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Research Paper

Do Drought Vulnerable Farmers Adapt More to Drought? A Case of Dry Zone Paddy Farmers in Sri Lanka

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Abstract: Frequent droughts in Sri Lanka have caused production losses in considerable amounts due to reduced water supply for irrigation. Drought adaptation has become imperative. It is important to understand the drought vulnerability and adaptation of farmers in order to propose amicable solutions. This study assessed drought

vulnerability of farmers in major and minor irrigation schemes and the relationship of drought vulnerability with adaptation level. Secondary data from Sri Lankan Environmental and Agricultural Decision-making Survey (SEADS) carried out under the Agricultural Decision Making and Adaptation to Precipitation Trends in Sri Lanka project (ADAPT-SL) and meteorological data were used for the study. Based on the definition of Inter-Governmental Panel on Climate Change (IPCC), the integrated approach was used to conceptualize the framework of drought vulnerability where a vulnerability index was defined using adaptive capacity, sensitivity and exposure to drought. IPCC's concept of adaptation was used to measure the adaptation level. Correlation tests were done to find the relationship among vulnerability and adaptation level and mean comparison tests were carried out to compare farmers in the major and minor irrigation schemes. The study finds that, while farmers in major irrigation scheme are low in drought exposure they are high in adaptive capacity and sensitivity. In contrast, farmers in minor irrigation scheme while high in drought exposure are low in adaptive capacity and sensitivity. According to correlation tests, we find that the vulnerable farmers are low in adaptation level. The mean comparison results showed that the farmers in minor irrigation scheme are highly vulnerable but show low adaptation level to drought than the farmers in major irrigation scheme.

Keywords: Drought, Vulnerability, Adaptation Level, Irrigation, Farmer

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Introduction

Drought is one of the major natural hazards. It affects the water supply and agriculture sector by its slowly occurring and long lasting nature (Bekele et al. 2014). Farmers and the rural economy are being affected mostly (Khoshnodifar et al. 2012; Zhang et al. 2014; Sullivan and Meigh 2005). According to the National Vulnerability Index, Sri

Lanka is a highly drought vulnerable country (Figure 1 Panel B). Around 75% of the population in Sri Lanka is directly or indirectly employed in the agriculture sector (Costa, 2010) and around 65% of rural households are engaged in paddy cultivation in 25% of the arable land (Shantha and Ali 2014). Paddy is the most important crop in Sri Lanka

economically as well as socio-culturally as rice is the staple food of the people. Paddy production held 0.5% of 7.1% on agricultural GDP in 2017 (CBSL, 2018). Paddy is a high water consuming crop and in Sri Lanka most of paddy is cultivated in the country's Dry Zone, which is highly prone to drought. The darkest areas shown Figure 1 Panel A belongs to the Dry Zone. Hence, drought is a serious concern for the livelihood and rural economy of the

Dry Zone of Sri Lanka and drought adaptation has been identified as essential. There is a significant difference in cropping systems, agricultural practices and institutional arrangements in the Dry Zone. Even though Dry Zone of Sri Lanka is more vulnerable to drought, all areas of the Dry Zone are unlikely to be equally vulnerable and hence all farmers are unlikely to be equally vulnerable

Figure 1. Proxy Drought Risk Map (A) of Sri Lanka (1960-2000; Lyon et al., 2009) and State of Sri Lanka based on the National Drought Vulnerability Index (A) [Drought monitoring system]

There are two main irrigation schemes in the Dry Zone of Sri Lanka, namely major (>80 ha of command area) and minor (<80 ha of command areas) irrigation schemes. There is a huge difference in the agricultural practices and institutional arrangements in areas irrigated by the respective irrigation scheme. Because of these differences, farmers may differ largely in their drought vulnerability. And hence, it is unlikely that they would adapt to drought in the same way. Drought adaptation is promoted to cope up with droughts. It is important that differences in drought vulnerability of farmers are understood for effective implantation of drought adaptation programmes.

