Perception of Climate Change and Farmers' Adaptation: An Analysis for Effective Policy Implementation

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Abstract
Divergence in the actual practices and policy goals often leads to ineffective policy implementation. Shedding light on this issue, this study intends to enrich the debate on the adaptation to climate change, which includes farm-level adaptation practices in the Dry Zone of Sri Lanka and enabled policies. The study involved analysing the farm level adaptation practices and the factors influencing actual adaptation practices adopted by employing a Multinomial Logit Model. The study used primary data collected from Sri Lanka Environmental and Agricultural Decision-Making Survey. The impact of perception of climate change on adaptation techniques was measured by developing an index on Climate Change Perception. The index was generated as a composite of multiple statements related to climate change by utilising Multiple Correspondence Analysis. The results revealed that cultivating other field crops and short duration seed varieties increased with climate change awareness. Further income, education, age, cost, and irrigation scheme affect choosing the adaptation practices. A comparison of climate change adaptation practices adopted by farmers with the program goals shows a mismatch between farmers’ perceptions and the adaptation practices promoted by the government. This study proposes to consider the grassroots level scenario before developing policies and that programs have to be developed and implemented based on adaptation practices preferred at the ground level.

Keywords
Climate change, adaptation policy, multinomial logit model, adaptation practices in Sri Lanka

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Introduction

Climate change in Sri Lanka is apparent when observing the changes in rainfall patterns, frequently occurring floods, landslides, drought conditions, and an increase in temperature (Aheeyar, 2012). Numerous studies have suggested that climate change can have adverse impacts on agriculture as it is a nature-based system. Apart from the physical losses, the yield of crop and livestock, food prices, input prices, and resource availability are affected by changes in climatic factors. Temperature and precipitation are highly changing climatic factors and they increase the frequency and severity of extreme events like droughts, floods, and wind storms (Melillo et al., 2014). In Sri Lanka, the concern about climate change is high due to the dependency in the agricultural sector for the country’s economy and livelihoods. Agriculture contributes 7.9 per cent to the GDP of the country, but the importance of the agriculture sector cannot be judged only by its contribution to the GDP, as its contribution to the socio-economic development, employment opportunities, food security, and the ecology are high in Sri Lanka (Food and Agricultural Organization of the United Nations [FAO], 2018; Weeraratna, 2010).

Nearly 77.4 per cent of the people in Sri Lanka live in rural areas and are engaged in farming activities (Department of Census and Statistics, 2012). Almost all the food crops such as cereals, legumes, field crops, fruits and vegetables produced in the country, valued at around Rs. 150 billion, is cultivated in the rural area (Gunawardana & Somaratne, 2000). The major produce of the domestic agricultural sector is rice, and it is the staple food of Sri Lankans. About 92 per cent of the rice consumed by Sri Lankan is produced domestically. If climate change impacts unfavourably on the agricultural activities it could seriously hinder the country’s sustainable development. Following the Intergovernmental Panel for Climate Change (IPCC) report (2007a), the projections for an increase in mean annual temperature for Sri Lanka will span between 0.5–1.2 °C by 2020, 0.88–3.16 °C by 2050 and 1.56–5.44 °C by 2080. On the other hand, rice yields are expected to decline by 0.75 tons/ha if the temperature increase traverses between two and four degree Celsius. It would result in 9–25 per cent reductions in the net revenue of farmers (Knox et al., 2012). Despite agriculture contributing to 7.9 per cent of GDP, the country will face an average economic loss of around 2 per cent of their collective GDP by 2050 and it will increase up to 9 per cent by the year 2100 due to climate change lead yield losses (Asian Development Bank, 2015; Truelove et al., 2017). Hence, climate change is likely to be one of the most significant developmental challenges faced by Sri Lanka. Thus, to ensure future food security and livelihood of the farmers, it is important to transform current agricultural practices into climate-resilient agriculture practices and strengthen farmers’ adaptive capacity to climate change. Therefore, climate change adaptation has gained attention in research and policy development.

Sri Lanka has endorsed the Rio+20 outcomes and focused on achieving the embraced sustainable development goals, specifically with climate change and food security through actualising resilient agricultural practices and strengthening the capacity for adaptation. Further, under the developed national policy on
climate change, the government implemented several programs and projects to motivate the farmers to achieve sustainable development through coping with the adverse climate change impacts. Sustainable production in the agriculture sector needs to be supported by farming practices. Several adaptation practices such as; planting hazard resilient crop varieties, dry seeding, crop diversification, and so forth are proposed by experts. However, policies and programs aimed at promoting adaptation practices are still constrained by poor resource bases, income inequalities, weak institutions, and limited technology. Consequently, it is required to revisit the current policies and strategies to become more resilient to climate change and ensure the food security of the country.

Due to recurring and prolonged climate-induced disaster experiences in Sri Lanka, climate change adaptation has become a requirement. Adaptation is defined as modification in systems in reaction to climatic stimuli or their effects (IPCC, 2007). Adaptation can be achieved in many ways and it is promoted through engaging in the climate change adaptation practices throughout the cultivation season. The government of Sri Lanka implements several promotional programs to uplift the farmers’ adaptation level under the major National Adaptation Plan. Even though the programs are well defined and strategically planned at the higher level, when it comes to the implementation stage current programs are following the same promotional processes for the entire Dry Zone without recognising differences in the ongoing adaptation practices. There could be differences among farmers at the grass-root level which could affect the climate change adaptation failing to understand which could hamper the effective implementation of these programs. We posit that it is important to understand the difference in actual scenarios and implemented programs for the effective implementation of programs.

