Contents available at: Sri Lanka Journals Online

Tropical Agricultural Research

Journal Home Page: https://tar.sljol.info

Vulnerability of Other Field Crop (OFC) Cultivating Farmers to Climatic Variability – A Study in Palugaswewa Cascade and Mahaweli System H in Anuradhapura, Sri Lanka.

S.D.N.M. Senadeera[1*], N.D.K. Dayawansa[2] and R.P. De Silva[2]

[1]*Postgraduate Institute of Agriculture, University of Peradeniya, Sri Lanka.*
[2] *Department of Agricultural Engineering, Faculty of Agriculture, University of Peradeniya, Sri Lanka*

ARTICLE INFO

Article history:
Received: 30 July 2022
Revised version received: 10 October 2022
Accepted: 14 December 2022
Available online: 01 January 2023

Keywords:
Climate change
Irrigation systems
OFC farmers
Vulnerability index

Citation:
Senadeera, S.D.N.M., Dayawansa, N.D.K. and De Silva, R.P. (2023). Vulnerability of other field crop (OFC) cultivating farmers to climatic variability – a study in Palugaswewa cascade and Mahaweli system H in Anuradhapura, Sri Lanka. Tropical Agricultural Research, 34(1): 31-42.

DOI:
http://doi.org/10.4038/tar.v34i1.8602

Senadeera, S.D.N.M
https://orcid.org/0000-0002-8310-7246

* Corresponding author- nelunimalindya@gmail.com

ABSTRACT

Frequently occurring extreme weather events have caused agricultural production losses in considerable amounts in the dry zone of Sri Lanka. Hence, it is important to understand the farmer groups and the systems that are highly vulnerable to climate change before proposing remedial measures. Paddy is the main crop cultivated by the dry zone farmers in Sri Lanka. The majority of the farmers cultivate paddy during the *Maha* season while Other Field Crops (OFC) are cultivated in the *Yala* season in the same land due to water scarcity. This study developed a climate vulnerability index for OFC farmers and tested the applicability of the developed vulnerability index using major and minor irrigation systems. For this study, secondary data was collected from relevant government institutions and field- level organizations. Yield data, demographic data, socioeconomic data, and marketing data were collected through a questionnaire survey. Indicators were selected under three dimensions of vulnerability, representing physical and environmental factors, socioeconomic factors, and external assistance factors. All indicators were calculated for each major and minor irrigation system separately. The results revealed that, farmers in both irrigation systems are highly vulnerable to the external assistance index while scoring low in the physical and environmental index and the socio-economic index. The minor irrigation scheme has a high external assistance to climate change compared to the major irrigation scheme. Overall vulnerability index results Indicated that, the climatic vulnerability of farmers in minor irrigation system is higher (61.6) than in major irrigation systems (57.1). Thus, these types of indices are useful in assessing the status of the farmers so that interventions can be applied to reduce their vulnerability and facilitate their livelihoods.

INTRODUCTION

Temperature rise, frequent floods and droughts, sea level rise, landslides, and hurricanes are all symptoms of global climate change. The Inter-governmental Panel on Climate Change (IPCC, 2001) defines climate change, as any change in climate over time, either due to natural variability or as a result of human activity. Climate change impacts have spread all over the world and affected lives at all levels in economic, environmental, and social aspects (Ezra, 2016). Many factors influence the magnitude of climate change impacts, including level of development, population density, institutional capacity, government policies, and available technologies (Hertel & Rosch, 2010). Understanding the impacts and the pattern of climate variability is important in making decisions in various sectors, including agriculture.

In the 2019 Global Climate Risk Index, Sri Lanka has been ranked second among the countries most affected by extreme weather events in the past 20 years. In Sri Lanka, agriculture is one of the key sectors that contribute to the national economy. However, agricultural GDP contribution (7.9%) is very small and declining in comparison to industry (27% of GDP) and service sectors (56.8% of GDP) in the country (Department of Census and Statistics, 2019). In 2009, the agricultural sector contributed 12.69% to GDP, and it decreased to 7.87% in 2018 (Central Bank of Sri Lanka, 2019). There are many reasons behind this transformation of economic structure toward the manufacturing and service sectors. The declining trend in the agricultural sector reflects the impact of adverse weather conditions and labour shortages (Ministry of Mahaweli Development and Environment, 2016). It is anticipated that the Sri Lankan economy can lose 1.2% of its GDP by the year 2050 due to climate change (Esham & Garforth., 2013).

The agricultural sector, which consists of a large number of poor and marginalized farmers, is the main segment having huge climate change impacts (Kurukulasuriya and Ajwad, 2007). Sri Lanka has a tropical monsoon climate with seasonal rainfall variations among the first inter-monsoon (March–April, FIM), southwest monsoon (May–September, SWM), second inter monsoon (October–November, SIM), and northeast monsoon (December–February, NEM). There are three climatic zones in the country: wet, dry, and intermediate, where the wet zone receives relatively high mean annual rainfall (over 2500 mm) without pronounced dry periods and the dry zone receives less than 1750 mm of rainfall with a dry season from May to September. In the dry zone, the majority of the population depends on agriculture as their main livelihood option (Chithranayana & Punyawardena, 2014). Most of the crops are cultivated during the rainy season, and the existing climate variation is the biggest problem that creates the gap between potential and actual yields (Wickramasinghe, 2013).

