



Assessing the Role of Irrigation as an Adaptive Measure to Climate Change Induced Water Insecurity: Case Study of the Market Gardening Sector in Parts of the Northwest and West Regions of Cameroon

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Climate change induced extreme weather events are having major repercussions on availability and accessibility to water and water resources especially for farmers across the globe. This is more so for small-scale farmers in the developing world who largely depend on rain-fed agriculture. The market gardening sector in particular is known for its high dependence on suitable weather conditions for adequate productivity. However, in recent years, market garden crop cultivation has been severely threatened by climate change induced extreme weather events such as prolonged dry spells, scanty and erratic rainfall, rising temperatures, extreme sunshine and storms. This study was undertaken to understand the role of irrigation as an adaptive measure to climate change induced water insecurity, with focus on the market gardening sector in parts of the west and northwest regions of Cameroon. Data were collected through a survey of 260 market gardeners involved in different irrigation practices geared toward countering water insecurity problems induced by climate change. Findings indicated that water insecurity is induced by extreme weather events such as prolonged dryness, scanty and erratic rainfall, extreme sunshine and rising temperatures. A majority of the market gardeners surveyed reported the existence of water insecurity which has led to crop failure in many instances placing them in financial difficulties and seriously hampering their livelihood. Market gardeners were involved in different types of irrigation practices including sprinkler, drip, furrow, and manual with some taking to no irrigation practice. The main factors influencing market gardeners' practice of irrigation in the face of extreme weather induced water scarcity/insecurity were household income, age of market gardeners, educational level, farm size, number of farm plots, proximity to source of water, gender, water requirement of crop, support from government and NGOs, extension services, access to credit, membership in farming group and membership in common initiative group (CIG). Climate change has therefore induced water insecurity forcing market gardeners to indulge in different irrigation practices all year round in a bid to improve crop productivity and reduce recurrent crop failures. On the basis of these findings, the use of more sustainable

irrigation methods in order to conserve water and water resources is recommended as this will go a long way to phase out the problem of water insecurity induced by climate change. Policy makers need to craft and implement favorable policies that encourage more market gardeners to adopt sustainable irrigation practices in the face of climate change induced water scarcity/insecurity.

Keywords: climate change, irrigation, water insecurity, market gardening, adaptation, Cameroon

INTRODUCTION

Climate change adversely affects availability and accessibility to water and water resources across the world (Fischer et al., 2007; Kemp et al., 2018; Zaveri and Lobell, 2019). Studies show that climate change is already precipitating increasingly drier weather and climatic conditions across the world making it difficult for farmers and livestock keepers to sustain their livelihoods (Save et al., 2012; Elliott et al., 2014; FAO et al., 2018). With the recurrence of extreme weather events like rising temperature, scanty and erratic rainfall, and extreme sunshine, dwindling supplies of water and resources are predicted to become the norm rather than the exception worsening the already precarious situation of smallholder agro-pastoralists (Woznicki et al., 2015; Rosa et al., 2020; Thiery et al., 2020). Across different parts of the world, water shortages are already occurring at an alarming rate precipitating famine, malnutrition, death of livestock and wildlife, and crop failure (Thomas, 2008; Xiong et al., 2010). This has made the practice of irrigation widespread as an adaptation measure to counter the adverse effects of climate change induced water scarcity (Faurès et al., 2002; Gondim et al., 2012; Schaldach et al., 2012; Kresovica et al., 2014; Batchelor and Schnetzer, 2018; Asian Development Bank, 2020).

In Africa, ClimDEV-Africa (2008), predicted that temperature could rise to 2°C if the business-as-usual trajectory continues, which will lead to a 4.7% loss in the Gross National Product (GNP) across the African continent. Worst case scenario of this prediction is that temperature could rise to about 2.5–5°C precipitating sea level rise of between 15 and 95 cm, triggering floods that could affect over 108 million people especially those living around coastal areas. Climate change will also trigger droughts and dwindling water resources especially in the Sahel, East Africa and Southern Africa; as well as erratic rainfall and prolong dry spells in the humid and equatorial parts of Africa (Bates et al., 2008; Ngoran et al., 2015; Zadawa and Omran, 2018; Näschen et al., 2019; Opere et al., 2019; Segnon et al., 2021). The adverse effects of climate change are felt the most in Africa where a large proportion of the population depend on agriculture and livestock keeping for survival (UNECA, 2011; Montpellier Panel Report, 2015; Awazi and Tchamba, 2019). Recurrent extreme weather events—especially prolong dry spells, scanty and erratic rainfall and droughts are pushing farmers to practice irrigation in order to cushion themselves from the shocks of water scarcity (Boko et al., 2007; UNECA, 2011; Chung and Nkomozepi, 2012; Malabo Montpellier Panel, 2018; FAO, 2021). Among the farmers mostly involved in different irrigation practices faced with extreme weather events are market gardeners

(Soumaoro, 2021). Market gardening being a farming practice requiring intensive care, most market gardeners have adopted irrigation in order to guard against the adversities of climate change especially extreme sunshine, rising temperature, scanty and erratic rainfall and prolong dryness (Soumaoro, 2021).