Even though climate change has been extensively studied in many decision-making situations, there are only a few studies that have identified the importance of identifying the difference in the grass-root level and high-level policy goals in terms of climate change adaptation (Senaratne & Rodrigo, 2014; Samarathunga, 2010). Several studies carried out on climate change adaptation by farmers in Sri Lanka neglected the importance of climate change perception and did not consider the need for policy development based on grassroots level perceptions (Gunda, et al., 2016; Truelove, et al., 2017; William & Carrico, 2017). Identifying this research gap in understanding the adaptation practices, this study thus aims to analyze the farm level adaptation practices and farmers’ perception of climate change in the Sri Lankan context as understanding the grassroots realities is fundamental in proposing reforms to the existing programs in promoting climate change adaptation practices at the field level. The results will help in designing programs for effective climate change adaptation to reduce adverse effects of climate change and to reform the programs such as a way that supports self-sufficiency and food security through climate change adaptation practices.

The paper is organised as follows. First, it gives an account of the adaptation practices in the Dry Zone of Sri Lanka and previous knowledge on the factors affecting climate change adaptations. It is followed by a description of the development of the climate change index and employed methodology. Next, the
results are presented with a discussion. Finally, conclusions and policy implications are presented.

**Literature Review**

*Climate Change Impact in Dry Zone of Sri Lanka*

A large extent of land area in the Dry Zone is utilised for the paddy cultivation where the extents of the cultivation in the major, minor and rain-fed systems for both Maha and Yala seasons in 2010 were 440,000, 65,000 and 40,000 ha, respectively (Weerakoon et al., 2011). At present, the Dry Zone significantly contributes to the nation’s economy. Over 800,000 metric tons of paddy were produced annually in this zone (Manthrithilake & Liyanagama, 2012) and the Dry Zone area in Sri Lanka contributes to 70 per cent of national paddy production (Withanachchi, et al., 2014). Out of the total harvested crop area (including paddy, other field crops (OFC) and vegetables), Dry Zone contributes to 67.2 per cent and it contributes to 83.11 per cent of the national paddy harvested area. Since the contribution of Dry Zone to the agricultural economy is high, the impact of climate change on Dry Zone has been identified as a critical issue. At present, the Dry Zone agriculture is facing severe losses due to climate change. According to the statistics, the failures in two consecutive monsoonal drops of rain (2016/2017 Maha and 2017 Yala) had a detrimental effect on Dry Zone agriculture and the water storage of some reservoirs. Accordingly, many reservoirs in the Dry Zone have failed to supply the demanded irrigation water for the upcoming season (Ministry of Disaster Management and World Food Program, 2017).

*Farmers’ Adaptation Practices*

From ancient times onwards, Sri Lankan farmers practice several agricultural practices that could be useful for them in reducing the adverse impacts of climate change (Chithranayana & Punyawardena, 2013). Several evidences from the literature provide details on these different farm-level adaptation practices. For an instance, Mohamed and Garforth (2013) indicate that the Dry Zone farmers adapted to climate change stress by cultivating drought-tolerant crop varieties, reducing irrigation depth, involving micro-irrigation, diversifying crops, changing planting time, mulching, shortening of cultivation season, and planting shade trees. These adaptation practices intend to avoid the dry spell overlapping with the cultivation, mainly changing planting time, changing crop type, shortening of the growing season, and crop rotation (Williams & Carrico, 2017). To cope with the water shortage, Sri Lankan farmers select short duration paddy varieties, dry seeding¹, cultivation of other field crops, rainwater harvesting, using groundwater, employing soil water conservation techniques such as mulching, planting shade trees and so on (Mohamed & Garforth, 2013).
Non-traditional drought-tolerant crops were highly promoted by the government and non-government institutions as one of the major agriculture adaptation practices to support the livelihood of the farmers (Morton, 2007; O’Brien et al., 2004). Farmers utilise novel farming practices to continue with local crops with high yield (Morton, 2007). Besides, low-cost innovations such as the cultivation of locally developed hybrid seeds help to increase the yields of traditional crops (Ceccarelli et al., 2010; Wassmann et al., 2009). Further, farmers are practicing a new method of paddy transplantation called ‘parachute method’, which consumes a low amount of water and produces higher yields (Thilakasiri, et al., 2015).

One of the ancient communal adaptation practices is ‘bethma’. If the water is scarce, individual paddy ownership would be suspended, and those closer to the water source required to allow those further away to share portions of their land. The permanent field boundaries are abolished and the land is divided among farmers who cultivate in the common area. Usually, equal sizes of land were given to all households and all of the work will be regulated by government bodies such as the irrigation department, agrarian service centers, etc. (Burchfield, 2017; Spiertz & de Jong, 1992; Thiruchelvam, 2010). In the recent past, the use of agro-wells became more into practice and it causes a significant reduction in bethma cultivation. Besides, agro-wells help farmers to shift for OFC (Other Field Crops) cultivation during water scarce periods (Burchfield, 2017).

**Factor Affecting Adaptation Practices**

The factors can be classified into broader groups named as the factors established through the social groups, demographic factors, institutional and management factors, environmental factors, and characteristics of adaptation practices (Agrawal, 2008; Dhanapala 2006; Gunda et al., 2016; Masuku & Manyatsi, 2014; Tran Cao Uy et al., 2015; Williams & Carrico, 2017). Burchfield and Gilligan (2016) classified the factors as dynamic and structural factors.

