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An Empirical Investigation into the Policy Instruments to Promote Eco-friendly Technologies Replacing Chemical Fertilizer Use in Paddy Farming in Sri Lanka

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***Abstract*—**In this study, the 'Policy Instruments' available to promote Eco-Friendly Technologies (EFTs) in paddy farming over the use of Chemical Fertilizers (CFs) were examined. The key products coming out from a multi-objective multi-phased research project, including 'Bio Fertilizer' (BF) and 'Bio-char' (BC) were of interest. Data were collected by way of questionnaire-based face-to-face interviews carried out with a cross-section of farmers (n=85) involved with paddy farming (> 1 Ha) during October/November 2020 in the Kurunegala and Anuradhapura districts. A list of pre-identified policy instruments through literature review/stakeholder discussion was enlisted as objective statements and the farmer responses to which were evaluated on a 10-point 'Likert-scale'. Exploratory Factor Analysis was carried out to analyze data, which classified those policy instruments into 05 categories based on the value of aggregated Mean Attribute Score (MAS), including: 'Government' (18.9), 'Finance' (11.1), 'Subsidy' (9.63), 'Regulation' (3.76), and 'Service' (7.51). The outcome of the analysis stresses the importance of having a well-established facilitative institutional setup and regulatory framework combining both the market and government to promote the adoption of environmentally-friendly fertilizer to replace chemical fertilizer and to support such activities across the agri-food value chain.

***Keywords*—**Chemical fertilizer, Eco-friendly technologies, Paddy farming, Policy instruments

I. Introduction

Sri Lankan traditional agriculture was mainly based on organic fertilizer. In 1950, the green revolution was introduced to the world as a solution for a high level of food demand due to the rapidly increasing world population. This concept paved the path to consuming chemical fertilizer on a large scale for agriculture as it was proved that higher yield per unit can be obtained from chemical fertilizers than organic fertilizers (Nihar *et al*., 2005). An incredible impact on food production, socio-economic conditions, and environmental sustainability was resulted (Khush, 2001). Even under the circumstances like land scarcity and rising land values, the developing world achieved an extraordinary period of food crop productivity growth over the past 50 years (Pingali, 2012).

In Sri Lanka, CF is distributed at a subsidy rate under the 'Kethata Aruna' subsidy program. This has made farmers tend to apply over and above the recommended rates without a correct understanding (Herath *et al*., 2015). Though CF is beneficial with ease of use, it adds extra costs on social and health issues which influence government policies and it is a huge burden to the treasury. Further, it increases virtual expenditure on farming practices, as low fertilizer use efficiency leads to 50% to 70% losses of CF used in paddy cultivation (Sirisena *et al*., 2016).

With time, some CFs in agro eco-systems created the main source of heavy metals, and some results in the accumulation of inorganic pollutants (Savci, 2012). Also, CF application to paddy cultivation paves the path for emission of N2O like greenhouse gases (Bhattacharyya *et al*., 2012). According to the findings of Jayasumana *et al*. (2013), the major source of inorganic arsenic in Chronic Kidney Disease (CKD) endemic areas is found as phosphate fertilizers. Other than that, eutrophication is another impact of severe CF usage. Enhancing the growth of aquatic plants and algae formation, degradation of water quality and aquatic environment occurs due to the increased amount of nitrogen and phosphorous in water bodies (Savci, 2012).

Rice production has taken a greater place of contribution to Sri Lankan agriculture as it is the staple food in the country. Therefore, the highest proportion of agrochemicals imported to the country is utilized for paddy cultivation. Sri Lankan

treasury is spending 2% of foreign exchange for fertilizer subsidy scheme, annually. Literature proves that overuse of CF has imposed a critically hazardous on the aspects of the environment, society, and health (Jayasumana *et al*., 2013; Dharmawardena *et al*., 2015).

Under these circumstances, Eco-Friendly Technologies (EFTs) were identified as a mechanism that can reduce the environmental damage caused by CF, while maintaining the productivity of crops and improving soil fertility. This study presents results of analysis on policy instruments implementation, connected to a multi-objective, multi-phased research project funded by the National Research Council of Sri Lanka. This project is focusing on developing a single package of EFTs which includes both Bio-Fertilizer (BF) and slow-release urea fertilizer using rice husk Bio-Char (BC). This aims to reduce CF usage in Sri Lanka while safeguarding the state of food security and environmental health. Microbial inoculants that are capable of improving nutrient availability to plants were used when formulating BF. BC was evolved by coating Nitrogen fertilizers with organic materials.

