traditional and modern/hybrid varieties
- selection of proper production sites for specific crops as these technologies, particularly, vegetable production, are sensitive to micro-climatic environments
- promote use of more organic inputs, such as cowdung, compost, and other bio-fertilizers rather than outright thrust in inorganic chemical application
- promotion of IPM technologies by building own staff capacity as well as its beneficiaries
- promote fisheries diversity using a combination of traditional and exotic fish rather than concentrating on producing limited exotic fishes
- promote poultry diversity using a combination of traditional and exotic breeds instead of few exotic breeds
- introduce intensive environmental awareness campaign among beneficiaries first by building its own capacity in this respect
- collaborate with national/international research organizations to conduct research that are more basic science oriented, for example, impact on soil fertility and water quality from modern/hybrid seed production for a long period

BRAC is a learning organization and has reached international excellence in devising new and unique approaches to rural development. Similarly, in the field of promoting agricultural productivity vis-à-vis improving the welfare of the poor beneficiaries, BRAC needs to go through a phase of learning to adopt/modify modern/hybrid agricultural technologies that are suited to socio-economic and environmental context of Bangladesh.

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Table 3.1 Summary of study samples.

Program components	District	Thana	Village	Sample size
(a) Agriculture program				
• Contract seed growers	Dinajpur	Dinajpur Sadar, Birganj, Birol, Kahabol	22	64
	Bogra	Sherpur, Kahalu	7	17
• BRAC seed production farm	Dinajpur	Dinajpur Sadar	-	1
• BRAC research farm	Gazipur	Tongi	-	1
• BRAC seed processing centre	Bogra	Sherpur	-	1
	Gazipur	Sripur	-	1
Sub-total	3	8	29	85
(b) Fisheries program				
• Nursery ponds: member operated	Dinajpur	Dinajpur Sadar	2	2
	Joypurhat	Joypurhat Sadar	1	1
	Mymensingh	Trishal	2	2
• Culture ponds: member operated	Dinajpur	Dinajpur Sadar	1	1
	Mymensingh	Trishal	1	1
• Culture ponds: BRAC operated	Jessore	Jessore Sadar	-	2
	Jessore	Jhikargacha	-	1
• Hatchery (fish/prawn): BRAC operated	Bogra	Sherpur	-	1
• Hatchery (prawn): BRAC operated	Jessore	Jessore	-	1
Sub-total	5	6	7	12
(c) Poultry program				
• Chick rearers	Dinajpur	Dinajpur Sadar	1	2
	Joypurhat	Joypurhat Sadar	1	1
	Mymensingh	Trishal	1	1
• BRAC poultry project	Bogra	Mirzapur	-	1
Sub-total	4	4	3	5

Table 4.1 Frequency of pesticides used in BRAC foundation seed production farm, Dinajpur.

Crop name	Area	Frequency of pesticides														Frequency of hormones	
	(dec)	Meg aphos	Rip-cord	Sym-bosh	Tap-gar	Redo meal	Di-thane M-45	Azo-drine	No-gos	Mela-thion	Bavis tine	Dime cron	Ders-burn	Tilt	Ruv-ral	Bio-ferty	Theo vit
Unit of doses		ml	ml	ml	ml	ml	gm	ml	ml	ml	gm	ml	ml	ml	gm	ml	gm
Bean	35	3	3	3													
Yardlong bean	20								2			2					
Mungbean	25									2		2					
Bottle gourd	50				8	1	1									2	
Bitter gourd	30	2			8				2								
Ridge gourd	30				1		1					2	2				
Pumpkin	20				1		1					2	2				
Chalkumra	25				1		1					2	2				
Cucumber	10				1		1	2	4		1	2					
Kangkong	5				2					4							2
vatishak	25	4													2		1
Red amaranth	40					2	2						2	2			
Amaranth	15					2	3						2	2			
Tomato	330					2	1		1								
Radish	40						1	3							1		
Eggplant	75	4					1		4							2	
Okra	366							2			2						
Cauliflower	5					2	1	2							2		

Table 4.2 Amount of pesticides used in BRAC foundation seed production farm, Dinajpur.

Crop name	Area	Amount of pesticides used														Amount of hormones	
	(dec)	**Megaphos**	**Rip-cord**	**Sym-bosh**	**Tap-gar**	**Redomeal**	**Di-thane M-45**	**Azo-drine**	**No-gos**	**Mela-thion**	**Bavistine**	**Dimecron**	**Ders-burn**	**Tilt**	**Ruv-ral**	**Bio-ferty**	**Theovit**
Unit of doses		ml	ml	ml	ml	ml	gm	ml	ml	ml	gm	ml	ml	ml	gm	ml	gm
Bean	35	420	420	420													
Yardlong bean	20								160			160					
Mungbean	25									200		200					
Bottle gourd	50				1600	200	200									800	
Bitter gourd	30				960				240								
Ridge gourd	30				120		120					240	240				
Pumpkin	20				80		80					160	160				
Chalkumra	25				100		100					200	200				
Cucumber	10				40		40	80	160		20	80					
Kangkong	5				40					80							40
vatishak	25	400													200		100
Red amaranth	40					320	320						320	320			
Amaranth	15					120	180						120	120			
Tomato	330					2640	1320		1320								
Radish	40						160	480				320			160		
Eggplant	75	1200					300		1200			1200				600	
Okra	366							2928			2928	2928					
Cauliflower	5					40	20	40			40	40					
Sub-total		2020	420	420	2940	3320	2840	3528	3080	280	2948	5528	1040	440	400	1400	140

