Replacing the Chemical Fertilizer Through Eco-Friendly Technologies Developed for Paddy Cultivation: How Much Farmers are Willing-To-Pay For?

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ABSTRACT

Bio-fertilizer is one of the Eco-Friendly Technologies (EFT) developed through a multi-phased project to reduce the quantity and frequency of Chemical Fertilizer (CF) usage in paddy farming. What factors trigger farmers to adopt EFTs in the field, and more importantly, the "role of economics" in adoption of such technologies is, however, not yet fully understood. This study explores the outcome of an economic analysis carried out to determine the willingness-to-pay (WTP) of farmers, as potential end-users, for Bio-fertilizer. Structured questionnaire-based, face-to-face interviews were conducted aiming a set of paddy farmers (n=120) registered with a multi-stage, multi-criteria project in Anuradhapura and Kurunegala Districts to collect data. Choice Experiment (CE) method was employed to elicit farmers' Marginal Willingness-To-Pay (MWTP) for the deliverables of the product. The estimates from Conditional Logit model revealed that certain attributes, including 'high nutrient solubilizing rate' (i.e. the highest value of Rs. 908 per acre), 'promotional activities through farmer meetings' (Rs. 749 per acre), 'low environmental damage' (Rs. 471 per acre), 'powdered form of fertilizer' (Rs. 458 per acre) and 'availability through private markets' (Rs. 320 per acre) possess a significant relationship with farmer's WTP. The outcome of the study implies that the farmers, in general, exhibits positive attitudes and willing to pay relatively high prices for eco-friendly attributes associated with EFTs like Bio-fertilizer, but needs to expose a modified product according to farmer preferences to offset short-term benefits of chemical fertilizer use.

KEYWORDS: Choice experiment, Eco-friendly technologies (EFTs), Marginal willingness-to-pay (MWTP)

Introduction

Food production in 'Green Revolution' era emphasized on higher usage of agrochemicals which are not competent to increase food production while considering the quality, nutritional aspects, and safety of the consumer. Since the majority of agricultural soils found in Sri Lanka are known to have poor fertility, several strategies

have been introduced by different institutes to increase the soil fertility (i.e. incorporation of organic manure with inorganic fertilizer).

However, unavailability of required amounts of organic manure at necessary time period and handling of large quantities were considered as frequent issues faced by producers and users of organic manure. This phenomenon leads to trigger the excessive use of inorganic fertilizer for soil fertility improvement. The frequent and continuous application of inorganic fertilizers into agricultural fields causes numerous and severe negative impacts on human health, environment and ecology along with demand on the national budget.

The chemical fertilizer application rate in Sri Lanka has been ranged from 0 to 830 percent of the recommended level in different cropping systems (Kendaragama, 2006). It was identified that about 800 million kg of chemical fertilizers are imported annually to Sri Lanka, of which about 70 percent are being used in rice cultivation. At present, the Treasury is spending about Rs. 50 billion (about 2 % of foreign exchange earnings) on fertilizer subsidy scheme.

Paddy cultivation considered to be the crop which consumes the highest proportion of agrochemical imports, and at the same time, with low fertilizer use efficiency (i.e. 50 to 70 percent loss) (Sirisena *et al.,* 2016). However, the integration of Chemical Fertilizer (CF) with Organic Fertilizer is an emerging trend in the paddy sector. Highly subsidized fertilizer schemes e.g. "Kethata Aruna" discourages paddy farmers to adopt best management practices which will reduce the chemical fertilizer usage (Herath *et al.,* 2015).