In Cameroon, climate change is already impacting the agricultural sector in general (Molua and Lambi, 2002; Molua, 2006, 2008) and the market gardening sector in particular (Amawa et al., 2015; Usongo et al., 2021). Market gardening is commonly practiced in the western highlands (Dewang, 2008; Kometa, 2013; Tarla et al., 2013, 2015; Asongwe et al., 2014; Amawa et al., 2015; Engwali et al., 2019; Angwafo and Bime, 2020), parts of the littoral and southwest regions (Tandi et al., 2014; Nkemleke, 2019; Usongo et al., 2021), the center region (Abang et al., 2013) and parts of the Adamawa region (Assokeng et al., 2017). The western highlands in particular is noted for its high rate of cultivation of market garden crops even extending into wetlands (Kometa, 2013). The most commonly cultivated crops are potato, leeks, tomato, cabbage, lettuce, green beans, aubergine, huckleberry, celery, water melon, cucumber (Amawa et al., 2015; Angwafo and Bime, 2020; Usongo et al., 2021). These crops demand constant and intensive care especially through the application of pesticides, fertilizers and manure. With the recurrence of extreme climate change events which have induced water shortages, market gardeners have resorted to regular irrigation of their crops especially during the dry season (Amawa et al., 2015; World Bank, 2020; Usongo et al., 2021). However, not all market gardeners are involved in these irrigation practices as some are still mainly involved in rain-fed market gardening. These are market gardeners who only cultivate their crops during the rainy season and during the dry season, they are involved in other income generating activities like commercial bike riding, livestock rearing as well as petty trade.

In the northwest and west regions, most specifically in Santa and Babadjou, market gardeners are increasingly adopting different irrigation practices in the face of recurrent extreme weather events notably rising temperature, extreme sunshine, drop in the total quantity of rainfall and longer dry spells. Although, extreme weather events are adversely affecting market gardeners across Cameroon in general and Santa and Babadjou in particular, pushing them to adopt different irrigation practices, limited research has been carried out to understand what these market gardeners are going through and measures that could be taken to improve their lot. It was within this framework that this study was carried out to fill this loophole. The main objective was to examine the role of irrigation as an adaptive measure to climate change induced water insecurity. Specifically, the

study sought to identify the extreme weather events precipitating water insecurity; identify the irrigation practices of market gardeners faced with extreme weather events; examine the role played by irrigation in enhancing market gardeners' adaptation to water insecurity induced by recurrent extreme weather events; and assess the factors influencing market gardeners' adoption/non-adoption of irrigation practices in the face of extreme weather events.

MATERIALS AND METHODS

Study Area

This study was carried out in the northwest and west regions of Cameroon (the western highlands agroecological zone), specifically in Santa and Babadjou, two communities reputed for market garden crop cultivation in Cameroon. The western highlands of Cameroon is one of the five agroecological and relief regions of Cameroon and the two selected communities are found in this agroecological zone. The climate in these communities is the tropical highland type characterized by two main seasons, i.e., rainy and dry seasons and an average temperature of 25°C. Savannah grassland vegetation dominates, and with respect to hydrography, a dense network of streams and rivers drain the area especially during the rainy season. There are equally some lakes—mostly crater lakes. The relief is undulating and characterized by hills and mountains interspersed with some plains. Agriculture is the main economic activity practiced by the population. Among the different agricultural practices, market gardening is largely practiced in Santa and Babadjou. Main food crops cultivated are beans, cocoyams, maize, yams, cassava, cow pea, soybeans, groundnuts, plantains; main cash crops are oil palms, banana and coffee; common livestock reared include goats, pigs, indigenous fowls, table birds, sheep, rabbits, ducks, guinea pig; fruit trees like mango, plums, avocado, guava, papaya. The main market garden crops commonly cultivated are tomato, cabbage, potato, celery, huckleberry, cucumber, green beans, leeks, lettuce, aubergine. The cultivation of these different types of crops serves as an important livelihood option for a large proportion of the population living in Santa and Babadjou.

Sampling and Data Collection

The multiphase sampling procedure was adopted for this study. At the first phase, the study sites (Santa and Babadjou) were selected purposively owing to the predominance of market gardening and different irrigation practices taken up by market gardeners in the face of extreme weather events. The second phase involved reconnaissance trips to the study sites to appraise the realities on the ground as well as meeting agricultural extension agents working in the study sites. The third phase involved household surveys with market gardeners in the study sites. The household surveys were conducted with the help of a semi-structured questionnaire and mainly household heads were surveyed. The perspective of the household head was taken as representing that of the entire household. The fourth and last phase involved direct field observations in the different study sites. Direct field observations enabled the investigator

and his team to confirm and triangulate the perspectives of market gardeners.