Table 4.3 Amount of fertilizers used in BRAC foundation seed production farm, Dinajpur

Crop name	Area (dec)	Cowdung (kg)		Urea (kg)			MP (kg)			TSP (kg)	Gyp-sum (kg)	Zinc (kg)	Borax (kg)	Magnesium (kg)
		Sowing (15 days before)	Sowing (3-4 days before)	Land preparation	Sowing (10-15 days after)	Sowing (30-35 days after)	Land preparation	Sowing (10-15 days after)	Sowing (30-35 days after)	Land preparation	Sowing (4-5 days before)	Land preparation	Land preparation	Land preparation
Bean	35	1750	-	7.0	3.5	-	10.5	10.5	-	26.3	10.5	1.4	1.5	1.4
Yardlong bean	20	600	-	4.0	2.0	-	6.0	2.0	-	12.0	6.0	0.8	0.6	0.8
Mungbean	25	na	-	na	na	na	na	na	na	na	na	na	na	na
Bottle gourd	50	3000	-	15.0	15.0	-	10.0	7.5	-	30.0	15.0	2.0	1.5	2.0
Bitter gourd	30	1800	-	9.0	6.0	4.5	6.0	3.0	3.0	18.0	9.0	1.2	0.9	1.2
Ridge gourd	30	1800	-	9.0	9.0	-	6.0	4.5	-	18.0	9.0	1.2	0.9	1.2
Pumpkin	20	1200	-	6.0	6.0	-	4.0	4.0	-	12.0	6.0	0.8	0.6	0.8
Chalkumra	25	1500	-	7.5	7.5	-	5.0	5.0	-	15.0	7.5	1.0	0.8	1.0
Cucumber	10	600	-	3.0	3.0	-	2.0	2.0	-	6.0	3.0	0.4	0.3	0.4
Kangkong	5	300	-	2.0	1.5	1.5	1.0	1.0	0.5	3.8	2.0	0.2	0.2	0.2
vatishak	25	1500	-	15.0	10.0	5.0	5.0	3.8	2.5	15.0	10.0	1.0	1.0	1.0
Red amaranth	40	2000	-	20.0	20.0	-	10.0	6.0	-	30.0	16.0	1.6	1.2	1.6
Amaranth	15	750	-	7.5	7.5	-	3.8	2.3	-	11.3	6.0	0.6	0.5	0.6
Tomato	330	9900	9900	132.0	132.0	132.0	99.0	66.0	33.0	297.0	132.0	13.2	13.2	13.2
Radish	40	2400	-	20	12.0	8.0	12.0	8.0	4.0	32.0	20.0	2.0	1.6	1.6
Eggplant	75	2250	2250	30	30.0	30.0	37.5	22.5	15.0	37.5	22.5	3.0	3.0	3.0
Okra	366	21960	-	146.4	73.2	73.2	109.8	93.2	36.6	366.0	146.4	14.6	14.6	14.6
Cauliflower	5	150	150	1.8	1.8	1.8	0.9	0.9	0.9	4.0	2.5	0.3	0.2	0.2
Sub-total		53460	12300	435.2	421.0	256.0	333.5	222.1	95.5	963.8	423.4	45.3	42.6	44.8

Table 4.4 Mean use rates of pesticides and chemicals in BRAC seed production farm including five year projection.

Inputs	Unit	Total use level in 1999	Mean use rate (mg/ml per dec of net sown area)
Pesticides			
Megaphos	ml	2260	3.77
Ripcord	ml	420	0.70
Symbosh	ml	420	0.70
Tapgar	ml	2940	4.90
Redomeal	ml	3320	5.53
Dithane M-45	gm	2840	4.73
Azodrine	ml	3528	5.88
Nogos	ml	3080	5.13
Melathion	ml	280	0.47
Bavistine	gm	2948	4.91
Dimecron	ml	5528	9.21
Darsban	ml	1040	1.73
Tilt	ml	440	0.73
Rovral	gm	400	0.67
Hormones			
Bioferty	ml	1400	2.33
Theovit	gm	140	0.23
Fertilizers			
Urea	kg	1112.2	1.85
MP	kg	651.1	1.09
TSP	kg	963.8	1.61
Gypsum	kg	423.4	0.71
Zinc	kg	45.3	0.08
Borax	kg	42.6	0.07
Magnesium	kg	44.8	0.07

Table 4.5 Frequency of pesticide used in BRAC Research Farm, Tongi.

Crop name	Area (dec)	Varieties in trial	Frequency of pesticides							
			Melatuff	Tapgar	Dithane M-45	Nogos	Tilt	Kelthane	Lanirate	Ripcord
Unit of doses			ml	ml	gm	ml	ml	ml	gm??	ml
Tomato	384	8	10	2	4					
Chilli	7	7		3	2	2	1			
Pumpkin	8.4	2			1	5		2		
Cabbage	17	8							1	
Cauliflower	5	2							1	
Yardlong bean	3	8		3						4
Radish	6	10	2							
Spinach	1	3				1				
Chinasak	1	1								
Corriander	0.5	1								
Carrot	6	1	2							

Table 4.6 Amount of pesticides used in BRAC Research farm, Tongi.