The controversial issue of an excessive usage of chemical fertilizers in paddy farming led scientists to investigate on and invent environmentally-friendly production technologies (EFTs) such as 'Bio-fertilizer'. It is believed that negative environmental impacts can be manipulated by encouraging the use of EFTs. In light of these, this paper highlights on "Bio-Fertilizer" (BF) which as an outcome of multi-objective research study funded by the National Research Council of Sri Lanka. BF is formulated using microbial inoculants that improve nutrient availability to plants. It is targeted to develop a farmer-friendly bio-fertilizer technology, which will be effective in a range of rice growing environments. The challenge is to develop and utilize a product which consist with the elements where farmers highly emphasized. Even though new product development based on farmer expectations, adoption of such technologies have been lacking. It is vital to look into socio-economic aspects prior to introducing a brand new technology since "profitability" is a matter for farmers to adopt any technology in their field. Farmer's call to adopt associate innovative technology depends extremely on profits (increased benefits) over the expenses (decreased costs). Having recognized the foremost important attributes pertaining to the benefits and costs, the purpose of this analysis was to find the extent to which those potential end-users in the paddy sector are willing to pay for the deliverables of EFTs that replace the CF.

The appropriate 'Choice Modeling' techniques, as applicable to the real case in practice, was adopted to estimate the Willingness-To-Pay (WTP) of those potential 'end-users'. In such a situation, information regarding WTP for deliverables of EFTs can be used to identify the most concerned factors by the farmers. Therefore, this

information will help the project participants to develop their product according to the end users preferences.

Methodology

Theoretical Framework

Because of the fact that BF has not yet been introduced to the market commercially, it is difficult to make a choice on price and other economic attributes. Economic analysis is, therefore, warranted to find out how much farmers are Willingness-To-Pay for the product prior to the introduction process. On this justification, Stated Preference (SP) method was employed in the research process to estimate Marginal Willingness-To-Pay (MWTP). SP technique allows designing several varieties of a product, prior to the introduction to the market. Here, the responses were reported based on hypothetical situations. Since choice experiment based on consumer's utility maximization, it uses random utility theory. It emphasizes that rational decision maker will maximize the utility gained from his/her choice made.

Conceptual Framework

The conceptual framework of the study reflects the paddy farmers' willingness to pay for the deliverables of developed EFTs and how it will influence on product development and further adoption of the EFTs among paddy farmers (Figure 1).

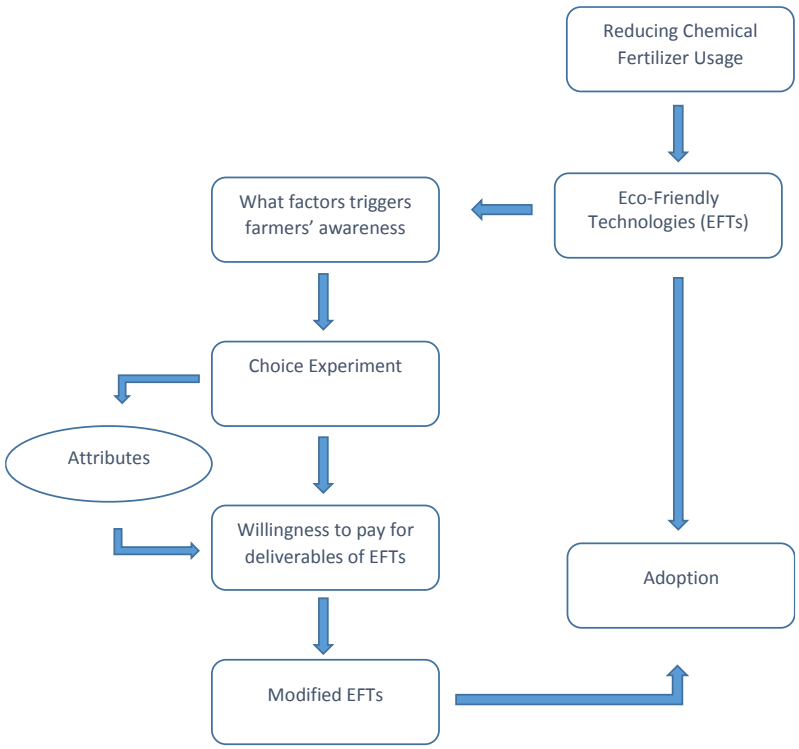

Figure 1: Conceptual Framework of the Study

Choice Experiment

Choice Experiment (CE) is a commonly used SP method to gather farmers' Willingness-To-Pay (WTP) / Willingness-To-Accept (WTA) or farmers preferences for several measures. Estimation of trade-offs between different attributes, attribute levels and values of individual components can be assessed through CE.

