Determinants and Methods of Integrated Pest Management Adoption in Bangladesh: An Environment Friendly Approach

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ABSTRACT

Integrated pest management (IPM) is an environment friendly approach that consider as central to achieve sustainable agricultural development. This paper addresses two aspects of IPM; i) to discuss the factors that influence farmers decision for adoption of IPM, and ii) to critically analyze various methods of determination of IPM adoption level. Based on secondary data, the study revealed adoption of IPM is influenced by economic, social, institutional, and management factors where economic factors have greater influence and management have less. Regarding measurement techniques, proportional measures are more appropriate than others to determine IPM adoption level. After due consideration of different measurement techniques, we proposed a method to determine the level of IPM adoption in Bangladesh. In addition, we suggested a set of determinants for better understanding about the adoption of this environment friendly agriculture.

Key words: IPM, determinants, methods, adoption, environmental sustainability

Introduction

Pest and pesticide management problems affect most countries around the globe, and Bangladesh is not an exception to this. A significant amount of production is lost every year due to relentless attack by various pests. According to estimation, the average annual loss of various major crops due to pest is; 30-40% of vegetable, 16% of rice, 15% of jute, 11% of wheat, and 25% of pulses (MoA, 2002). Albeit no formal record, but it is assume that this loses exceeds loss that caused by natural calamities like flood, drought, cyclone and others. To control pest, still majority of the farmers are rely on conventional system that is application of chemical pesticide. To rely fully on chemical control is not feasible in social, economic and environmental aspect. That is why, an alternative strategy is needed that can control pest in less expensive and environment friendly way. In this line, organic agriculture is an alternative which is entirely rely on organic inputs, synonymous with sustainable agriculture, as it has no adverse impact on ecological health (Lampkin, 1994; Kilcher, 2006; Henning et al, 1991). Despite this advantage, one of the significant limitations of organic agriculture is less productivity. In a country like Bangladesh where food demand is so high, there is no compromise with production. By considering this, another one alternative that can ensure both productivity and environmental safetyness is integrated pest management (IPM) (Bonabana-Wabbi et al, 2006; Hristovska, 2009).

Over the years, what IPM means in concrete terms has been a matter of debate ((World Bank, 2003). Up to the present, there are over 65 definitions of IPM (Prokopy and Kogan 2003). However, to control pest in a sustainable way is the common message of all the given definition. According to Prokopy (2003), IPM is “a decision-based process involving coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and economically sound manner”. For ecological sound nature of IPM, various scholars treated IPM in various ways like environmentally friendly agriculture (Dasgupta et al, 2007), clean agricultural technologies (Hadi Veisi, 2012), sustainable farming (De Souza Filho, et al., 1999) etc. For ensuring a sustainable tomorrow in aspect of agriculture, there is no alternative without adoption of IPM practices. To realize this, the government is disseminating IPM information for better adoption of these practices among the farmers.

Adoption is an outcome of a decision to accept a given innovation. It is a mental process an individual passes from first hearing about an innovation to final utilization (Feder et al, 1985). Several stages go before adoption. First of all, awareness of a need is generally perceived in adoption process. The other stages are; interest, evaluation, acceptance, trial, and finally adoption (Rogers, 1995). Hence, adoption of IPM is complex, and every stage is influenced by various factors. An understanding about these factors is important to better disseminate of IPM information. How well dissemination is occurring can be understand through adoption rate.

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Hence, determination of adoption rate or level is also important. Considering these two issues (influencing factors and measurement technique); the study will face the following questions:
1. What are the factors that influence farmers’ decision to adopt IPM?
2. What type of factor influence more in IPM adoption?
3. What are the methods to determine the level of IPM adoption?
4. Which method is more appropriate?

The output of the study will be useful to the agricultural professionals, extension personnel, environmentalist, community leaders, and other personnel of GOs and NGOs currently working for dissemination and adoption of IPM. Moreover, the proposed factors and method will be act as a cover area of study for the future researchers.

Methodology:

This study is primarily based on secondary information available from various sources like books related to integrated pest management, journal, thesis, proceedings and periodicals. Furthermore, few informal discussions were held with experts in crop science, agricultural extension and environmental scientist to get proper direction of the study. In addition to this, various reports like national IPM policy report (MoA, 2002), and World Bank report (ARD, 2003) were assisted to fulfill the purpose of the study in an effective and meaningful way.

