

# Introducing Eco-Friendly Technologies to Reduce Chemical Fertilizer Usage in Paddy Farming in Sri Lanka

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## Abstract

The study explores the probability of substituting Chemical Fertilizer (CF) with Eco-Friendly Technologies (EFTs) which are to be introduced to the Sri Lankan paddy farmers in the form of a product package of Biochar (BC) and Bio Fertilizer (BF). The main focus was to elaborate whether the benefits of EFTs have outweighed the costs of EFTs and to identify the policy tools, incentives and key instruments, by employing a semi structured questionnaire based survey carried out in Anuradhapura and Kurunegala for a sample of 100 farmers. The perception analysis revealed that EFTs are beneficial over the CFs and if proper governance is established by the regulatory bodies EFTs are much preferred by the farmers over CFs.

**Keywords:** *Chemical Fertilizers, Eco-Friendly Technologies, Paddy farmers, Perception analysis, Policy Tools, Sri Lanka*

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## INTRODUCTION

At the onset of the Green Revolution in the early 1950s the world was focusing on crop production in intensive scales, which ultimately resulted in introducing high yielding varieties of crops that were highly responsive to Chemical Fertilizer (CF). Even though the era of “Green Revolution” was credited for the higher levels of food production and productivity of agricultural lands, quality and health aspects of the production procedures could not be achieved due to the massive reliance on agro-chemicals. Actually traditional farming practices especially prior to the 20th century were generally regarded as ‘organic’. But the introduction of synthetic farm inputs proved to increase crop yield overshadowing those green / organic approaches (Paull, 2006). Several studies have been carried out to stress on the crucial environmental, social and health problems associated with CF usage in paddy cultivation and those findings have further emphasized the fact that a solution is required for the problems associated with the CF (Jayasumana et al., 2013; Dharmawardena et al., 2015).

Rice is not only the staple food in Sri Lanka but makes up almost the total livelihood in the rural areas of the country. Paddy farming gradually changed from the organic background to complete dependency on CF and the frequency and quantity of using it intensified with the stretched budgetary allocations of the government for the fertilizer subsidy under projects like “Kethata Aruna” (Herath et al., 2014). Due to excessive use of CF on agricultural lands the soil fertility has drastically dropped over the past few decades. When considering the situation in Sri Lanka, CF has ranged from 0 to 830 percent of the recommendations in different cropping systems (Kendaragama, 2006). Most critically 70 percent of the CF imported to Sri Lanka is used in paddy farming. The history proves that the subsidizing triggers the use of CF. In 1990 CF usage was reduced and the reason was the subsidy scheme being completely removed. But today the situation has changed. The treasury spends about Rs. 50 billion on the fertilizer subsidy scheme and that amount is almost 2% of the foreign exchange earnings (Herath et al., 2014).

As a solution for these issues, National Research Council (NRC), of Sri Lanka has funded the implementation of the multi-year, multi- disciplinary project “Development of Eco-Friendly farming technologies to minimize inorganic fertilizer usage while maintaining adequate productivity and improving soil fertility” in 2016. The project is supposed to run for several consecutive years. The project consists of seven work packages which are monitored and conducted by veterans in the agriculture sector from different academic and research institutes. Development of farmer friendly site specific nutrient management for rice cultivation through a Nutrient Expert Decision Support tool, Production of Biochar (BC), Development of Bio Fertilizers (BF) and developing technologies associated with the production of the Eco-Friendly Technologies (EFTs) are some of the major tasks covered by the work packages.

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About 2/3rd of rice production in the country is done in dry and intermediate zones. Kurunegala, Polonnaruwa and Anuradhapura can be identified as the three major rice growing districts which contribute to nearly 50 % of the national rice production in Sri Lanka. In these districts the water management systems and the cropping systems reflect major variations and diversities based on the climatic factors (Anon, 2017). Hence, the compatibility or the adaptability of new technologies can be efficiently assessed and the results will be applicable to a wide range of rice growing environments in Sri Lanka. In addition to these reasons RRDI of DOA has regional experimental stations and good links with farmer groups to conduct participatory research activities, which strengthens the development of farmer friendly new technologies. Therefore, hundred farmers were registered representing these districts and their lands were utilized for the field experiments with the consent of the farmers. For the field experiments conducted Bg 352 rice variety was used.

This study was conducted regarding the product package which is to be launched to the market in the near future. The product package includes the BC and the BF developed under the work packages of the project. The socio economic importance of the product package was assessed by this research study. Actually what matters for the farmers is the profitability of the EFTs. Therefore the study was aimed at identifying the social acceptability and the economic viability of the product via a perception analysis of the farmers.

BC and BF are supposed to be introduced to the agriculture market as a single product package to be incorporated in the paddy fields as a solution to the CF usage. BF is formulated using microbial inoculants that improve nutrient availability in soils (Hayat et al., 2010 and Bhattacharyya and Jha, 2012) and the complementary product, the BC as well is supposed to be of equally beneficial to the nutrient management of agricultural soils. Through these EFTs, the quantity and the frequency of inorganic fertilizer usage in paddy farming is intended to be reduced significantly.