There are significant variations in the level of productivity between minor and major irrigation schemes due to the level of variability in adaptation to water stress (Aheeyar, 2013). Credit support and guaranteed crop cultivation are high in major schemes compared to other schemes (Begum, 1987). Further, the management level is varying between schemes. Mostly the government institutions, Mahawali Development Authority, and the Department of Irrigation regulate the activities of major irrigation schemes and the other schemes are managed by communities or individual farmers (Aheeyar, 2013; Begum, 1987; IWMI, 1986). Mostly major projects and researches were done in the major schemes because of the easiness of analysing, conducting, accessing, and regulating; other than that several projects are legally approved only for major irrigation schemes such as Participatory Irrigation Management (PIM) (Aheeyar, 2013). These facts result in variation in the adaptation level between irrigation schemes.
The lack of resources also constrains the adaptation level of farmers, among villages, communities, and Grama Niladhari Divisions, and so on. For example, on low lying riverbanks and steep lands, low adaptation to changing conditions were observed due to the lack of resources in the natural soils (Murray & Little, 2000). Several studies found that the communities under village irrigation systems show low levels of adaptation than their neighbours in Dry Zone, which have access to water from major irrigation schemes (Aheeyar, 2013). Poterie et al. (2018) reported that efforts at adaptation are more likely to be successful if governments target farmer organisations and communities as a whole rather than individual farmer.

Demographic and socio-economic factors that affect the level of adaptation include the household economic and demographic characteristics as well as the community’s demographic characteristics. Gender of the household head (Tran Cao Uy et al., 2015), occupation of household head (Herath & Thirimarpan, 2016), age (Farid et al., 2015; Herath & Thirimarpan, 2016), household size, less formal education (Farid, et al., 2015; Herath & Thirimarpan, 2016) ethnic homogeneity (Tran Cao Uy et al., 2015), high proportion of paddy land at the tail-end of a canal, engagement in off-farm labor, small-scale farmers, economic constraints (Herath and Thirimarpan, 2016), lack of assets (Herath & Thirimarpan, 2016; Tran Cao Uy et al., 2015; Udmale et al., 2014), wealth and livelihood security (Burchfield & Gilligan, 2016), income (Tran Cao Uy et al., 2015) tenure status (Farid et al., 2015), credit use (Burchfield & Gilligan, 2016), high incidences of crop pests and diseases, high input prices, high food prices, land ownership (Farid et al., 2015; Udmale et al., 2014), poverty (Farid et al., 2015; Udmale et al., 2014), lack of savings (Herath & Thirimarpan, 2016), farm size, lack of technical skills and off-farm employment (Tran Cao Uy et al., 2015), livestock ownership (Herath & Thirimarpan, 2016), and storage capacity of irrigation tanks (Burchfield & Gilligan, 2016) are the major factors identified by the previous studies as affecting climate change adaptations that come under the demographics and socio-economic classification.

**Government Programs and Farmers’ Practices**

The intervention of the government and non-governmental institutions on farmers’ decision-making process is high. Therefore, the impacts of the intervention have to be identified clearly when analysing the adaptation practices. For example, the following factors are identified in the literature as coming from institutional involvement and support. In Sri Lanka under the settlement schemes, lands are governed by the government organisations such as Mahaweli Development Authority, Department of Irrigation, and Department of Agrarian Development. According to the governing institution, the farmers’ control on those lands also varies. There is an identified difference among lands not fed by the state-managed irrigation systems and lands fed by these systems (Udmale et al., 2014). Further farmers’ connections to formal institutions (Udmale et al., 2014; Herath & Thirimarpan, 2016; Burchfield & Gilligan, 2016), agricultural extension programs (Herath & Thirimarpan, 2016; Tran Cao Uy et al., 2015; Udmale et al., 2014),
institutional involvement (Farid et al., 2015; Herath & Thirumarpan, 2016; Tran Cao Uy et al., 2015; Udmale et al., 2014), management regimes (Farid et al., 2015), no subsidy programs (Udmale et al., 2014), received drought information, political or market instability (Axelsen, 1983; Burchfield & Gilligan, 2016; Herath & Thirumarpan, 2016; Tran Cao Uy et al., 2015) are some of the factors that are affecting the adaptation level related to the involvement and management of the institutions.

Even though the government and non-governmental organisations promote several adaptation practices in the Dry Zone, factors such as villages, districts, irrigation schemes, other geographical delineations, and so on, alter the farmers’ ability to adapt proactively to drought (Berkes & Jolly, 2002; Dhanapala, 2006; Kumari et al., 2011; Uphoff & Wijayaratna, 2000; Valdivia et al., 2010). Accordingly, a comprehensive review was done to identify the elusive causes of such variation in the farmer’s adaptation level. For instance, the government has involved in promoting OFC cultivation in many regions of the country. The villages which are still following traditional skills are reluctant to switch to OFC cultivation. For them, the adaptation is rooted in their conventional wisdom, consequently, they perceive having a stock of rice as a source of food security since OFCs are difficult to store (Emily & Jonathan, 2016). Such instances reveal the government’s negligence on promoting adaption strategies and show that the decision on the adaptation had made on the island level and not at the grass-root level (Samarathunga, 2010; Senaratne & Rodrigo, 2014).

Methodology

Study Area and Data Collection

The analysis is based on survey data from the Sri Lankan Environmental and Agricultural Decision-making Survey (SEADS) collected as part of the Agriculture Decision Making and Adaptation to the Precipitation Trends in Sri Lanka (ADAPT–SL) project. The project focused on smallholder farmers located in the Dry Zone of Sri Lanka, the region most vulnerable to drought consequences. SEADS employed a questionnaire survey designed to collect data on farm-level adaptation practices, which address the farm level resilience to climate change. The data were collected among 1,148 farming households in 30 Grama Niladhari Divisions in nine districts of the Dry Zone, across certain major and minor irrigation schemes in Sri Lanka during the 2015/2016 production season.