Results and Discussion

The discussion is divided into four sections. The first section deals with the factors influencing farmers’ decision of IPM adoption. The second section deals with the proposed set of factors of IPM adoption in Bangladesh. The third section deals with the methods that are used to measure IPM adoption. The final section is proposed method to determine adoption rate of IPM in Bangladesh.

a) Factors Influencing adoption of IPM:

According to the Rogers’ theory, the decision to adopt any innovation like integrated pest management is influenced by the information receivers’ socio-economic characteristics, social systems and the characteristics of the innovations (Rogers, 1995, Thapa and Rattanasuteerakul, 2011). Several empirical studies have corroborated this theory, some of which have expanded the dimensions of the theory by including the role of the institutional and management factors in the decision-making process (Bonabana-Wabbi, 2002; Hristovska, 2009). Therefore, the factors that are previously analyzed to identify the importance on IPM adoption, can be organize into four broad items; economic, social, institutional and management. A brief description of these factors are given below:

Economic factors:

Usually if any technology is more profitable than the existing one, then there is a tendency to accept that new one. That’s why economic issue is related with technology adoption. The single most important category of influential factors for the adoption of IPM technologies is economic forces (Bonabana-Wabbi et al., 2006). Farm size is one of the important economic factors that influence the farmers in a great extent for IPM adoption. The farmers who have large farm size have more scope to take risk about adoption of new practices. In addition, farm size can effect and in turn be affected by the other factors influencing adoption. Household income or farm income is another important determinant that positively influences the farmers for IPM adoption. The reason may be if the farmers’ households have enough income then they feel mentally strong to take decision regarding adoption of new practices. The other important economic factors that found to influence IPM adoption including labor availability, level of full time worker, level of expected benefits, farm ownership etc. (Bonabana-Wabbi, 2002; Samiee et al., 2009; Idrisa, et al., 2012). Table 1 shows a summary of the economic factors that were influenced adoption of IPM practices.

Social factors:

To take decision regarding adoption of any technology, individual first should know about that technology. After knowing about a technology, then perception is formed towards that technology which play important role to take decision regarding adoption. On the other hand, individual’s age or educational level also have influence on decision making regarding adoption. These demographic and psychological factors are together considered as social by the previous scholars. So, it can be said that adoption of IPM is influenced by different social factors. Among social factors, age is said to be a primary latent characteristics in adoption decisions. Adoption
behavior is strongly influenced by various aged stage. There is contention on the direction of the effect of age on adoption. Some other social factors that have influence on IPM adoption are educational level, knowledge, risk perception, farming experience, etc (Dudley, 1997; Samiee, et al, 2009; Dasgupta et al., 2007). Influence of social factors on IPM adoption are shown in Table 2.

**Table 1:** Economic factors influencing adoption of IPM.

<table>
<thead>
<tr>
<th>Source</th>
<th>location of study</th>
<th>individual factor</th>
<th>direction and degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bonabana-Wabbi, 2002)</td>
<td>Uganda</td>
<td>Farm labor availability</td>
<td>+ve</td>
</tr>
<tr>
<td>(Harris, 2011; Hristovska, 2009)</td>
<td>Bangladesh and Nepal, Iran</td>
<td>Household annual income</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Ricker-Gilbert, 2005; Fernandez-Cornejo and Jans 1996)</td>
<td>Bangladesh, Columbia, U.S.A</td>
<td>Farm size</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Li et al, 2011)</td>
<td>England</td>
<td>Level of full time worker</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Alston and Reding, 1998; Samiee et al, 2009)</td>
<td>U.S.A., Iran</td>
<td>Income (On/off farm)</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Dasgupta et al, 2007; Bonabana-Wabbi et al, 2006)</td>
<td>Bangladesh, Uganda</td>
<td>Farm ownership</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Li et al, 2011)</td>
<td>England</td>
<td>Level of benefit</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Amir et al, 2012)</td>
<td>Malaysia</td>
<td>Profit share</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Sharma et al, 2011)</td>
<td>UK</td>
<td>Profitability</td>
<td>+ve and significant</td>
</tr>
</tbody>
</table>