Crop name	Area (dec)	Varieties in trial	Pesticides							
			Melatuff	Tapgar	Dithane M-45	Nogos	Tilt	Kelthane	Lanirate	Ripcord
Tomato	384	8	38400	7680	30720					
Chilli	7	7		210	280	70	35			
Pumpkin	8.4	2			168	210		84		
Cabbage	17	8							4.3	
Cauliflower	5	2							1.8	
Yardlong bean	3	8		90						24
Radish	6	10	120							
Spinach	1	3				5				
Chinasak	1	1								
Corriander	0.5	1								
Carrot	6	1	120							
Sub-total			38640	7980	31168	285	35	84	6.1	24

Table 4.7 Amount of fertilizers used in BRAC Research farm, Tongi.

Crop name	Area (dec)	Varieties in trial	Cowdung (kg)	Poultry litter solution (litre)	Urea (kg)	TSP (kg)	MP (kg)
Tomato	384	8	26880	38.40	1920	768	768
Chilli	7	7	-	0.35	14	5.3	5.3
Pumpkin	8.4	2	-	0.40	25.5	6.3	12.6
Cabbage	17	8	-	0.85	51	17	17
Cauliflower	5	2	-	0.25	15	5	5
Yardlong bean	3	8	-	0.30	6	3	3
Radish	6	10	-	0.30	12	6	6
Spinach	1	3	-	0.05	2	1	1
Chinasak	1	1	-	0.05	3	1.5	1.5
Corriander	0.5	1	-	-	0.8	0.3	0.3
Carrot	6	1	-	-	2	1	1
Sub-total			26880	40.70	2051.3	814.4	820.7

Table 5.1. Number of contract seed farmers in Dinajpur and Bogra seed farm area.

Crop Name	Number of farmers	Area cultivated (dec.)	Production (kg)	Number of farmers	Area cultivated (dec.)	Production (kg)
Area	**Birganj, Dinajpur**					**Raniganj Seed farm**
Vegetable seeds						
Tomato	1	42	4	-	-	
Radish	12	1000	2495	18	1500	769
Bottlegourd	1	85	160	1	10	3
Bean	2	100	641	5	100	16
Puishak	1	40	80	-	-	-
Spinach	6	250	983	2	100	15
Pumpkin	3	250	46	2	50	-
Yardlong bean	11	430	531	4	150	-
Red amaranth	16	955	264	31	1750	3087
Amaranth	-	-	-	2	100	81
Cucumber	-	-	-	1	10	1
Vatishak	2	70	104	-	-	-
Snakegourd	3	100	135	2	30	1.5
Kangkong	15	1687	3196	22	1500	3219
Okra	-	-	-	19	1550	1461
Bittergrourd	-	-	-	1	10	-
Area	**Sherpur seed farm, Bogra**			**Birol seed farm, Dinajpur**		
Maize	51	5021	113524	7	1500	18015
Wheat	-	-	-	6	3300	50010
Area	**Kahalu seed farm, Bogra**					
Rice	18	486	4900	95	13000	146090

Table 5.2 Distribution of farmers by broad crop groups.

Crop name	Dinajpur		Bogra		Total
	Rabi season	Kharif season	Rabi season	Kharif season	
Vegetables	43	23	-	-	66
Leafy vegetables	28	4	-	-	32
Maize	7	-	7	-	14
Wheat	6	-	-	-	6
Rice	-	-	10	-	10
All crops	84	27	17	-	128

Note: Vegetables include radish (16), okra (10), yardlong bean (9), bean (6), ridgegourd (4), pumpkin (3), tomato (1), eggplant (1), cucumber (1), and bottlegourd (1).
Leafy vegetables include red amaranth (18), kangkong (14), palangsak (8), amaranth (3), chinasak (2) and spinach (1).

Table 5.3 Area cultivated, average yield and gross value of output per acre of various crops.

Crop name	Area cultivated (acre)		Average yield (kg/acre)		Gross value (taka/acre)	
	Mean value	Standard deviation	Mean value	Standard deviation	Mean value	Standard deviation
Vegetables	0.68	0.63	196.09	217.97	14,246.31	14,441.26
Leafy vegetables	0.53	0.50	199.98	142.96	10,817.67	7,956.70
Maize	1.47	1.94	1977.58	402.87	13,426.13	3,242.97
Wheat	5.33	3.20	881.38	578.11	8,912.14	5,752.47
Rice	0.34	0.16	973.7	419.71	8,623.78	3,938.40

Table 5.4. Recommended rate of fertilizer use for the contract seed farmers.