Estimation Method

Multinomial Logit Model (MNL) has been applied to determine the choice probabilities for different adaptation practices. As the study employed a binary variable which is the choice of adaptation practices as the dependent variable and due to more than two adaptation practices MNL was chosen for the study. The
multinomial logistic regression is generally effective where the dependent variable is composed of more than two levels or categories (El-Habil, 2012; Yamaguchi, 2000). In the MNL model, the categorical dependent variable is important and it should satisfy the Independent Irrelevant Alternative Assumption (IIA) (Petrucci, 2009; El-Habil, 2012; Yamaguchi, 2000). In this study, adaptation practices were categorised and as a base outcome, ‘no adaptation practice’ was chosen, and adoption of other adaptation practices was compared with ‘no adaptation practice’.

To describe the MNL model, let $y$ denote a dependent variable taking on the values $\{1, 2, \ldots, n\}$, a positive integer, and let $x$ denote a set of independent variables. In this study, $y$ denotes adaptation practices (Table 1) and $x$ contains different household attributes and climate change perception index (CCPI)$^5$. The MNL model has response probabilities; a general expression of the likelihood in the model is described below. If $x$ is a $1^*k$ vector, the model yield probabilities.

$$P(y = n|x) = \frac{e^{xbn}}{\sum_{k=0}^{n} e^{xbm}}$$  \hspace{1cm} (1)

$Y$ = adaptation practices,
$N$ = no of categories in the adaptation practices,
$X$ = independent variables (Socio-economic factors and CCPI),
$b$ = set of coefficients,
$m$ = reference category,
$P(y = n \mid x)$ = probability of choosing one adaptation practices over reference category.

Further, to understand the mismatch between the adaptation practices proposed by the government and the practices seen in the ground level, climate smartness values, and the adoption rate of farmers were compared. Climate smartness values are developed by the Ministry of Mahaweli Development and Environment for National Adaptation Plan 2016–2025 for several adaptation practices. The adoption rate of farmers was calculated by way of dividing the number of farmers adopting particular adaptation practices by the total number of farmers.

Table 1. Farmers’ Adaptation Practices

| Variable                        | Percentage of Respondents Who Engage in Adaptation Practices |
|---------------------------------|-------------------------------------------------------------|
| Planting other field crops      | 18.71                                                       |
| Dry seeding                     | 34.34                                                       |
| Bethma/sharing land             | 31.61                                                       |
| Planting short duration seed    | 11.23                                                       |
| Practicing two practices        | 3.57                                                        |
| Practicing more than two practices | 0.54                                                         |

Source: Author’s calculations.
Developing Climate Change Perception Index (CCPI) Using Multiple Correspondence Analysis (MCA)

To develop the constructs, Multiple Correspondent Analysis (MCA) was used, where the categorical outcomes were scaled according to the relatedness to the construct. MCA was particularly designed to analyse the categorical variables. Compared to other dimension reduction methods such as Factor analysis and Principal Component Analysis (PCA), MCA does not require data that are normally distributed and this supports the data used in this study as the index was calculated based on categorical variables. Moreover, it specifically identifies the relatedness of each category to the construct rather than giving one weighted value for the variable. It is highly used in socioeconomic studies by several researchers due to its suitability in developing constructs (Abdi & Valentin, 2007; Costa et al., 2013). Due to the abovementioned reasons and nature of variables as multiple categories, MCA is preferred over PCA and Factor Analysis. The surveyed farm households were asked questions about their perception of the changes in temperature and rainfall (Table 2). The questions addressed in Table 2 were used to develop CCPI through MCA which provides weighted values for each category and the following equation was used to develop CCPI. Weighted values form MCA is obtained from the coordinates of MCA analysis. Coordinates are computed based on the indicator method. The standard row coordinate for the \( r \)th dimension for the \( i \)th observation with indicator matrix elements, \( Z_{ih} \) is computed as

| Environmental Changes                        | Has Decreased | Has not Changed | Has Increased | Can’t Say |
|----------------------------------------------|---------------|-----------------|---------------|-----------|
| 1. Changes in the environment temperature    | 9             | 7               | 83            | 1         |
| 2. Changes at the beginning of the rain in Maha | 22           | 21              | 42            | 15        |
| 3. Changes in the rainfall during Maha season | 25           | 20              | 44            | 10        |
| 4. Changes in the spread of rain during the Maha | 30           | 24              | 38            | 8         |
| 5. Changes in heavy rain within a short period in Maha | 19           | 19              | 51            | 11        |
| 6. Changes at the beginning of the rain in Yala | 33           | 22              | 33            | 12        |
| 7. Changes in the rainfall during Yala       | 39           | 19              | 34            | 8         |

(Table 2 Continued)
Environmental Changes

| Environmental Changes                              | Has Decreased | Has not Changed | Has Increased | Can’t Say |
|---------------------------------------------------|---------------|-----------------|---------------|-----------|
| 8. Changes in the spread of rain during the Yala   | 42            | 22              | 27            | 9         |
| 9. Changes in heavy rain within a short period in Yala | 33            | 19              | 36            | 12        |
| 10. Changes in the predictability of rainfall     | 20            | 23              | 17            | 41        |
| 11. Changes in the frequency of drought            | 16            | 16              | 55            | 13        |

Source: Author’s calculations.

\[
R_{ij} = \sum_{k=1}^{q} \frac{Z_{ik} A_{jk}}{q \sqrt{\phi_j}}
\]  

(2)

where \( A \) is the matrix of standard coordinates, \( q \) is the number of active variables in the analysis and \( \phi_j \) is an eigenvalue of the CA on the Burt matrix.

The mathematical formula of the MCA model for CCPI is shown in Equation (3). The accuracy of the MCA results was analysed through the coordination of the answers by checking whether they are giving the value for the answers which have a high positive relationship with the main construct. The option ‘Can’t say’ was coded as ‘0’ so the coordination of this option was neglected. With increasing confidence the coordination also increases.

\[
P_{i}^{MCA} = R_{i1} W_1 + R_{i2} W_2 + \ldots + R_{ij} W_j
\]  

(3)

where 
\( P_{i}^{MCA} \) = CCPI for the \( i \)th individual,
\( R_{ij} \) = response of \( i \)th individual to the category \( j \),
\( W_j \) = MCA weight applied to the \( j \)th category.