**Table 2:** Social factors influencing adoption of IPM.

<table>
<thead>
<tr>
<th>Source</th>
<th>location of study</th>
<th>individual factor</th>
<th>direction and degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Dudley, 1997; Dasgupta et al., 2007; Hristovska, 2009)</td>
<td>U.S.A, Albania, Ecuador, Bangladesh</td>
<td>Educational level</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Bonabana-Wabbi, 2002; Dasgupta et al., 2007; Ofooku et al., 2008)</td>
<td>Uganda, Bangladesh, Nigeria</td>
<td>Farming experience</td>
<td>+ve and significant, --ve</td>
</tr>
<tr>
<td>(Bonabana-Wabbi, et al., 2006; Dasgupta et al., 2007; Chaves &amp; Riley, 2001; Ofooku et al., 2008)</td>
<td>Uganda, Bangladesh, Columbia, Nigeria</td>
<td>Age</td>
<td>+ve and significant, --ve</td>
</tr>
<tr>
<td>(Dudley, 1997)</td>
<td>U.S.A</td>
<td>Risk perception</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Li et al, 2011)</td>
<td>England</td>
<td>Knowledge</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Ofooku et al, 2008)</td>
<td>Nigeria</td>
<td>Household size, Marital status</td>
<td>+ve</td>
</tr>
</tbody>
</table>

**Institutional factors:**

Beyond socio-economic characteristics, adoption of IPM is also influenced by government or institutional support in which some studies treated as exogenous factors. Institutional support assist farmers to better understand how IPM can be used. Frequency of extension contact, access to credit, training on IPM, and access to irrigation etc. are the institutional factors that influence farmers’ decision regarding IPM adoption. Most of the cases the direction of these characteristics were positive which indicated higher these factors higher adoption of IPM. A summary of institutional factors influence are given on Table 3.

**Table 3:** Institutional factors influencing adoption of IPM.

<table>
<thead>
<tr>
<th>Source</th>
<th>location of study</th>
<th>individual factor</th>
<th>direction and degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Veisi, 2012; Dudley, 1997)</td>
<td>Iran, U.S.A</td>
<td>contact with information sources</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Veisi, 2012)</td>
<td>Iran</td>
<td>external factors</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Harris, 2011; Hristovska, 2009)</td>
<td>Bangladesh, Ecuador, and Uganda</td>
<td>Farm ownership</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Fernandez-Cornejo and Jans 1996)</td>
<td>USA</td>
<td>access to training and access to credit</td>
<td>+ve</td>
</tr>
</tbody>
</table>

**Management factors:**

Management factors indicate farmers’ additional farming characteristics or features that increase their experience as well as help them to manage their crops in a better way. Comparatively few scholars considered management factors and found mixed results. From their findings, it is assumed that management factors have less affect on decision regarding IPM adoption. A summary of this type of factors influence are given on Table 4.

From the above table and discussion it can be said that, economic factors are more and management factors are less important in influencing adoption of IPM.
Table 4: Management factors influencing adoption of IPM.

<table>
<thead>
<tr>
<th>Source</th>
<th>location of study</th>
<th>individual factor</th>
<th>direction and degree</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Bonabana-Wabbi, et al. 2006)</td>
<td>Uganda</td>
<td>input purchase decision</td>
<td>-ve</td>
</tr>
<tr>
<td>(Bonabana-Wabbi, 2002)</td>
<td>Uganda, Bangladesh and Nepal</td>
<td>belong to farmer organization</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Amir et al. 2012)</td>
<td>Malaysia</td>
<td>Farm hours</td>
<td>+ve and significant</td>
</tr>
<tr>
<td>(Bonabana-Wabbi, et al. 2006)</td>
<td>Uganda</td>
<td>participation in farm trial</td>
<td>+ve</td>
</tr>
</tbody>
</table>

b) Proposed determinants of IPM adoption in Bangladesh:

Previous studies have given considerable attention on social, economic, institutional and management factors. Locational factors are not considered that are believed to affect agricultural technology adoption (Raut, et al., 2011, Mariano, 2012). Since, adoption is a complex issue and it has dependency with various types of factors, then there is a need to analyze locational factors with others to identify whether has or has not influence on IPM adoption behavior. Hence, we proposed following determinants of IPM adoption in Bangladesh (fig 1). This will extend the scope of dimension regarding adoption of IPM as well as to better understand about the effect of various factors influence on IPM adoption in Bangladesh.

![Fig. 1: Proposed set of factors for IPM adoption in Bangladesh.](image)

c) Methods to measure IPM adoption:

Measuring the adoption of IPM practices can be more complex than it sounds. Apparently, it seems to be nothing more than a simple question of whether a farmer is or is not using IPM practices. But, this simplistic view will be changes if one begins to assess how and when it is being used, and the appropriateness of that use relative to actual pest conditions. All these assessments are important for measuring adoption of IPM in a valid and reliable fashion.
However, the previous studies say adoption of IPM practices can occur at four different levels of measurement. These are; measuring adoption with accounting measures, measuring adoption with proportional measures, measuring adoption with accuracy-in-use measures, and measuring adoption with distributional measures (Lynch et al., 1996). Measuring adoption with accounting measures is similar with many of the traditional methods where audience responses to programming efforts are counted. For an example, counting the number of individuals who participate in a program, who attend at field days or demonstrations or who receive a booklet or pamphlet or other educational material.

