# Bridging the Gap: Factors Influencing Farmers' Willingness and Behaviour in Biopesticide Application


## ABSTRACT

Replacing chemical pesticides with biopesticides is crucial for ensuring high-quality agricultural products and advancing environmental sustainability. This study examines farmers' willingness and behaviors regarding the use of biopesticides. A survey of 127 farmers in Junagadh district, Gujarat, was conducted, and a logistic model was employed to analyze factors influencing deviations between farmers' willingness and their actual behaviors. The findings revealed that 37% of farmers showed a discrepancy between their willingness to use biopesticides and their actual application. Factors significantly impacting this deviation included price affordability, peer influence, education level, land size, emergency conditions, awareness of biopesticides, knowledge of the harmful effects of chemical pesticides, and awareness of agricultural product safety and quality. The primary reason for the gap between willingness and behavior is the farmers' insufficient knowledge about biopesticides and the incomplete market structure for these products. To address this issue, it is recommended to improve farmers' professional skills, raise awareness about green production methods, and accelerate the development of the biopesticides market to boost their adoption.



*Keywords: biopesticides; willingness; behaviour; deviation.*


## 1. INTRODUCTION

Conventional pesticides are associated with numerous negative externalities, such as environmental degradation and the development of pest resistance. As a result, their use in commercial farming is facing increasing regulatory restrictions. This shift has led to a 2% annual decline in the use of synthetic pesticides. In contrast, there is a 10% annual increase in the use of biopesticides as alternative agrochemicals [1]. Biopesticides are categorized into microbial biopesticides, biochemical biopesticides, and plant-incorporated protectants (PIPs). Together, these categories account for 5% of the global pesticide market. Among these, microbial biopesticides hold the largest share [2]. The full adoption of biopesticides faces several challenges. There is a limited supply of products available to meet farmers' demands. Additionally, the high cost of refined biopesticides and their generally slower action compared to conventional pesticides further hinder their widespread use [3]. Biopesticide-driven sustainable agriculture benefits from social acceptability, enhances economic productivity, and fosters environmental stewardship. These three aspects align with the tripartite concept of sustainable development. This concept is prominently featured in the United Nations 2030 Agenda, commonly known as the Sustainable Development Goals (SDGs). The SDGs aim to promote comprehensive development, including the eradication of hunger, reduction of poverty, and advancement of sustainable farming practices, among other objectives [4].

Globally, approximately 6 million tons of pesticides are used each year to manage crop pests and diseases, but less than 30% of these pesticides are used effectively, with up to 70% being misapplied. Pesticide residues spread rapidly through the air, oceans, soil, and organisms due to wind, rain, and other weather conditions [5]. This extensive use of chemical pesticides not only exerts significant pressure on the environment but also negatively impacts the quality and safety of agricultural products due to potential residue contamination [6]. These residues can pose risks to human health by accumulating in the food chain and through bioaccumulation [7]. To address issues related to limited agricultural resources and food safety, biopesticides are increasingly being favoured over traditional chemical pesticides [8]. Biopesticides, derived from natural substances or organisms, offer several benefits: they are versatile, less likely to cause resistance, and are safe for plants, humans, animals, and the environment [9]. Additionally, biopesticides are essential for organic farming and play a vital role in promoting agricultural sustainability [10]. Biopesticide-driven sustainable agriculture is characterized by social acceptance, increased economic productivity, and reduced environmental hazards. These qualities exemplify the ternate approach to sustainable development. Biopesticides offer several advantages, including their ability to act through various mechanisms. They can function as metabolic poisons, neuromuscular toxins, gut disruptors, non-specific multisite inhibitors, and growth regulators [11].

Differences between farmer's willingness to use bio-pesticides and their actual application in agricultural practices have been observed [12]. Pray et al. discovered that while more than one-third of agricultural producers in India were interested in using biopesticides, only 3% of the farmers in their study had actually used them in the past year. Despite the inclination towards biopesticides among a significant portion of farmers, their practical adoption remains quite low [13].This phenomenon, where a gap exists between farmers' willingness to use bio-pesticides and their actual behaviours, has been identified by some scholars and is described as a deviation or conflict between intentions and actions. [14]. Such discrepancies can result in misguided decisions by governments and enterprises regarding the production and promotion of bio-pesticides. Consequently, minimizing the gap between farmers' stated willingness and their actual use of bio-pesticides is crucial for effectively advancing their adoption and achieving a sustainable agricultural transformation.