The largest percentage of the agricultural land extent of Sri Lanka's total agricultural lands is covered by the North Central Province (Prasanna *et al*., 2012). The Climate Change Vulnerability Data Book (2011) revealed that the North Central and Southern regions of Sri Lanka are the most affected by long droughts. With more frequent extreme rainfall events, areas under major and minor irrigation schemes face serious issues due to excess water during unfavorable crop growth periods and due limited water availability during crop production (Eriyagama *et al*., 2010).

Though major irrigation schemes are paddy dominated, paddy cultivation is mostly confined to the Maha season due to less rainfall and water scarcity in the Yala season. As an adaptation to water scarcity, farmers are opting to cultivate other field crops (OFCs) such as pulses, cereals, and other less water consuming grains (Mar *et al*, 2018). Although paddy production has reached a self-sufficient level, OFCs have not reached such levels (DOA, 2020). The demand gap is filled by importation, and in the meantime, the Department of Agriculture concentrates on its extension services for OFC cultivation (DOA, 2008).

Based on the statistics of OFC cultivation in the Anuradhapura district, it is evident that the production has a high degree of temporal variation (Esham, & Garforth., 2013). There may be multiple reasons behind these fluctuations in production. However, it is common knowledge that water availability is a factor that plays a major role. In Anuradhapura District, farmers cultivate OFCs under both major and minor irrigation systems and face variable challenges during cultivation (Chithranayana & Punyawardena, 2014). In these systems too, water scarcity is one of the common problems experienced in variable proportions. Hence, to propose interventions to improve agriculture in these systems to obtain optimum production to face food insecurity, understanding the system dynamics within water shortage conditions is essential.

The major objective of this study was to develop a climate vulnerability index for OFC farmers and test the applicability of the developed vulnerability index using major and minor irrigation systems to understand the existing situation in the field.

METHODOLOGY

Study area

This study was carried out in the Thalawa block (409 and 410 units) in Mahaweli System H, which represents a major irrigation system, and Palugaswewa Grama Niladhari (GN) division in Anuradhapura District, which represents a minor irrigation system.

System H is the oldest irrigation system developed under the accelerated Mahaweli Development Program. A major part of this system is located in the North Central Province of Sri Lanka and covers two administrative districts: Anuradhapura and Kurunegala. A total of 62,054 families were settled in the system, and 46% of them are farmers (MASL, 2018). Irrigation water is released for both the Yala and Maha seasons for the area by the Mahaweli Authority. The amount of water issued is much higher in the Yala season (281.89 MCM in 2018 Yala) than in the Maha season (225.27 MCM in 2017/18 Maha), which receives good rainfall throughout the season. It consists of seven blocks and 26 units (Figure 1). Among them, the Thalawa block (409 and 410 units) was selected for the application of the developed vulnerability index since this block experiences water scarcity conditions in the Yala season.

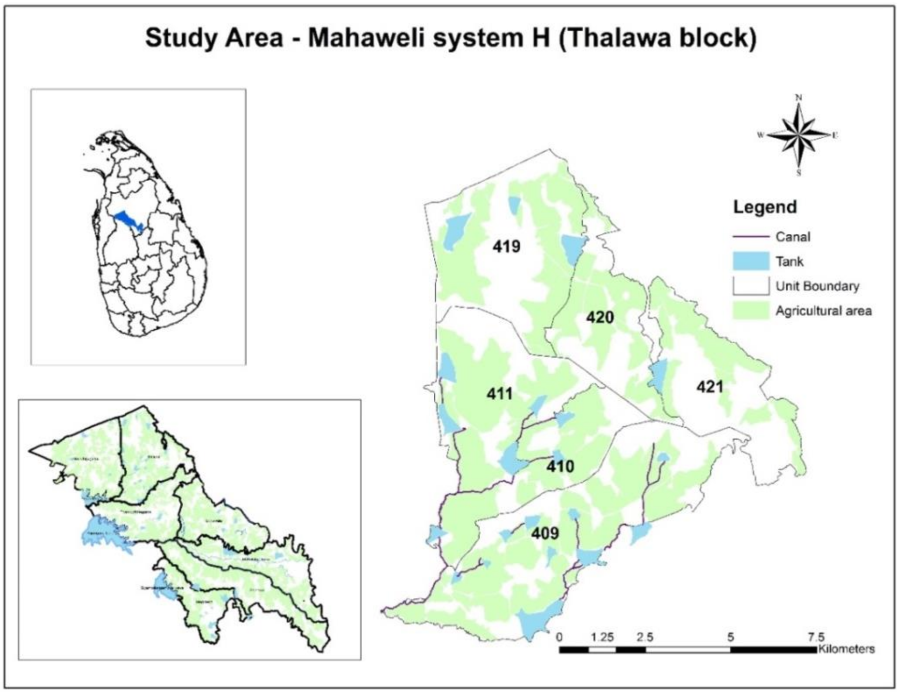

Figure 1: Study area and its land use – Thalawa Block of Mahaweli System H

The cascade system located in Palugaswewa Divisional Secretariat Division (DSD) in Anuradhapura, has been declared as a Globally Important Agricultural Heritage System (GIAHS) by the FAO on the request of the Ministry of Agriculture, Sri Lanka and the DS division occupies 12 cascaded village tank systems (FAO, 2018).