Past studies related to drought vulnerability in Sri Lanka were limited to a particular geographical area and aggregated data (Sakeena 2014; Eriyagama and Smakhtin 2011; Chithranayana and

Punyawardena 2013). Further, existing literatures failed to consider differences in organizational structure of different irrigation systems and capacity of farmers under different irrigation schemes (Wickramasinghe 2014; Chithranayana and Punyawardena 2013; Lazarus 2011). This study overcomes the above limitations of the existing literature on drought vulnerability and adaptation of Dry Zone farmers in Sri Lanka by employing a large farmer level data set to understand the difference in drought vulnerability of farmers and its relationship with drought adaptation.

Drought vulnerability receives higher concern among all other vulnerability types associated with a system related to its physical, social and economic factors (Wu et al. 2011; Khoshnodifar et al. 2012). Though drought impacts occur throughout the world, societies depending on agriculture sector

and with higher poverty level, lower adaptive capacity and large dependence on natural resources largely get affected (Jamir et al. 2012). So, vulnerability assessment is needed to provide a framework for identifying the various causes of drought impacts (Sookhtanlo et al. 2013; Zarafshani et al. 2016) and helps to develop adaptation strategies (Sullivan and Meigh 2005).

Experts from miscellaneous fields of specialization have been theorizing vulnerability for natural hazards in different ways (Zarafshani et al. 2016). Various conceptualization of vulnerability based on the different objectives of the studies give way for various methodological approaches (Zarafshani et al. 2016; Sullivan 2002; Vincent 2007; Sullivan and Meigh 2005; Hahn et al. 2009). According to Inter-Governmental Panel on Climate Change (IPCC), vulnerability is a function of exposure, sensitivity and adaptive capacity where adaptive capacity is defined the ability of a system to adjust to actual or expected climate stresses or to cope with the consequences of climate stresses. Exposure is the nature and degree to which a system is exposed to climate variations or hazard and sensitivity is the degree to which a system is affected (Deressa et al. 2008). IPCC definition is widely used in several studies (Nelson et al. 2007; Deressa et al. 2008; Micah et al. 2009; Zarafshani et al. 2016).

Wisner (2001) argues that basic approaches to measure social vulnerability such as demographic,

taxonomic, household livelihood and contextual and proactive approach can also be used for drought (Deressa et al. 2008). But there are also different set of categorizations as socioeconomic, biophysical and the integrated assessment approaches (Deressa et al. 2008). With these three, Fussel (2007) added risk-hazard approach (Zarafshani et al. 2016). The biophysical approach mainly deals with both social and biological systems unlike risk hazard approach, which mostly considers the physical system. Integrated assessment approach combines both socioeconomic and biophysical approaches (Zarafshani et al. 2016). In that way, IPCC definition provides an integrated approach as it combines both internal dimensions as sensitivity and adaptive capacity and external dimension as exposure (Hahn et al. 2009; Zarafshani et al. 2016).

Drought vulnerability has been assessed at different levels such as country level, regional level and household level (Deressa 2010; Zhang et al. 2014; Jamir et al. 2012; Hahn et al. 2009). Even though there are several studies done at different scales or levels, it is argued that studies should be conducted using household level as unit of analysis since decision making related to adaptation and mitigation acutely is taken place at individual level (Zarafshani et al. 2016). Depending on the data availability and the context of the study different variables are used for the sub-constructs of vulnerability. Table 1 summarizes few variables used in different studies.

Table 1. Different variables used for sub-constructs of vulnerability in literature

Sub construct of vulnerability	Variables and indicators of vulnerability	Source
Socio economic factors	Percentage of agricultural economic loss to gross domestic product, the female to male ratio, population density, illiteracy rate, dependency ratio and percentage of agricultural population to total population, percentage of people living below poverty level	Zhang et al. (2014), Khoshnodifar et al. (2012).
Physical factors	Percentage of effective irrigation & drought-affected area to the total arable land area, unit area yield, percentage of irrigated land, soil moisture holding capacity and food production per unit area	

Exposure	Variables for extreme climate, drought duration and dry land extent, natural disasters and climate variability indicators, temperature and precipitation changes, frequency and severity of drought	Jamir et al. (2012), Hahn et al. (2009), Deressa et al. (2008); Zarafshani et al. (2016).
Sensitivity	The land extent under shifting cultivation, rain fed and irrigation, irrigation availability, crop diversity index, rural population density, percentage of different scale farmers as medium and small, value of crop lost, food, health and water indicators, duration, magnitude and spatial extent of drought	
Adaptive capacity	Annual crop production, farm income, literacy rate, farm holding size, farm assets, accessibility for health care, banks and market (distance in km), area under drought resistant crops, alternative livelihood like forest, compensation by government, house hold percentage with drought preparedness, socio-demographic profile, livelihood strategies, social networks and socio-economic indicators like irrigation potential, wealth, technology, literacy rate, social institutions and infrastructure, managerial skills of farmers	