Household surveys were conducted in Santa and Babadjou between the months of January and February 2021. A total of 260 market gardeners (household heads) were sampled during the household surveys, i.e., 130 in Santa and 130 in Babadjou. A simple random sampling of market gardener household heads was done in each of the study sites. The sampled market gardeners were involved in the cultivation of different crops including tomato, celery, potato, cabbage, lettuce, aubergine, leeks, huckleberry, green beans and different types of spices. Both market gardeners involved in irrigation and those not involved in irrigation were sampled. The household survey was done using semi-structured questionnaires. The questionnaires were structured to capture information regarding the socio-economic/demographic attributes of market gardeners; common extreme weather events inducing water insecurity/scarcity; the practice of irrigation and reasons; the non-practice of irrigation and reasons; sources of water for irrigation; different types of irrigation practices and how they influence adaptation to water scarcity/insecurity. Adaptation to climate change was measured on the basis of adoption/non-adoption of irrigation and the effectiveness of the irrigation practices in buffering climate change induced extreme weather events. The surveys were done face-to-face and each market gardener's consent was sought before going on with the administering of the questionnaire.

Data Analysis

Analysis of data was done using the data analysis software Microsoft Excel 2013 and the Statistical Package for Social Sciences (SPSS 17.0). Data collected were coded and imputed into Excel spreadsheets and then exported to SPSS for descriptive and inferential statistical analysis. Descriptive statistics included percentage indices and frequencies while inferential statistics computed were chi-square, correlation and regression. Charts (spider web and bar charts) were equally generated.

RESULTS AND DISCUSSION

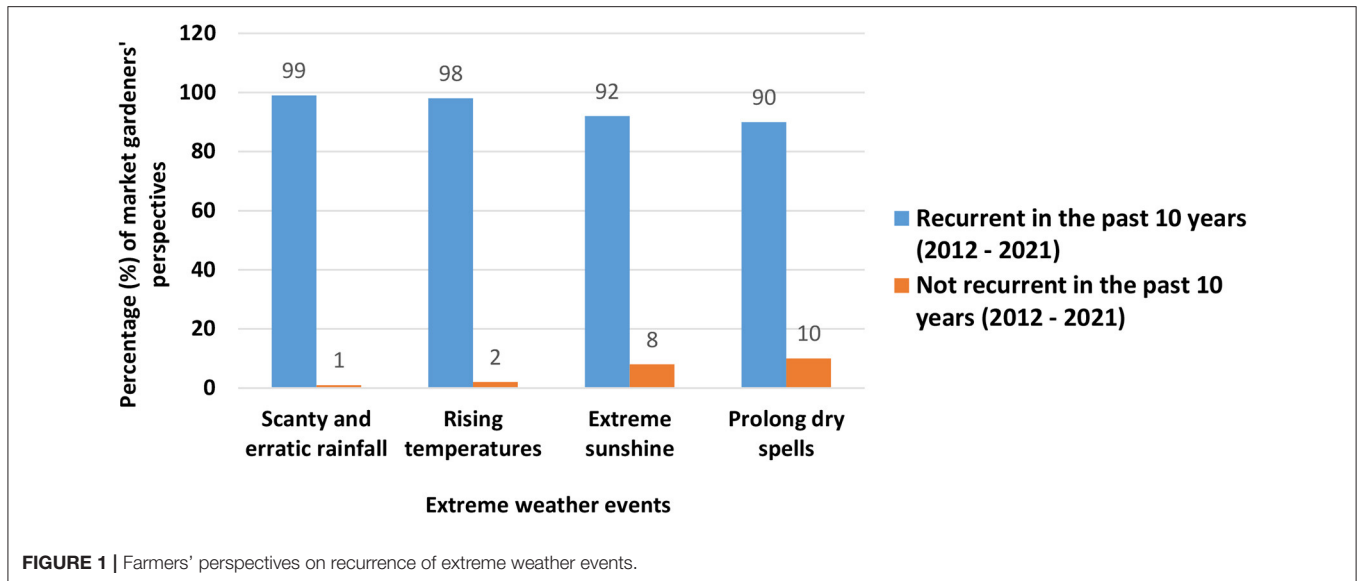
Extreme Weather Events Inducing Water Scarcity/Insecurity

Market gardeners identified different extreme weather events inducing water scarcity/insecurity (**Table 1**). The most identified

TABLE 1 | Farmers' perspectives regarding extreme weather events.

Extreme weather event	Frequency	Percent (%)	Chi-square (χ^2)	p-level
Rising temperatures	254	97.70	5.81 ^{ns}	0.736
Extreme sunshine	238	91.54		
Scanty and erratic rainfall	260	100		
Prolong dry spells	229	88.08		

^{ns}, Not significant at 5% probability level.



extreme weather events were rising temperatures (97.7%), extreme sunshine (91.54%), scanty and erratic rainfall (100%) and prolong dry spells (88.08%). Market gardeners' perspectives are in line with trend analyses which show significant levels of fluctuation in climate elements and recurrent extreme weather events (Appendices 1, 2). Chi-square test statistic revealed no significant difference ($p > 0.05$) in market gardeners' perspectives regarding extreme weather events. This goes to show that market gardeners had very similar perspectives regarding extreme weather events inducing water insecurity. The unanimity of markets gardeners' perspectives on extreme weather events is testament to the reality on the ground.