Hence, Palugaswewa GN was selected to represent a minor irrigation system (Figure 2). Among the total population of the area, 25% of the people are engaged in farming as their major livelihood option (FAO, 2016).

Data collection

The study was based on primary and secondary data analysis. Accordingly, secondary data were collected from relevant government institutions and field-level organizations. Major irrigation system data was collected from 409 and 410 units in the Thalawa block. 409 and 410 units represent more than 27% of the OFC land extent in the Thalawa block. Minor irrigation system data was collected in the Horiwila-Palugaswewa cascade system, especially focusing on OFC cultivation. Table 1 indicated the data collected data and its sources.

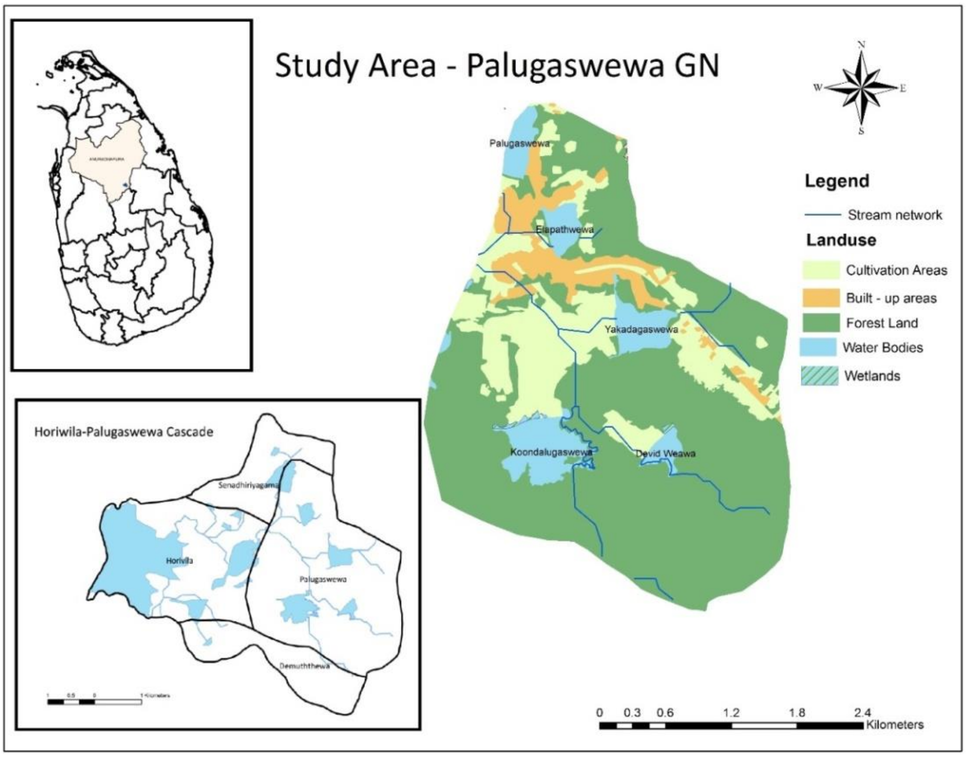

Figure 2: Paluggaswewa Grama Niladhari Division – Minor irrigation system

Table 1: Secondary data used in the study and their sources

Data: For Major Irrigation system	**Data source**
Rainfall data	Anuradhapura, Maha Illupallama Mahagalkadawala, Diyabeduma and Girithale rain gauging stations (2020 daily rainfall data)
Yield data (2020 Yala season), Productivity, Number of agro wells, demographic details	Statistical handbook of the Mahaweli Authority of Sri Lanka, 2021, Mahaweli Block Manager's office, Thalawa
Data: For Minor Irrigation system	
Rainfall data	Diabeduma and Girithale rain gauging stations (2020 daily rainfall data)
Tank capacities, command areas	Statistical Handbook - Anuradhapura District, 2020
Yield data (2020 Yala season),	Agrarian Service Center, Palugaswewa

Primary data were collected from the Palugaswewa GN division by using a pre-tested structured questionnaire. Sixty farmers were randomly selected among the total of 208 farmers in the village. As such, the sample represents 29% of the population. In this study, depending on the availability of the data, the vulnerability of OFC farmers was assessed for the 2020 Yala season because OFC cultivation is more prominent in the Yala season. Through the questionnaire, data on demographic details, cultivation and production, infrastructure facilities, marketing details, farmer organizations, and government interventions were gathered.

The rainfall data were collected from two rain gauge stations close to Palugaswewa. The nearest meteorological stations are located 22.13 km and 22.16 km from the Palugaswewa GN, respectively. Three closely located rain gauges were selected to represent Mahaweli System H, namely, Anuradhapura, Maha Illupallama, and Mahagalkadawala.

Development of climatic vulnerability index

The analysis is focusing on identifying water scarcity by developing a composite climatic Vulnerability Index (VI). Climate-related vulnerability assessments are based on the characteristics of the vulnerable system, the type and number of stressors and their root causes, their effects on the system, and the time horizon of the assessment (Fussel, 2007) (Figure 3). Anthropogenic activities, climate variability, and water scarcity are identified as the major stressors faced by the OFC cultivating farmers in the selected major and minor irrigation systems.

