

# Assessing the Overuse and Health Costs of Pesticide Use in Crop Cultivation: Findings from a Micro-level Study

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## Abstract

Pesticides are widely used in agricultural production to prevent and control pests, diseases, weeds, and other plant pathogens to reduce or eliminate yield losses and maintain high product quality. Chemical pesticides can cause undesirable effects on human health and also to the environment because of misuse that concerned with its overuse and exposure to human health and environment. This paper made an attempt to examine the current pesticide use practices for agriculture in Keraniganj Upazilla of Dhaka district in Bangladesh. It analyzed the overuse of pesticide and short-term health costs of pesticide exposure using primary data purposively collected from 60 farmers from the study area. It found that the farmers used 21479.4 grams of extra pesticides commonly used in Bangladesh than the recommended amounts that should be used for the 5 different types of crops: *boro* paddy, cauliflower, potato, eggplant, red leaf vegetable, and gourd leaf vegetable for per acre of land. This generates an additional production cost of Tk.65,640.07 per acre in each growing season. Using the cost of illness (COI) method it is founded that the average health cost generated from pesticide application was estimated to be Tk.284.09 for one incidence of pesticide use related health problem. About 3.3% of the pesticide applicators were found to face breathing problem, 10% faced skin diseases, 13.3% diarrhea, 8.3% eye irritation and 18.3% headache because of pesticide pollution. It is also understood that 88.3% of the surveyed farmers were unaware about the side-effects of pesticide use, while 98.3% applicators did not use any special dress or personal protective equipment (PPE) and 61.7% used no mask during pesticide application in their crop fields. It is also found that there is an absence of bio-pesticide use in the study area. Based on the study findings this paper indicates that there is a need for rigorous training and knowledge sharing efforts among the pesticide applicators in the study area as well as in the entire country. Policy makers and the Agriculture Extension Department (AED) thus are particularly expected to address the issue with utmost importance to ensure proper use of pesticides for agriculture in the country.

**Keywords:** Pesticide overuse, Cost of illness, Bangladeshi agriculture, Excessive production cost

## 1. INTRODUCTION

Agriculture sector plays a very crucial role in Bangladesh economy. According to the BBS, agricultural sector's share in country's GDP was 11.50% (BER, 2022). Among the total employment, 45.33% of the country's employments are generated by agricultural sector (LFS, 2022). In addition, the sector also plays a crucial role in ensuring country's food security. Since the independence, Bangladesh's agriculture sector has shown remarkable changes, particularly foodgrain production increased by about 4.5 times between 1971-72 to 2020-21, while the population increased by 2.6 times [Bangladesh Economic Review, 2022]. High yielding varieties (HYV) seeds, use of fertilizers and pesticides and increasing mechanization have contributed much in this regard. Despite that, issues like overuse of

fertilizers and pesticides and workers" occupational health safety remained some key areas of concerns for Bangladesh's agriculture sector that demands immediate attention.

Pesticide is a very important input in agricultural production, but the use of chemical pesticides may be very harmful for human health and also for the environment (Alauddin et al., 1995, p. 242; Nepal, 2010). But identifying the exactness of the damages due to pesticide use is quite difficult. Some pesticides have instant observable effects if they are consumed directly by human body, but most of the pesticide applicators are unaware about the impacts of pesticides on human health because of rather slow poisoning effect. Health impacts from pesticides depend on the pesticide exposure of the effected person. Farmers" exposure to pesticides in agriculture is higher when protective measures used by the farmers are improper (Damalas, 2016). Percentage-wise very less applicators use personal protective equipment during pesticide handling in Bangladesh (Shubhra, 2013; Huq, 2005).

The use of chemical pesticides for pest controlling is an unsustainable process (Wilson, 2000). Because of the increased pest attacks and increased pest varieties in Bangladesh the intensity of pesticide use (quantity per hectare) in recent years has increased. On the other hand, the pesticide productivity in Bangladesh has been declining, at a rate of -8.6% per year (Rahman, 2013). According to a study Shubhra (2013), among the applicators, 64.22% farmers in Bangladesh used hazardous pesticides and 9.06% used highly hazardous pesticides in 2010. About 47% of farmers were found to be overusing pesticides, with an average overuse rate of 3.4 kg per growing season (Dasgupta et al., 2006). One of the reasons for this overuse is farmers" lack of proper knowledge and training about pesticide use. Farmers are unaware about the excessive cost they need to bear as a result of this overuse of pesticides in agriculture.

Health of agricultural workers largely depends on pesticide and fertilizer use practices for the applicators. But not many studies have been conducted to assess applicators" health costs due to pesticide or fertilizer use. Thus economic valuation of workplace hazards of farmers in Bangladesh is necessary to be analyzed as over 40% of the country"s labor force are farmers. The National Institute of Cancer Research and Hospital found in a report that in 2017 among the male cancer patients, 64% were related to agricultural works, which was 60% in 2015. Also among the male and female cancer patients, 34% were occupationally farmers. Many other studies also showed that there are health issues faced by the farmers because of pesticide use in different countries (DEV, 2007). ATREYA (2007) analyzed that one of the reasons for this increase of cancer disease among the farmers is improper way of pesticide use.

Against this backdrop this paper made an effort to address the health impacts of pesticide use on Bangladeshi farmers. It also tried to show a careful assessment of the current situation of pesticide overuse in Bangladesh from an economic view point. It addressed the need for increasing farmers" awareness and knowledge levels and also an improved role of policymakers and agriculture extension agents in the rural Bangladesh. After achieving some success on food security, now government"s main focus is to ensure nutrition security and promote safe food production. It is mentionable here that the exports of vegetables from Bangladesh are gradually increasing, which also have created the demand for good agricultural practices (GAP) in the country. In this situation, improvement in safe pesticide use practices and exploring options like the use of bio-pesticides demand serious policy attention in Bangladesh. This paper also addressed the issue of large-scale ignorance among farmers on the use of bio-pesticides.

The goal of this paper was to present the need of the proper use of pesticides for agriculture in Bangladesh by analyzing its overuse and health costs to farmers, while the specific objectives were: to estimate additional production cost of excessive use of pesticides for crop production for farmers; and to quantify the health effect of pesticide use by farmers for not taking due precautionary measures at the time of pesticide spraying.