It emphasizes on the individual product attributes separately rather than considering it as a "single product". CE is useful when information is required in relative values for different attributes. It allows a direct path to value characteristics of good and marginal changes in the characteristics.

Choice experiment based on the statistical design principle, where it enables to model the probability of an alternative being chosen in terms of attributes (characteristics) used. It is, therefore, assumed that higher utility is associated with the higher level of a desirable attribute in an alternative (Bennett, and Blamey, 2001).

Two theories constitute the basis of CE. Micro economically CE is based on Lancaster's theory of consumer choice. It explains that individual's consumption decision depends on the utility gained by the attributes of the consumed good (Lancaster, 1966). On the other hand, Random Utility theory illustrates the econometric basis of the CE (McFadden, 1974). It emphasizes that rational decision maker will maximize the utility gained from his/her choice made. Hence, utility (U) of a choice is consists with deterministic component (V) and an error component (ε), which is independent from the deterministic part, follows a pre-determined distribution. Error component was added to imply, predictions cannot be made with certainty. Utility U for alternative *i* can be written as,

$$U_{ji} = V_{ji} + \varepsilon_{ji} \quad (1)$$

Uji = Total utility from alternative *i* by individual j
Vji = Explainable component with the assigned attributes
εji = Error component

Probability of individual *j* selects option *i* can be expressed as the probability that utility associated with option *i* is greater than utility of other options (Mussa, 2015).

$$P_{ji}=Pr(U_{ji}>U_{jk}) \quad (2)$$

Marginal Willingness-To-Pay (MWTP)

MWTP is the marginal welfare measure that seeks for a change in any of the attributes (i.e. the amount that respondent willing to pay in order to switch into an identical product along with an additional attribute level). It is calculated using the ratio of the estimated coefficients (β) of the respective attribute and the monetary attribute, holding all else equal.

$$\text{MWTP attribute} = -1\ (\beta \text{ attribute}/\beta \text{ monetary attribute}) \quad (3)$$

Choice Sets

Choice cards were prepared separately using crucial attributes and attribute levels to find out the value placed on product (i.e. Bio-fertilizer). Attributes were selected based on price, place, product and promotion categories, where it reflects the possibilities that end user may expect to experience. Focus group discussions and past literature (Khachatryan *et al.,* 2016) was used to select attributes. The chosen attributes and their levels are given in Table 1. The monetary attribute was incorporated as percentage reduction compared to the current chemical fertilizer application practices.

By doing so, it refers to the price of the product that might be experienced by the farmer in the real case in practice while it helps to compare farmers' preferences.

Table 1: Attributes and Attribute Levels

Attributes	Attribute Levels
Preferred Form	Liquid Form Powder Form
Nutrient Solubilizing Rate	Low High
Purchasing from	Through Regional Agricultural Service Stations Through private markets
Promotional Activities	Field Demonstrations Farmer meetings
Environmental Damage	High Low
Cost of Fertilizer Application (per Acre)	25% lower than current practice 40% lower than current practice

In this study, the farmers were likely to select an option from available combinations of eco-friendly features. Options were described in terms of the common set of attributes respective to each EFT. Farmers' choice on preferred option illustrates about their willingness to pay for each attribute. The monetary attribute was incorporated hence it simplifies the computation process of marginal willingness to pay.

Under the full factorial design, 64 possible choice alternatives (i.e. 2^6) were prepared using six attributes and two attribute level per each. Orthogonalization procedure resulted sixteen possible choice combinations and those were randomly blocked into eight different versions including two options per each technique.

Collection and Analysis of Data

Primary data were collected from 120 paddy farmers who have registered under this multi-phased project for five years. The survey was conducted in Anuradhapura and Kurunegala districts during the period of August to September in 2018. (The survey instrument was pre-tested using a pilot survey prior to the original data collection).