In developing the vulnerability index, major components were selected based on a widely accepted vulnerability index framework suggested by the IPCC (2007). Indicators were selected under three dimensions of vulnerability, representing physical and environmental factors, socioeconomic factors, and external assistance factors (Figure 4). Physical and environmental factors assess the extent to which the farmers are exposed to climatic variations and describe the state of the environment within that community. Socioeconomic factors assess how climatic variations are sensitive to the economic sector in OFC communities. External assistance factors evaluate the adaptation methods used to cope with adverse climatic conditions.

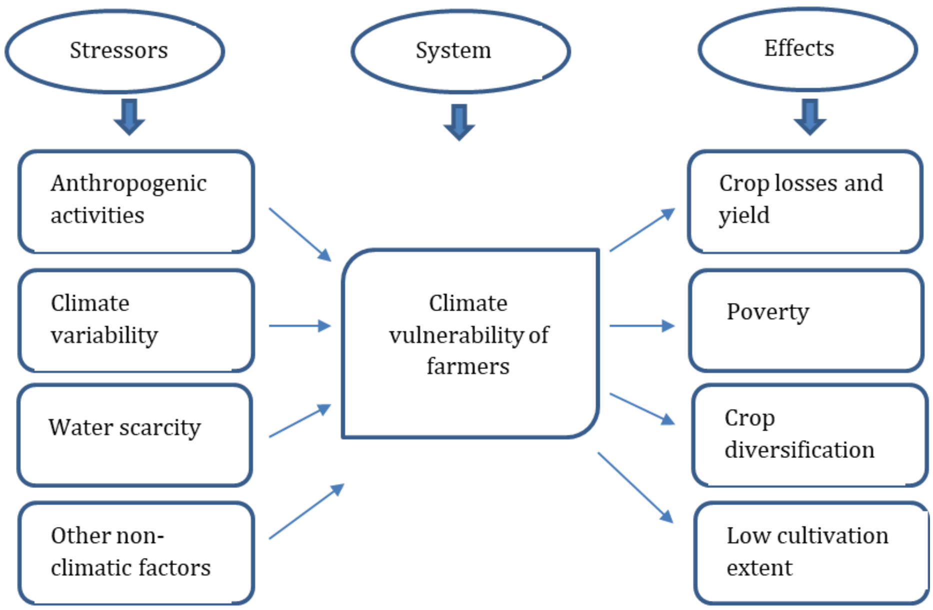

Figure 3: Conceptual framework of developing climatic vulnerability index

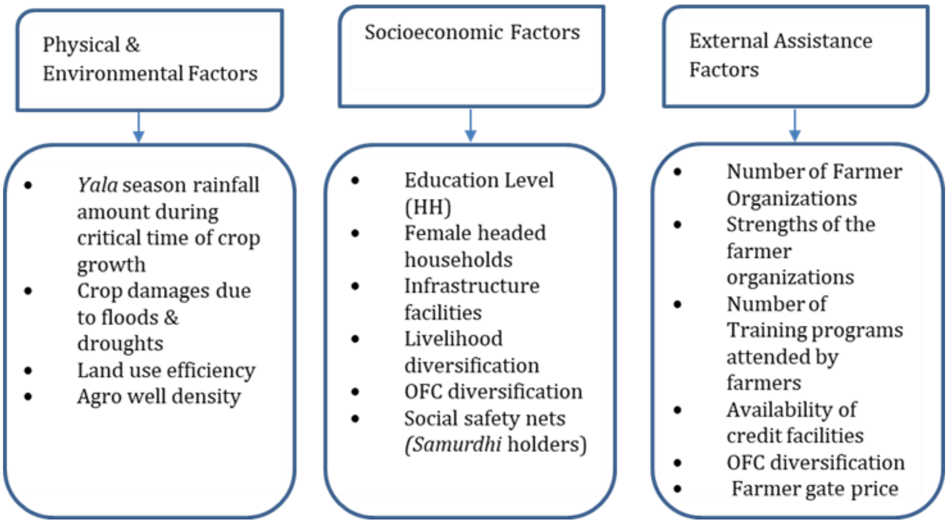

Figure 4: Indicators selected under each sub-component of the VI

The process flow for the development of VI is shown in Figure 5. Index development and index application were carried out in this study. As the first step, indicators for each sub-component were selected based on the literature and considering data availability. Subsequently, threshold levels were set for some indicators. Normalization and weight-assigning processes were followed using the analytical hierarchical process (AHP).

Setting the threshold levels for indicators

In this assessment, the majority of the indicators were measured as percentages. The rest of the indicators were converted to a 0–100 scale with the assumption of a linear relationship. Minimum and maximum limits were set based on the literature (threshold values). For example, the first indicator refers to the rainfall amount in the study area during different growth stages of the crops, based on the finding that the vulnerability to extreme climatic conditions and the resulting economic losses depend on the growth stage of the crops (Mallari, 2016; Mar *et al.*, 2018). The threshold levels identified for rainfall amounts are given in Table 2.