There were several methods and techniques such as statistical analysis, GIS and mapping, cluster analysis and index creation used to assess the vulnerability and most of the studies formulated indices (Zarafshani et al. 2016). In index creation, various weighing methods as equal (hide the influence of each indicator on overall index) and

unequal as expert opinion (Vincent 2007), stakeholder (Sullivan et al. 2002) discussion (Hahn et al. 2009) were used. Tables 2 and 3 show different models and techniques based on those used in several studies and IPCC definition, respectively.

Table 2. Different models and techniques of various studies

Model	Weighting method	Source
Drought risk index was measured using the drought vulnerability index with drought hazard index.	Rating with natural break technique	Zhang et al. (2014)
Me-Bar and Valdez's formula	Delphi technique	Zarafshani et al. (2012); Sookhtanlo et al. (2013)
Model referred to IPCC definition LVI-integrated IPCC (2001) model	Ranking the variables balanced weighted	Jamir et al. (2012) Hahn et al. (2009)

Adaptation to climate change or drought is “the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which tempers destruction or exploits beneficial opportunities” (IPCC 2001). Adaptation

is one of the options to reduce the negative impacts of climate change or drought and is important to the present state of the society or the world (Deressa and Hassan 2010).

Table 3. Different models used to measure vulnerability according to IPCC definition

Model	The study used
Vulnerability = Adaptive Capacity – (Sensitivity + Exposure)	Deressa et al. (2008)
Vulnerability = (Exposure + Sensitivity)/ Adaptive Capacity	Fontaine et al. (2009)
Chronic vulnerability index = Exposure + inability to cope	Burg (2008)
Vulnerability = hazard-coping	Webb and Harinarayan (1999)
(LVI-IPCC) d = (Exposure - Adaptive Capacity)d*Sd	Hahn et al. (2009)

Source: Zarafshani et al. (2016).

The socio-economic factors such as farmers' experience, education, social networks and accessibility to extension and credit services and information, household income, credit and membership of farmer-based organization have influence on adaptation (Deressa and Hassan 2010; Uddin et al. 2014; Ndamani and Watanabe 2015; Ali and Erenstein 2017). Farm level adaptation depends on the capacity and actions undertaken by farmers (Deressa and Hassan 2010; Ndamani and Watanabe 2015). Yet, the process of adaptation begins with an assessment of the different dimensions of vulnerability (Beddington 2012).

Adaptive capacity as a sub construct of vulnerability determines the internal ability or

capacity of farmers to adapt to the drought. Cost, lack of information and farmers' perceived barriers limits the adoption of adaptation practices. Thus, it is important to study the adaptation level of farmers along with the vulnerability in order to help policy makers to provide appropriate and effective solutions to overcome the impacts of drought under various contexts (Ndamani and Watanabe 2015).

Conceptual Framework:

Based on this IPCC definition of vulnerability the conceptual framework of the study was formed. It is shown in the Figure 2.

Figure 0. Framework for the drought vulnerability assessment of Dry Zone farmers (Adapted from Deressa et al. 2008)

Methodology

Data:

The study used data from the Sri Lankan Environmental and Agricultural Decision-making Survey (SEADS), which was carried out under the Agricultural Decision Making and Adaptation to Precipitation Trends in Sri Lanka (ADAPT-SL) project¹. The SEAD survey was carried out on Dry Zone paddy farmers in Sri Lanka and predominantly paddy farmers. Sampling has been carried out to represent geography, ethnic groups and irrigation scheme and weighted according to

the size of the community. The sample consisted 543 households of major irrigation scheme and 475 household of minor irrigation scheme.

Meteorological data of monthly rainfall at district level from year 2008 to 2015 was obtained from the annual reports of the Department of Census and Statistics of Sri Lanka. The detailed characteristics and variables obtained for the vulnerability assessment from the SEAD survey data are tabulated in Table 4.