Results and Discussion

Descriptive Statistics of the Variables Used

Socio-economic factors, the average cost for the adaptation practice, irrigation schemes, district, and climate change perception were used in the analysis as independent variables and adaptation practices were used as the dependent variable.

Farmers’ adaptation practices were shown in Table 1 with the percentage of sample engages in each adaptation practices. Due to the engagement in multiple adaptation practices, practicing two and more than two adaptation practices were categorised as separate categories. Based on the frequencies of adaptation
practices farmers are mostly practicing dry seeding and bethma whereas cultivation of short duration seed variety is practiced by less amount of farmers. Four per cent of farmers among the farmers who are at least engage in one adaptation practices, practicing more than one adaptation practices.

Distribution of income and education level across the sample as shown in Figures 1 and 2 while descriptive statistics of other variables were shown in Table 3. The study sample consist 543 major irrigation scheme farmers and 475 minor irrigation scheme farmers. Most of the farmers’ monthly income ranged between Rs. 15,858 and Rs. 50,000. Majority of the farmers’ education level was between grade 6 and grade 11. Same scenario was observed in major and minor irrigation scheme in terms of education and income level.

![Figure 1. Income Distribution of Farmers across Irrigation Schemes](image1)

**Source:** Authors’ calculations.

![Figure 2. Education Level across Irrigation Schemes](image2)

**Source:** Authors’ calculations.
The impact of socio-economic factors on choosing selected adaptation practices over the ‘no adaptation’ category was explained hereinafter through marginal values and marginal plots. Principally, climate change perception of farmers and irrigation schemes considered as the most important factor and unique from existing literature. Therefore, this section unfolds an in-depth discussion on the impact of climate change perception index (CCPI) and irrigation schemes.

Table 2 displays the variables used for the construction CCPI with percentage of respondents. According to Table 2 more than 50 per cent of farmers perceived the changes correctly regarding changes in temperature, changes in the frequency of drought and changes in heavy rain within a short period in Maha season. While majority of farmers are unsure about changes in the predictability of rainfall.

Table 4 indicates the marginal values of choosing adaptation practices with CCPI and socio-economic factors. Figures 3–8 show the trends of adopting Other Field Crops (OFC), bethma (Sharing land for cultivation), planting Short Duration Seed Variety (SDSV), and dry seeding with varying levels of the climate change perception index (CCPI).

Impact of the Cost of Cultivation on Adaptation

When considering the cost of cultivation, while other variables are in the mean values, the probability of cultivating OFC is reduced by 0.5 per cent if the cost of cultivating is increased by 1 per cent. In contrast, other adaptation practices are increased with increasing costs. Due to the high expenses, farmers abandon the cultivation of OFC. As paddy is considered as the main food crop in Sri Lanka, when OFC cultivation cost is increased there is a higher potential to shift to paddy, and further because of the subsidies provided for paddy the cost of cultivation is low, unlike OFC. Regarding the dry seeding, the probability of practicing dry seeding is increased by 4.1 per cent if the cost of cultivating is increased by 1 per cent. When the cost of cultivation is increasing in other inputs (Fertilise, seeds, and pesticides), farmers tend to shift to dry seeding to minimise the cost of land preparation. For the dry seeding, paddy seeds are sown without land preparation like puddling and flooding so farmers can reduce the cost for land preparation.

### Table 3. Descriptive Statistics of Variables Used in MNL

| Continuous Variables                  | Mean (SD)       |
|--------------------------------------|-----------------|
| CCPI                                 | 0.48 (0.26)     |
| Age                                  | 49.98 (12.09)   |
| Total cost of cultivation            | 170,653.00 (55,567.23) |
| Annual non-farm income               | 209,537.4 (232,420.7) |

| Categorical variables                | Frequency      |
|--------------------------------------|----------------|
| Irrigation scheme                    | Major – 543    |
|                                      | Minor – 475    |

Source: Authors’ calculations.
### Table 4. Marginal Values of Regression Results

| Dependent variable | OFC       | Dry seeding | Bethma     | SDSV      | Practicing two practices | Practicing more than two practices |
|--------------------|-----------|-------------|------------|-----------|-------------------------|-----------------------------------|
| Irrigation scheme  | −0.071*** | 0.031*      | −0.05      | −0.063    | 0.098*                  | 0.061*                            |
| CCPI               | 0.030 (0.071)*** | −0.01 (0.092)*** | −0.262 (0.107)*** | 0.028 (0.124)*** | 0.051 (0.12)*** | 0.165 (0.09)***                  |
| Log non farm income| 0.008 (0.016)*** | 0.062 (0.027)*** | 0.009 (0.022)*** | −0.054 (0.02)*** | −0.022 (0.02)*** | −0.002 (0.01)***                |
| District           | 0.008 (0.003)*** | 0.007 (0.006)*** | −0.039 (0.004)*** | 0.022 (0.005)*** | −0.001 (0.005)*** | 0.001 (0.003)***                |
| Age                | 0.001 (0.001)*** | 0.003 (0.002)*** | 0.002 (0.002)*** | 0.0002 (0.002)*** | −0.003 (0.003)*** | −0.002 (0.001)***              |
| Education          | 0.002 (0.016)*** | 0.025 (0.028)*** | 0.004 (0.033)*** | 0.006 (0.033)*** | 0.034 (0.034)*** | 0.004 (0.22)***                |
| Log cost of cultivation | −0.005 (0.02)*** | 0.041 (0.028)*** | 0.027 (0.036)*** | −0.044 (0.04)* | 0.024 (0.04)* | −0.041 (0.026)*               |