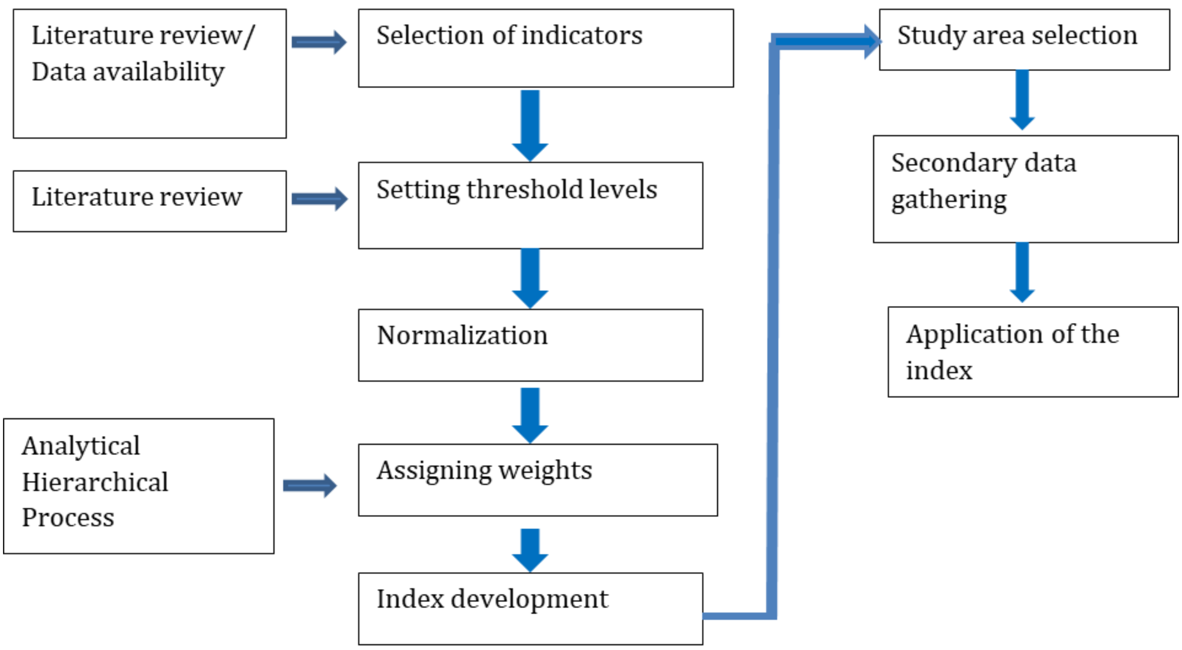

Figure 5: Vulnerability index development and application process

Table 2: Threshold values for the hydrological parameter (Mar *et al*, 2018)

Actual value	Scale value	Level of vulnerability
Rainfall amount during land preparation and sowing stage		
30 - 50	0	Not vulnerable
51 - 70	25	Less Vulnerable
71 - 90	50	Moderate Vulnerable
91 - 120	75	Highly Vulnerable
> 120	100	Extremely Vulnerable
Rainfall amount during the vegetation stage		
>= 120	0	Less vulnerable
119 - 100	25	Vulnerable
99 - 80	50	Moderate Vulnerable
79 - 60	75	Highly Vulnerable
<= 59	100	Extremely Vulnerable
Rainfall amount during the flowering & fruit setting stage		
>= 270	0	Less vulnerable
269 - 230	25	Vulnerable
229 - 210	50	Moderate Vulnerable
209 - 190	75	Highly Vulnerable
< 190	100	Extremely Vulnerable
Rainfall amount during the maturation stage & harvesting stage		
<= 50	0	Not vulnerable
51 - 70	25	Less Vulnerable
71 - 90	50	Moderate Vulnerable
91 - 120	75	Highly Vulnerable
> 120	100	Extremely Vulnerable

Table 3: Level of vulnerability in relation to agro-well density

Actual value	Scale value	Level of vulnerability
X > = 30	0	Less Vulnerable
29 - 25	25	Vulnerable
24 - 20	50	Moderate Vulnerable
19 - 15	75	Highly Vulnerable
X <= 14	100	Extremely Vulnerable

According to Kikuchi *et al.* (2003), more than 50% of agro-wells are located in non-irrigable highlands, and the rest are located in irrigable areas in Sri Lanka. According to their results, major irrigation schemes in the dry zone have high agro-well densities (27–22 per 100 ha), which helps to increase the cropping intensity of the Yala season. Nevertheless, too many agro wells disturb the sustainability of the cascade systems in the dry zone (Dharmasena, 2020). According to those criteria, the following table was developed (Table 3). The higher the agro well density in the given area, the lesser the vulnerability of that farming community.

After setting the threshold levels, the normalization procedure was followed as described.

Normalization

The normalization process was carried out by identifying the functional relationship between indicators and vulnerability. Table 4 shows +/- marks to represent the functional relationship of the indicators with vulnerability. If there is a positive relationship (+) with the indicator, the same value was used as the normalized value. When the indicator has a negative relationship (-) with the vulnerability of OFC farmers, the value of the indicator was calculated by subtracting it from 100.