Extreme weather events inducing water insecurity have been recurrent in the past 10 years (Figure 1). Based on market gardeners' perspectives, the most recurrent extreme weather events inducing water insecurity in the past 10 years were scanty and erratic rainfall (99%), rising temperature (98%), extreme sunshine (92%) and prolong dry spells (90%), respectively.

Extreme weather events are a recurrent phenomenon in the northwest and west regions of Cameroon. Studies carried out in the northwest and west regions—known geographically, agro-ecologically and topographically as the western highlands (Kimengsi and Balgah, 2015; Ndoh et al., 2016; Awazi and Tchamba, 2018; Awazi et al., 2019a,b, 2020a,b,c,d, 2021, 2022; Ngala et al., 2020; Tume et al., 2020; Yufenyuy and Nguetsop, 2020; Awazi and Quandt, 2021; Kongnso et al., 2021; Tume and Ngwa, 2022) have demonstrated the recurrence of extreme weather events in the past five decades. With respect to extreme weather events inducing water insecurity, the studies of Molua and Lambi (2006), Ndah-Anyang et al. (2021), Mairomi and Tume (2021), Tume (2021), Zoyem and Nfor (2021), and Nkiaka (2022) have shown that scanty and erratic rainfall as well as prolong dry spells are the leading causes of water shortages across the region in the past five decades and more. Across other parts of Africa, studies carried out by Bates et al. (2008), Giannini et al. (2008), Urama and Ozor (2010), Montpellier Panel Report

TABLE 2 | Irrigation practices of market gardeners.

Type of irrigation practiced	Frequency	Percent (%)	Chi-square (χ^2)	p-level
Drip irrigation	10	3.85	75.86***	0.000
Sprinkler irrigation	73	28.08		
Furrow irrigation	25	9.61		
Manual irrigation	52	20		
No irrigation	100	38.46		

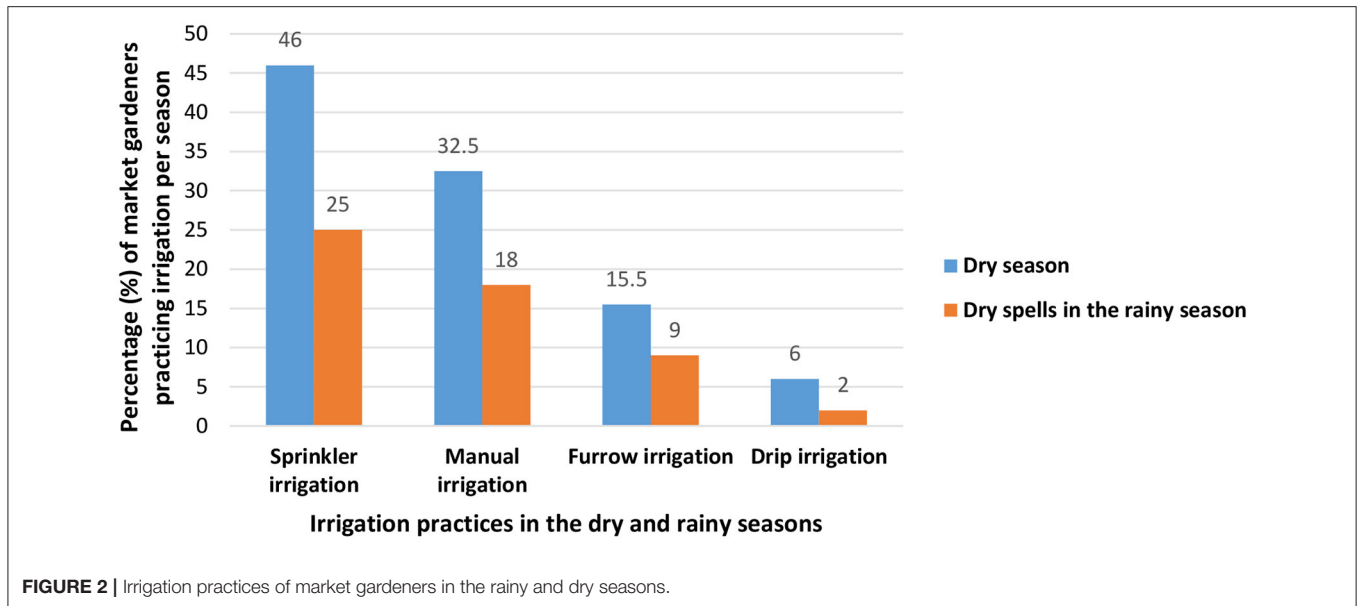
*** Significant at 0.1% probability level.

(2015), and Segnon et al. (2021) have shown that recurrent extreme weather events induced by climate change have triggered water scarcity/insecurity.

Irrigation Practices of Market Gardeners in the Face of Recurrent Extreme Weather Events Inducing Water Insecurity

Confronted with the adversities of recurrent extreme weather events, market gardeners adopted different irrigation practices (Table 2). These irrigation practices were drip irrigation (3.85%), sprinkler irrigation (28.08%), furrow irrigation (9.61%) and manual irrigation (20%). Despite the adversities of recurrent extreme weather events, some market gardeners (38.46%) practiced no irrigation as they depended mainly on rainfall for cultivation. Chi-square test statistic revealed the existence of a significant difference in market gardeners' irrigation practices confronted with recurrent extreme weather events, indicating that market gardeners adopted different irrigation practices in their drive to adapt to water insecurity induced by extreme weather events.