**Source:** Authors’ calculations.

The probability of practicing bethma is increased by 2.7 per cent with an increase in the cost of cultivation. Cost could be higher in owned land than share cultivated land. This is due to more long-term investment in soil and water conservation in owned land. The reason why share cultivators do not invest in long term investments may be due to change in land quality in the next season. Since farmers know the contract is expiring at the end of the season, they would apply less organic manure and other soil conservation practices (Thiruchelvam, 2010). The probability of cultivating SDSV is reduced by 4.4 per cent if the cost of cultivating is increased by 1 per cent. Comparative to traditional and long term seed varieties, SDSV is costly so with the increasing cost of cultivation, preference of SDSV is reduced. The probability of practicing two adaptation practices is increased by 2.4 per cent and practicing more than two adaptation practices reduced by 4.1 per cent if the cost of cultivating is increased by 1 per cent. Even though the cost of adopting several adaptation practices is high due to the climate change impacts, farmers are willing to engage in adaptation practices but if the cost is too high they restrict their adaptation with two practices.

**Impact of Irrigation Schemes**

Regarding the impact of irrigation schemes on the selection of adaptation practices, Table 5 depicts the probability difference between irrigation schemes in the selection of adaptation practices. Based on the farmers’ responses there were
many promotional programs related to climate change adaptation carried out by
the government in major irrigation schemes and fewer programs were carried out
in minor irrigation schemes. Major irrigation scheme is relatively high in extent
and production which demands greater attention of government officials. The
probability of choosing OFC is high when farmers belong to a major irrigation
scheme. The probability difference between the two irrigation schemes is high
and this is due to the promotion programs on OFC in the major irrigation scheme.
As a result of water scarcity and inadequate extension programmes about new
adaptation practices in minor irrigation schemes, a higher number of farmers are
adopting dry seeding in the minor irrigation scheme compared to major irrigation
schemes (Aheeyar et al., 2012). Dry seeding is a traditional practice (called ‘Nava
Kekulan’) that helps minor irrigation farmers to tackle the climate change issue in
the absence of knowledge on new adaptation practices. The probability of adopting
dry seeding is 3.8 per cent in major irrigation schemes and 5.4 per cent in the
minor irrigation scheme. Bethma is highly practiced in major irrigation schemes.
The probability of practicing bethma in a major irrigation scheme when other
variables are in the mean value of 2.2 per cent. According to Marambe et al.
(1996) unlike major irrigation schemes, land fragmentation is high in minor
irrigation schemes and it leads to scattered smallholdings. Land fragmentation is
mainly due to the inheritance and as a consequence, many social problems had
arisen including low social cohesion. Moreover, the strength of institutions that
are monitoring minor irrigation systems is lower than that of the monitoring
authorities of major irrigation schemes, thus it could be that they are unable to
enforce bethma effectively under minor irrigation schemes.

Short duration seed varieties are cultivated in major irrigation schemes than
minor irrigation schemes. The probability of choosing SDSV in major irrigation
schemes is 15 per cent but it is 11 per cent in minor irrigation schemes due to the
low extension programs on new adaptation practices in minor irrigation schemes
(Aheeyar, 2012). Major irrigation farmers practiced more adaptation practices
than minor irrigation farmers as more programs on adaptation practices are
conducted in major irrigation schemes by the government (Aheeyar, 2013).

| Adaptation Practice       | Major Irrigation Scheme | Minor Irrigation Scheme |
|---------------------------|-------------------------|-------------------------|
| OFC                       | 0.0138                  | 0.0036                  |
| Dry seeding               | 0.0381                  | 0.0540                  |
| Bethma                    | 0.0220                  | 0.0047                  |
| SDSV                      | 0.1502                  | 0.1123                  |
| Two adaptation practices  | 0.4265                  | 0.2468                  |
| More than two adaptation  | 0.4736                  | 0.2621                  |

Source: Authors’ calculations.
Impact of Climate Change Perception

The impact of CCPI on adapting different practices is evident in all the Figures 3–8. Further choosing OFC, SDSV and bethma are low in minor than major irrigation schemes.

**Figure 3.** Trend of Marginal Value for Choosing OFC with Climate Change Perception Index

*Source:* Authors’ calculations.

**Figure 4.** Trend of Marginal Value for Choosing Bethma with Climate Change Perception Index.

*Source:* Authors’ calculations.
Figure 5. Trend of Marginal Value for Choosing Dry Seeding with Climate Change Perception Index

Source: Authors’ calculations.

Figure 6. Trend of Marginal Value for Choosing SDSV with Climate Change Perception Index

Source: Authors’ calculations.
Figure 7. Trend of Marginal Value for Choosing Two Adaptation Practices with Climate Change Perception Index

Source: Authors’ calculations.

Figure 8. Trend of Marginal Value for Choosing more than Two Adaptations with Climate Change Perception Index

Source: Authors’ calculations.
With increasing CCPI, the estimated probability for the willingness to cultivate OFCs is increasing in both major and minor irrigation schemes as shown in Figure 3. OFC cultivation is one of the accelerated projects of Sri Lankan government to cope up with climate change, to achieve self-sufficiency in supplementary food crops, achieve high production in the Yala season, and promote third season cultivation. For instance, chili cultivation in Mahawali zone H, onion cultivation in Dambulla, potato, vegetable, and banana cultivation in different parts of the country are few successful projects implemented to improve the OFC cultivation. The awareness programs on OFCs accelerated the farmers’ intention to choose OFC with increasing CCPI but comparatively the percentage of choosing is less with other practices.