Biochar(BC)– Nitrogen, Phosphorus and Potassium or commonly known as NPK are macronutrients that are required by plants in large quantities are not adequately present in the general soil to support the sustainability of the plants. Therefore NPK are supplied to the plants externally through fertilizer. Since the conventional fertilizer compositions are water soluble 50%-70% of nitrogen applied using conventional fertilizers is lost without efficient plant uptake (Monreal et al., 1986). Number of technologies have been developed in the past to increase the nitrogen use efficiency in cropping fields. Slow release technologies use coating N fertilizers with organic or inorganic materials or combine with other chemicals (Shaviv, 2000; Majeed et al., 2015). The EFT project has focused on such background information and have produced biochar from rice husk using simple pyrolysis technique, and it shows a range of micro pore spaces (Dharmakeerthi,

2015). The BC produced from rice husk under this project has a porous structure ranging from sub-micro to nano scale and subsequently will be impregnated with urea into these pores in order to formulate the new slow release fertilizer. Use of BC to produce a slow release N fertilizer is supposed not only to reduce chemical fertilizer usage in the country, but also to apply BC into the soil every season which could contribute to improving soil fertility gradually.

Bio-fertilizer (BF)– The next product. The project was focusing on BF. BFs play a very significant role in improving soil fertility by fixing atmospheric nitrogen and in association to plant roots. Without it, solubilizes insoluble soil phosphates and produces plant growth substances in the soil. They are in fact being promoted to harvest the naturally available, biological system of nutrient mobilization (Venkateshwarlu, 2008). The EFT project aims to develop a bio-fertilizer integrated with Plant Growth Promoting Rhizobacteria (PGPR). The microorganisms living in association with root system stimulating the plant growth are called as PGPR and they are expected to show high adaptability to a wide variety of environments. Enabling them to successfully establish in soil eco-systems can help to reach a faster growth rate and biochemical versatility, to metabolize a wide range of natural and xenobiotic compounds (Battacharya and Jha 2012). Given this concrete background and since at present there is no recommendation by Rice Research and Development Institute of Sri Lanka on integration of bio-fertilizers in nutrient management programme in rice cultivation, the project targets at further developing a farmer friendly bio fertilizer technology, which will be effective in a range of rice growing environments.

From all the deliverables which are proposed to be fulfilled by the project, it is important to pay attention to the socio- economic aspects of the process as well and to identify the influence of these production process and use of the EFT package of interest (BC and BF)with regard to the paddy cultivation sector of Sri Lanka. This study specifically assesses such benefits and costs from the perception of the farmers, and introduces policy tools, incentives and key instruments as per the preference of the farmers.

## **RESEARCH PROBLEM**

Prior to introducing the EFTs to the market it is important to get a clear picture of the perception of the paddy farmers (the potential end users of the product) about the product package. The major problem encountered was to obtain a vivid image of the mind-set of the end users and their preferences. The study aims at recognizing whether the paddy farmers identify the use of EFTs as beneficial over the use of CFs with regard to the associated costs, and to elaborate the criteria placed as important by paddy farmers to replace CFs with EFTs. Through this economy based research it is also attempted to

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discover the major concerns of the farmers when it comes to developing policy tools, incentives and key instruments for the EFT usage in paddy farming in Sri Lanka.

### **OBJECTIVE**

The main objective of the study was to assess the perception of the paddy farmers on development and use of BC and BF over the CFs in an economic point of view and to introduce the farmer preferred policy tools, incentives and key instruments to the regulatory bodies for the betterment of the paddy farming of Sri Lanka.

### **METHODOLOGY**

#### **Theoretical Framework**

As implied in theories conveyed by Buchanan (1969), the organizational decision making can be supported with an analysis of benefits and costs of the product to launch. In order to confirm the continuation of developing the EFTs, a benefit-costs analysis was conducted for the sample to identify the expected benefits and the associated costs of the product package inclusive of BC and BF. Following equations are to be employed and achieved in order to make decision favourable to EFTs.

Using notations from Figure 1,

$$\begin{aligned}TB - TC &> 0 \\(IB - DB) - (IC - DC) &> 0\end{aligned}$$

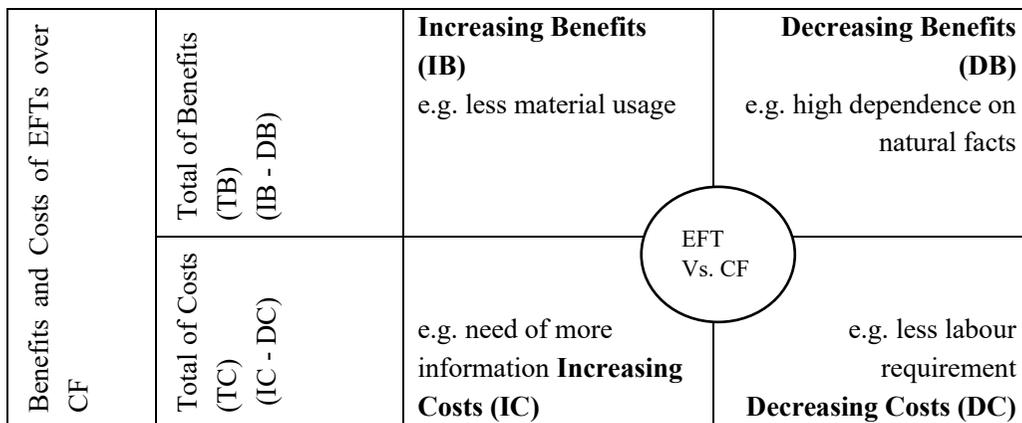
Compliance decision based on the final outcome,  
Benefits – Costs > 0

To identify the major preferences of the farmers in terms of benefits or costs as per their point of view, 20 statements were generated and classified into six major criteria identified through the “expert perception analysis” by Chandrasiri et al., (2018) for previous studies on the same discipline on EFTs. The criteria identified were (1) Regulation (RT), (2) Cost of Application (CT), (3) Effect on the Environment (ET), (4) Expected Performance (PC), (5) Availability of Related Services (SE), and (6) Level of Acceptance (AC) and each score given for statements represented the attitudes of the farmers regarding the EFTs.