The development of a new product is not the end of this process. According to Enyong *et al*. (1999), farmers' decisions on moving away from CF and adopt to soil fertility enhancing technologies depend on factors like availability and use of policies on land and labor, food security concerns, perceived profitability, etc. It was revealed that if proper governance is established by the regular bodies EFTs are much preferred by Sri Lankan paddy farmers than the CF (Silva *et al*., 2020). Therefore, it is important to identify farmer preferences on implementing policies regarding the new product as it is necessary to help project participants and the authority when developing new policy instruments. According to the findings of previous studies, EFTs have the ability to replace CF usage in Sri Lankan paddy cultivation and it is repeatedly proved when considering the social acceptability and economic viability of this project (Chandrasiri *et al*., 2019). This study aims to address policy implementation on EFTs where if paddy farmers were given a chance to assess the policy instruments.

II. METHODOLOGY

A questionnaire was developed which was contained 16 statements on policy instruments to promote the usage of EFTs over CF. The statements were assessed against a 10-point 'Likert Scale' which was used to identify the farmers' preferences in a quantitative form. The scale was ranging from 'extremely not suitable' (-5) to 'strongly suitable' (+5) keeping the 'neither suitable nor not suitable' (0) as the neutral point.

Eighty-five farmers from Anuradhapura and Kurunegala districts, who are registered under the EFT project were subjected to this study. They were the first consumers of newly released EFTs to the market. Data were collected from October to November in the year 2020.

Parameter	Category	Percentage (%)
Gender	Male	82
	Female	18
Age (Year)	<35	1
	>=35	99
Education level	Unschooled	11
	Up to O/L	55
	Up to A/L	27
	Degree/Diploma	7
Farming experience (Years)	<5	2
	05-Oct	8
	Nov-15	5
	16-20	9
	>20	76

For analyzing the data, the method 'Exploratory Factor Analysis was used. By that 16 statements were categorized into five main factors; Government, Finance, Subsidy, Regulation, and Service. The data were coded, to determine if the scale is reliable, the internal consistency of statements was measured by using the 'Cronbach's Alpha'. As demonstrating the scale is internally consistent or reliable, the alpha values greater than 0.7 are generally accepted (Christmann Aelst, 2006).

Then to reveal the patterns among the interrelationship of the variables, the 'Exploratory Factor Analysis' was carried out. The objective was to reduce all the variables into a parsimonious set of few factors. Since unrotated factors are ambiguous, factors were rotated for better interpretation. Direct oblimin rotation was used as the rotation technique. It gave a pattern matrix that contains the factor loadings and a factor correlation matrix that includes the correlations between the factors.

For the selection of factors, the Eigenvalue criteria were used. It measures the variance of the observed variables that a factor explains. Any factor with an eigenvalue 1 explains a higher variance than a single observed variable. Then the values indicated by respondents on the Likert scale were used to derive mean attribute scores (MAS) and then the aggregated mean attribute score (AMAS) of the factors were developed using them (Jayasinghe-Mudalige and Henson, 2006).

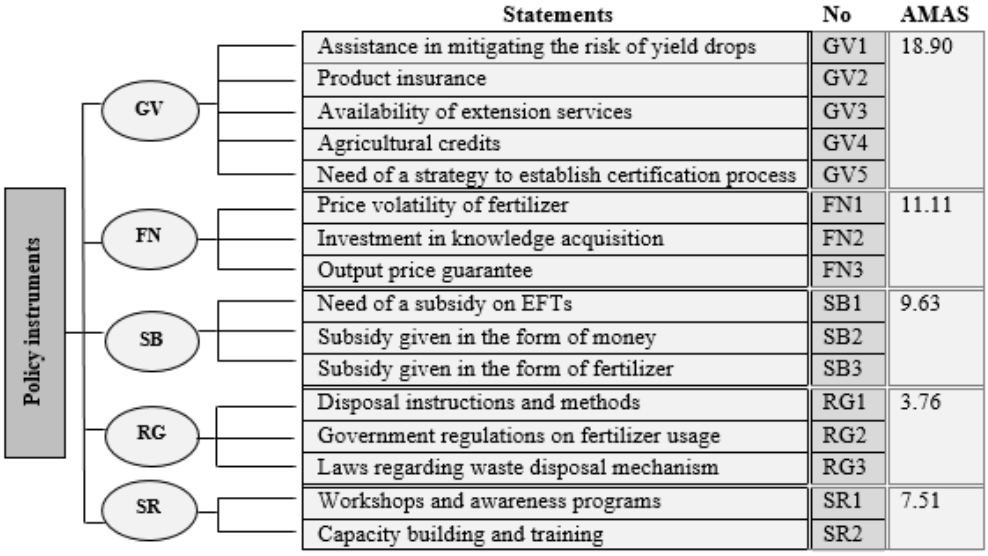
III. RESULTS

A. Descriptive statistics of the sample

The majority of farmers were males accounting for 82% as indicated in Table I.