This present paper being based on a micro-level study based on a small sample and a smaller study area are thus expected to have all limitations commonly found in such studies. A larger sample size scientifically drawn from a bigger study area could certainly produce results that could be considered with higher confidence level. Furthermore, the study findings are based on a purposive sampling technique, although there are certain limitations that can be accruing to this unscientific sampling based study but this study has the scope of presenting a scenario of the pesticide overusing behavior of farmers and the health hazards pesticide create on them due to negligence. This paper thus aims to create evidence on the need to generate mass awareness among the farmers about the impacts of improper pesticide use. Not many recent works are found to have focus on the occupational health of the pesticide using farmers in the country. This paper thus tries to show the improper practices of pesticide use by the farmers, which is imposing health cost and excessive cost generating because of pesticide overuse on farmers.

## 2. LITERATURE REVIEW

With increase in population, there is also an increase in food production around the world, but the pressure across the developing world appears to be even higher as their population growth is higher than that of the developed world. This demands the countries to use high productive inputs such as chemical pesticides, fertilizers, etc. Unfortunately alternatives to chemical pesticide are costlier for farmers in the developing countries. Farmers' cost of production in the developing world becomes even higher as they are often ignorant and unaware about the proper use of chemical pesticides and often end up using excessive quantities. Moreover, they have little knowledge about the side effects of using chemical pesticides without proper measures. This not only causes health problems, but also costs them more as input cost in agricultural production. It is also not free from environmental consequences.

Literatures on health exposure and costs of illness on pesticide using farmers support this proposition that farmers across the developing countries like Bangladesh because of lack of knowledge and awareness often end up causing health problems due to overuse of chemical pesticides for their agricultural produces. The most notable literatures on these issues are reviewed below:

### ***Pesticide Exposure:***

Pesticides can cause undesirable effects on human health and the environment. The risk from pesticides depends on the toxicity of the material and the possibility of exposure when used. Farmers are routinely exposed to high levels of pesticides continuously. Farmers' exposure mainly occurs during the preparation and application of the pesticide spray solutions and the cleaning-up of spraying equipment (Damalas, 2016). Available studies showed that the probability of falling sick from pesticide-related symptoms is 133% higher among the pesticide applicators compared to the non-applicators (Kishor, 2007). Farmers' exposure to pesticides can be reduced through less use of pesticides and the correct use of the appropriate type of personal protective equipment in all stages of pesticide handling (Koutroubas, 2016).

### ***Pesticide Use in Bangladesh:***

In developing nations like Bangladesh many old, non-patented, more toxic, environmentally persistent, and inexpensive types of chemicals are used extensively, creating significant acute health problems and also causing local environmental contamination (Eleftherohotinos, 2011). Studies also showed that pesticide use in the underdeveloped regions of Bangladesh is higher (Rahman, 2003). Shubhra (2013) laid out the fact that, in Bangladesh 64.22% and 9.06%, farmers used moderately and highly hazardous pesticides respectively in the year 2010. These not only cause health hazards and extra costs of inputs to the farmers, but also create enormous impacts on the local environment.

### ***Pesticide Overuse Tendency among Farmers:***

The tendency of overusing pesticides is present among the farmers. A study showed that as many as 47% farmers were found to have overused pesticides, with an average overuse rate of 3.4 kg per growing season in Bangladesh (Mainul, 2005). Excessive use of pesticides often not only causes such hazards, but their level of productivity also declines and thus costing farmers more for their agricultural production. An analysis on pesticide use in Bangladesh over a period of 33 years (1977–2009) showed that although pesticide use grew at an alarming rate of 10.0% per year in Bangladesh, pesticide productivity was found to be declining steadily at a rate of -8.6% per year (Rahman, 2013). The overusing scenario is also observed in different other countries. A study in Kuttanad, India showed that there is excessive use of pesticides in rice production, from the lowest excessive use of 17.5% for a particular pesticide to the highest excessive use of 233.33% for another particular pesticide (Indiradevi, 2007). In most cases farmers are found to be ignorant about the exact level of pesticides to be used in pesticide using crop production in the developing countries.

### ***Health Effect of Pesticide Use:***

Farmers face several health issues generated from pesticide use because of high exposure. Pesticide use causes eye irritation, neurological issues like headaches, dizziness, gastrointestinal issues like vomiting, respiratory issues like shortness of breath, dermal issues like skin irritation, and fever on farmers health (Muhammad, 2011; Nepal, 2010; Kishor, 2007; Elspeth White, 2004). The health effect of pesticide is observable worldwide. About 5 million people die every year as a result of intentional, accidental, and occupational exposure to pesticides worldwide (Singh and Gupta, 2009). The World Health Organization (WHO) and the United Nations Environment Program (UNEP) estimated pesticide poisoning rates of 2-3 per minute.

Many studies showed the health impacts into monetary values which make the fact to understand economically. A study by Indiradevi (Indiradevi, 2007) found that the welfare loss from total acute health damages from pesticide exposure in the Indian State of Kerala is Rs.18 crores per year. Another study by Muhammad (2011) analyzed that farmers have a positive willingness to pay which is 8.1% of the pesticide cost for avoiding pesticide-related health risks in Pakistan. The study conducted by Kishor (2007) estimated the annual health cost resulting from pesticide exposure is estimated to be US\$ 15,797 per year in Nepal. The study by Elspeth White (2004) analyzed that \$6 million to \$36 million per year can be saved if air-borne pesticide inhalation can be reduced. According to the analysis of Atreya (Atreya, 2012), predicted costs of illness, defensive expenditures, annual expenditure on chemical pesticides, and opportunity costs of spraying time ranges from NRs1,906 to NRs2,460 in the Kavrepalanchowk district of Nepal per individual per year time period.

### ***Effects of Pesticide on Farmers' Health in Bangladesh:***

In Bangladesh too, many studies are found to have analyzed the occurrence of health problems among the farmers due to pesticide exposure. The study by Nepal (2010) investigated the use of pesticides in vegetable farms and found that during pesticide use, farmers felt burning sensations of the skin, breathing problems, itching, and dizziness, and burning in their eyes. Another study by Mainul (2005) analyzed that 49% of farmers experienced at least one health issue, 26% of the respondents experienced multiple health effects. The results showed that the major health issues faced by the farmers were neurological (such as headaches, dizziness, eye irritation, dermal or skin problem, and gastrointestinal (like vomiting after mixing and spraying pesticides). Shubhra (2013) in her study also found that excessive sweating, burning eyes, and fatigue were reported by 26.3%, 24.4%, and 18.8% of the pesticide using farmers of Ghior and Manikganj Sadar Upazilla in Bangladesh.