The policy tools, incentives and key instruments for the EFTs are considered in case of introducing the product to the market. Based on the perceptions and general concepts on EFTs 28 statements (Table 2) were selected to the study and classified into four major categories as, ‘Price’, ‘Service’, ‘Materials’ and ‘Other’. These were once again

subcategorized as ‘Government’, ‘Market’, ‘Judiciary’ and ‘Self’ based on methods explained by Jayasinghe–Mudalige and Henson (2007).

**Figure 1: Conceptual Framework**



*Appendix A*

**Table 1. Statements Classified Under the Criteria**

Criteria	Notation	Statement
(1) Level of Acceptance	AC1	Risk level of diminishing the current yield
	AC2	Durability of EFTs after opening the package
(2) Cost of Application	CT1	Management of the workload associated with the use of EFTs
	CT2	Labour requirement and management
	CT3	Need of using heavy machinery to support the procedure of applying EFTs in the field
	CT4	Storage cost and space requirement for the EFTs
	CT5	Wastage/ over utilization of resources
	CT6	Expenses related to soil treatments to maintain soil health and fertility
(3) Effect on the Environment	ET1	Potential damage to the surrounding environment
	ET2	Possible human well being and safety matters resulted by the use of EFTs
	ET3	Priority given to the eco system safety and sustainability
	ET4	Disposal of waste materials after use of EFTs
(4) Expected Performance	PC1	Possibility of improving productivity of paddy fields

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	PC2	Chances of enhancing predictability of paddy production
	PC3	Ability to be integrated with other technologies in paddy farming
	PC4	Capability of forecasting the optimum fertilizer recommendations for paddy fields based on external conditions. (rain, temperature)
(5) Regulation	RT1	Guidance and advice needed in handling the product package (ex- through agrarian service centers, agriculture instructors)
	RT2	Need of prior knowledge and acceptance of regulatory bodies on field conditions and technology
(6) Availability of Related Services	SE1	Requirement of external services to get information on weather to decide on EFT application
	SE2	Need of abundance in technology with the related farmer communities to apply EFTs

*Note: (1) Regulation (RT), (2) Cost of application (CT), (3) effect on the Environment (ET), (4) expected Performance (PC), (5) availability of related Services (SE), and (6) level of Acceptance (AC)*

**Table 2: Policy Tools, Incentives and Key Instruments**

Classification	Notation	Statement
<b>Price</b>		
<i>government</i>	Pg1	Steps taken to reduce rice volatility
<i>market</i>	Pm1	Information on market pricing conditions
	Pm2	Systems to adjust supply and demand
<i>judiciary</i>	Pj1	Fertilizer price controls
<i>self</i>	Ps1	Monthly income and affordability
<b>Services</b>		
<i>government</i>	Sg1	Workshops, awareness and capacity building
	Sg2	Proper standardization processes
	Sg3	Need of agricultural credit
	Sg4	Importance of subsidy on CF
	Sg5	Importance of subsidy on EFT
<i>market</i>	Sm1	Subsidy given in the form of fertilizer
	Sm2	Providing information on production process

	Sm3	Providing information on product
	Sm4	Availability of guidelines
<i>judiciary</i>	Sj1	Establish supply chain management
	Sj2	Laws regarding disposal of materials
<i>self</i>	Ss1	Disposal of residues of EFTs
	Ss2	Investment on acquisition of knowledge on EFTs
<b>Materials</b>		
<i>government</i>	Mg1	Provision of materials for EFT production
<i>market</i>	Mm1	Availability of input materials to produce EFTs
<i>judiciary</i>	Mj1	Regulations on material usage
	Mj2	Controlling of material imports
<i>self</i>	Ms1	Requirements of storage facilities
<b>Other</b>		
<i>government</i>	Og1	Government regulations on EFT usage
<i>market</i>	Om1	Establish a proper information network between farmers
<i>judiciary</i>	Oj1	Other legal and regulatory controls (environmental, social, ethical)
<i>self</i>	Os1	Information on climatic changes
	Os2	Knowledge on previous field conditions

*Note: Main Categories -P- Price related factors, S- Service related factors, M- Material related factors, O- Other factors, Subcategories- g- should be administered by the government, m- controlled by the market conditions, j- related to law and authority, s- can be controlled by one's own self*

## COLLECTION AND ANALYSIS OF DATA

For 100 farmers from districts of Anuradhapura and Kurunegala, who were registered for the EFT project, a questionnaire-based survey was conducted through face to face interviews during August and September, 2019, to obtain the farmer perceptions on switching from CF to EFTs based on their current knowledge and experience. Previously identified 20 statements (Table 1) were listed to differentiate the costs and benefits of EFTs over CF and 28 statements regarding policy tools, incentives and key instruments were included to discover the importance farmers place on each of the segments under the given categories. The statements were evaluated against a 10 point Likert scale ranging from 'extremely important' to 'extremely unimportant'.