Cropname	Urea	TSP	MP	Gypsum	Zinc	Borax
Vegetables						
Tomato	120	90	30	40	4	4
Radish	100	80	30	50	5	4
Bottlegourd	100	100	35	55	5	5
Snakegourd	80	60	20	30	4	4
Bittergourd	70	50	20	30	3	3
Ridgegourd	80	60	20	30	4	3
Pumpkin	80	60	20	30	4	3
Bean	60	60	20	30	4	3
Yardlong bean	60	60	20	30	4	3
Puishak	100	80	30	40	4	4
Spinach	110	80	20	30	4	3
Red amaranth	100	75	15	40	4	3
Chinasak	100	60	25	40	4	3
Amaranth	100	75	15	40	4	3
Okra	80	100	30	40	4	4
Cereals						
Wheat	80	60	20	45	3	3
Rice	60	50	30	15	3	-
Maize	80	60	20	45	3	3

Table 5.5 Proportion of contract growers using fertilizers in seed production.

Crop name	Fertilizer types						All
	Urea	TSP	MP	Zinc/Gypsu m	Borex	Magnesium	
Farmers using fertilizers	120 (93.8)	126 (98.4)	113 (88.3)	123 (96.1)	55 (43.0)	12 (12.5)	128 (100)
Vegetables	48 (72.7)	49 (72.2)	43 (65.2)	51 (77.3)	21 (31.8)	5 (7.6)	66 (100)
Leafy vegetables	32 (100)	32 (100)	32 (100)	32 (100)	19 (59.4)	6 (18.8)	32 (100)
Maize	12 (85.7)	14 (100)	13 (92.9)	14 (100)	12 (85.7)	1 (7.1)	14 (100)
Wheat	6 (100)	6 (100)	6 (100)	6 (100)	3 (50.0)	-	6 (100)
Rice	10 (100)	10 (100)	9 (90.0)	-	-	-	10 (100)

Table 5.6 Fertilizer application rates and costs per acre of contract seed farmers.

Crop name	Fertilizer use rate (kg/acre)		Fertilizer cost (taka/acre)	
	Mean value	Standard deviation	Mean value	Standard deviation
Vegetables	210.9	139.3	1,959.5	1,185.2
Leafy vegetables	223.7	136.9	2,127.6	1,215.2
Maize	381.4	178.9	3,364.6	1,620.6
Wheat	202.6	76.1	2,001.8	295.5
Rice	117.7	38.9	1,064.8	373.4

Table 5.7. Proportion of farmers using various pesticides for seed production.

Pesticide name	**Number of farmers**	**Farmers using (%)**
Organochlorine {Diathene, Xolon, Nogos}	4	3.12
Organophosphate {Basudin}	1	0.78
Organophosphorus {Dimecron, Sumithion, Diazinon, Melathion}	34	26.56
Carbamate {Furadan}	6	4.68
Synthetic pyrithroid {Ripcord, Cymbush}	36	28.12
Fungicide {Redomyl, Tilt}	3	2.34
Dersban	53	41.4
Sifanan	4	3.1
Symbar	1	0.1
Azodrin	16	6.3
Secufon	1	0.78
Relithion	4	3.12
Tafgar	3	2.34
Ostad	4	3.12
Regent	2	1.56
Okosam	1	0.78
Cap	5	3.90
Megaphos	1	0.78
Rezonil	1	0.78
Benicron	1	0.78

Table 5.8 Pesticide application rates and costs per acre of contract seed growers.

Crop name	Pesticide use rate (ml or gm/acre)		Pesticide cost (taka/acre)	
	Mean value	Standard deviation	Mean value	Standard deviation
Vegetables	1391.7	3567.6	599.9	608.2
Leafy vegetables	565.7	543.4	428.7	511.8
Maize	1259.3	1470.8	493.9	389.5
Wheat	95.8	158.4	85.7	165.8
Rice	2809.5	5413.2	334.2	514.9

Table 5.9 Vitamin application rates and costs per acre of contract seed farmers.

Crop name	Vitamin use rate (gm or ml/acre)		Vitamin cost (taka/acre)	
	Mean value	Standard deviation	Mean value	Standard deviation
Vegetables	440.4	934.7	110.9	220.2
Leafy vegetables	204.4	476.3	66.2	100.8
Maize	-	-	-	-
Wheat	-	-	-	-
Rice	800.0	1686.6	60.0	129.6

Table 5.10 Proportion of contract growers using bio-fertilizers in seed production.

Crop name	Bio-fertilizers					All
	Cowdung	Ash	Compost	Poultry litter	Oilcake	
Farmers using fertilizers	113 (88.3)	5 (3.9)	2 (1.6)	4 (3.1)	1 (0.8)	128 (100)
Vegetables	58 (87.9)	3 (4.5)	1 (1.5)	3 (4.5)	-	66 (100)
Leafy vegetables	28 (87.5)	1 (3.1)	1 (3.1)	1 (3.1)	-	32 (100)
Maize	12 (85.7)	1(7.1)	-	-	1 (7.1)	14 (100)
Wheat	6 (100)	-	-	-	-	6 (100)
Rice	9 (90.0)	-	-	-	-	10 (100)

Table 5.11 Bio-fertilizer application rates and costs per acre of contract seed farmers.