Table 4. Summary of SEAD Survey Data Used for the Vulnerability Assessment

Socioeconomic and demographic characteristics	Agricultural variables	Health and Well-being
Demographics of household members	Agricultural inputs (seed choice, chemical application, farm expenditures)	Food security
Education, Employment	Yield	Access to medical care
Household & farm assets	Knowledge of, use, and attitudes about climate adaptation strategies	Subjective well-being
Land holding	(parachute method, other field crop cultivation, short duration seed varieties).	
Household building structure		
Water and energy sources		
Debt holdings		

Source: SEADS (2017).

Model for Vulnerability Index:

To measure the vulnerability as defined by the IPCC (2001), this study adopts a model similar model to that used by Deressa et al. (2008) in vulnerability assessment of Ethiopian farmers. Hence, in this

study, vulnerability index was defined as follows (Equation 1). The variables used to measure the sub-constructs of the vulnerability index (i.e. AC, S and E) are summarized in the Table 5.

$$\text{Vulnerability Index (VI)} = \text{Adaptive Capacity (AC)} - \text{Sensitivity (S)} - \text{Exposure (E)} \quad (\text{Equation 1})$$

Construction of indices

Since each variable included in sub-constructs of the vulnerability index is in different units,

normalization was done to make them unit-less using Equations 2 and 3.

$$\text{Normalized value} = \frac{\text{Actual value} - \text{Minimum value}}{\text{Maximum value} - \text{Minimum value}} \quad (\text{Equation 2})$$

$$\text{Normalized value} = \frac{\text{Maximum value} - \text{Actual value}}{\text{Maximum value} - \text{Minimum value}} \quad (\text{Equation 3})$$

¹ADAPT-SL (2015-2017) project was led by scientists from Vanderbilt University, University of North Florida, and University of Colorado-Boulder, and coordinated by the

Climate Research Unit of the National Building Research Organization (NBRO).

After the normalization, the Principle Component Analysis (PCA) was carried out separately for the variables under the three major sub-contracts (i.e. AC, S and E) to select the dominant uncorrelated variables in order to describe maximum variation of data using appropriate less number of variables without multi-co-linearity (Othmana et al. 2015) and to obtain factor loadings. The variables with Eigen values greater than 1 and hence high percentage of explained variation were selected while considering the relationship of variables with

the major sub-constructs. The variables that yielded opposite relationship relative to major sub-constructs were removed from the list of variables. The results of PCA after removal of variables with opposite relationships are shown in Table 6. It shows the weighted values from the PCA for the major-sub constructs of the drought vulnerability index; adaptive capacity, sensitivity and exposure. The variables showing high impact are given in bold letters except for sensitivity where all of the variables have high impact.

Table 5. Composition of Variables in Sub-Constructs of Vulnerability Index.

Sub-construct	Indicators	Variables	Unit of Measurement	Relationship with Vulnerability
Adaptive capacity	Human capital	Farmer's experience (farmer's age)	Age of farmers in years	For all variables higher the value lesser the vulnerability
		Family labors for farming	Number of family members engaged in farming	
		Farmer education level	Years of schooling of head famer	
		Other educated members	Number of educated members $\geq 0/L$	
	Physical capital	Wealth (quality of home)	Quality score of house	
		Own machinery usage	Number of machines use	
	Financial capital	Non-farm income Crop insurance	LKR. per year Present or absent of insurance	
	Social capital	Effective use of agricultural service Group farming Effective FO participation	Present or absent of 1920 usage, group farming and FO participation	
Sensitivity	Human sensitivity	Typical <i>Maha</i> (major season), <i>Yala</i> (minor season) paddy cultivation Total paddy land Total land	Land extent in acres	Higher the value higher the vulnerability
Exposure	Climate change	Rainfall change	Average variation of rainfall (mm/year)	Higher the value higher the vulnerability
	Extreme climate	Lees yielding seasons Cultivating seasons	Number of seasons per year	Higher the value lesser the vulnerability