Based on the scores given by the farmers on EFTs and CF, on the benefits and costs of the product package in a socio economic point of view, a relative value was taken considering 5 as the neutral point. Mean scores above 5 were considered as an IB or DC based on the implied idea of the statement and mean scores below 5 were considered as

either a DB or IC. Then based on the relative “Mean Importance Scores (MIS)” given, the equations suggested by Buchanan (1969), were employed to identify the economic feasibility.

For the 20 statements developed under the six criteria the “Confirmatory Factor Analysis” was carried out to establish the validity of the classification and ascertain the “Scale Reliability” and the “Unidimensionality”. Once the validity and reliability of data, were confirmed MIS related to those criteria and statements were employed for further analysis (Jayasinghe-Mudalige and Henson, 2006).

Analysis of the policy tools, incentives and key instruments on EFTs was also based on the MIS obtained by each statement. According to the ‘relative rank’ method explained by Powers and Xie (1999), after deriving the aggregate scores given by the respondents, the summed scores were divided by the number of farmers in the sample to obtain the MIS. As per the value of the statement after the process, they were ranked and ordered based on the importance as the most and least prioritized ones.

The Exploratory Factor Analysis (EFA) was conducted using the coded data of policy tools, incentives and key instruments to identify the internal consistency of the statements the “Cronbach’s Alpha value”. Statements assessed against the 10 point Likert scale were taken as ‘multiple-item scales’ and ‘Principal Axis Factoring’. This was the technique used to bring out that the data set available for the study which was ‘Unidimensional’. High reliability is assured if a value above 0.7 is obtained.

But with multidimensional and orthogonal data, related to the nature and sample design of the research a value exceeding 0.5 is considered to be sufficient (Lord and Novick, 1968). EFA was further extended to identify the co- relation between the factors with the objective of reducing variables in a way that only closely related and most focused ones will be remained. Then based on the scores given against the 10 point Likert scale, the MIS was derived for each sub -category for further proceeding of the study to obtain a relative rank of each statement (Jayasinghe–Mudalige and Henson, 2006).

## **RESULTS AND DISCUSSION**

The project from which the study is derived aims at further developing BC and BF for the purpose of reducing CF usage in paddy farming of Sri Lanka. Several ventures on the same matter have been carried out by different personnel previously and have obtained progressive results. Biochar has been tested for its effect on paddy cultivations at numerous level experiments and has been proven as an effective mode of soil amendments and to be acting as a barrier against the leaching of nutrients. Biochar has

been used on paddy related experiments and has resulted in developing height, dry mass and tillers (Utomo et al., 2010). If the nutrient carrier could be made from waste organic materials using a simple technology, it would provide multiple advantages. There is an increased interest in using biochar as a soil amendment in agriculture, as a carbon sequestration technology as well as a method for improving soil fertility (Lehman and Joseph, 2015). Regarding the BF being produced under the project using PGPR has sound evidence of its ability to facilitate growth of paddy. The mechanisms of plant growth promotion by these organisms include solubilization of nutrients (eg. P and Si) N<sub>2</sub> fixation, production of growth regulators, competitive exclusion of pathogens or removal of phytotoxic substances, induction of systematic resistance, etc. (Tsavkelova et al., 2006; Battacharya and Jha 2012; Dandeniya and Rajapaksha, 2013). Bio-fertilizer are formulated using microbial inoculants that improve nutrient availability to plants. There are number of scientific reviews discussing bio fertilizer and their potential to cut down chemical fertilizer usage in crop cultivation (Hayat et al., 2010; Battacharya and Jha 2012; Bharadwaj et al., 2014). With that background on the BC and BF, it is important to focus on the economic aspects of the product package which is the major focus of this study.

The multiyear, multidisciplinary project has been the subject of several studies for the purpose of scientific and survey matters. The previous authors have conducted several studies to check the social acceptability and economic viability of the same project. An expert view perception analysis on “Adoption of Eco-Friendly Technologies to Reduce Chemical Fertilizer Usage in Paddy Farming in Sri Lanka” reveals that EFTs can play a significant role towards reduction of CF usage in Sri Lankan paddy cultivation if the key issues associated with the use of EFTs are addressed successfully. The study further highlights the need of providing services, extension services and private incentives to the farmers in order to promote the use of EFTs (Chandrasiri, 2018). Following the expert perception analysis several other studies have been carried out to identify the willingness of the farmers to pay for EFTs over CF and to explore the willingness of the farmers to adopt EFTs over CFs. To replace CFs with EFTs the farmers in general, exhibits positive attitudes and willing to pay relatively high prices for eco-friendly attributes associated with EFTs like and Biochar and Bio-fertilizer, but there is the need to expose a modified product according to farmer preferences to offset short-term benefits of chemical fertilizer use (De Silva, 2019). A study on the farmer perception on willingness to adopt the EFTs over CFs highlights the importance of generating private and market-based incentives for farmers as potential end-users to encourage adoption of Eco-Friendly Technologies in paddy cultivation, where the availability of related services and facilitative institutional framework will have a direct impact on the adoption such eco-friendly technologies (Colombage, 2018). Thereby the project leaves room for further experiments.