### ***Farmers' Awareness about Pesticide Use:***

The adverse effects depend not only on the toxicity of the pesticide, but also the measures taken during its application. The awareness level and practice of using protective measures among the farmers in

Bangladesh are very poor (Mainul, 2005). In a study by Mainul (2005) showed that 4% of the farmers were formally trained in pesticide use or handling, and over 87% openly admitted to using little or no protective measures while applying pesticides in Bangladesh. This lack of training is reflected in the misperception of farmers about pesticide risks, where over 34% of respondents incorrectly classified their pesticide hazard. According to Nepal (2010), in Bangladesh 85-90% of the farmers are not accustomed to take any protection during pesticide application as well as preservation and transportation. Masura (2018) reported that 69% of the farmers of Savar Upazila in Bangladesh used partial protective measures, while 48% had no covering in Mehendiganj Upazila. The study found that only 14% and 5% of the surveyed farmers reported the full use of PPE in both the areas respectively.

#### ***Role of Integrated Pest Management (IPM) System:***

Some studies showed that the Integrated Pest Management (IPM) system plays a positive role to improve the condition of pesticide impact on health and the environment. Because of the harmful health effects of pesticide use farmers become motivated to pay more for practices like IPM that reduce dependence on pesticide use (Muhammad, 2011). But IPM coverage remains quite inadequate in Bangladesh. A study by Rahman (2013) showed that only 7.4% of the total farmers followed the guidelines of IPM after 30 years of efforts. George (2019) viewed that adoption of IPM practices significantly reduces the number of pesticide applications, which also imply environmental benefits from their adoption.

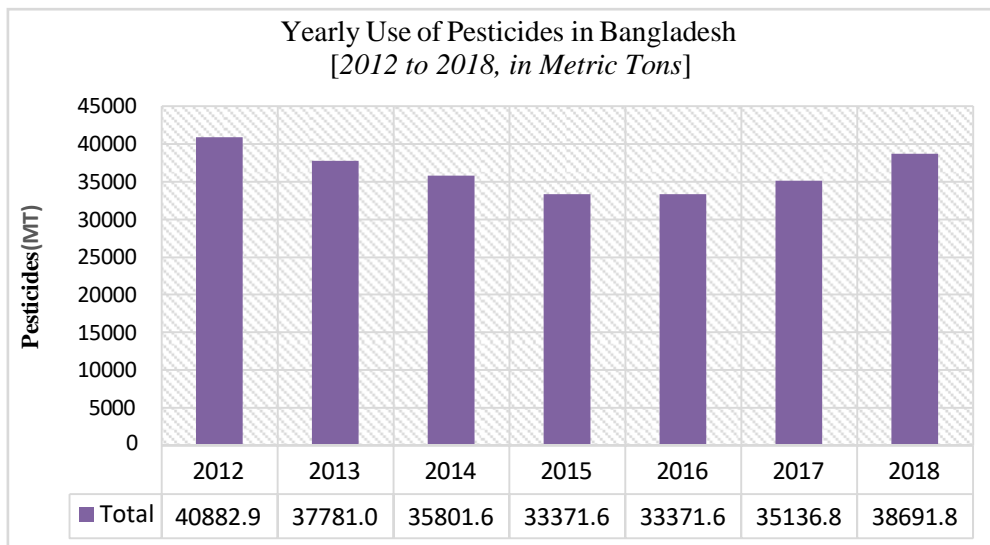
#### ***Impacts of Pesticide Use on the Environment:***

Nepal (2010) in his study showed that 27% of the farmers perceived that fish had been reducing and water pollution occurred due to the wash-out of agro-chemicals from agricultural farms in Bangladesh. Victorin (2006) in a study also showed that there were livestock losses due to intoxication from pesticides. The cost of this livestock loss is estimated to be US\$0.33 per treated hectare in one year. Nepal's vegetable farmers were found to be willing to pay between 53 and 79% higher prices of the existing pesticide bills to protect their own and environmental health (Atreya, 2012). Because of the improper management practice of pesticide containers, the threat to the environment increases. Mashura (2018) in her study reported that 39% and 42% farmers of the Savar Upazila and Mehendiganj Upazila respectively threw empty pots into the nearby waterbodies in Bangladesh. It also reported that 67% of farmers of Savar and 26% of farmers of Mehendiganj responded that environmental quality was deteriorating. Since there is a lack of policy guidelines regarding preparation, storing, and disposal of pesticide containers for the end-user like farmers in the legislation, of "The Pesticides (Amendment) Act, 2009" and also in "Environmental Conservation Amendment Act 2010" the indiscriminate disposal of pesticide and its containers are posing a serious threat to the health of farmers, their family, and the environment.

Not many recent works can be found that assessed the health costs of pesticide use in Bangladesh. The same is also true in the case of the economics of pesticide overuse in Bangladesh. But these issues demand careful assessment for appropriate policy decisions.

### **3. STATE OF PESTICIDE USE IN BANGLADESH**

In Bangladesh, January–March and October–December periods experience the higher use of pesticides (BBS, 2018). As many as 1000 pests that attack 178 crops in Bangladesh are reported by the Department of Agricultural Extension (2020). Currently there are 228 pesticide marketing companies operating in Bangladesh with 5500 registered pesticides, although 4500 pesticides are mainly used in the country. Along with that, there are also 30 types of registered bio-pesticides that can be found in Bangladesh now. It is also known that as many as 196 types of pesticides are found in Bangladesh (Sher-e-Bangle Agricultural University, 2018).



Source: Bangladesh Crop Protection Association (BCPA), 2019

**Figure 1:** Total use of Pesticides in Bangladesh from 2012 to 2018

The figure-1 shows that pesticide use is increasing in recent years in Bangladesh. From the year 2015 to 2018 the yearly use of pesticides has increased by 5320.26 metric tons. In 2015 the total yearly pesticide use was 3371.6 metric tons which become 38,691.86 metric tons in the year 2018. This indicates the increasing trend of pesticide use in Bangladesh and the associated danger from its misuse, health and economic consequences.

#### 4. METHODOLOGY

**Selection of Study Area:** For the present paper, a survey was conducted in KeraniganjUpazilla of Dhaka district by using a purposive sampling technique. The rationale behind choosing this area lies on its characteristics of having both rural and urban areas and production of crops like vegetables that demand higher use of pesticides.