Crop name	Bio-fertilizer use rate (kg/acre)		Bio-fertilizer cost (taka/acre)	
	Mean value	Standard deviation	Mean value	Standard deviation
Vegetables	3059.5	2965.3	598.8	571.9
Leafy vegetables	2923.8	2746.1	662.1	687.6
Maize	5412.3	3990.2	935.7	636.8
Wheat	2248.3	1368.3	330.0	193.3
Rice	2069.9	2071.5	404.9	284.9

Table 5.12 Symptoms of sickness after handling pesticides as responded by farmers.

Symptoms of sickness after handling pesticides as responded by farmers	Responses (%)
Feeling sick	23.5
Tired/ feel weak	17.2
Vomiting tendency/ headache/ bodyache	4.9
Burning sensation in eyes/chest/from knee down	4.9
Do not feel hungry	2.5
Do not feel sick	75.3
Non-response	1.2

Note: Multiple response meaning total will be more than 100.

Table 5.13. Sources of precautionary measures learned.

Sources of precautionary measures learned	Responses (%)
Sources	
BRAC staff	43.2
Written instruction in bottles/leaflet	27.1
From neighbours	16.0
Agricultural extension office	3.7
Chemical dealer	3.7
Block supervisor	2.4
Media (radio, TV)	1.2
Pysicians	1.2

Note: Multiple response meaning total will be more than 100.

Table 5.14 Precautions taken during pesticide application by contract seed farmers.

Precautions taken during pesticide application	Responses (%)
Examples	
Cover the face with cloth/mask/eye-glasses etc.	86.7
Spraying in the direction of wind flow	6.2
Using cap/plastic helmet	12.5
Wearing shirts	3.1
Wearing polythene packets as hand-gloves	4.7
Spray pesticide before meals	2.3
Spray pesticide during evening so as not to harm useful insects	3.1
Did not use pesticides	13.3

Note: Multiple responses meaning total may exceed hundred.

Table 5.15 Examples of storing chemicals as responded by farmers.

Examples of storing chemicals as responded by farmers	Responses (%)
Examples	92.6
Keep in safe place at home/ keep in locked place/ keep in a specific place	49.4
Keep outside reach of children	24.7
Keep in secret place at home/in toilet	7.4
Keep in dry place at home	7.4
Keep anywhere in the home	3.7
Keep in polythene wrap	2.4
Do not know/ did not use	7.4

Note: Multiple response meaning total will be more than 100.

Table 5.16 Examples of disposing empty chemical cans as responded by farmers.

Examples of disposing empty chemical cans as responded by farmers	Responses (%)
Examples	90.2
Bury in soil	53.1
Clean and re-use for other purpose	11.1
Keep anywhere at home	9.8
Throw in the woods	4.9
Throw in river/waterbody	4.9
Wash and kids sell them	4.9
Keep in specific place	3.7
Did not use	4.9
Non-response	4.9

Note: Multiple response meaning total will be more than 100.

Table 5.17 Good effects of pesticide use as opined by farmers.

Good effects of pesticide use in crops as opined by farmers	Responses
Have good effects	92.7
Increases production	85.2
Inset and pests cannot do any harm	31.2
Improve quality of crop/seed	14.8
Reduces rot in crops	2.4
Non-use of pesticides damages production	2.4
Prevents dropping of flowers during crop growth stage	1.2
Prevents damage in leaf	1.2
No good effects	2.4
Non-response	4.9

Note: Multiple responses meaning total will be more than 100.

Table 5.18 Harmful effects of pesticide use as opined by the farmers.

Harmful effects of pesticides used as opined by the farmers	**Responses (%)**
Have harmful effects	37.3
Useful insects and animals (honey-bee, frog, earthworm) die	9.9
Effects human health	8.6
Damages crop and flowering due to excessive use	7.8
Damages soil fertility/leads to increase in fertilizer doses	7.4
Birds die	4.9
Effects the environment/damages environmental balance	3.7
Food gets poisonous	1.2
Reduces fish	1.2
Increases crop pests	1.2
If inhaled causes stomach pain	1.2
No harmful effects	49.4
Did not examine whether have any harmful effects	8.6
Non-response	3.7

Note: Multiple response meaning total will be more than 100.

Table 5.19 Examples of adverse environmental impacts associated with modern agricultural technology adoption.

Examples of adverse environemntal impacts associated with modern agricultural technology adoption as responded by farmers	**Responses (%)**
Examples	39.5
Beneficial insects and animals (frogs, grasshoppers, bees) are dying	16.1
Disease in human increasing	8.6
Earthworm in soils declining due to pesticide use	7.4
Fish production is declining	6.2
Lacking vitamins in vegetables	6.2
Soil fertility is declining	4.9
Natural balance is damaging/ environment is deteriorating	4.9
Bird population is declining	2.5
Air pollution increasing	2.5
Increasing insects	1.2

Note: Multiple response meaning total will be more than 100.

Table 5.20 Perception on adverse environmental impacts associated with modern agricultural technology adoption.