The majority of the sample was above the age of thirty-five years. Fifty-five (55%) of farmers are educated up to the Ordinary Level.

It could be further identified that the majority of them have experience in paddy farming where 76% of them have more than twenty years of experience which implies that most of them had considerable practical exposure to paddy farming and they are aware of the issue related to the field of study.



Statements	No	AMAS
Assistance in mitigating the risk of yield drops	GV1	18.90
Product insurance	GV2	
Availability of extension services	GV3	
Agricultural credits	GV4	
Need of a strategy to establish certification process	GV5	
Price volatility of fertilizer	FN1	11.11
Investment in knowledge acquisition	FN2	
Output price guarantee	FN3	
Need of a subsidy on EFTs	SB1	9.63
Subsidy given in the form of money	SB2	
Subsidy given in the form of fertilizer	SB3	
Disposal instructions and methods	RG1	3.76
Government regulations on fertilizer usage	RG2	
Laws regarding waste disposal mechanism	RG3	
Workshops and awareness programs	SR1	7.51
Capacity building and training	SR2	

Figure 1: Statements of policy instruments(AMAS-Aggregated Mean Attribute Score, No–Notation, GV-Government, FN–Finance, SB–Subsidy, RG–Regulation, SR–Service)

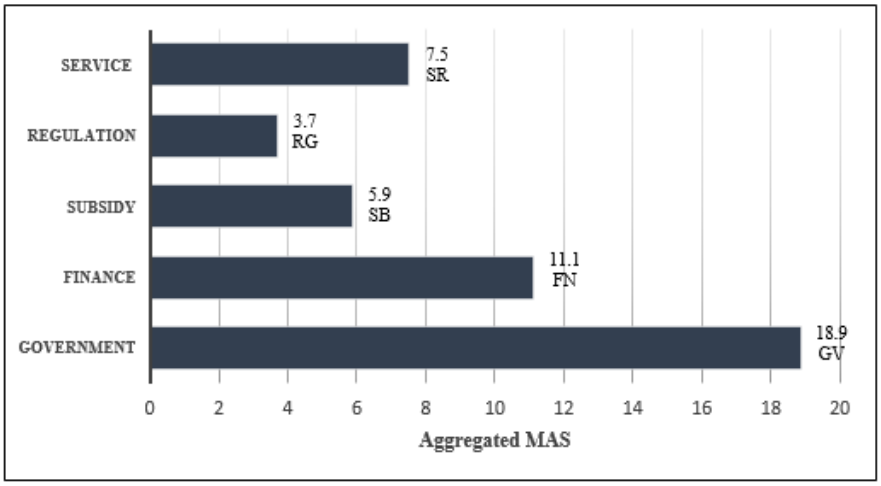


Figure 2: Aggregated MAS of policy instruments

B. The outcome of Analysis for policy instruments

The Cronbach's Alpha value of the scale reliability analysis was 0.702, which is greater than 0.700 where the scale is internally consistent or reliable.

Five significant factors were identified according to the eigenvalues (factors with eigenvalues >= 1) and clubbed all statements into these statements considering the factor loading value of each statement. The way of representing each variable within a factor was considered when naming factors and they were Government, Finance, Subsidy, Regulation, and Service. Scores given by the farmers were used to calculate Mean Attribute Score (MAS) by aggregating all scores given by the respondents for each statement, and dividing it by the number of respondents (n=85).

Figure 02 indicates the aggregated MAS for each of the five categories; Government(GV), Finance (FN), Subsidy (SB), Regulation (RG), and Service (SR). When considering the results obtained, farmers have placed some aspects of policies more preferable over other policy tools. 'Government' has scored the highest aggregated MAS (18.9) while 'Regulation' has scored the lowest aggregated MAS (3.7). The outcome of the analysis emphasizes that the farmers' perception of switching from CF to EFTs is highly dependent on the policies based on the governmental aspect.

'Finance' is the second most weighted category as it consists of the statement of 'Output price guarantee' (FN3) where most farmers are selected as a highly concerning instrument (Figure 04). Due to the price fluctuations of the harvest, farmers face many problems as they do not get sufficient income sometimes even to cover their production cost. Farmers are highly concern about financial-based policy instruments as it directly affects their final income.