The non-adoption of irrigation by some market gardeners could be attributed to limited income to buy irrigation equipment, limited know-how to use irrigation tools, limited



support from governmental and non-governmental bodies, and absence of a source of water for irrigation. Studies carried out by UNECA (2011), Chung and Nkomozepi (2012), Soumaoro (2021), Usongo et al. (2021) have shown that, the adoption or non-adoption of irrigation in the face of climate induced water shortages is influenced by several factors.

In the dry season and dry spells in the rainy season, market gardeners adopted different irrigation practices (Figure 2). Market gardeners' perspectives revealed that in the dry season the most practiced forms of irrigation were sprinkler irrigation (46%), manual irrigation (32.5%), furrow irrigation (15.5%) and drip irrigation (6%). Meanwhile during dry spells in the rainy season, the most practiced forms of irrigation were sprinkler irrigation (25%), manual irrigation (18%), furrow irrigation (9%) and drip irrigation (2%). Chi-square test statistic revealed the existence of a significant difference ($p < 0.05$) in market gardeners' practice of irrigation in the dry season and during dry spells in the rainy season, indicating that there is a difference between the practice of irrigation in the dry season and the practice of irrigation during dry spells in the rainy season.

These findings show that, there is a reduction in the adoption of irrigation practices by market gardeners as we move from the dry season to dry spells in the rainy season. This trend is similar for the different irrigation practices adopted by market gardeners. Sprinkler irrigation was adopted highest for both the dry season and at dry spells in the rainy season while drip irrigation was adopted least for both scenarios. More adoption of irrigation practices during the dry season than dry spells in the rainy season could be attributed to the increasingly prolonged and harsh nature of the dry season which obliges market gardeners to adopt irrigation in order to cultivate market garden crops. Market gardeners affirmed that, they adopted the sprinkler irrigation system in both the dry season and dry spells in the rainy season because of its ability to simulate rainfall conditions which increases crop growth and productivity.

Regarding the sources of water used for irrigation, most market gardeners sourced water from streams, wells, rivers, ponds and lakes (Table 3). For sprinkler irrigation, water was mostly sourced from streams (73%) and wells (17%). For manual irrigation, water was mainly sourced from wells (58%) and streams (32%). For furrow irrigation, water was largely sourced from streams (71%) and rivers (19%). And for drip irrigation, water was mostly sourced from streams (43%), wells (27%) and rivers (18%). Chi-square test statistic revealed that, for the different types of irrigation (sprinkler, manual, furrow and drip), there was a significant difference ($p < 0.05$) in the sources of water used.

Though, overall, the main sources of water for irrigation is the streams, market gardeners use streams, wells and rivers more than lake and ponds as these three are those located in proximity to them and are available all year round. Studies carried out in Cameroon (Amawa et al., 2015; World Bank, 2020) and other part of Africa (UNECA, 2011; Segnon et al., 2021; Soumaoro, 2021) have shown that the main sources of water for irrigation are rivers, streams, lakes as well as wells.

Adaptation to Climate Change Induced Water Insecurity Through Irrigation

Based on the adoption/non-adoption of irrigation as well as the effectiveness of the different irrigation practices adopted in buffering climate change induced extreme weather events notably prolonged dry spells that cause water insecurity, there were differences in adaptation/non-adaptation among market gardeners (Table 4; Figure 3). From market gardeners' perspectives, it was found that, more market gardeners that adopted drip, sprinkler, furrow and manual irrigation practices were able to adapt to climate change induced water insecurity. Meanwhile for market gardeners that adopted "no irrigation practice", most were not able to adapt to climate change induced water insecurity. Chi-square test statistic revealed that, for

TABLE 3 | Sources of water used for different irrigation practices.

Type of irrigation	Source of water for irrigation					Chi-square (χ^2)	p-level
	Streams	Wells	Rivers	Ponds	Lakes		
	%	%	%	%	%		
Sprinkler	73	17	7	2	1	78.92***	0.000
Manual	32	58	6	3	1	51.46**	0.023
Furrow	71	1	19	6	3	82.59***	0.000
Drip	43	27	18	10	2	41.71**	0.035

***, **, Significant at 1% and 5% probability levels, respectively.

TABLE 4 | Chi-square test statistic showing differences in adaptation between market gardeners applying different irrigation practices.