Adverse environmental impacts associated with modern agricultural technology adoption	**Farmers responding in the affirmative (%)**	**Index weighted by rank of responses[a]**	
		Index	Rank
Reduces fish catch	97.5	0.844	1
Increase pest attack	87.7	0.575	2
Reduces soil fertility	61.7	0.541	3
Effects human health	75.3	0.536	4
Increase disease	90.1	0.486	5
Compact the soil	53.1	0.232	6
Deteroriates nearby water body	14.8	0.069	7
Increase soil erosion	6.2	0.022	8
Causes chemical runoff in water	3.7	0.017	9
Leaves chemical residues in soil	3.7	0.016	10
Creates water logging	3.7	0.015	11
Increase soil salinity	1.2	0.007	12

Note: Multiple response meaning total will be more than 100.
The higher the index, the stronger the perception.
[a] Ranking done by weighting individual resposnes by their ranks.
Index = $\{R_{VH}(1.0) + R_H(0.8) + R_M(0.6) + R_L(0.4) + R_{VL}(0.2) + R_0(1.0)\}/N$,
where R_{VH} = very high rank, R_H = high rank, R_M = medium rank, R_L = low rank, R_{VL} = very low rank, and R_0 = farmers responding in the negative, respectively. N = sample size.

Table 6.1 Amount of input recommended by nursery ponds

Poison, fertilisers, food and lime	BRAC recommendation rates (Hossain in verbis, 2000)		FRI recommendation rates (FRI in verbis, 2000)	
	Pond preparation requirement (gm/dec)	Continuous requirement (gm/dec)	Pond preparation requirement (gm/dec)	Continuous requirement (gm/dec)
Poison				
Rotenone	16 – 18 per feet of water depth (concentration 9.1%)	-	160 per decimal	-
Rotenone	18 – 25 per feet of water depth (concentration 7.0%)	-	-	-
Dipterax (or)	10 – 12 per feet of water depth	-	20 gm	-
Sumithion	2 – 3 ml per feet of water depth	-	-	-
Kerosene (or) diesel	100 – 125 ml for average 3 feet of water depth	-	-	-
Copper sulphate	-	-	8 – 10 gm/dec (weed control)	-
Bleaching powder	-	-	1200 gm/dec	-
Phostoxin	-	-	3-5 tablets/dec	-
Secophone	-	-	20 gm/dec	-
Inorganic fertilisers:		weekly basis		Fortnightly depending on water quality
Urea	100	50 – 100	100	100
TSP	50	25 – 50	100	100
MP	25	-	-	-
Organic fertilisers		weekly basis		
Cow dung (or)	6000 – 10000	500 – 1000	40,000	-
Poultry litter	3000 – 5000	250 – 500	20,000	-

Poison, fertilisers, food and lime	BRAC recommendation rates (Hossain in verbis, 2000)		FRI recommendation rates (FRI in verbis, 2000)	
	Pond preparation requirement (gm/dec)	**Continuous requirement (gm/dec)**	**Pond preparation requirement (gm/dec)**	**Continuous requirement (gm/dec)**
Food		daily basis	-	-
Rice bran	-	total of 5% of fish biomass weight	-	-
Mustard oil cake	-	250 – 500	-	-
Lime	1000 – 2000	250 – 300 for every 3 – 4 months of culture	1000	-

Table 6.2 Use of poison in BRAC fish nursery and culture ponds.

Pond location	Culture type	Date started	Area (dec)	Depth (feet)	Poison used in pond preparation		Type of fish grown
					Name	Amount used (ml)	
Asgar Ali (1) Dinajpur	Nursery	1999	26	4	Sumithion	100	Silver carp
Asgar Ali (2) Dinajpur	Culture	1996	48	5	Phostoxin	300	Multiculture
Aminul Islam Dinajpur	Nursery	1999	75	4	Rotenone	1500	Silver carp
Mahmuda Joypurhat	Nursery	1999	36	4	Sumithion	100	Japanese Curfue
Jahan Ara (1) Mymensingh	Culture	1995	30	5	None	De-watering	Multiculture: Grass carp, Silver carp, Rui, Katla, Mrigel, Sarputi, Curfue
Jahan Ara (2) Mymensingh	Nursery	1998	12	5	Rotenone	216	Multiculture: Grass carp, Silver carp, Rui, Katla, Mrigel, Sarputi, Curfue
Rahima Mymensingh	Nursery	1996	12	3	Rotenone	240	Silver carp
BRAC (1) Jessore	Culture	1999	400	5	Rotenone	7200	Pangas
BRAC (2) Jessore	Culture	1994	100	7	Lime	100,000	Pangas
BRAC (3) Jessore	Culture	1994	20	5	Lime	20,000	Pangas

Table 6.3. Amount of fertilizers and food used in BRAC nursery and culture ponds.