As Figure 05 indicates, 'Subsidy' is the category where the highest MAS contains. The farmer group has highly

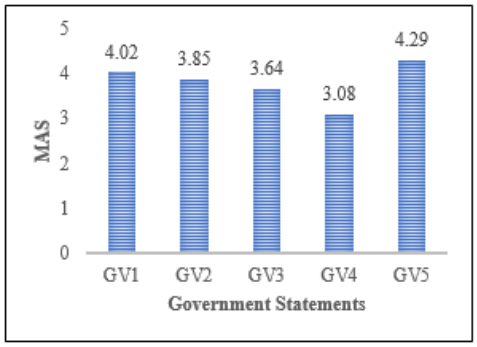


Figure 3: MAS of government-related statements

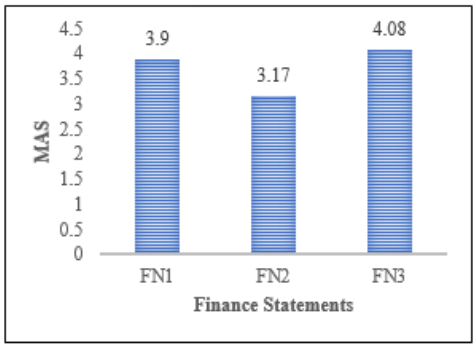


Figure 4: MAS of finance statements

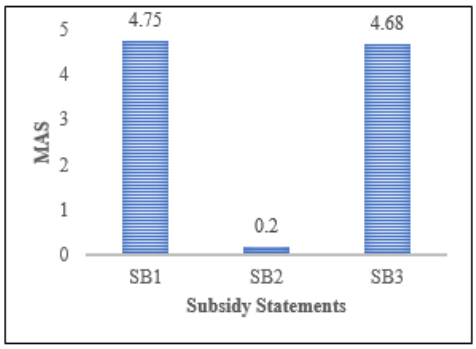


Figure 5: MAS of subsidy related statements

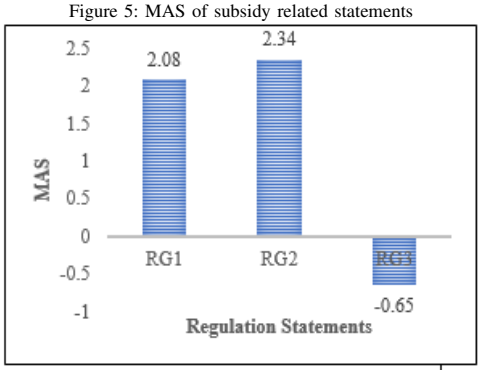


Figure 6: MAS of subsidy regulation related statements

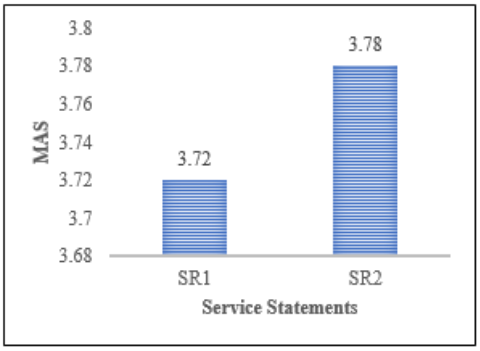


Figure 7: MAS of service-related statements

a weighted 'Need of subsidy on EFTs' (SB1), while the statement of 'Subsidy given in the form of money (SB2) measuring as the least preferred policy tool. They preferred to have a 'fertilizer subsidy' highlighting that the easiness of getting them. Still, farmers are expecting to implement policies on subsidies for EFTs as well as subsidies given for CF.

Furthermore, Figure 06 describes that farmers do not much consider the policy instruments regarding 'Regulation' which contains policies on waste disposal and fertilizer usage. Even they have given a negative score for the policy regarding 'laws on waste disposal mechanism' (RG3).

Finally, the statements of the category of 'Service' which consists of workshops and awareness programs (SR1) and capacity building training (SR2) policies are scored relatively equally (Figure 07).

IV. DISCUSSION

Based on the findings, Sri Lankan paddy farmers highly depend on CF and they apply over and above the recommended level of fertilizer to their cultivation (Herath *et al.*, 2015). Eco-Friendly Technologies package which contains bio-char and bio-fertilizer has a great potential to reduce the usage of CF (De Silva *et al.*, 2018). Also introducing this individual and collective package can result in significant benefits to the economy of the country.

This study reveals that farmers in this selected sample highly preferred 'government' policy instruments on EFTs usage. Even under that farmers are willing to have a strategy to establish a certification process for the EFT-based products. The major reason for this is, there is a high price for organic food in the Sri Lankan market (Narmilan Amuthenie, 2015). By using this certification farmers can sell their harvest at high prices in the market. Therefore, establishing this type of strategic process will motivate farmers to shift to using EFTs. Thus, it is effective that implementing more promotional activities by government or government-associated organizations. It will encourage farmers to use EFTs over the CF.

V. CONCLUSION

The paddy farmers highly rely on the policy instruments that are to be influenced by the 'Government'. Given the

support of the government by providing them necessary incentives and if certification is satisfactory, it is important to have a stable facilitative environment and regulatory mechanism with the participation of the market/fertilizer value chain and government to place the EFTs over and above the CFs.

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