Table 6. Results of PCA

Variables used for Adaptive Capacity	Weight	Variables used for Sensitivity	Weight
Age of the farmer	0.0395	Typical <i>Maha</i> rice cultivation	0.5344
Education level of the farmer	0.3801	Typical <i>Yala</i> rice cultivation	0.4165
Other educated family members	0.4723	Total paddy extent	0.5321
Family labour	0.1938	Total land extent	0.5075
Quality of home	0.4347	Variables Used for Exposure	Weight
Use of own machinery	0.3740	Average rainfall variation	0.7423
Non-farm income	0.3921	Cultivated seasons in 5 last years	0.6699
Past use of agricultural services 1920	0.0882	Less yielded seasons due to water scarcity	0.0145
Future use of agricultural services 1920	0.2457		
Group farming	0.0866		
FO participation	0.1850		
Crop insurance	0.0293		

Constructing vulnerability index

Sub-constructs of vulnerability index adaptive capacity, sensitivity and exposure were calculated separately by multiplying the normalized value of variables with their respective weights obtained

from PCA (Equation 4). The vulnerability index is calculated as per Equation 5.

Adaptation score calculation:

Drought adaptation agricultural practices and their advantages are shown in Table 7.

$$I_m = \sum_{i=1}^n NiWi \quad (\text{Equation 4})$$

where, I_m : - Sub-construct of vulnerability index, N_i : - Normalized value of i^{th} variable, W_i : - Weight of i^{th} variable.

$$VI = I_m(AC) - I_m(S) - I_m(E) \quad (\text{Equation 5})$$

where, VI : -Vulnerability index, $I_m(AC)$: - Adaptive capacity index, $I_m(S)$: - Sensitivity index, $I_m(E)$: - Exposure index

Table 7. Adapting Practices and Usefulness of the Practice

Adaptation Practice	Usefulness of the practice
Setting water at a lower height than the weir	Reduce the waste of water
Recycling irrigation drainage water, capturing and reusing drainage water	Avoid the wastage of water and use the water in efficient way
Use short duration seed variety	Reduce the water consumption for the cultivation
Use transplanted seedlings	Efficient production with use of water
Alternate wetting and drying irrigation; saturation irrigation,	Reduce water consumption and efficient water management instead of continuous standing water (IRRI)
SRI/ Madagascar method	Reduce the water consumption and increase the productivity (30% of yield increasing with 40% less water usage than conventional method-retrieved on www.agsri.com on 29-2.2017)
Practicing "Bethma"	Reduce the water consumption with dry sowing
Practicing "Kakulan"	Reduce the water consumption
Planted other field crops in low land	Increase the profit with reduced water consumption

As a measure of the level of drought adaptation, an adaptation score was calculated through assigning scores for the drought adaptation agricultural practices (Table 7), carried by farmers, in accordance with the purpose (for water scarcity or not) and perceived effectiveness of farmers. The

variables were recorded in order to provide higher values for very effective adaptation practices for water scarcity. PCA was done to get weights and they are given in Table 8. Negatively correlated practices were removed.

Table 8. The adaptations practices adopted by farmers and PCA Weights

Various adaptations practices	Weights
Setting water at a lower height than the weir	0.5960
Recycling irrigation drainage water; capturing and reusing drainage water	0.0187
Short duration seed varieties	0.2546
Transplanted seedlings with other methods rather than parachute method	0.1721
Alternative wetting and drying irrigation; saturation irrigation	0.5042
Sri method/Madagascar method	0.0718
Practiced " <i>Bethma</i> "	0.3348
<i>Kakulan/Kakulama</i>	0.0357
Planted other field crops in low land	0.2315
Parachute method (removed)	-0.1122
Measuring water level by using a PVC pipe and setting water(removed)	-0.2743

Statistical analysis:

Simple correlation tests were done with the 0.05 significant levels to test the following hypotheses between vulnerability index and adaptation score.

H₁: There is a relationship between drought vulnerability and level of adaptation

Mean comparison test was done to test if there a significant difference in drought vulnerability and

adaptation level between the two irrigation schemes, major and minor. Following hypothesis was tested.

H₂: There is a significant difference of vulnerability of major and minor irrigation schemes.

H₃: There is a significant difference of adaptation level of major and minor irrigation schemes.