A structured questionnaire-based, face-to-face interviews were conducted to collect data. Prior to the choice sets, farmers were presented with the description of the background and introduced the attributes and attribute levels separately. They were advised to evaluate their preferred set within the given a "Choice Card" (i.e. 1 out of 8 prepared with varied combinations) and asked to select the 'best-preferred option'.

The full design was completed by presenting each block to a different respondent. Furthermore, prepared choice sets were randomized across questionnaires in order to eliminate order biases. An example choice set is given in Figure 2.

	Choice 1	**Choice 1**
Preferred Form	Liquid Form 	Powder Form 
Nutrient Solubilizing Rate	Low 	High 
Purchasing from	Through Regional Agricultural Service Stations 	Through Private Markets 
Promotional Activities	Farmer Meetings	Field Demonstration
Environmental Damage	Low 	High 
Cost of Fertilizer Application (per Acre)	40% lower than current practice	25% lower than current practice
Preferred Option		

Figure 2: An Example of a Choice Card

Results and Discussion

Descriptive Statistics of the Sample

Majority of the farmers (76 %) were male and most of them were educated up to the ordinary level (40%). Sample consist with farmers who were over 60 years in age. Further, results indicate that just about 64 percent do have an additional financial gain except paddy farming (Table 2). Nearly 71 percent of the respondents do cultivation in their own land and most of the farmers practice broadcasting technique for seeding procedure.

Since allotted cash amount in 'cash grant subsidy scheme' doesn't directly utilized in the cultivation process, survey statistics illustrate that almost 78 percent of farmers prefer material based fertilizer subsidy scheme.

Table 2: Descriptive Statistics of the Sample

Parameter	Category	Percentage
Gender	Male	76
	Female	24
Age	<30	03
	30-40	13
	41-50	17
	51-60	25
	>60	42
Education Level	No Education	03
	Up to Grade 8	33
	Up to O/L	40
	Up to A/L	20
	Other	04
Land Ownership	Owner	71
	Rent	16
	Both	13
Cultivated Land Extent	<2 Acres	53
	2-5 Acres	31
	>5 Acres	16
Extra Income	Yes	64
	No	36
Seeding Technique.	Broadcasting	91
	Transplanting	02
	Parachute Tech:	07
Preferred Subsidy Type	100 % Material	78
	100 % Financial	18
	Integrated	04

Outcome of Choice Experiment

How attributes are relatively important and influence on individual preference are obtained through parameters of the utility equation. Direct conclusions on the parameter size cannot be drawn while using CLR. But the sign of an individual parameter indicates positive or negative impact of an attribute on the total utility of respondents (Table 3). Negative coefficients for price attributes matched with expectations while it indicates an inverse relationship between choice probability and price.

According to the results obtained, all selected attributes were significant at 95% confidence level. Significant attributes were assumed to be relevant when respondents select a choice.

Table 3: Outcome of Choice Experiment

Attribute Level	Coefficient	P value
Preferred Form		
Liquid Form*	*	*
Powder Form	0.42	0.00
Nutrient Solubilizing Rate		
Low *	*	*
High	0.83	0.00
Purchasing From		
Through Regional Agricultural Service Stations*	*	*
Through Private Markets	0.29	0.01
Promotional Activities		
Field Demonstrations*	*	*
Farmer Meetings	0.68	0.00
Environmental Damage		
High*	*	*
Low	0.43	0.00
Cost of Fertilizer Application (per Acre)	$-9.1*10^{-4}$	0.03

*Note: *Base level, Log likelihood - (-139.29)*

Results were presented with respective to baseline attributes. Baseline attributes were picked as being the least preferred option. As shown in asterisk (*), baseline attributes include, liquid form, low nutrient solubilizing rate, availability through regional agricultural service stations, promotion through field demonstrations and high environmental damage.

MWTP values were calculated based on the available results from the CLR model (Figure 3). Paddy farmers were willing to pay the highest value of Rs. 908 per

acre for high nutrient solubilizing ability. Farmers pay attention to particular attribute since it increases the nutrient availability in the soil where it might emphasis on diminishing the excessive use of CF.