Newman proposed that inconsistencies between willingness and behaviour can manifest in two ways: either as a failure to translate willingness into actions or as a divergence between behaviour and initial willingness due to external factors. He suggested that without addressing these issues, willingness alone may not lead to effective behavioural changes. [15]. Jeffrey R. found that the theory of planned behaviour incorporates not only an individual's subjective willingness but also the conditions and abilities necessary to perform a specific behaviour. According to this theory, an individual's behaviour is influenced by their willingness, as well as by the external conditions and personal capabilities required for that behaviour [16]. Since the ability to perform a behaviour and subjective willingness are collectively known as perceived behavioural control, this concept can directly affect individuals' behavioural intentions and actual behaviours. Perceived behavioural control encompasses both the individual's capability and their willingness, which in turn can influence their intentions and the likelihood of performing a specific behaviour [17]. Kumar S.M. et al. also used binary logistic regression in Trichy District in Tamil Nadu [18].

Existing international research on bio-pesticides indicates that the topic has been extensively studied and well-documented. However, there is a lack of research focusing specifically on farmer's behaviours regarding the application of bio-pesticides. Notably, there is a gap in understanding the discrepancy between farmer's willingness to use bio-pesticides and their actual application behaviours, and the factors driving this deviation require further investigation. To address this, this study employs a logistic regression model to empirically examine the factors affecting the deviation between farmers' willingness and their actual use of bio-pesticides.

## 2. METHODOLOGY

### 2.1 Data source

The data used in this study were obtained from survey questionnaires and interviews among farmers in Junagadh district of Gujarat. A multi-stage random sampling method was used to select the samples during the actual survey. In the first stage of sampling, the Junagadh district was selected. In the second stage two talukas was selected. At the third stage, four villages from each talukas was selected. From each villages 10 users and 10 non-users farmers was selected. In this way total 160 farmers was selected for the study purpose.

### 2.1 Statistical method

A binary logistic regression model was used to investigate the factors contributing to the discrepancy between farmers' initial willingness to use biopesticides and their actual behavior. For those farmers that don't have bio-pesticide application behaviour, deviation exists and $y = 1$; if farmers have bio-pesticide application behaviour, there's no deviation and hence $y = 0$. The logistic regression model is as follows:

$$P_i = F(y_i) = \left(\beta_0 + \sum_{j=1}^{n} \beta_j X_{ij}\right) = \frac{exp(\beta_0 + \sum_{j=1}^{n} \beta_j X_{ij})}{1 + exp(\beta_0 + \sum_{j=1}^{n} \beta_j X_{ij})} \quad \ldots(1)$$

Where,
$P_i$ = probability of deviation between the application intentions and behaviour of $i^{th}$ farmer
$F(y_i)$ = probability distribution function
$\beta_0$ = intercept
$\beta_j$ = regression coefficient of the $j^{th}$ independent variable
$n$ = number of independent variables
$X_{ij}$ = value of the $j^{th}$ variable of the $i^{th}$ farmer.
By taking the logarithm of both sides of Equation (1), the simplified form is obtained as:

$$y_i = \ln\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \sum_{j=1}^{n} \beta_j X_{ij} \ldots(2)$$

The study focused on farmers who initially expressed a willingness to use biopesticides in their agricultural practices. Statistical analysis revealed that out of 160 sampled farmers, 127 were willing to use biopesticides, hence this study was conducted empirical analysis based on these 127 samples. For those farmers that don't have bio-pesticide application behaviours, deviation exists and y = 1; if farmers have bio-pesticide application behaviours, there is no deviation and hence y = 0.

## 3. RESULTS AND DISCUSSION

Based on that, the regression analysis of the sample data was performed using SPSS software and the results are shown in Table 1.The results of the logit regression analysis show the overall percentage of case correctness for the model stands at 84.3 percent. Goodness of fit measures indicated that the model is acceptable. The likelihood ratio was significant ($p<0.05$), indicating that the amount of variation explained by the model is significantly different from zero. The Cox and Snell R Square value, a commonly used measure for goodness of fit for binary choice model was 0.558, which means 55.8 per cent of the total variation in the dependent variable could be explained by the X variables that were included in the logit model. A Nagelkerka R Square statistical test gave a p- value of 0.726, which indicated that the model fits reasonably well.The results of the logit regression analysis indicated that among the twelve independent variables included in the model, eight were statistically significant in influencing a farmer's behavioural decision to adopt bio-pesticide.

**Table 1. Factors affecting deviation between farmers willingness and behaviour application of bio-pesticide n=127**

| Variable | B | S. E. | Sig. |
|---|---|---|---|
| Age | 0.09 | 0.05 | 0.190 |
| Education | -1.21* | 0.38 | **0.012** |
| Farming income | -0.34 | 0.28 | 0.224 |
| Land size | -0.56* | 0.17 | **0.023** |
| Bio-pesticide awareness | -2.25* | 0.66 | **0.045** |
| Awareness of Hazardous Effect from Chemical Pesticides | -2.06* | 0.65 | **0.041** |
| Quality and Safety Awareness of Agricultural Products | -2.20* | 0.59 | **0.050** |
| Confidence Level over Bio-pesticides Promotion | -0.31 | 0.56 | 0.584 |

| | | | |
|---|---|---|---|
| Peer influence | 3.44** | 0.63 | **0.001** |
| Emergency condition | 2.41* | 0.64 | **0.036** |
| Bio-pesticide availability | 0.60 | 0.72 | 0.384 |
| Price affordability | 3.96** | 0.69 | **0.000** |
| Constant | -2.47 | 2.86 | 0.389 |