Figure 4 explains the changing trend of practicing bethma with CCPI. Many stakeholders such as government agents, officials from the Department of Irrigation, Mahaweli Authority, and the Department of Agriculture, and so forth, are involved in the decision making process for the seasonal bethma practice. Even though the perception of climate change is low, farmers are highly engaged in bethma in Major irrigation schemes. With increasing CCPI, the farmers adopt bethma less; it is because each farmer gets a small portion of land for cultivation after the division under the bethma practice. Thus it is not possible to generate economically viable income out of an allotted small piece of land. In a minor irrigation scheme, due to some cultural appropriateness such as low social cohesion, the likelihood of practicing bethma as a communal activity is comparatively low and the reasons for low level of practicing bethma is explained in the section, impact of irrigation scheme.

Figure 5 explains that the farmers with a higher climate change perception have a higher likelihood of practicing dry seeding but a changing trend is observed after the highest likelihood of adaptation. Specifically, in the rain-fed rice system, dry seeding is practiced when initial rain gets delayed. However, losses are high in the dry seeding which requires a higher seed rate (150 kg/ha) than transplanting, and stress and physical damage are also high in the dry seeding method (International Rice Research Institute, 2008). Farmers prefer dry seeding for short duration varieties and transplanting for long-duration varieties but the main objective of practicing dry seeding is water scarcity and that is evident by the response given by the farmers. However, there is a fewer number of programs implemented to promote dry seeding due to the high loss and less effectiveness (Weerakoon et al., 2011; Institute of Policy Studies, 2002). This analysis indicates the expectations and perceptions of farmers about the dry seeding and the trend of practicing with CCPI. The change in the trend is due to the highest perception of climate change that leads the farmers to shift from paddy cultivation to other crops. So the shifting pattern from paddy cultivation results in a low likelihood of practicing dry seeding. Further, the underlying phenomena for the change are explained by the reasons given by the farmers on why they are not practicing dry seeding. Most of them are of the view that it is not an effective practice (32.9 per cent) while some think that there is no need to practice dry seeding (15.5 per cent). Thus farmers who have high knowledge of climate change tend to opt for better adaptation practices than dry seeding.
Figure 6 shows the declining trend in the likelihood of choosing short duration seed varieties (SDSV) for cultivation with an increasing perception of climate change. Even though planting SDSV is considered as a climate change adaptation practice, in the farmers’ point of view use of traditional varieties scored high among adaptation measures. Particularly 38.1 per cent of farmers out of total farmers reveal that they are practicing SDSV cultivation due to the water scarcity and 23.1 per cent of farmers reveal that they practicing it for income generation. However, SDSV is highly susceptible to pest attacks and water stress. The duration of irrigation is low for SDSV but the total water requirement of SDSVs is more than that of traditional varieties (Chithranayana & Punyawardena, 2013; Dhanapala, 2006). The contradicting results and perception of farmers towards SDSVs and traditional varieties result in a reduction in the likelihood of adaptation of this technology with climate change perception. Moreover, the yield reduction in SDSVs due to the high susceptibility is mentioned as the foremost problem in planting SDSV by 40.9 per cent farmers and 24 per cent of farmers specify that this practice is not effective due to the above-mentioned reasons.

The trend in practicing two and more than two adaptation practices was shown in Figures 7 and 8 for both major and minor irrigation schemes. Both are displaying an increasing pattern where minor irrigation scheme shows a high probability of adopting compared to major irrigation scheme.

Overall the practices such as OFCs and dry seeding were perceived as good adaptation practices by farmers when they perceive high climate change whereas SDSVs and bethma are less considered by farmers. Moreover, major and minor irrigation schemes show a different pattern in practicing selected adaptation practices.

Limitation of Current Programs

Sri Lanka developed the National Climate Change Policy in 2012 to give direction to all the stakeholders to handle the adverse impacts of climate change efficiently and effectively. There are several key areas addressed regarding climate change which are vulnerability, adaptation, mitigation, sustainable consumption and production, knowledge management, and general statements. Under adaptation, food production and food security were addressed to cope up with the negative impact of climate change and ensure a sufficient level of production. Particularly National Adaptation Plan was prepared to attain the policy goals under the agriculture adaptation statement. Climate-smart agriculture programs were introduced to cope up with climate change.

Moreover, the following programs are implemented in the field level to promote the adaptation practices among farmers. They are National Climate Change Research Program, National Capacity Needs Self-Assessment Action Plan, Haritha Lanka Programme, Yaya Block Demonstration Project, Research on Flood and Salinity Tolerant Rice Varieties and Plant Breeding Program, Program on Promoting OFC cultivation, Program on Promoting Mulching and CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS)
When considering these goals of these programs and farmers’ perceptions and constraints which are derived by the in-depth analysis, there is a mismatch between them in the Sri Lankan context. To understand the deviation between farmers’ actual practices and recommended practices by government, climate smartness values, and farmer adoption rate based on the sample were compared. Climate smartness value is proposed in the National Adaptation Plan in terms of water usage, nitrogen leachate, energy consumption, climate adaptation, and knowledge by the Ministry of Mahawali Development and Environment (2015) for selected adaptation practices. The climate smartness values range between 1 and 5 and are displayed in Table 6 (Ministry of Mahawali Development and Environment, 2015). The level of adoption is the level of actual practice among farmers in the Dry Zone according to the selected sample. According to the National Adaptation Plan, SDSVs have to be a high adaptation practice compared to dry seeding. But at the farmers’ level, the perception of dry seeding as an adaptation practice is more favourable than the SDSVs. Bethma and dry seeding have been practiced over the past several years, therefore farmers easily adopt these practices more than that of the practices currently proposed by the government.