**Sources and Collection of Data:**As mentioned, the paper is mainly based on data collected through questionnaire survey. Face to face interviews were conducted using a specially designed questionnaire and purposively selected 60 farmers from Keraniganjupazilla. In addition, a key informant interview (KII) was also conducted on 3 shopkeepers and one agriculture extension department officer from the study area. The survey was conducted in the local language of the area and questionnaire was used in local language for quality assurance of the data. A well-designed key informant interview (KII) schedule was prepared together information about key informants’ views and opinions and their suggestions on the state of pesticide use by the farmers of the study area. These also included issues like pesticide use condition, use of recommended quantity and amount of pesticides for selected crops, among others.

#### Data Processing and Analysis

**Data Entry:**For the study, data entry was done by following the World Bank Enterprise Survey’s data entry method.

**Data Processing:** Before data entry data cleaning had been done by carefully examining all questionnaires and the responses and certain outliers in the answers have been deleted from the sample.

Once the master sheet was prepared, data were carefully screened once again for making it ready for the final analysis. Microsoft Excel and SPSS software were used for this process.

*Data Analysis:* For the data analysis process, descriptive analyses were done using statistical techniques like Cost of Illness (COI) and estimation of additional economic cost from excessive use of pesticides. The study applied both qualitative and quantitative descriptive analytical techniques to analyze data collected from the respondents. Usual descriptive techniques like percentage, ratio, graphical and tabular formats were used to present the outcomes from the study. Qualitative information collected through the survey on respondents and their socio-demographic and gender information were analyzed. Further, an attempt was also made to analyze the health impact of pesticide use by using Cost of Illness Method (COI) and overuse of pesticides using descriptive analysis techniques to estimate additional economic cost from excessive use of pesticides. It also included analysis of respondents' awareness towards proper pesticide application and impacts of improper pesticide application. The using condition of bio-pesticide in the study area was also analyzed.

### **Cost of Illness (COI) Method:**

The cost of illness method was used to estimate the money spent on all direct aspects of illness related to pesticide use. The direct aspects that were taken into account included medical expenses and the cost of productivity loss. The medical expenses included cost of treatment, hospital fees, and transportation costs during journey of seeking medical help. For this exercise 5 types of health problems: breathing problems, skin diseases, diarrhea, eye irritation, and headache for applicators and non-applicators were analyzed. As some health problems can be observed in both applicators and non-applicators commonly the difference in the cost of illness of applicators and the cost of illness of non-applicators was estimated to have the true medical expenses that occurred because of pesticide use.

The formulae that were used are presented below:

Average Cost of Illness for Applicators = Average medical expenses + Average cost of work-time lost because of illness

Average Cost of Illness for Non-Applicators = Average medical expenses + Average cost of work time lost because of illness

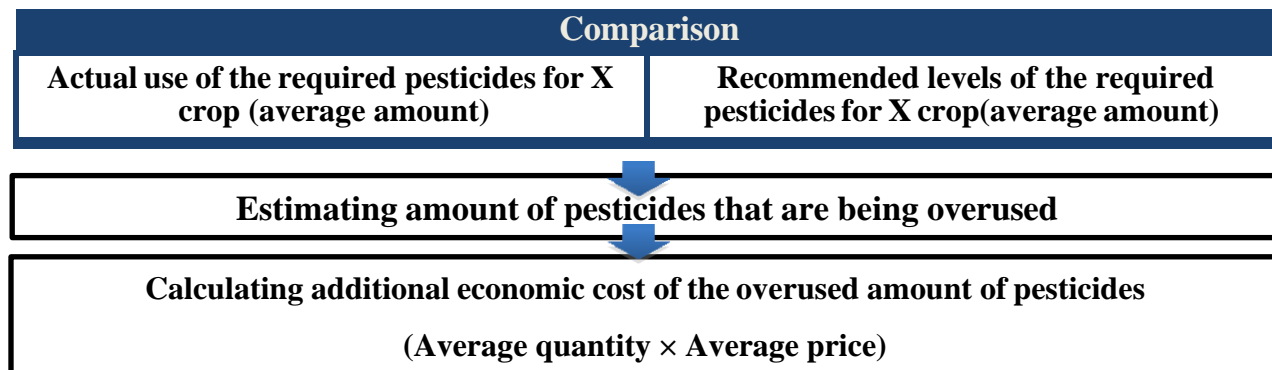
Average cost of illness due to pesticide use = Average cost of illness of applicators - Average cost of illness of non-applicators.

### **Method of Estimating Additional Production Cost From Excessive Use of Pesticides:**

To estimate the additional production cost from excessive use of pesticides the difference between the average amount of pesticides for a particular crop ( $X$  crop) that was used by a farmer and the average amount of the recommended levels of the pesticides for the same crop ( $X$  crop) was calculated. This calculated result represents the average amount of pesticides that had been overused by the farmer for that crop ( $X$  crop). The average quantity of pesticides that had been overused was then multiplied by the average price of pesticides for that particular crop ( $X$  crop). The result of this calculation is the additional economic cost from excessive use of pesticides for that crop ( $X$  crop).

In the case of the present exercise, 2 major types of crops were considered for estimation of additional production cost from excessive use of pesticides. These were vegetables and irrigated paddy. Among vegetables, cauliflower, red leaf vegetable, gourd leaf vegetable, potato, eggplant had been selected and

in the case of irrigated paddy, *boro* rice were selected because during the data collection period these crops were mainly cultivated in the study area.



**Figure 2:** Framework of the method for estimating the additional economic cost from excessive use of pesticides.

Using this method the additional economic costs from excessive use of pesticides for the selected crops which were cauliflower, red leaf vegetable, gourd leaf vegetable, potato, eggplant and *boro* rice were estimated carefully.

## 5. RESULTS AND DISCUSSION

### Descriptive Analysis

#### *Respondent Characteristics:*

Respondents' average age was estimated to be 44.8 years, which shows that most of the respondents considered for the study were middle-aged farmers. As most of them were at the onset of their middle age and carrying relation with agricultural work for a long time, they were highly experienced in agricultural work and pesticide use; so they were supposed to give the proper information about the pesticide use practices in crops cultivation. The average number of family members among the respondents' families was 4.9 (almost 5) persons, though the average number of income-earning members were found to be 1.35 persons per family. This shows that one income-earning member had to take the responsibility of almost 3 people, including the farmer himself/herself. The analysis also shows that 98.3% of the respondents were male and only 1.7% of them were female. This shows the male dominating practices in case of participating in the agricultural works like pesticide application in farmlands. As most of the male workers were doing the physically challenging tasks of agricultural production and also handling the external interactions with people.