Irrigation practice	Adaptation		Non-adaptation		Chi-square (χ^2)	p-level
	Frequency	%	Frequency	%		
Drip	9	90	1	10	47.52**	0.039
Sprinkler	70	95.89	3	4.11	89.60***	0.000
Furrow	23	92	2	8	53.18**	0.016
Manual	45	86.54	7	13.46	62.94***	0.000
No irrigation	2	2	98	98	91.75***	0.000

***, **, Significant at 1% and 5% probability levels, respectively.

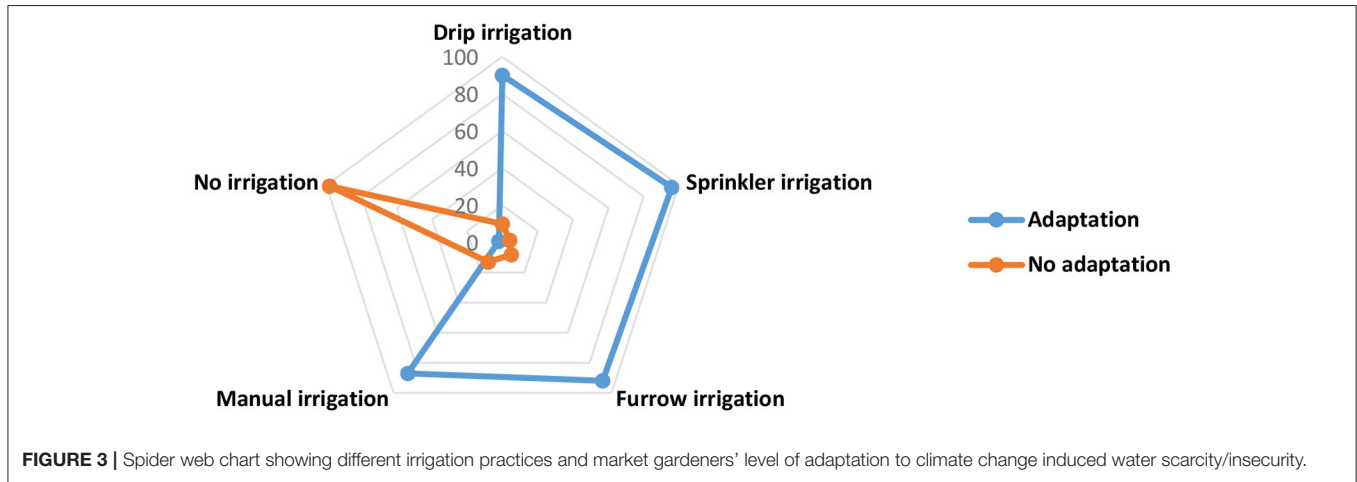


FIGURE 3 | Spider web chart showing different irrigation practices and market gardeners' level of adaptation to climate change induced water scarcity/insecurity.

the different irrigation and non-irrigation practices of market gardeners (drip, sprinkler, furrow, manual, and no irrigation), there was a significant difference ($p < 0.05$) in adaptation and non-adaptation to climate change induced water insecurity.

Market gardeners involved in irrigation practices including drip, sprinkler, furrow and manual irrigation adapted far better than their counterparts involved in the no-irrigation practice. This could be attributed to the fact that, market gardeners involved in drip, sprinkler, furrow and manual irrigation were able to grow their market gardening crops all year round especially during the dry season and prolong dry spells in the rainy season. Meanwhile market gardeners involved in the no-irrigation practice were only able to grow their market gardening crops in the rainy season and prolong

dry spells in the rainy season often resulted in stunted growth and sometimes crop failure. The findings of Soumaoro (2021) in southern Mali revealed that market gardeners practicing irrigation adapt better than their counterparts practicing no-irrigation.

Correlation and regression coefficients indicated the existence of a significant direct relationship ($p < 0.05$) between adaptation to water insecurity induced by extreme weather events and market gardeners' adoption of different irrigation practices (sprinkler, drip, furrow, and manual irrigation) (Table 5). Meanwhile, "no irrigation practice" had a significant inverse relationship ($p < 0.05$) with market gardeners' adaptation to water insecurity induced by extreme weather events (Table 5), implying that market gardeners practicing no irrigation have

TABLE 5 | Relationship between irrigation practices and adaptation to climate change induced water scarcity/insecurity.

Explanatory variable	Adaptation to climate induced water scarcity/insecurity			
	r	p-level	β	p-level
Drip irrigation	0.648***	0.000	0.483**	0.039
Sprinkler irrigation	0.992***	0.000	1.247***	0.000
Furrow irrigation	0.801***	0.000	0.705**	0.014
Manual irrigation	0.907***	0.000	0.892***	0.008
No irrigation	-0.950***	0.000	-3.461***	0.000
Intercept			-4.286***	0.000
Pseudo R ²			0.396	
Number of observations		260		

***, **, Significant at 1% and 5% probability levels, respectively.

a limited propensity to adapt to climate change-induced water scarcity.

Adaptation to climate change induced water insecurity was largely influenced by the irrigation practices of market gardeners. The practice of drip, sprinkler, furrow and manual irrigation had a direct relationship with adaptation to climate induced water insecurity, implying that, the more market gardeners adopt these irrigation practices, the better their adaptation capacity faced with climate induced water shortages. This could be attributed to the fact that drip, sprinkler, furrow and manual irrigation practices helps market gardeners involved in their use to grow their crops all year round especially in the dry season and prolong dry spells in the rainy season.