Results and Discussion

Summary statistics of characteristics of farmer household and cultivations and adaptation score for major and minor irrigation schemes are shown in the Table 9. Apart from the continuous variables listed, several categorical variables were also used. In major irrigation schemes, forty five percent of farmers had schooling up to grade 6-11 where as it is 46% among farmers in minor irrigation schemes. A larger majority of farmers lived in self-contained small houses (95% and 92% in major and minor irrigation schemes respectively. Fifty one per cent of farmers in major irrigations schemes believed that they mostly engaged in group farming whereas

52% of farmers in minor irrigation schemes believed same. Twenty one percent of farmers in major irrigation schemes believed that the rarely engaged in group farming whereas only 20% of minor irrigation farmers believed so. Interestingly, a larger majority farmers in both major (75%) and minor (72%) irrigation schemes revealed that they received lower yields in both *Maha* and *Yala* seasons due to water scarcity. Forty eight per cent of Farmers in major irrigation scheme highly agreed that there are effective participation farmer organizations while 48% of farmers in minor irrigation agreed on the same.

Table 9. Summary Statistics of Variables of Minor and Major Irrigation Schemes

Variable	Minor irrigation scheme		Major irrigation scheme	
	Mean	Standard Deviation	Mean	Standard Deviation
Age (years)	49.37	11.98	50.58	12.17
Number of family members (excluding farmer)	3.11	1.47	3.00	1.43
Number of other educated members	0.83	0.96	0.95	0.96
Number of family labour	1.36	0.99	1.34	0.91
Number of own machinery used	1.07	1.11	1.27	1.06
Annual non-farm income (Sri Lanka Rupees)	209,537.4	232,420.7	223,702.3	246,335.7
Number of other crops cultivated by farmer	1.58	1.67	0.59	1.21
Area of typical <i>Maha</i> * rice cultivation (Acres)	2.968	2.893	3.701	3.271
Area of typical <i>Yala</i> * cultivation (Acres)	0.790	1.331	2.936	2.564
Area of total paddy cultivation (Acres)	2.746	3.097	3.844	3.434
Area of total cultivated land (Acres)	4.790	3.654	4.600	3.867
Number of seasons cultivated in 5 years				
<i>Maha</i>	4.49	1.24	4.51	1.20
<i>Yala</i>	2.53	2.33	2.54	2.33
Average rainfall (mm/year)	105.24	21.08	105.52	23.50

**Maha* – major season; *Yala* – minor season

Adaptation level:

The adaptation level of the farmers in major scheme is higher than the farmers in minor scheme (Table 10), because the farmers under the major scheme are highly sensitive to drought since they

do paddy cultivation in large extent. So they are in the need of practicing some adaptation practices in order to avoid the water wastage and to use the irrigation water in an efficient manner.

Table 10. Summary of the mean difference of adaptation score

Irrigation scheme*	Mean	Standard error	Pr(T > t)
Major	3.7258	0.1032	0.0139
Minor	3.3540	0.1101	

Major irrigation scheme: >80 ha of command area; Minor irrigation scheme: <80 ha of command area

Vulnerability Index and its Sub-Constructs:

The mean comparison results of vulnerability index and its sub-constructs between farmers in major and minor irrigation schemes are shown in the Table 11. There is a significant difference in adaptive capacity of major and minor irrigation farmers where farmers in major irrigation scheme have a higher adaptive capacity than those in minor irrigation scheme which is driven by the socio-economic characteristics of the farmer household and institutional support available in major irrigation schemes. The farmers in the major irrigation scheme are wealthier than the farmers who are in minor scheme as their cultivation extent is higher comparatively. The support from the farmer organizations and water availability is high

in major scheme. So, they can do the cultivation without much difficulty compared to minor scheme farmers. The farmers with higher educational level and educated members are higher in the major scheme (see Table 9). Therefore, access to information and the ability to get benefits are high in major scheme. When compare with minor irrigation scheme, the experience of farmers is higher in major irrigation scheme, since they extensively engage in farming in a year. Group farming is high in major irrigation scheme as they cultivate in large extents comparatively there is a need for sharing equipment and labour. These characteristics of farmers in major scheme led them to have high capacity to adapt for drought.