In case of measuring adoption with proportional measures, individuals are asked about certain IPM practices they use or not. Their responses are then statistically manipulated in one of three ways: (1) individuals are categorized as adopters or non adopters of IPM based on the proportion of the yes to no answers; (2) individuals are classified as some ordinal scale of measurement like low, medium, or high, based on the proportion of practices used; or (3) the area that an individual use practices in proportion of applicable area.

The third system, measuring adoption with accuracy-in-use measures attempts to account for the appropriateness of the salient behaviors. For example, spot spraying a post emergent herbicide at reduced rates may be an appropriate IPM behavior depending on weed composition and pressure. The last method, measuring adoption with distributional measures is an ecologically based measure of adoption that determining which behaviors can be classified as IPM is dependent on pest dynamics across space and time. A summary of these measurement techniques are presented in table 5.

**Table 5: Comparative analysis of different measures of IPM adoption.**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Accounting</th>
<th>Proportional</th>
<th>Accuracy-in-use</th>
<th>Distributional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement issue</td>
<td>Any indicator of program participation</td>
<td>Dichotomous measure of IPM use or extent of use</td>
<td>When and how specific practices are used</td>
<td>Where specific practices are being used</td>
</tr>
<tr>
<td>Unit of measurement</td>
<td>Individual</td>
<td>Number of practices used or percent of used area</td>
<td>Difference between actual and recommended use</td>
<td>Spatial pattern of use in a landscape</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>Moderate</td>
<td>Moderate to high</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>Ease of use evaluation</td>
<td>Ease</td>
<td>Moderate</td>
<td>Complex</td>
<td>Complex</td>
</tr>
<tr>
<td>Utility effectiveness</td>
<td>Low for program</td>
<td>Adequate to estimate</td>
<td>Good for increasing</td>
<td>Good for increasing</td>
</tr>
<tr>
<td>Validity level or extent of adoption</td>
<td>level or extent of adoption</td>
<td>efficiency of IPM programs</td>
<td>of IPM programs</td>
<td></td>
</tr>
<tr>
<td>Sample frame participants</td>
<td>Low</td>
<td>Moderate</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Sample frame</td>
<td>None; count program participants</td>
<td>Usually random sample</td>
<td>Random, population of targeted area, proportionate by IPM user</td>
<td>Spatial sampling based on geographical or ecological feature</td>
</tr>
<tr>
<td>Required disciplinary</td>
<td>None; any discipline can manage</td>
<td>Typical leadership by one discipline with co-operation of other sciences</td>
<td>Multidisciplinary with responsibilities among social and biological sciences</td>
<td>Interdisciplinary with methods being developed concurrently</td>
</tr>
</tbody>
</table>

Data source: (Lynch et al., 1996)

From the above discussion and table 5, it is observed that, measuring adoption with accounting measures, and measuring adoption with distributional measures are the simplest and toughest measure of IPM adoption respectively. Because of low validity and also reliability, the researchers avoid the first method. On the other hand, after having high validity and effectiveness, the researchers also avoid the method of measuring adoption with distributional measures. One of the important reasons to avoid this method is high complexity. Besides, costs of this method are also high, and there is need to concurrently develop method at the time of apply. For these reasons, it is hardly seen to use any of these two methods to determine the level of IPM adoption. The third method is comparatively better in aspect of validity and utility. But, this method always demands a multidisciplinary team which is difficult to arrange in aspect of time, cost and others resources. In addition, the method is also complex. Because of having these limitations, the users of this method are few. The rest method, measuring adoption with proportional is comparatively better among all others in various aspects. Albeit, this method belongs to less validity than accuracy-in-use and distributional methods, but regarding costs, ease of use and required discipline, this is better. Besides, this method is more valid than accounting. Moreover, it has more popularity because of random sampling frame, and single disciplinary can use with co-operation with other sciences. For these advantages, majority of the scholars use measuring adoption with proportional measures. (Govindasami et al., 2001; Kaine and Bewsell, 2008; Borkhani et al., 2011; Ali and Sharif, 2012; Blake et al., 2007).