#### *Level of Education:*

The analysis shows that 76.7% of respondents had primary education or no education at all. This implies that a very high number of farmers were not properly literate in the study area even though the area is closer to Dhaka and quite urbanized. Only 8.3% of the surveyed farmers had acquired junior level education i.e. from class 6 to 8 and only 8.3% of them had secondary level education (class 9 to 10). Again in the case of higher secondary education, only 5% of them were found to complete it and only 1.7% of them had their higher education. This scenario of the education level of the farmers in the study area is very concerning as a very high percentage of the farmers were found to have very low education level.

#### *Occupational Distribution:*

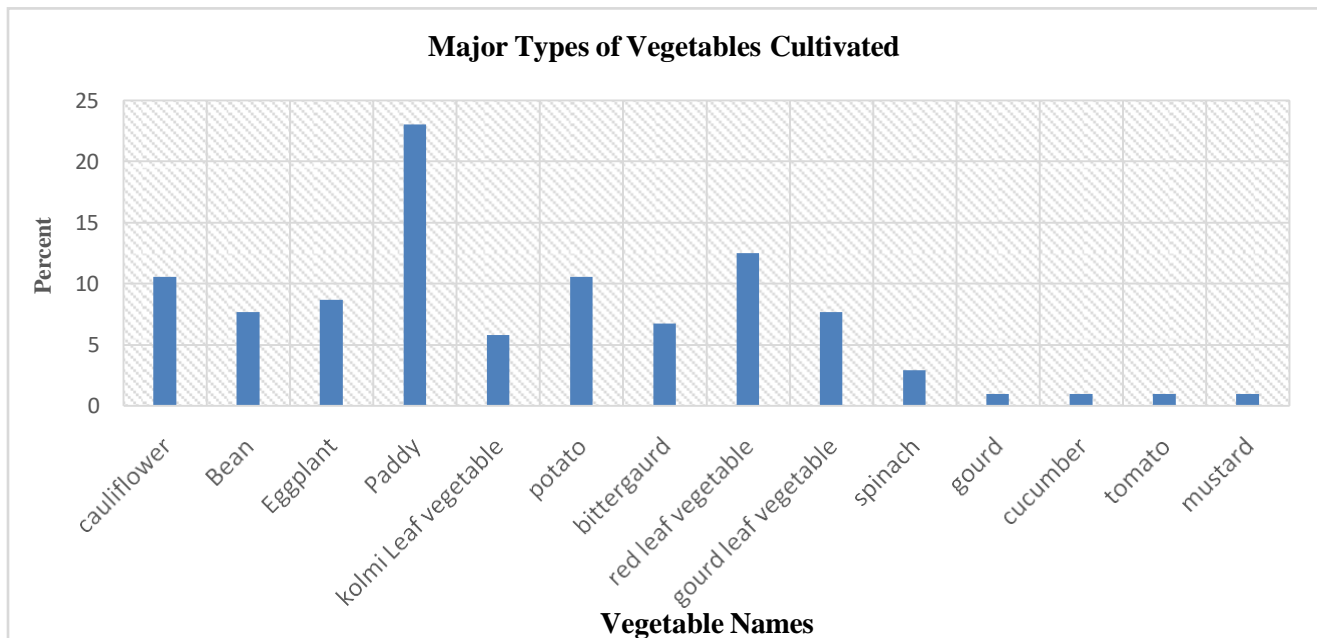
It is found that 81.7% of the respondents' main occupation was farming. Though 8.3% of the respondents' main occupation was other than farming, but they were related to agricultural production



for a long time in addition to their main occupation. So information from these respondents was thought to be useful and thus collected for this study. Also, all of the respondents were related to farming activities of crop cultivation. So the information on pesticide use in agricultural production was also collected from them.

**Information on Crop Cultivation:**

In the study area 61% of the respondents were found to cultivate vegetables only. Also, 34.1% of them mainly cultivated paddy and only 4.9% spices in the study area. This shows that farmers of the study area were mainly involved in vegetables and paddy cultivation. Figure 3 below shows the types of vegetable produced by the surveyed farmers included cauliflower (10.6%), bean (7.7%), eggplant (8.7%), kolmi leaf vegetable (5.8%), potato (10.6%), and bitter gourd (6.7%), red leaf vegetable (12.5%), and gourd leaf vegetable (7.7%) area. As paddy and vegetables were the main crops in the study area, pesticide use for these two crops was analyzed for this study. Among the vegetables, cauliflower, eggplant, potato, red leaf vegetable, gourd leaf vegetable- these five types of vegetables were taken into account for this study as they were found to be cultivated by the majority of the surveyed farmers.



**Figure 3: Major Types of Vegetable Cultivation**

**Family Income:**

The average yearly family income of the respondents families in the year 2020 was estimated to be Tk.1,23,583.33. This means that the average monthly income of the respondents families was Tk.10,298.61 in 2020. It shows that the average family size per surveyed family was 4.9. Considering this situation, a family of almost 5 members had to cope up with an income of Tk.10,298.61 per month only in a district like Dhaka. Also, the farmers were found to face different disasters during the crop cultivation seasons which make their lives more difficult to survive in this situation. Flood in the monsoon period is a common phenomenon in the study area, which causes great loss to the farmers. The analysis also shows that the respondents' average annual income from non-agricultural activities was Tk.47,900 for the year 2020.

**Pesticide Use for Crop Cultivation:**

From the findings of the study, it is understood that 100% of the respondent farmers used pesticides in the paddy and vegetable production. It is also found that 88.3% of the surveyed farmers regularly purchased pesticides from the nearby local shops and only 11.7% of them purchased pesticides from the markets. This shows that there is an easy availability of the required pesticides for the farmers in the study area. The survey found that two commonly used pesticides by the farmers in the study area were- Ridomil Gold and Furadon, which are in the canceled pesticides list given by the Government of Bangladesh. It is a very concerning situation as canceled pesticides have major harmful effects on human health and many farmers are still using them for their crop fields.