To achieve food security, climate change adaption is highlighted. It is planned to be carried out through developing stress-tolerant varieties to heat, drought, and floods, promoting water-efficient farming methods, and adjusting cropping calendars according to weather forecasts. However, from the farmers’ point of view, they are reluctant to cultivate resistant varieties due to its low yielding character. Therefore, in a plant breeding program, a high yielding trait also has to be incorporated for effective adaptation of such varieties.

| Adaptation Practices   | Climate Smartness Value | Level of adoption        |
|------------------------|-------------------------|--------------------------|
| Dry seeding            | 3.0                     | High adoption (42%)      |
| OFC                    | 4.0                     | Low adoption (22.9%)     |
| Bethma                 | 3.2                     | High adoption (36%)      |
| Short duration seed variety | 4.2                     | Low adoption (15.1%)     |

Source: Climate Smartness Value - Ministry of Mahawali Development and Environment, 2015; Level of Adoption - Authors’ calculation.
OFC cultivation is highly promoted by the government through promotion on home gardens projects, Haritha Lanka programs, and so on, but due to the high restrictions on importing seeds of high yielding varieties, strict regulations, monopoly behaviour, and so on, Sri Lanka is still cultivating low yielding varieties of OFC (Chandrasiri & Bamunuarachchi, 2015; Hirimuthugodage, 2014; Wickramasinghe, 2013). Therefore, the comparison between the revenue and cost of production of OFCs and subsidies and guaranteed price for paddy retain farmers in paddy cultivation. Other reasons include failures in addressing the soil degradation issue resulted from continuous and extensive cultivation and lack of consideration of interactions with other factors such as pests and diseases (Chandrasiri & Bamunuarachchi, 2015; Thiruchelvam, 2005).

Deviations between proposed adaptation practices and farmers’ perception towards the adaptation practices caused ineffectiveness of policy when it was implemented as programs in the grass-root level. Thus, when developing the programs to support the national-level policies, the farmers should be considered as one of the important stakeholders. The programs need to be developed through participatory approaches and focus group discussions. Moreover, currently, blanket programs are implemented across the Dry Zone irrespective of irrigation schemes or different cropping systems. But the results of the in-depth analysis using farmer level data indicate the significant difference among farmers’ perception between different irrigation schemes. Therefore, separate programs have to be developed for different irrigation schemes for implementation.

Conclusions

There is no doubt that the effects of climate change cannot be eliminated, but their impact on the society and country at large can be considerably minimised by taking proper remedial measures well in advance and in a planned manner. In this regard, adaptation measures should be a policy priority. This study analysed the farm level adaptation practices and farmers’ perception of climate change in the Sri Lankan context. Irrigation schemes play a major role in Sri Lankan agriculture and based on the results of this study, the adaptation practices vary among irrigation schemes. OFCs and dry seeding were highly preferred by farmers with a high level of climate change awareness.

The policy implications are wide-reaching as changes in agriculture could affect food security, trade policy, livelihood activities, and water conservation issues, impacting large portions of the population. For effective policy implementation, understanding the grassroots realities is fundamental and according to the results found in this study, it is essential to reform the existing programs in promoting climate change adaptation practices at the field level. The results in this study clarified that policy implementation becomes a failure due to the improper understanding between the farmers’ perspective and policy goals. Therefore, policymakers must consider the farmers’ perception and their actual practices to motivate farmers to enhance their adaptive capacity through adaptation.
practices. By capturing the factors that affect the farmers’ engagement in the adaptation, policymakers can develop proper goals for effective implementation. The variation among irrigation schemes is understandable through the different trends obtained in this study. Therefore, appropriate programs have to be developed and implemented for different irrigation schemes. These findings help design programs for effective climate change adaptation to reduce adverse effects of climate change and to reform the programs in a way that supports climate change adaptation practices.

The study covered only the dry zone of Sri Lanka under two different irrigation schemes. Understanding the practices in rain-fed agriculture of Dry Zone, intermediate and wet zone will give a complete picture of designing policy. Further, farmers’ perception is one side of the coin. We need to get the opinions and information from government officials which will give a better knowledge of climate change adaptation practices and their success rates as a whole system. This study considered only the farm-level agricultural adaptation behaviours. However, agricultural adaptations can include other household-level decisions outside of how land is cultivated, such as financial management strategies, purchasing insurance, livelihood diversification. Moreover considering individual farmer behaviour will also lead to a better understanding of the adoption of agricultural practices such as self-efficacy, risk-taking, and social cohesion, and so on.

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Notes
1. Dry seeding is one of the major adaptation practices promoted and followed by the farmers. In the dry seeding dry paddy seeds are broadcasted or drilled on unpuddled soil expose to tillage or no tillage operations.
2. Bethma is an ancient communal practice, if the water is scarce, individual paddy land ownership would be suspended, and owners of the land closer to the water body were required to share their land with those who are farther away.
3. Other field crops include millets, and other cereals, other than paddy, pulses, condiments, fruits and vegetables.
4. In Sri Lanka all irrigation works were divided into major and minor works by Ordinance No. 32 of 194.6 (Begum, 1987), based on the irrigation canal distribution, extent and management (International Irrigation Management Institute (IIMI), 1986). Minor scheme–Irrigated by a single canal, no field canals, managed by Department of Agrarian Services and maintained by farmers, predominantly lands are privately owned, designed for Maha season (North-East monsoon from September to March) cultivation, crop invariably rice under subsistence farming.
Major schemes–Irrigated by a complete distribution system with branch distributaries and field canals, managed by Irrigation Department or Mahawali Authority, predominantly lands are provided under Land Development Ordinance, designed for Maha and Yala (Monsoon spans between the months May to August) cultivation, mainly rice cultivation in Maha and end of Yala.

5. Climate Change Perception Index measured the awareness of farmers reading climate change and their knowledge on perceiving climate change

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