Meanwhile the practice of “no irrigation” had an inverse relationship with market gardeners’ adaptation to climate-induced water insecurity, implying that, markets gardeners involved in the no-irrigation practice have a very limited propensity to adapt to climate-induced water shortages. This could be attributed to the fact that market gardeners depending largely on rainfall for cultivation are unable to withstand shifts in weather patterns especially when prolong dry spells take hold in the rainy season, which often leads to stunted growth in crops or crop failure.

Factors Influencing Market Gardeners’ Adoption/Non-adoption of Irrigation Practices in the Face of Extreme Weather/Climate Events Inducing Water Insecurity

A plethora of factors including household income, age of market gardeners, educational level, farm size, number of farm plots, proximity to source of water, gender, water requirement of crop, support from government and NGOs, extension services, access to credit, membership in farming group and membership in common initiative group (CIG) played a great role in influencing market gardeners’ adoption/non-adoption of irrigation practices (Table 6).

TABLE 6 | Determinants of markets gardeners’ adoption of irrigation practices faced with extreme weather/climate events inducing water insecurity.

Explanatory variable	Practice of irrigation		No practice of irrigation	
	β	p-level	β	p-level
Household income	0.836***	0.000	-2.528***	0.000
Age of market gardener	-2.493***	0.000	1.064***	0.000
Educational level	0.527***	0.000	-0.906***	0.000
Farm size	-0.013	0.851	0.041	0.579
Number of farm plots	-0.009	0.932	0.002	0.784
Proximity to source of water	1.358***	0.000	-2.734***	0.000
Gender	0.941***	0.000	-0.980***	0.000
Water requirement of crop	0.453***	0.007	-0.225**	0.048
Support from government and NGOs	1.306***	0.000	-3.582***	0.000
Extension services	0.251**	0.047	-0.761***	0.000
Access to credit	0.462**	0.023	-0.508***	0.004
Membership in farming group	0.675***	0.000	-0.937***	0.000
Membership in CIG	0.933***	0.000	-0.774***	0.000
Intercept	-4.374***	0.000	-3.582***	0.000
Number of observations		260		
Pseudo R ²		0.378		0.294

***, **, Significant at 1% and 5% probability levels, respectively.

Among these factors, household income, educational level, proximity to source of water, gender, water requirement of crop, support from the government and NGOs, extension services, access to credit, membership in farming group and membership in CIG had a significant direct relationship ($p < 0.05$) with market gardeners’ practice of irrigation; meanwhile age of market gardener had a significant inverse relationship ($p < 0.05$) with market gardeners practice of irrigation. With respect to “no irrigation practice”, there was a significant inverse relationship ($p < 0.05$) between market gardeners’ practice of “no irrigation” and various factors (household income, educational level, proximity to source of water, gender, water requirement of crop, support from the government and NGOs, extension services, access to credit, membership in farming group and membership in CIG). Meanwhile, age of market gardener had a significant direct relationship ($p < 0.05$) with market gardeners’ practice of “no irrigation”.

Household income had a direct significant relationship with market gardeners’ adoption of irrigation (sprinkler, furrow, drip, and manual), implying that, the bigger the household income, the greater the propensity to adopt irrigation faced with water shortages induced by extreme weather events, and the smaller the household income, the lower the propensity to adopt irrigation in the face of extreme weather events inducing water insecurity. This could be attributed to the fact that, households with more income are able to buy irrigation equipment and even dig wells/boreholes to use for irrigation.

Educational level equally had a significant direct relationship with the adoption of irrigation by market gardeners, meaning that, the higher the education level of the market gardener,

the higher his/her propensity to adopt irrigation and vice versa. This could be because, more educated persons have the know-how to use irrigation equipment and easily adopt best practices vulgarized by governmental and non-governmental extension agents.

Proximity to source of water also played a major role in influencing adoption of irrigation among market gardeners. The direct relationship existing between adoption of irrigation and proximity to source of water, implies that the closer the source of water, the greater the propensity to adopt irrigation and vice versa. This could be attributed to the fact that, closeness to the source of water could enable some market gardeners with limited financial means to adopt manual irrigation. Closeness to the source of water equally motivates market gardeners generally to practice irrigation because they see it as an opportunity to grow crops all year round and make more profit.

Gender is another major factor influencing market gardeners adoption of irrigation in the face of extreme weather events inducing water shortages. The direct relationship existing between gender and the adoption of irrigation implies that, the greater the number of males involved in market gardening, the higher the adoption of irrigation and vice versa. This could be attributed to the fact that males are generally the household heads and those controlling household income and they generally take decisions on whether to adopt irrigation or not. Equally, males are those mostly involved in market gardening practices due to the labor intensive nature of the practice which most females cannot support. Last but not the least, males are those who own farm plots and irrigation equipment.

Water requirements of the market gardening crop plays an important role in the adoption of irrigation. A direct relationship existed between the water requirement of a crop and the adoption of irrigation, implying that, crops that demand a lot of water push market gardeners to practice irrigation that crops that demand less water. This could be attributed to the fact that, market gardeners are aware of the stakes involved if they do not irrigate their fields containing crops with high water requirements.