Pond location	Culture type	Area (dec)	Input type	Actual amount used		Recommended Requirement	
				Pond preparation	Continuous requirement	Pond preparation	Continuous requirement
Asgar Ali (1)	Nursery	26	Urea	2000	?	2600	?
Dinajpur Sadar			TSP	1000		1300	
Dinajpur			MP	500		550	
			Cowdung	75,000		86,000>	
			Rice bran	-		-	
			Oil cake	-		-	
			Lime	12,000		26,000	
Asgar Ali (2)	Culture	48	Urea	9600	?	4800	?
Dinajpur Sadar			TSP	4800		2400	
Dinajpur			MP	2400		1200	
			Cowdung	187,500		288,000>	
			Rice bran	-		-	
			Oil cake	-		-	
			Lime	56,250		48,000	
Aminul Islam	Nursery	75	Urea	7500	?	7500	?
Dinajpur Sadar			TSP	5000		5000	
Dinajpur			MP	2500		2500	
			Cowdung	450,000		450,000	
			Rice bran	-		-	
			Oil cake	-		-	
			Lime	7500		7500	

Pond location	Culture type	Area (dec)	Input type	Actual amount used		Recommended Requirement	
				Pond preparation	Continuous requirement	Pond preparation	Continuous requirement
Mahmuda Joypurhat Sadar Joypurhat	Nursery	36	Urea	2000	?	3600	
			TSP	1800		1800	
			MP	4000		900	
			Cowdung	30,000		216,000	
			Rice bran	-		-	
			Oil cake	-		-	
			Lime	10,000		36,000	
Jahan Ara Trishal Mymensingh	Culture	30	Urea	4000	?	3000	
			TSP	2000		1500	
			MP	-		750	
			Cowdung	75,000		180,000	
			Rice bran	-		-	
			Oil cake	75,000		-	
			Lime	10,000		30,000	
Jahan Ara Trishal Mymensingh	Nursery	12	Urea	2000	?	1200	
			TSP	500		600	
			MP	-		300	
			Cowdung	120,000		72,000	
			Rice bran	-		-	
			Oil cake	-		-	
			Lime	4000		12,000	
Rahima Trishal Mymensingh	Nursery	12	Urea	2000	-	1200	-
			TSP	1000	-	600	-
			MP	500	-	300	-
			Cowdung	120,000	-	72,000	-
			Rice bran	-	-	-	-
			Oil cake	-	250	-	250
			Lime	24,000	500	12,000	500

Pond location	Culture type	Area (dec)	Input type	Actual amount used		Recommended Requirement	
				Pond preparation	Continuous requirement	Pond preparation	Continuous requirement
BRAC Pond (1) Jhikargacha Jessore	Culture	400	Urea TSP MP Cowdung Rice bran Oil cake Lime	40,000 20,000 20,000 4,000,000 - - 400,000	- - - - - - 100,000 every 3 months	0,000 20,000 20,000 4,000,000 - - 400,000	- - - - - - 100,000 every 3 months
BRAC Pond (2) Jessore Sadar Jessore	Culture	100	Bone meal20% Rice polish 40% Soy oilcake20% Wheat bran10% Lime	- 100,000	100,000 @ 3% of body weight daily upto 1 year 250,000 every 3 months	-	100,000 @ 3% of body weight daily upto 1 year 250,000 every 3 months
BRAC Pond (3) Jessore Sadar Jessore	Culture	20	Bone meal20% Rice polish 40% Soy oilcake20% Wheat bran10% Lime	- 100,000	100,000 @ 3% of body weight daily upto 1 year 250,000 every 3 months		100,000 @ 3% of body weight daily upto 1 year 250,000 every 3 months

Table 8.1 Achievements of BRAC Agricultural Programs.

Components	Target and achievements		
	Upto Dec. 1998	Target for 1999	Cumulative upto October 1999
VO members			
Vegetable growers (persons)	57577	134184	106060
Vegetable area (acres)	19695	35120	29369
Maize area (acres)	-	13394	1797
Cotton area (acres)	-	1916	327
Sunflower area (acres)	-	4994	174
Rice area (acre)	-	34637	4673
Wheat area (acres)	-	14325	-
Marginal farmers			
Vegetable growers (persons)	-	65673	25212
Vegetable area (acres)	-	35707	11008
Maize area (acres)	-	17478	910
Cotton area (acres)	-	3254	898
Sunflower area (acres)	-	8199	164
Rice area (acre)	-	45473	5695
Wheat area (acres)	-	26215	42

Table 8.2. Targets and achievements of BRAC Fisheries Program.

Program components	Achievements of fisheries program								
	Cumulative upto Dec. 1992	1993	1994	1995	1996	1997	1998	1999	Cumulative upto Dec. 1999
Fish farmer (persons)	12690	15029	12749	11910	20831	17388	38492	21505	105616
Pond area (Acres)	1268	1895	2881	1921	3537	3202	8225	3411	21949
Nursery operator (persons)	240	283	495	505	616	696	713	-	3548
Nursery pond area (Acres)	107	48	174	137	196	100	300	-	895
Fish extension worker (Fry/fingerling producer)	-	-	-	-	-	-	-	7190	7190
Extension pond area (Acres)	-	-	-	-	-	-	-	2337	2337

Note: Cumulative figures for 1999 does not follow from subsequent addition probably due to reporting error owing to revision during 1996 – 1999 period.

Table 8.3 Achievements of BRAC poultry program.

Program components	Achievements of fisheries program								
	Cumulative upto Dec. 1992	1993	1994	1995	1996	1997	1998	1999	Cumulative upto Dec. 1999
Poultry workers	20707	2081	10864	4780	3474	7456	4625	2775	42160
Chick rearers	4321	1515	3986	2882	1635	3736	2971	2005	13658
Feed sellers	490	317	708	1285	141	157	61	-	1236
Key rearers	341446	113995	182663	258356	53028	350002	229710	24914	1150480
Day old chick distributed	1.53	2.31	5.20	5.23	5.96	7.93	8.65	10.24	47.05

Note: Cumulative figures for 1999 does not follow from subsequent addition probably due to reporting error owing to revision during 1996 – 1999 period.