By following measuring adoption with proportional measure, individual can measure IPM adoption in three ways. These ways are treated as extent of adoption, intensity of adoption, and level or rate of adoption. Among these approaches, extent of adoption is simple as it indicates how much area an individual use IPM practices out
of total probable area. On the other hand, intensity of adoption is little confusing since there is no rule of thumb to define low, medium and high adoption. For these limitations, we will focus on rest option like adoption rate of IPM.

To determine the rate of IPM adoption, there is a need to categorize the growers into adopter and non-adopter. To make this categorization is difficult as IPM is not a single technology. Rather IPM is an approach that belongs to a number of technologies. So, the question arises, how the growers can be categorized as IPM adopter or non-adopter? To get answer, we reviewed the previous scholar techniques of IPM adopter determination and found following ways.

Dasgupta (2007), distinguished IPM farmers form conventional and determined adoption rate. At first he identified seven IPM practices that were available in the study area for long. Then out of these practices the farmers who adopted any one were treated as IPM farmer otherwise non-ipm or conventional. Fernandez-Cornejo et al. (1994), also determined the level of IPM adoption in the same manner. The only difference is, he preliminary selected four practices then distinguish farmers into IPM and non-ipm by asking about adoption of any one from the selected four practices.

The limitation of these methods is if any farmer follows only one practice then he or she would be treated as an IPM farmer what is contradict with the concept of IPM. The concept of IPM is to control paste by following a combination of method. Therefore, to avoid this limitation, recently Li et al. (2011), distinguished IPM farmers from conventional based on expert opinion (Lamb, 2011) and borrowing principles of IPM described by the U.S. Environmental Protection Agency (EPA 2011). The U.S. environmental protection agency (2011) has identified 36 IPM practices under four key components like Monitoring, Pest Identification, Prevention and Control. The distribution of the IPM activities related to each component was; 6 practices under Monitoring, 4 under Pest identification, 17 under Prevention, and 9 under Control.

Lamb (2011) argued to be an IPM adopter one should follow all the components, but at a different extent. This is because; all components are not equal regarding importance. He commented prevention is the most important followed by control, pest identification and monitoring (prevention > control > monitoring and pest identification). Hence, to be an IPM adopter, a farmers should give more emphasize on the activities under prevention and control rather than others. Li et al (2011) defined IPM adopter who followed nine practices from four components according to importance. The distribution of that nine practices was; 4 from prevention, 3 from control and 1 from pest identification and same from monitoring.

**d) Propose method to determine the level of IPM adoption in Bangladesh:**

Since, adoption is called site specific or area wide then to measure IPM adoption, special attention should be given on the location where it will be done. This is because; though there are some IPM practices that exist around the globe, but there always have some country or location specific IPM practices that are mostly usable by the farmers of that country. The 36 IPM practices that are identified by the U.S. environmental protection agency (2011), all are not applicable for Bangladesh context. In this line, to determine the IPM adopter, first we have identified the IPM practices that are available in Bangladesh. At present, there are 20 IPM practices are currently exist in the country and farmers use these practices at a different extent (fig.2). The first two principles belong to single IPM activity and these are common to all farmers. For this reason, we have given importance on the rest two, prevention and control. Between these two, since prevention is more important than control, then the farmers who follow any 3 activities from prevention and 2 activities from control will be treated as IPM farmers. Thus, to be an IPM farmer, one should follow 5 practices from prevention and control group collectively which will be acted as an indicator of IPM adopter in Bangladesh.

**Conclusion:**

In this paper we attempted to give an overview about two aspects of IPM adoption which one is influencing factors and other measurement techniques. Findings from discussion will help the future researcher to curtail their valuable time and industry to conduct research related to adoption of IPM. Regarding first point, we found adoption of IPM is influenced by a number of factors that can be classified into four broad items like economic, social, institutional, and management. The importance of economic factors is more among all while the influences of management factors are comparatively less. Additionally, to better understand about the influence on adoption of IPM as well as to extend the dimension, we proposed a set of factors.

Regarding second issue, we critically analyzed various measurement techniques of IPM adoption. We found measurement adoption with proportional measure is comparatively better than others to determine the level or rate of IPM adoption. However, because of varying nature of adoption, we proposed a technique to determine the level of IPM adoption in Bangladesh. It would be an example of determination of IPM adoption level for the other developing countries where this environment friendly farming is practicing.
Fig. 2: IPM practices in Bangladesh with four key components (a framework to measure IPM adopter and non-adopter in Bangladesh).

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References