Table 1: Respondent farmers’ sources of knowledge about the use of pesticides for their cultivation

Source of Knowledge	Percentage
Farmers follow fellow farmers/neighbors/local communities as their main source of knowledge on pesticide use	16.70
Pesticide sellers/shopkeepers as the main source of knowledge on pesticide use	100.00
Local NGOs as the main source of knowledge source on pesticide use	0.00
Local agricultural officer as the main source of knowledge source on pesticide use	1.70
Other sources	3.30

Table-1 shows the sources of knowledge that farmers follow while using pesticides for cultivation. This knowledge included information about the types of pesticides to be used, the number of times pesticides be used in a season, and their quantity, among others. The analysis also shows that 100% of the farmers were dependent on pesticide sellers or shopkeepers as their main source of knowledge on pesticide use. Most of the farmers were not knowledgeable about the use of pesticides and were not trained or informed about the right use of pesticides. Almost all of them had to depend on the pesticide sellers and shopkeepers for this information. But the information provided by the pesticide sellers is not the right one. The study found that 66.3% of recommended pesticides by the shopkeepers were incorrect and for the wrong crops. Only 1.7% of the respondent farmers used to depend on local agricultural officers as their main source of knowledge on pesticide use, whereas the local agricultural officers can give the proper information about the right use of pesticides to the farmers. Unfortunately extension services were found to be quite inadequate. Some 3.3% of farmers were also found to use sources like internet and television to get information about pesticide use.

***Farmers’ Awareness about the Right Use of Pesticides:***

The analysis found that 88.3% of the surveyed farmers were not aware of the side effects of pesticide use. Not many farmers were found to consider that there are harmful effects of pesticide use. Only 15% of the surveyed farmers were aware of the health effects of pesticide use; only 5% believed that there are effects on waterbodies because of pesticide use; and only 3.3% were aware of the effect of pesticide use on biodiversity. Also, no surveyed farmer was found to believe that there are effects of pesticide use on soil and groundwater.

Over 93% of the farmers opined that there is a need for more awareness generation among the farmers about the proper use of pesticides in the study area. This shows the need for the availability of proper information and needs for proper training for the farmers. Besides the agricultural officers, the proper information about right pesticide use is available on digital platforms but farmers’ access to digital

platforms is very limited. Because of this reason, most of the farmers take information from the pesticide sellers and shopkeepers to whom they can reach easily.

**Table 2:** Farmers’ perceptions about the proper source of information on the right use of pesticides

Main Source of Information on the Right Use of Pesticides	Percentage
Shopkeepers	45.00
Agriculture Officer	50.00
The Label on Pesticide Bottle	3.30
Internet, etc.	1.70

Table 2 above shows that 50% of the respondent farmers were found the proper information about the right use of pesticides from local agriculture officers. Also, 45% of the farmers opined that the proper information about the right pesticide use was available from the pesticide sellers and shopkeepers. This blind trust and high dependency on the pesticide sellers is not a good indication. The high dependency of the farmers on pesticide sellers shows that there is a need for training and making proper information available for the pesticide sellers and shopkeepers about the right use of pesticides to cover a large number of farmers.

**The Use of Bio-pesticide and Protective Measures:**

The survey further indicated the unavailability of bio-pesticides in the study area. None of the farmers was found to use bio-pesticides in his/her crop production. It is also reported that as many as 91.7% of the farmers were found to be ignorant about the use of bio-pesticides due to their unawareness about bio-pesticides’ suitability in crop production. Biological pesticides or bio-pesticides are the pesticides derived from natural materials, such as microorganisms or plants. Bio-pesticides have an important future role in controlling pests and diseases because they provide a safer alternative to chemical pesticides. That’s why this unavailability of a bio-pesticide is not a good indication of enhancement towards sustainable agricultural growth.

**Table 3:** Precautions taken by the farmers during pesticide application

Types of Precautions Pesticide Applicators Use During Spraying Time	Response(%)
Use of special dress during pesticide spraying	1.70
Use of face mask during pesticide spraying	38.30
Taking bath or washing body parts after spraying pesticides by applicators	85.00
Use of spraying machine for spraying pesticides for crop fields	100.00

The analysis also found that in 23.5% of the cases pest-labeling was not found to be done correctly. It is also known that 76.5% pest-labeling was done correctly following the prescribed dosage rate by the government.

The exposure of the farmers to pesticides depends on the precautions that farmers are adopting during pesticide application. Table 3 here shows that only 1.7% of the respondent farmers used special dress

during pesticide spraying. That shows that these farmers didn't use hand gloves, goggles, and any other personal protective equipment to protect themselves from pesticide exposure. However, only 38.3% of the farmers were found to use face masks during pesticide application. The study also shows that 85% of the farmers take bath or wash their body parts after spraying pesticides and 100% of them use spraying machines for the application of pesticide in the crop fields. The negligence towards using protective measures is making the health effect of pesticide more severely.

### Quantitative Analysis

#### Overuse of Pesticide:

The farmers of the study area were mainly found to depend on cultivating paddy and vegetables as crops. During the data collection period, the farmers were found to cultivate *boropaddy*, thus the study undertook the analysis of the overuse of pesticides for *boropaddy* only. Again among the cultivated vegetables cauliflower, potato, eggplant, red leaf vegetable, and gourd leaf vegetables were selected as these vegetables are majorly cultivated in the study area. For this reason, the data availability of pesticide use for these crops was more considered to be more accurate.

Table 4 has summarized the overuse of pesticides for selected crops. It has concluded that there are citable divergence between the actual average use of pesticides and the recommended level of pesticide that should be used.

The overuse of pesticides in one seasonal time for per acre of land were estimated to be 675.66 grams, 1078.13 grams, 1,184.91 grams, 17,365.66 grams, 321.54 grams and 853.5 grams respectively for *boro* paddy, potato, cauliflower, eggplant, red leaf vegetable and gourd leaf vegetable cultivation.

This gives that pesticide use was 43.63%, 30.69%, 59.76%, 52.26%, 21.66% and 32.46% more than the recommended level respectively in *boro* paddy, potato, cauliflower, eggplant, red leaf vegetable and gourd leaf vegetable cultivation. This scenario gives the evidence of eminent overuse in crop cultivation by the farmers in Bangladesh.

The additional economic cost from this excessive use of pesticides was estimated to be Tk.2,512.18 for *boro* paddy, Tk.4,319.30 for potato, Tk.3,649.50 for cauliflower, Tk.53,312.58 for eggplant, Tk.431.83 for red leaf vegetable and Tk.1,414.68 for gourd leaf vegetable cultivation in per acre of area in every season of cultivation. These are significant amount of cost for the farmers whose income levels are very low and also the profit levels of agricultural activities are truncated which is economically irrational. In this case if these excess costs could be reduced the profit margins for the farmers can also be increased.