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Farmers have been using CFs for decades in the paddy fields and the introduction of the EFT product package would make some vital shifts in their normal farming patterns. There can be opportunities and constraints in switching from CFs to EFTs. Actually studies have been previously conducted on similar subjects and they have revealed that such type of projects even though they are initiated with a purpose of conserving environment and addressing human health issues, they still can have both positive and negative reviews in different perspectives of people. One such study found that in developing countries there is a potential to apply “fertigation” as a way of environmentally friendly fertilizers application as it has been adopted in China. These opportunities include abundant natural resources like land and water, less polluted environment, conducive agricultural policies, zero duties levied on imported irrigation equipment. However, a number of limitations also are there such as, lack of investment, lack of infrastructure, lack of information, the requirement of expertise on plant nutrition and management of fertigation system, requirement of soil analysis and proper interpretations by experts (Kabirigi et al., 2017). Non-availability of sufficient organic supplements, bio fertilizers and local market for organic produce and poor access to guidelines, certification and input costs, capital-driven regulation by contracting firms discouraging small farm holders were identified as drawbacks in the case of substituting chemical fertilizer with environmental friendly matters (Pandey and Singh, 2012).

With the background provided by the previous studies in the related fields the gaps were identified and the study was launched to identify the farmer perception of the EFTs in terms of benefits and costs and to bring out the farmer preferences for developing policy tools, incentives and key instruments associated with the EFTs (BC and BF). Focussing on the results obtained by the study,

### Descriptive Statistics of the Sample

When considering the demographic information of the sample selected, data were first collected from Anuradhapura district during August 2019 and then data were collected from Kurunegala district during November 2019. As indicated in Table 3, if taken separately,

**Table 3: Descriptive Statistics of the Sample**

Parameter	Category	Anuradhapura Percentage (%)	Kurunegala Percentage (%)	Overall Percentage (%)
Gender	Male	67	75	71
	Female	33	25	29
Age (Years)	<35	11	4	8
	35- 65	83	83	83
	>65	6	13	9
Farming experience (Years)	<5	4	7	5
	5-10	15	13	14
	11-15	7	8	6
	16-20	7	12	9
	>20	67	60	64
Education level	Not schooled	6	0	3
	Up to grade 5	16	9	13
	Up to grade 8	21	4	14
	Up to O/L	44	36	40
	Up to A/L	13	36	23
	Degree/Diploma	-	15	7
Land ownership (ac)	>2	36	73	53
	2-5	46	22	35
	>5	18	5	12

In Anuradhapura and Kurunegala the demographics were almost the same except for the education level and land ownership. In Kurunegala the farmers were much educated. Some of them (15%) is qualified with tertiary education. Compared to that, Anuradhapura did not have that much of educated farmers. 6% of them had not even been to school. In Anuradhapura a high portion of farmers (46%) owned 2-5 acres of land whereas in Kurunegala 73% of the farmers owned less than 2 acres of land. When considering both the districts as a whole, or the sample subjected to the study, majority of the farmers were males (71%) between the age of 35-65 years. Actually a very less number of farmers were under the age of 35 years. Despite the district they came from, 64% of them had experience over 20 years in the farming field. The highest education level for most of them (40%) was the GCE Ordinary Level except the slight deviations, which was the education level they had achieved.

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Based on the scores given by the farmers “Lowering expenses on soil treatment due to the sustainability of soil health”, has the highest points 3.9, where it can be expressed as a DC. The second in score is “Less wastage of fertilizer due to reduction of excessive applying” with a score of 3.8, which is also a DC. From the statements presented the respondents have identified “Ensuring human and environmental health and safety” as an IB and it has the third highest score of 3.7. Then some of the statements have scored minus values. Such as “High dependence on soil, water and weather conditions”, with a score of -3.5 and it is a DB whereas -3.4 scored, “More knowledge requirement on prior information on the field” can be identified as an IC. A complete demonstration on all 20 statements and relative scores are indicated in Table 1 and Figure 2.

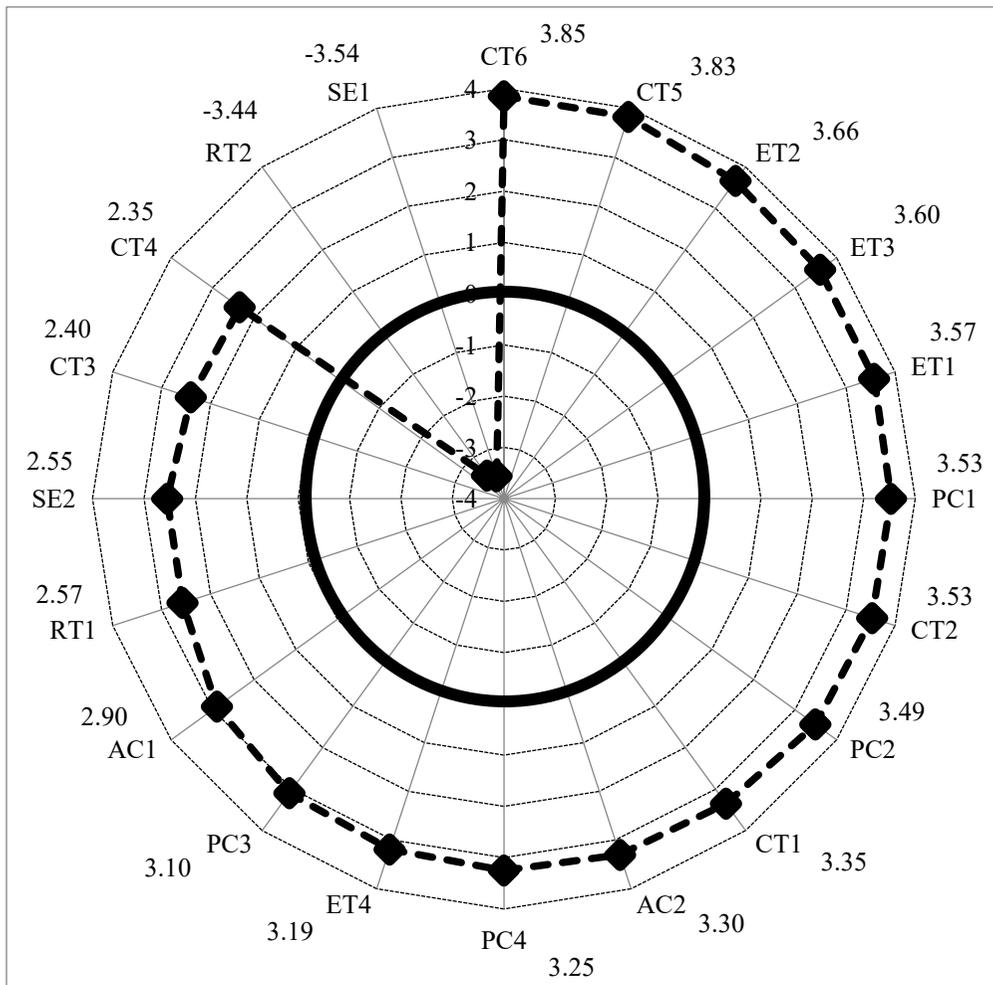
The aggregate mean scores of each statement decide the economic feasibility of the project.