Deriving the weights for indicators

After the normalization, the Analytic Hierarchy Process (AHP) was applied separately for the variables under the three major sub-components, namely the Physical and Environmental Index, the Socioeconomic Index, and the External Assistance Index. In the AHP process, the input format for decision makers to express their preferences derives from a pairwise comparison among various elements (Benítez *et al*., 2011). Comparisons were determined by using a numerical scale of 1–9 to represent opinions ranging from equal importance to extreme importance. In this assessment, pairwise comparisons were computed by field experts (farmers, field officers, and professionals in the agrarian sector) based on their knowledge. The relative weightages were assigned to the major subcomponents of the climate change vulnerability index based on the results of AHP are shown in Table 5.

Table 4: Functional relationship of the indicators with vulnerability

Environmental & Physical Index	Socioeconomic Index	External Assistance Index
• *Yala* season rainfall amount during land preparation & sowing stage (+) • *Yala* season rainfall amount during vegetative stage (-) • *Yala* season rainfall amount during flowering & fruit setting stage (-) • *Yala* season rainfall amount during maturation stage & harvesting stage (+) • % of Crop damages due to flood & drought (+) • Land use efficiency (-) • Agro wells density (-)	• Education Level (-) • % of Female-headed households (+) • % of available micro irrigation systems (Sprinkler or drip) (-) • % of tractors (-) • % of Vehicles (-) • Available storage facility per farmer (-) • Livelihood diversification (-) • OFCs diversification (-) • *Samurdhi* holders (+) • Yield gap (+)	• Number of Farmer Organizations (FO) per 100 farmers (-) • Financial status of the FO (-) • Active leadership (-) • % of participating *Kanna* meeting (-) • Number of Training programs per year (-) • Availability of credit facilities (-) • Farm gate price (-)

Table 5: Results of Analytical Hierarchical Process

Variable used for Physical & Environmental Index	Weight
Yala season rainfall amount during land preparation +sowing	0.05
RF amount in vegetative stage	0.07
RF amount in flowering & fruit setting stage	0.12
RF amount in the maturation stage & harvesting stage	0.03
% of Crop damages due to floods	0.23
% of Crop damages due to droughts	0.29
Land use efficiency	0.13
Agro well density	0.075
Variable used for Socio-economic Index	
Education level (HH)	0.03
% of female-headed household	0.04
Infrastructure facilities	0.24
Livelihood diversification	0.34
OFC diversification	0.14
% of poor-income people	0.08
Yield gap	0.14
Variable used for External Assistance Index	
No. of farmer organizations	0.03
Strength of the farmer organization	0.09
No. of training programs per year	0.15
Availability of credit facilities	0.23
Farmer gate price	0.50

Construction of vulnerability index

The composite vulnerability index was calculated by combining the sub-indices. Since the external assistance index is the primary factor that determines vulnerability (Oppenheimer *et al.*, 2015), a high weight was given to it. The following weights were assigned based on expert judgment (farmers, field officers, and officials in the agrarian sector) for each subindex:

$$VI = (0.1 \times PE) + (0.3 \times SE) + (0.6 \times EA) \longrightarrow \quad 02$$

Where;
PE - Physical & Environmental Index
SE - Socio Economic Index
EA - External Assistance Index

Finally, the values obtained from the vulnerability index were classified using the scale given in Table 6 (Eriyagama *et al.*, 2010).

The developed index was applied to two units in the Thalawa block (409 and 410) and Palugaswewa GN.

RESULTS AND DISCUSSION

Status of cultivation in two irrigation systems

In the minor irrigation system, 56 percent of the families are engaged in farming, while it is 47% in the major irrigation system. The majority of the farmers (80%) cultivated OFCs in the 2020 Yala season under the two irrigation systems. Among them in the minor irrigation system, 40 percent of the OFC farmers are engaged in various secondary occupations such as animal husbandry, working as laborers, and being self-employed. In the major irrigation system, 15 percent of OFC farmers have secondary occupations parallel to their farming activities. Full-time employment in farming can make them vulnerable if climatic disasters affect their crops.

A larger majority of the OFC cultivating farmers (81%) in the minor irrigation system have an education level of Ordinary Level (O/L) or above. In Palugaswewa, the younger generation is reluctant to engage in farming as their main occupation, and they have gone for higher education. Out of the total OFC farmers in the major irrigation system, 25% have an O/L or higher education level in these units.

Paddy is the most prominent crop (57%) in the minor irrigation system. In the 2020 Yala season, about 54% of the land extent was cultivated with paddy in the major irrigation system. However, compared to the Mahaweli System H (5.4 MT/ha), the paddy productivity is lower (4.3 MT/ha) in the Palugaswewa minor irrigation system. Marambe *et al*. (1996) revealed that rice yield is low in minor irrigation schemes compared to major irrigation schemes due to scarcity and the unreliability of irrigation water supply. The same conditions have been identified as the major causes of the low rate of success in minor irrigation schemes.

Big onion, Black gram, Sesame, and Maize are the widely grown OFCs in the minor irrigation system, whereas in the major irrigation system, the majority of the farmers have cultivated Soybean in the same season (Figure 6).