Support from government and NGOs plays a major role in influencing adoption of irrigation among market gardeners. The direct relationship existing between adoption of irrigation and support from government and NGOs implies that, the greater the support from the government and NGOs, the higher the propensity to adopt irrigation. This could be attributed to the fact that government and NGO support in terms of sensitization, education, training and offer of logistics helps market gardeners to adopt and improve on their irrigation practices. Equally, governmental and NGO support reduces the financial burden of buying irrigation equipment on market gardeners thereby enabling them to buy better farm inputs (manure, fertilizers, and pesticides) which go to improve farm productivity.

Access to extension services had a direct relationship with market gardeners' adoption of irrigation, implying that the greater the access to extension services the greater the adoption of irrigation. This could be attributed to the fact that agricultural and environmental extension agents/officials sensitize and educate market gardeners on best irrigation practices to obtain good yields.

Access to credit was equally another factor that influences market gardeners' adoption of irrigation faced with climate change induced water shortages. The direct relationship existing between access to credit and adoption of irrigation implies that the more the capacity of market gardeners to access credit, the more their ability to adopt irrigation and vice versa. This is because adopting irrigation entails huge financial expenses and access to credit helps to reduce this financial burden.

Membership in farming groups and membership in common initiative groups (CIGs) equally play an important role in influencing market gardeners' adoption of irrigation. This could be attributed to the fact that membership in these groups enables market gardener to market gardener extension and the sharing of ideas which pushes reluctant market gardeners to adopt best irrigation practices. Equally, membership in these groups permits market gardeners to benefit from governmental and non-governmental support through sensitization, education, training and logistics; as well as benefit from extension services. It also affords market gardeners the opportunity to rent irrigation equipment like water pumps and pipes which most market gardeners cannot afford as individuals.

However, an inverse relationship was found to exist between the age of the market gardener and the adoption of irrigation faced with water insecurities induced by extreme weather events. This implies that, the older the farmer, the lesser the propensity to practice irrigation and vice versa. This is because older farmers lack the know-how to maneuver irrigation equipment (especially water pumps and sprinkler irrigation techniques) when compared to their younger counterparts.

In Cameroon, limited research has been done to determine market gardeners' decision to practice irrigation or not when faced with extreme weather events that induce water shortages. Just the studies of Amawa et al. (2015), the World Bank (2020), and Usongo et al. (2021) have shown that in the face of climate variability and change, market gardeners in particular and farmers in general adopt different irrigation practices. In southern Mali, Soumaoro (2021), noted that market gardeners take to different irrigation practices to adapt in the face of climate change adversities. In Gambia, Segnon et al. (2021), indicated that farmers take to different adaptation measures faced with climate change adversities, with irrigation being one of them. These studies have generally indicated that farmers' practice of irrigation is influenced largely by the availability of a source of water as well as the capacity to access irrigation equipment.

CONCLUSION AND POLICY IMPLICATIONS

Climate change is impacting market gardening crop cultivation negatively with the main problem being water scarcity/insecurity which pushes market gardeners to adopt different irrigation practices in order to adapt to the adverse climatic conditions. From the findings of this study, market gardeners identified different extreme weather events inducing water scarcity/insecurity with the main being rising temperatures, extreme sunshine, scanty and erratic rainfall and

prolong dry spells. Extreme weather events inducing water insecurity have been recurrent in the past 12 years with the most recurrent being scanty and erratic rainfall, rising temperature, extreme sunshine and prolong dry spells. Confronted with the adversities of recurrent extreme weather events, market gardeners adopted different irrigation practices including drip irrigation, sprinkler irrigation, furrow irrigation and manual irrigation with some market gardeners taking the business-as-usual direction (no irrigation). Market gardeners mostly adopt irrigation practices in the dry season than during dry spells in the rainy season. Most market gardeners sourced water from streams, wells, rivers, ponds and lakes. Most market gardeners that adopted drip, sprinkler, furrow and manual irrigation practices were able to adapt to climate change induced water insecurity than market gardeners that adopted “no irrigation practice”. Thus, adaptation to climate change induced water insecurity was largely influenced by the irrigation practices of market gardeners. The main factors influencing market gardeners’ practice of irrigation in the face of extreme weather induced water scarcity/insecurity were household income, age of market gardeners, educational level, farm size, number of farm plots, proximity to source of water, gender, water requirement of crop, support from government and NGOs, extension services, access to credit, membership in farming group and membership in common initiative group (CIG). On the basis of the findings uncovered by this study, it is recommended that more market gardeners should adopt irrigation practices in order to adapt to climate change induced water insecurity/scarcity. Incentives and irrigation equipment should be provided to market gardeners as this will encourage them to practice irrigation confronted with climate change adversities. Favorable policies should be crafted that encourage market gardeners to practice irrigation especially during the dry season and dry spells in the rainy season. The factors influencing the practice of irrigation uncovered by this study should orientate policy makers in crafting better policies that will encourage more market gardeners to practice irrigation in the face of climate change adversities, as this will go a long way to reduce crop failure and improve the living conditions of market gardeners.

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DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for this study in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

NPA conceived the study, designed the study, organized the database, performed the statistical analyses, wrote the entire manuscript, undertook revision, read, and approved the submitted version.

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APPENDIX