$$\begin{aligned} & (IB - DB) - (IC - DC) \\ & (29.7 - (-3.5)) - (28.3 - (-3.4)) = 1.5 \\ & TB - TC = 1.5 \end{aligned}$$

The result exceeds 0. Therefore the project can be identified as an economically feasible venture since the obtained values suggests that the beneficial portion of the EFTs are overweighing the costs when compared with CF as per the perception of the farmers.

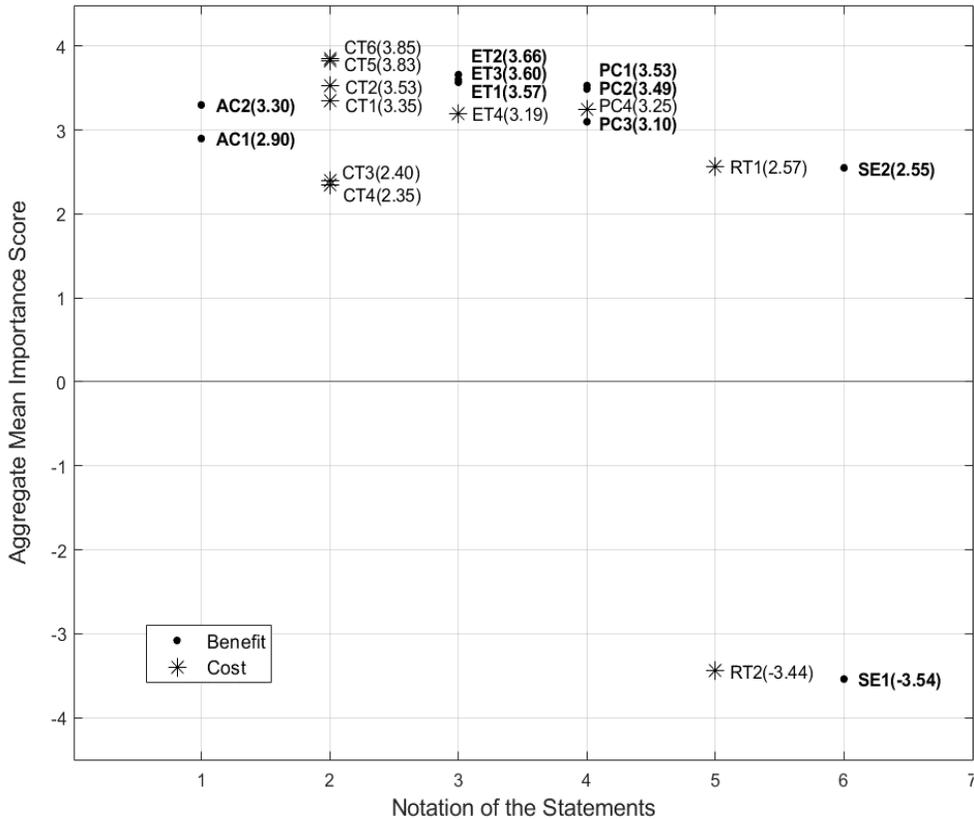
The results obtained from the ranking based on the MIS reveals that the paddy farmers are much concerned about the cost of application of the EFTs, and given that they have the capability of lowering the costs. Farmers have considered that fact favourably. When considering the next in line as important for the farmers are the environment concerns. They have looked at the product in a positive point of view with the belief that EFTs are capable of reducing the negative effects on the environment. What the farmers dislike as per the analysis are the regulations and availability of related services because of the additional work and effort they require. Figure 3 further enhances and separates the increasing benefits and decreasing costs from the increasing costs and decreasing benefits.