Table 6: Classification of vulnerability

Value range	Level of vulnerability
0 - 20	Less Vulnerable
21 - 40	Vulnerable
41 - 60	Moderate Vulnerable
61 - 80	Highly Vulnerable
81 - 100	Extremely Vulnerable

(Eriyagama *et al*., 2010)

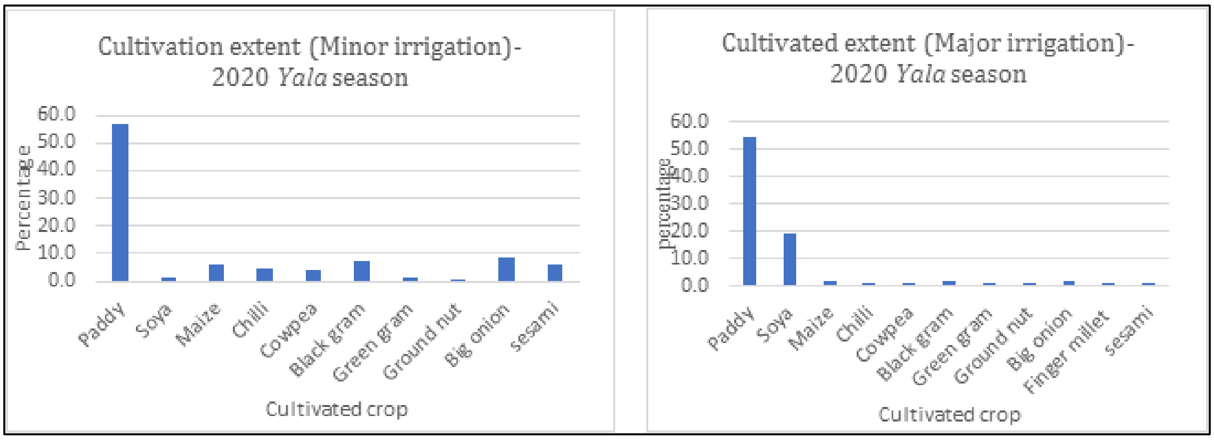

Figure 6: The cultivated land extent of different crops with respect to the total cultivated land extent in minor and major irrigation systems

Table 7: Physical environmental, socio-economic, and external assistant factors - Sub-indices values in two irrigation systems

	Minor irrigation	Major Irrigation
Physical & Environmental Index	2.6	2.6
Socio Economic Index	17.9	16.6
External Assistance Index	41	38.4
VI	61.6	57.1

Irrigation

There are five tanks located in the Palugaswewa GN division within Horiwila-Palugaswewa cascade system. All of these tanks have not been built for irrigation. Storage tanks were built in the forest area to trap the sediments and serve as a water source for wild animals. Olagam tanks are found immediately upstream of the irrigation tanks to prevent sediment intrusion. Palugaswewa Maha wewa is the only village tank located in Palugaswewa that is built for the purpose of irrigation (FAO, 2016). Farmers are reluctant to cultivate under the tanks, which are located far away from the village, as there is a high possibility of wild animal attacks.

However, it revealed that limited water availability exists for agriculture in the Palugaswewa in both seasons. In Palugaswewa, during the Maha season, there is adequate rainwater for paddy cultivation, while OFCs are more suitable in the Yala season to reduce irrigation water use. Cultivation decisions in dry zone farming are heavily reliant on observations of the intensity and duration of early season rains (Senaratne & Scarborough, 2011).

Vulnerability status of OFC cultivated farmers

The status of the physical environmental, socio-economic, and externally assisted factors related to OFC cultivation in the two irrigation systems is reflected by the sub-indices. A summary of sub-indices values for the two irrigation systems are shown in Table 7.

Two irrigation systems have obtained more or less similar results in three sub-indices. The external assistance index has been given more weight than the other two indices because it consists of various adaptive strategies to cope with climate change. According to the results, both irrigation systems scored highly in the external assistance index while scoring lowly in the physical and environmental index and the socio-economic index. The minor irrigation scheme has high external assistance to combat climate change compared to the major irrigation scheme (Table 7) because Palugaswewa agrarian services center has conducted various kinds of extension services to support their farmers. Even though farmers in the two irrigation systems have cultivated the same extent of OFCs, farmers in the minor irrigation system have cultivated a vast variety of OFCs in the 2020 Yala season (Figure 5). Therefore, farmers in the minor irrigation system get more benefits than farmers in the major irrigation system due to this diversity in cultivation. They have managed to earn more profit from their cultivation throughout the year.

In this assessment, the physical and environmental index has low values for both systems compared to the other two indices. There is no difference in physical and environmental Indices in the two irrigation systems because there is not much difference in rainfall between the major and minor irrigation systems. However, the water supply is different in the two irrigation systems, which has led to the minor irrigation system being more vulnerable to climate change than the major irrigation system. Therefore, considering overall vulnerability, farmers in the minor irrigation system show higher vulnerability than those in the major irrigation system.

Infrastructure facilities are also higher in the major irrigation system than in the minor irrigation system. Mahaweli Development Authority has built storage houses for big onion farmers to promote their cultivation. The two main economic centers in Sri Lanka, namely Thambuttegma and Dambulla, are located within the Mahaweli system H. This is an advantage to the farmers in the major irrigation system. As a result, the distance to market and transportation costs are much lower than in remote areas.