**Table 4:** Additional economic cost from excessive use of pesticides for the selected crops

Pesticide use for crop	Per acre average use of pesticide (in gram)	Average recommended level (in gram)	Excessive use of pesticide (in gram)	Excessive use of pesticide from the recommended level (in%)	The average price of pesticide for 1 gram (in Taka)	Additional economic cost from excessive use of pesticides/ acre
Pesticide for <i>boro</i> paddy	1548.39	872.73	675.66	43.63	3.72	2512.18
Pesticide for potato	3513.13	2435.00	1078.13	30.69	4.01	4319.30

Pesticide for cauliflower	1982.64	797.73	1184.91	59.76	3.08	3649.50
Pesticide for eggplant	33227.05	15861.39	17365.66	52.26	3.07	53312.58
Pesticide for red leaf vegetable	1484.62	1163.08	321.54	21.66	1.34	431.83
Pesticide for gourd leaf vegetable	2629.75	1776.25	853.50	32.46	1.66	1414.68

Among the selected crops, the highest level of pesticide use per acre of land was observed for eggplant cultivation. But in percentage-wise, the most overusing condition was observed for cauliflower cultivation. Although for different crops, there are different needs and levels of use of pesticides, but the analysis found that every selected crop for this study has notable pesticide overuse incidence. The farmers are found to be unaware of this additional cost that they are unintentionally bearing in crop cultivation. If the overuse could be minimized, it will not only make the production process more cost-effective for the farmers but also reduce the harmful effects of pesticide use on human health and the environment. This economic loss is not only a concern of the farmers, but also for the whole country.

**Health Cost of Pesticide Use:**

Using the cost of illness (COI) method, the health cost of pesticide use is estimated in the present study. The adaptive measures taken by the farmers depend on the severity of the illness felt by them. Generally farmers take medical treatments when the symptoms are acute. Also, farmers do not easily skip their work schedules without any acute physical instability. Also, the symptoms for health problems like breathing problems, skin disease, eye irritation, headache, and diarrhea have a very low influence on farmers to skip their works. For these problems, farmers generally use some home remedies. For this reason, the cost of work-time lost because of illness is a very negligible amount so it is taken as Tk.0. Again as farmers are very ignorant towards their illness mostly ignore these symptoms or if it is acute use treatments given by the nearby medical pharmacy or nearby doctors. That's why the traveling expenses to go for medical treatments are very negligible amount, which is taken as Tk.0. Again the cost for protective measures is also considered to be TK.0 as evident from above findings showed very insignificant number of farmers use protective measures during pesticide application (1.7% applicators use special dress/PPE).

Here, the following methods and calculations were applied for the present paper:

Average Cost of Illness for Applicators = Average medical expenses + Average cost of work-time lost because of illness-

$$= 324.92+0 \text{ [assuming the opportunity cost as 0]}$$

$$= 324.92$$

Average Cost of Illness for Non-Applicators = Average medical expenses +Average cost of work-time lost because of illness-

$$= 40.83+0 \text{ [assuming the opportunity cost as 0]}$$

$$= 40.83$$

The average cost of illness experienced because of pesticide = Average cost of illness for applicators – Average cost of illness for non-applicators-

= 324.92-40.83

= 284.09

The analysis shows that the average cost for an applicator's health treatment in case of one incidence of health problem is estimated to be Tk.324.92. Again the average cost for a non-applicator's treatment in one such incidence is calculated to be Tk.40.83. This estimation gives the result that the average cost generated from pesticide application in one incidence of pesticide use-related health problem is Tk. 284.09.

**Table 5:** Health problems faced by the respondent farmers because of pesticide use

<i>Health Problem</i>	<i>Percentage</i>
Breathing problem	3.30
Skin disease	10.00
Diarrhea	13.30
Eye irritation	8.30
Headache	18.30

The analysis shows that 3.3% of the surveyed farmers faced breathing problem mainly caused by pesticide use. Also, 10% faced skin diseases, 13.3% diarrhea, 8.3% eye irritation, and 18.3% headache because of pesticide use.

The excessive use of pesticides by farmers and the health impacts of unsafe pesticide use practices generate economic losses in the form of additional production cost and health cost that can be measured in monetary values. It is also evident that the awareness level was very low among the farmers about the negative impacts of unsafe pesticide use in crop fields. Also, protective measures taken by the farmers were understood to be improper, which lead to greater exposure and greater damage for the farmers. That's why the creation of mass awareness among the farmers about the proper use of pesticides is necessary and thus government should perceive this issue with great care and proper policy measures for managing best practices of regulation, proper use, and management of pesticide need to be adopted.

## 6. CONCLUSION AND RECOMMENDATIONS

Intensive agricultural practice is required to fulfill the food demand of increasing population, but it also is becoming harmful because of unwanted practices of chemical pesticides and fertilizers. The inevitability of farmers using chemical pesticides to protect their production is a common phenomenon in a country like Bangladesh where population is so high and the demands for more crops is always there; thus there is an urge feeling by farmers to produce more crops to meet the increasing demands. But the imperceptible awareness and knowledge about pesticide pollution is not only harmful for human health, but also for the environment and human health as it increases farmers' occupational exposure to pesticide pollution. This paper made an attempt to show the costs (excessive cost from the overuse of pesticide, and health cost of pesticide use) generated from incognizant behavior of the farmers towards pesticide use in the study area. Also the inadequacy of the use of alternatives of chemical pesticides in the study area is presented in this paper. This paper has thus presented the need of the proper use of pesticides for agricultural production by analyzing its overuse and health costs to farmers.

It is found that there is overuse of pesticides by the farmers. The farmers used more pesticides than the recommended amount that should be used for the 5 types of selected crops: *boro* paddy, cauliflower, potato, eggplant, red leaf vegetable, and gourd leaf vegetable. The additional production cost from excessive use of pesticides for per acre land is estimated to be a total of Tk.65,640.07 for per growing season of these selected crops in the study area. It is found that farmers are facing health related problems because of pesticide pollution. Among the respondents, 3.3% of the pesticide applicators had reported facing breathing problem, 10% skin diseases, 13.3% diarrhea, 8.3% eye irritation and 18.3% headache.