Table 11. Mean Comparison of Vulnerability and Its Sub-Constructs of Farmers in Major and Minor Irrigation Schemes

Construct	Major irrigation scheme		Minor Irrigation scheme		Pr(T > t)
	Mean	Standard error	Mean	Standard error	
Adaptive Capacity	1.0512	0.0108	0.9734	0.0116	0.0000
Sensitivity	0.2324	0.0080	0.1700	0.0065	0.0000
Exposure	0.5620	0.0140	0.6677	0.0109	0.0000
Vulnerability Index	0.2568	0.0187	0.1357	0.0168	0.0000

The farmers in major scheme are highly sensitive to drought compared to those in minor irrigation schemes (Table 11). Even though there is not much difference between major and minor irrigation farmers in total land cultivated, major irrigation farmers cultivate paddy in larger extent and in typical *Maha* and *Yala* seasons. Since the paddy cultivation need large amount of water, the drought incidence highly impacts the cultivation. Hence, farmers in major scheme are more sensitive to drought than those in minor irrigation scheme.

Exposure to drought is higher for farmers in a minor irrigation scheme compared to those in major irrigation scheme (Table 11). There is no significant difference in rainfall between major and minor irrigation schemes, since it was measured at district level and match paired selection of villages were taken to the sample from the irrigation schemes. But the variation due to the differences in the irrigation system and hence the water supply led farmers in minor irrigation to have the extreme effect of drought compared to those in major irrigation scheme. Therefore, farmers in minor irrigation scheme are more exposed to drought than the farmers in the major scheme. Farmers in a minor irrigation scheme show a lower mean value of vulnerability index than farmers in major irrigation scheme. Lower the value of vulnerability

index indicates higher vulnerability to drought. Due to the high exposure and low adaptive capacity to drought the farmers in the minor irrigation scheme are more vulnerable to drought than the farmers in major irrigation scheme.

Drought Vulnerability and Adaptation Level:

The Table 12 depicts the relationship of drought vulnerability index with adaptation level. It shows that the drought vulnerability index and the adaptation score are positively correlated meaning higher the vulnerability index higher the adaptation level.

Since, higher vulnerability index means lower vulnerability to drought, it yields that less drought vulnerable farmers have high adaptation level to drought and vice versa. Here the farmers in major scheme are less vulnerable; but they highly adopt the adaptation practices. This seems counterintuitive. Even though farmers in the major irrigation scheme are less exposed to drought they are more sensitive to drought since they engage in rice cultivation in larger extent comparatively. This high sensitivity of farmers in major irrigation scheme has led them to engage in more adaptation practices which are supported by their high adaptive capacity.

Table 12. Summary of the correlation test

Index	Adaptation score	Pr(t)
Vulnerability index	0.0539	0.0677
Adaptive capacity index	0.1006*	0.0006
Sensitivity index	0.1089*	0.0002
Exposure index	-0.0502	0.0890

Conclusion and Implications

This study analyzed the drought vulnerability and its relationship with drought adaptation level of farmers in the Dry Zone of Sri Lanka with a comparison between the major and minor irrigation schemes. The drought vulnerability was compared with adaptation level. In the assessment of drought vulnerability and the adaptation level, the definition proposed by the inter-governmental panel on climate change (IPCC, 2001) was used. The vulnerability index and adaptation score were calculated at the farmer level. The farmers in minor irrigation are more droughts vulnerable compared to farmers in major irrigation scheme. Drought adaptation level is lower in farmers in minor irrigation scheme compared to farmers in major irrigation scheme. The drought vulnerability of Dry Zone farmers in Sri Lanka is negatively correlated with adaptation level. The high exposure and less adaptive capacity made the farmers in minor irrigation scheme more drought vulnerable and their less sensitivity to drought reduced the need to

be adapted to drought. The opposite of above conditions in major scheme made farmers in major scheme less drought vulnerable, but highly adapted to drought.

Drought is a recurring challenge for Dry Zone farming in Sri Lanka. However, farmers across the Dry Zone are not vulnerable to drought in the same way. Hence, the farmers in minor irrigation scheme are highly vulnerable to drought, but less adapted. The exposure and sensitivity to drought are difficult to be changed. Hence, the practical way to reduce farmers' drought vulnerability is to improve their adaptive capacity. Ways to improve the adaptive capacity would be to educate and make farmers aware and knowledgeable, organize them as groups, diversify farm income and support farm households to diversify family income. Through farmer organizations farmers could be trained on drought adaptation practices and sharing limited resources.

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