**significant 1% and *significant 5%

Likelihood test: 89.534, Cox & Snell R Square: 0.558, Nagelkerke R Square: 0.726

### 3.1 Analysis of the impacts of individual and family characteristics

The regression analysis indicates that both education level and land size are statistically significant at the 5 percent level, each negatively impacting the discrepancy between willingness and behavior regarding bio-pesticide use. Higher education levels among farmers are associated with a reduced gap between their willingness and actual use of bio-pesticides. Educated farmers typically possess a better understanding of bio-pesticides, making them more likely to adopt these practices. Similarly, farmers managing larger areas of land are more committed to agriculture as their primary occupation. Consequently, they are more consistent in their behaviors and willingness to apply bio-pesticides, given the benefits these practices offer in supporting effective agricultural production.

### 3.2 Analysis of the influences from farmer's awareness

Bio-pesticide awareness has a significant negative impact on the gap between farmers' willingness and actual behavior regarding bio-pesticide use, with results being significant at the 5 percent level. Descriptive statistics reveal that most farmers currently have limited knowledge about bio-pesticides. This lack of awareness is exacerbated by their age and low education levels, which result in minimal efforts to seek out information about bio-pesticides. Although farmers express a willingness to use bio-pesticides, their insufficient understanding of their benefits leads to difficulties in translating this willingness into concrete actions.

The awareness of the harmful effects of chemical pesticides and the quality and safety of agricultural products are both negatively correlated with the deviation between farmers' willingness and actual behavior regarding bio-pesticide use. Both factors are statistically significant at the 5 percent level. Farmers who are more informed about environmental pollution and the risks associated with chemical pesticides tend to be younger and better educated. These individuals are generally more concerned about ecological and health issues, making them more likely to adopt bio-pesticides and thus reducing the gap between their willingness and actual behavior. Additionally, a strong awareness of the quality and safety of agricultural products reflects a sense of social responsibility and personal commitment to environmental protection. Consequently, greater awareness in these areas correlates with a smaller discrepancy between farmers' willingness and their actual application of bio-pesticides.

### 3.3 Analysis of the influences from external factors

Peer influences significantly and positively affect the discrepancy between farmers' willingness and actual behavior regarding bio-pesticide use, with a significance level of 1 percent. This suggests that farmers rely heavily on their peers for guidance on pesticide use and procurement. These peer influences, which reflect social norms and customs, create pressure for farmers to conform to community practices. The survey revealed that although many farmers initially intended to use bio-pesticides, this intention often faltered because their neighbors continued to use chemical pesticides.

Emergency conditions have a significant positive effect on the gap between farmers' willingness and behavior regarding the use of bio-pesticides, with results being significant at the 5 percent level. Farmers often face the dilemma of choosing between highly toxic, quick-acting chemical pesticides and environmentally friendly bio-pesticides. During times of emergency, characterized by stress, anxiety, and urgency in daily agricultural tasks, farmers' environmental attitudes can be swayed by their emotional states. This emotional fluctuation can widen the disparity between their willingness to use bio-pesticides and their actual adoption of these practices.

Price affordability significantly and positively impacts the gap between farmers' willingness and actual behavior in using bio-pesticides, with a significance level of 1 percent. This indicates that the cost of bio-pesticides is a major factor in farmers' purchasing decisions. Farmers, who are mainly concerned with maximizing profits, often find the higher price of bio-pesticides a deterrent, even if they are aware of their environmental benefits and are willing to use them. When the desire to protect the environment conflicts with the higher cost of bio-pesticides, most farmers tend to opt for the cheaper chemical alternatives.

## 4. CONCLUSION

This research reveals that while farmer's willingness to adopt bio-pesticides is significantly influenced by individual, awareness-related, and external factors. Higher education levels and larger land sizes correlate with reduced discrepancies between willingness and behaviour, as educated farmers better understand and apply bio-pesticides, and those with larger operations prioritize practices that ensure productivity. Awareness of the risks associated with chemical pesticides and a commitment to environmental safety also reduce deviations, but limited knowledge hampers practical adoption. External factors such as peer influence, emergency conditions, and the higher cost of bio-pesticides further complicate this alignment. Peer pressure often leads farmers to follow community norms, while emergency conditions and high costs can push them toward quick, less environmentally friendly solutions. Addressing these challenges requires enhanced education, improved access to affordable bio-pesticides, and supportive community initiatives to bridge the gap between farmers' willingness and actual application.

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