Table 8.4 Cumulative use levels of pesticides and chemicals in BRAC seed production farm including five year projection.

Inputs	Unit	Total use level in 1999	Mean use rate (mg/ml per dec of net sown area)	Projected cumulative use from 1999 to 2002	Projected cumulative use from 1999 to 2004
Pesticides					
Megaphos	ml	2,260	3.77	6,780	11,300
Ripcord	ml	420	0.70	1,260	2,100
Symbosh	ml	420	0.70	1,260	2,100
Tapgar	ml	2,940	4.90	8,820	14,700
Redomeal	ml	3,320	5.53	9,960	16,600
Dithane M-45	gm	2,840	4.73	8,520	14,200
Azodrine	ml	3,528	5.88	10,584	17,640
Nogos	ml	3,080	5.13	9,240	15,400
Melathion	ml	280	0.47	840	1,400
Bavistine	gm	2,948	4.91	8,844	14,740
Dimecron	ml	5,528	9.21	16,584	27,640
Darsban	ml	1,040	1.73	3,120	5,200
Tilt	ml	440	0.73	1,320	2,200
Rovral	gm	400	0.67	1,200	2,000
Hormones					
Bioferty	ml	1,400	2.33	4,200	7,000
Theovit	gm	140	0.23	420	700
Fertilizers					
Urea	kg	1,112.2	1.85	3,336.6	5,561.0
MP	kg	651.1	1.09	1,953.3	3,255.5
TSP	kg	963.8	1.61	2,891.4	4,819.0
Gypsum	kg	423.4	0.71	1,270.2	2,117.0
Zinc	kg	45.3	0.08	135.9	226.5
Borax	kg	42.6	0.07	127.8	213.0
Magnesium	kg	44.8	0.07	134.4	224.0

Table 8.5. Cumulative use levels of chemicals in BRAC agricultural program.

Inputs	Mean use rate	Estimated cumulative use upto 1999	Projected cumulative use from 1999 to 2002 based on reaching target of 1999 each year	Projected cumulative use upto year 2002
Fertilizer (combined)	**kg/acre**	**kg**	**kg**	**kg**
Vegetables	210.9	8,515,509.3	44,812,242.9	53,327,752.2
Leafy vegetables	223.7	-	-	-
Maize	381.4	1,032,449.8	35,323,742.4	36,356,192.2
Wheat	202.6	8,509.2	24,640,212.0	24,648,721.2
Rice	117.7	1,220,313.6	28,286,841.0	29,507,154.6
Pesticides (combined)	**kg/acre**	**kg**	**kg**	**kg**
Vegetables	1.39	56,124.0	295,348.6	351,472.6
Leafy vegetables	0.57	-	-	-
Maize	1.26	3,410.8	116,696.2	120,107.0
Wheat	0.10	4.2	12,162.0	12,166.2
Rice	2.81	29,134.1	673,051.2	702,185.3
Vitamin (combined)	**kg/acre**	**kg**	**kg**	**kg**
Vegetables	0.44	17,765.9	93,491.6	111,257.5
Leafy vegetables	0.20	-	-	-
Maize	-	-	-	-
Wheat	-	-	-	-
Rice	0.80	8,294.4	192,264.0	200,558.4
Bio-fertilizers (combined)	**ton/acre**	**ton**	**ton**	**ton**
Vegetables	3.06	123,553.6	650,191.9	773,745.5
Leafy vegetables	2.92	-	-	-
Maize	5.41	2,707.0	501,052.6	503,759.6
Wheat	2.25	94.5	273,645.0	273,739.5
Rice	2.07	21,461.8	497,483.1	518,944.9

Table 8.6. Cumulative use levels of chemicals in BRAC fisheries program.

Inputs	Total use level in 1999	Mean use rate (mg/ml per dec of net sown area)	Cumulative use upto 1999	Projected cumulative use from 1999 to 2002 based on reaching target of 1999 each year	Projected cumulative use from 1999 to 2002
Fertilizers	**kg**	**kg/dec**	**kg**	**kg**	**kg**
Urea	69.1	0.11	2,769.91	1,016.4	3,786.31
MP	29.9	0.05	1,259.05	462.0	1,721.05
TSP	36.1	0.06	1,510.86	554.4	2,065.26
Lime	723.8	1.13	28,454.53	10,441.2	
Pesticide	**gm or ml**	**gm or ml/dec**	**gm or ml**	**gm or ml**	**gm or ml**
Rotenone	9,156	18.34	461,819.51	169,461.6	631,281.11
Sumithion	200	3.22	81,082.82	29,752.8	110,835.62
Organic fertilizers	**kg**	**kg/dec**	**kg**	**kg**	**kg**
Cowdung	5,057.5	7.91	199,181.71	73,088.4	272,270.11
Fish feed	**kg**	**kg/dec**	**kg**	**kg**	**kg**
Oilcake	75.0	0.12	3,021.72	1,108.8	4,130.52