Using the cost of illness (COI) method it is found that the average cost generated from pesticide application in one incidence of pesticide use related health problem faced by the respondent farmers is Tk.284.09. It is understood that as many as 100% of the surveyed farmers' main source of knowledge on pesticide use (i.e. types of pesticides to be used, number of times pesticides be used in a season and their quantity) is local pesticide sellers or shopkeepers. Again 66.3% of the recommended pesticides by the pesticide sellers or shopkeepers were found to be incorrect. It is understood that the farmers were unaware about the damages chemical pesticides can cause to their health, yet 98.3% of the respondent applicators were found not using any special dress or personal protective equipment (PPE) and 61.7% did not use mask during pesticide application to protect them from pesticide exposure. The study findings also show that 88.3% of the surveyed farmers were unaware of the fact that there are side-effects of pesticide use which makes the fact more concerning.

Only 15% of the surveyed farmers were aware about the health effects of pesticide use, 5% of them believed that there is effect on water bodies, while only 3.3% were aware of their effects on biodiversity. Also none of them were found to be aware about the effects of pesticides on soil and groundwater. The study also found that the presence of some cancelled pesticides being used by the farmers in the study area. This shows that there is lack of proper monitoring and management of pesticides use in the study area by the administration and other concerned parties.

The unawareness of the losses and costs of improper use of pesticides is a very concerning fact, but the farmers were mostly not aware about these costs they are bearing as a result of their ignorance to this fact. But this issue is also not given proper attention by the government and policy makers because most of the damages from pesticides use are not observed directly or take time to show the effects in long run. So there is a need to understand both short and long term damages caused by pesticides use and take necessary steps to solve the problem of overuse of pesticides and take due health related precautions by the applicators while spraying pesticides in their crop fields. Based on the findings of the present study, this paper proposes the following specific recommendations to address the concerning issue of pesticide use in Bangladesh:

- Creation of mass awareness among the farmers on the need for proper use of pesticides is necessary to stop pesticide use related high economic cost of production and health costs due to health hazards. In this regard the Agriculture Extension Department (AED) of the country can organize special training or knowledge sharing sessions for farmers aiming to train them on the right use of pesticides for their crops.
- Encourage farmers for adopting improved pesticide use methods to overcome health hazards. The use of bio-pesticides can also be encouraged. Thus due fiscal measures (i.e. reduction of taxes on bio-pesticide use, imports of capital goods or raw materials of producing bio-pesticides or providing subsidies to encourage bio-pesticide producers and also farmers, etc.) can be introduced to encourage farmers for using bio-pesticides in crop production.

## REFERENCES

1. Atreya, K., “Pesticide Use in Nepal: Understanding Health Costs from Short-Term Exposure”, Kathmandu, Nepal: South Asian Network for Development and Environmental Economics (SANDEE), 2007.
2. Bangladesh Bureau of Statistics (BBS), District Statistics 2011 Dhaka, Dhaka: Ministry of Planning, Government of the People’s Republic of Bangladesh, 2013.
3. Bangladesh Bureau of Statistics (BBS), Yearbook of Agricultural Statistics. Dhaka: Ministry Of Planning, Government of the People’s Republic of Bangladesh, 2019.
4. BER, Bangladesh Economic Review, Dhaka: Ministry of Finance, 2022.
5. Cropper, M L and A M Freeman, “Environmental Health Effects”, Measuring the Demand for Environmental Quality, Ed. J B Braden and C D Kolstand, North Holland: Elsevier Science Publishers, 1991.
6. Damalas, C.A. and Eleftherohorinos, I.G., “Pesticide Exposure, Safety Issues, and Risk Assessment Indicators”, *International Journal of Environmental Research and Public Health*, 2011, 8, 1402-1419.
7. Dasgupta, S., “Health Effects and Pesticide Perception as Determinants of Pesticide Use: Evidence from Bangladesh”, New York: World Bank, 2005.
8. Devi, P. I., “Pesticide Use in the Rice Bowl of Kerala: Health Costs and Policy Options”, Kathmandu: South Asian Network for Development and Environmental Economics (SANDEE), 2007.
9. Dey, N. C., “Use of Pesticides in Vegetable Farms and Its Impact on Health of Farmers and Environment”, *Environmental Science & Technology*, 2010, 134-139.
10. FAO and WHO, Global situation of Pesticide Management in Agriculture and Public Health, Geneva: World Health Organization and Food and Agriculture Organization of the United Nations, 2019.
11. FAO, International Code of Conduct, Rome: Food and Agriculture Organization of the United Nations, 2002.
12. Faruq, A. N., “Agriculture and Pesticide Consumption in Bangladesh”, Sher-e-Bangla Agricultural University (pp. 1-31), Dhaka: Sher-e-Bangla Agricultural University, 2018.
13. Keraniganj Upazila, Retrieved May 18, 2021, from Banglapedia: [https://en.banglapedia.org/index.php/Keraniganj\\_Upazila](https://en.banglapedia.org/index.php/Keraniganj_Upazila)
14. LFS, Quarterly Labour Force Survey 2022: Bangladesh (Provisional Report), Dhaka: Bangladesh Bureau of Statistics (BBS), 2022.
15. Mashura Shammi, A. S., “Pesticide Exposures towards Health and Environmental Hazard in Bangladesh: A Case Study on Farmers’ Perception”, *Journal of the Saudi Society of Agricultural Sciences*, 2018.
16. Meisner, C., “Report of Pesticide Hotspots” In. New York: Development Economics Research Group, World Bank, 2004.
17. Pimentel, D., “Environmental and Economic Costs of the Application of Pesticides Primarily in the United States”, *Environment, Development and Sustainability*, 2005, Vol.7, 229-252.
18. Rahman, S., “Farm-level Pesticide Use in Bangladesh: Agriculture, Ecosystems and Environment”, 2002, 1-12.



19. Rahman, S., “Pesticide Consumption and Productivity and the Potential of IPM in Bangladesh”, *Sci. Total Environ*, 2013, 445-446, 48 - 56.
20. Shubhra Bhattacharjee, M. A., “Impacts of Pesticide Exposure on Paddy Farmers” Health”, *Jahangirnagar University Environmental Bulletin*, 2013, 2, 18-25.
21. WHO, *Public Health Impact of Pesticides used in Agriculture*, Geneva: World Health Organization, 1990.
22. World Health Organization and Food and Agriculture Organization of the United Nations, *Global Situation of Pesticide Management in Agriculture and Public Health*”, Geneva: World Health Organization and Food and Agriculture Organization of the United Nations, 2019.
23. World Resources Institute, UNEP, UNDP, World Bank, *Environmental Change and Human Health*, World Resources 1998-1999, 1998.