CONCLUSION

This study analyzed the climate variable vulnerability of OFC farmers in the dry zone of Sri Lanka with a comparison between a major and a minor irrigation system. It helps to understand the status of water scarcity and to make comparisons between systems to pick the most vulnerable for supportive activities.

The vulnerability index was calculated at the irrigation system level. The OFC farmers in the minor irrigation system are more vulnerable to climate variability compared to the farmers in the major irrigation system. The practical way to reduce OFC farmers' climate variable vulnerability is to improve their adaptive capacity. To improve the adaptive capacity, it is recommended to reduce the post-harvest losses, make farmers aware of and knowledgeable about climate variability impacts, and organize them as groups. Improving infrastructure facilities and creating good market access are also the best ways to improve the adaptive capacity of farmers.

Indices are developed by compositing several parameters. Hence, these kinds of indices are useful for comparing the systems and identifying the most vulnerable areas to introduce irrigation and other interventions.

ACKNOWLEDGEMENT

This work was carried out with the aid of a grant from the International Development Research Center (IDRC), Ottawa, Canada. Their financial support is greatly appreciated.

REFERENCES

Benítez, J., Delgado-Galván, X., Gutiérrez, J.A. and Izquierdo, J., 2011. Balancing consistency and expert judgment in AHP. *Mathematical and Computer Modelling*, *54*(7-8), pp.1785-1790.

Central Bank of Sri Lanka (CBSL), 2019. Annual Report, Central Bank of Sri Lanka (CBSL, Sri Lanka).

Chithranayana, R.D. and Punyawardena, B.V.R., 2014. Adaptation to the vulnerability of paddy cultivation to climate change based on seasonal rainfall characteristics. *Journal of the National Science Foundation of Sri Lanka*, *42*(2).

Department of Agriculture, 2008. Technical information paper, *Agro Technical paper, (2008 Jan- Feb)*, Department of Agriculture, Peradeniya. Ministry of Agriculture Development and Agrarian services 10(1).

Department of Agriculture, 2020, Technical information paper, technical paper 2, (2020 Jan), Department of Agriculture, National Agricultural Information and Communication Center 51(1).

Department of Census and Statistics, 2019. Sri Lanka Labour Force Survey, Annual report 2019. Ministry of Finance, Sri Lanka.

Esham, M. & Garforth, C., 2013. Climate change and agricultural adaptation in Sri Lanka: a review. *Climate and Development*, 5(1), pp.66-76.

Ezra, C.A., 2016. Climate change vulnerability assessment in the agriculture sector: Typhoon Santi experience. *Procedia-Social and Behavioral Sciences*, 216, pp.440-451.

FAO (2018). Sri Lanka among globally important agricultural heritage systems, Available on https://www.fao.org/srilanka/news/detail-events/es/c/1118377

FAO (2016). The cascaded tank-village system (CTVS) in the dry zone of Sri Lanka. Available on https://www.fao.org/documents/card/en/c/a9837a90-07ea-46ed-9039-1c8433d64dc0/

Füssel, H. M., 2007. Vulnerability: A Generally Applicable Conceptual Framework for Climate Change Research. *Global Environmental Change*, 17, pp.155–167.

Hertel, T.W., & Rosch, S.D., 2010. Climate change, agriculture, and poverty. *Applied economic perspectives and policy*, 32(3), pp.355-385.

IPCC, 2007. Impacts, Adaptation and Vulnerability Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report Summary for Policymakers, (2300)

IPCC. (2001). Climate change 2001: Impacts, adaptation, and vulnerability; Contribution of Working Group II to the third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.

Kikuchi, M., Weligamage, P., Barker, R., Samad, M., Kono, H. and Somaratne, H.M., 2003. Agro-well and pump diffusion in the Dry Zone of Sri Lanka: *Past trends, present status and future prospects*. Research Report 66. Colombo, Sri Lanka: International Water Management Institute.

Kurukulasuriya, P. and Ajwad, M. I., 2007. Application of the Ricardian technique to estimate the impact of climate change on smallholder farming in Sri Lanka. *Climatic Change,* 81, pp.39-59.

Mar, S., Nomura, H., Takahashi, Y., Ogata, K. and Yabe, M., 2018. Impact of erratic rainfall from climate change on pulse production efficiency in lower Myanmar. *Sustainability*, *10*(2), p.402.

Prasanna, R.P.I.R., Bulankulama, S.W.G.K. and Kuruppuge, R.H., 2012. Factors Affecting Farmers Higher Gain from Paddy Marketing: A Case Study on Paddy Farmers in North Central Province, Sri Lanka. *International Journal of Agricultural Management and Development (IJAMAD)*, 2(1), pp.57-69.

Saaty, T.L., 1980. The Analytic Hierarchy Process. McGraw-Hill, New York, USA.

Wickramasinghe, W., 2013. Change in other field crop cultivation in the North Western Province. Hector Kobbekaduwa Agrarian Research and Training Institute, 160

Senaratne, A. and Scarborough, H., 2011. Coping with climatic variability by rain-fed farmers in dry Zone, Sri Lanka: towards understanding adaptation to climate change. In *AARES 2011: Australian Agricultural & Resource Economics Society 55th Annual Conference Handbook* pp. 1-22.