**Figure 2: Outcome of the perception analysis on Benefits or Costs (Statements arranged from highest scored to the east scored)**



*Appendix B*

**Figure 3: Statements on Benefits and Costs Based on the MIS**



*Appendix C*

**Outcome of the EFA**

The Cronbach’s Alpha value obtained as an output of the “Scale Reliability Analysis” done was recorded as 0.76 which is greater than 0.7, implying that the scale is internally consistent (Jayasinghe–Mudalige and Henson, 2006). Furthermore, the Kaiser-Meyer-Olkin (KMO) test has been resulted as 0.544 and since the value is higher than 0.5 the sample adequacy can be ascertained. Bartlett’s test of sphericity (Significance level of  $P < 0.005$ ) was done to confirm the patterned relationship between the variables and the result being 0.000, less than 0.005 suggests that there is a patterned relationship among the variables of the study.

As indicated in Table 4, the eigenvalues ( $\geq 1$ ) and the scree plot indicate significant factors that could be explained out of the given variables. Based on the results and eigenvalues four major factors could be derived. The statement classification followed by the sub categorization as indicated in Figure 4, explores the exact priorities of the farmers when it comes to preference between options in policy tools, incentives and key

instruments.

The factors were labelled based on the nature of the variables flocked under each factor giving the highest factor loading value. The variables indicating similar characteristics were classified together and in each major category once again based on narrower similarities sub categories were designed. Therefore the labels considered to be employed were ‘price’, ‘service’, ‘materials’ and ‘other’ for the further continuation of the categorization for the convenience of the study.

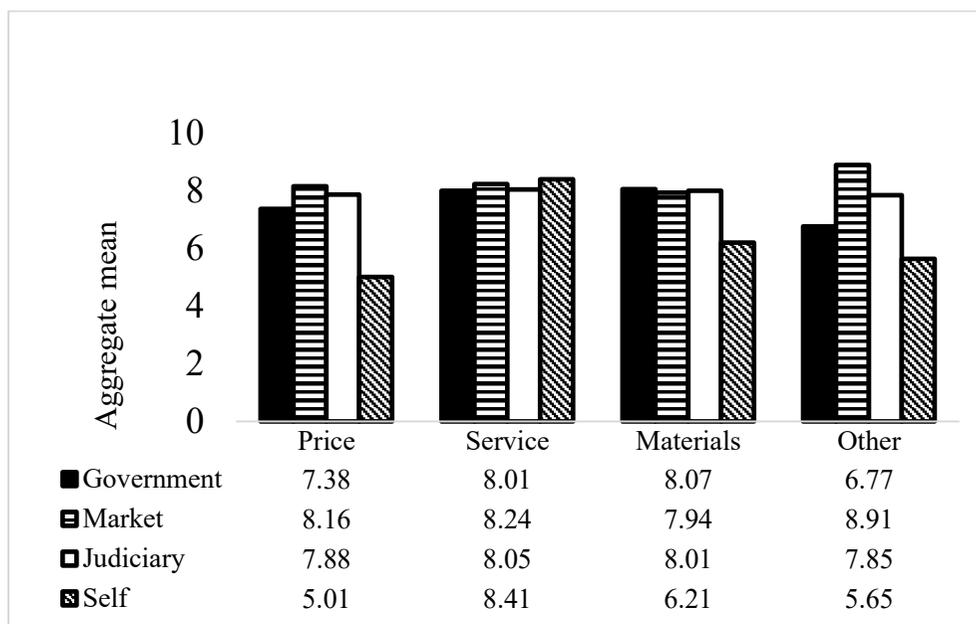
**Table 4. Outcome of the EFA**

<b>Factor</b>	<b>EV</b>	<b>Label</b>
1	3.97	Price
2	3.28	Services
3	2.64	Materials
4	2.01	Other

Note: EV- Eigenvalue

When analyzing the overall result of the MIS of policy tools, instruments and key instruments, general attitudes of the farmers could be realized for each subcategory. Highest importance was placed on ‘Establishment of proper information networks among the farmers’, scoring 8.91, which comes under ‘market’ sub category. In addition the highest scored situations are ‘Disposal and knowledge acquisition on EFTs’, ‘Information on product and related processes’ and ‘Laws regarding the disposal of materials’ each sub category scoring an aggregative mean of 8.41, 8.24 and 8.04 respectively. As ‘Price’ related facts under ‘Market’ subcategory, ‘Information on supply, demand and pricing conditions’ have scored 8.16 highlighting how important that is for farmers. However the least concern of the sample was based on the affordability of EFTs with a generated mean score of 5.01.

**Figure 4. Classification of policy tools, incentives and key instruments based on aggregated mean importance scores**



*Appendix D*

## CONCLUSIONS

The study brings into attention that the EFTs are actually beneficial over CF as recognized by the farmers. Most importantly when considering the general perceptions of the farmers to switch from CF to EFTs they are willing to convert. At the same time the farmers are well aware of the negative impact of CF on fields and human health, and under particular circumstances such as market information, hands on experience, training and subsidy schemes they are enthusiastically willing to experiment the EFTs in their fields given that it has economic incentives. Therefore with the illumination of the mindset of the responses, by organizing workshops, capacity building and training programmes and establishing proper information networks among farmers, they can be encouraged and motivated to switch from CF to continuous use of EFTs in the fields.