Farmers prefer farmer societies as a venue to conduct promotional activities since those conducted with an oversized gathering wherever concepts will be simply disseminated. Therefore, they willing to pay Rs. 749 per acre for promotional activities through farmer meetings. Furthermore, farmers always prefer low environmental damage (Rs. 471 per acre), which will help to maintain the cultivation consistently. Additionally, they prefer EFTs as a result of diminishing the negative impact of chronicle kidney diseases.

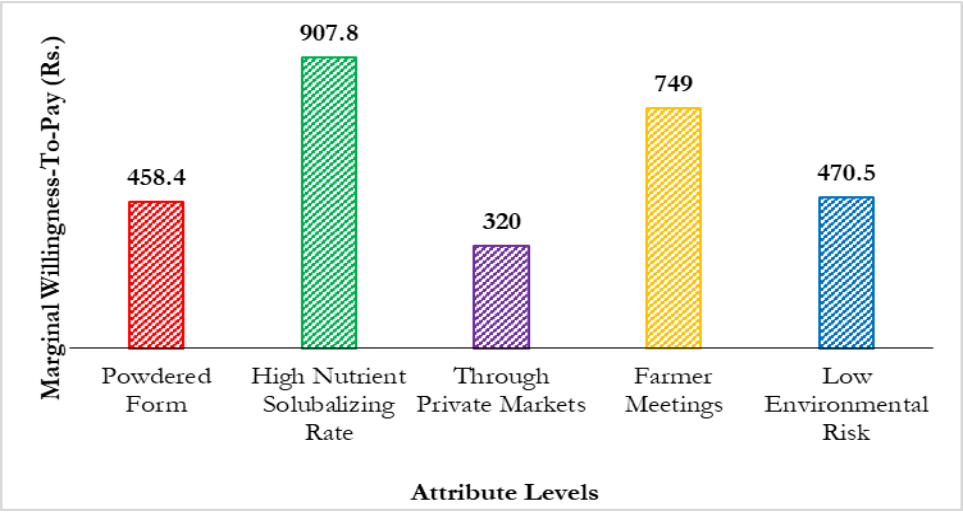

Figure 3: MWTP Values by the Farmers

Note: MWTP in Rs. per acre per season, MWTP value of presented level - MWTP value of its whole attribute

Since powdered fertilizers are easy to transport, handle and not result in high wastage as liquid fertilizers, farmers willing to pay an extra amount of Rs. 458 per acre for the BF in powder form than in liquid form. Additionally, they suggested powder form is best in land preparation stage and liquid fertilizers are appropriate for the latter stage of the cultivation. Although, farmers are willing to pay a lowest value (Rs. 320 per acre) for purchasing through private markets, if product quality is above the expected limit, farmers prefer to purchase it either through private or public markets. Consistency in supply and the quality of the product plays a significant role when farmers consider the private market as their choice. Apart of that farmers prefer to purchase fertilizer through government bodies, since it results in low cost along with low number of intermediaries.

Conclusions

Estimates of farmers' MWTP for all attributes pertaining to this technology are considered to be positive and significant. It emphasizes that farmers' in general, value those attributes explaining, powdered form of fertilizer, low environmental damage,

promotion through farmer meetings and purchasing through private markets. As a result, high nutrient solubilizing rate was accounted as the leading factor which affects paddy farmer's choice behavior while they willing to pay Rs. 908 per Acre.

The willingness to pay values obtained for the product attributes respectively provide pertinent information on stages of product development and market segmentation which successfully helps to penetrate the fertilizer market. The study highlighted that, at the ground level, farmers were more concerned on nutrient solubilizing ability of the fertilizer. Considering these, it is important to pay attention to take appropriate actions at the product development stage to enhance solubilizing ability of bio-fertilizer.

The outcome of analysis highlights that, at the ground level, farmers are more concerned about the economic and financial returns associated with moving into adoption of such technologies. In the light of this, it is important that public regulatory institutions and others stand for EFTs should generate both short-term and direct private and market-based incentives, over and above their counterpart, for farmers to shift into those EFTs.

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