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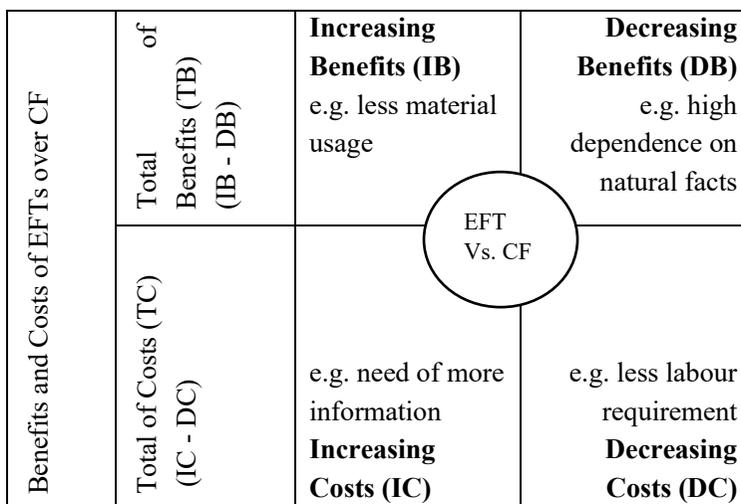
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## APPENDICES

### Appendix A

**Figure 1: Conceptual framework**

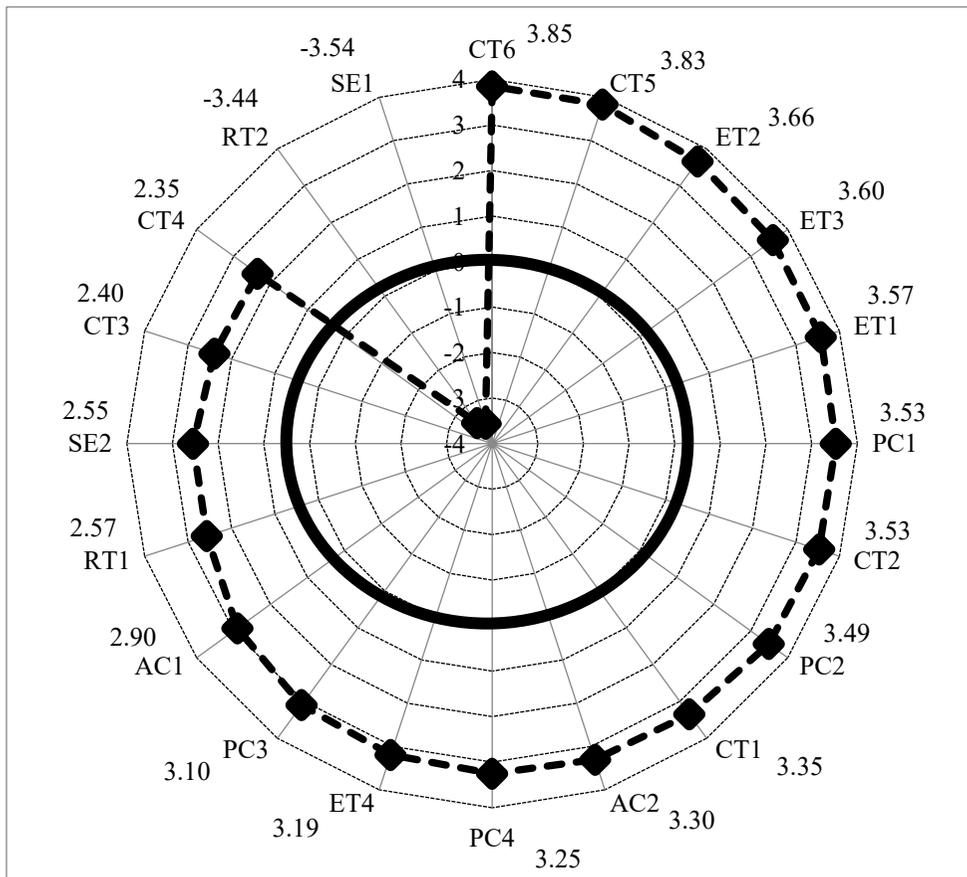


The conceptual framework is derived from the theories indicated by Buchanan (1969), to support organizational decision making by the analysis of possible benefits and costs associated with a particular venture. The figure explains the differentiation of the benefits and costs as per their tendency to increase or decrease. Based on the factor analysis conducted for this study the calculations done to identify the feasibility of the project is done based on the background provided by the framework. The structure highlights the identification of what weighs more via the simple calculation between benefits and costs.

### Appendix B

Figure 2 is aimed at demonstrating the aggregated MIS given for each and every statement by the farmers. Actually the statements are ranked as per the scores they have obtained and included in the figure. However it assists with identifying the facts which are considered highly important by the farmers and the facts which are considered less important by the farmers. By getting an overall picture of the perception of the farmers it indicates that the farmers major concern is on cost related actors and the environmental concerns and they have doubtful opinions on the regulation processes and the availability of services related to the product package due to numerous reasons such as possibility of incurring additional costs and efforts.

**Figure 2: Outcome of the perception analysis on Benefits or Costs (Statements arranged from highest scored to the east scored)**



**Appendix C**

Based on the MIS values obtained regarding the beneficial or cost aspects of the EFTs the figure is derived. It separates the costs and benefits as well as the plus scored statements from the minus scores ones. Therefore the structure is supposed to give the reader an idea about the MIS obtained by the statements and the difference of values when compared one by one. Also the distinguishing between the benefiting factors from the cost factors as identified by the farmers' perception is facilitated. It is derived based on the data obtained as MIS for each statement.

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**Figure 3: Statements on Benefits and Costs Based on the MIS**

