



RESEARCH ARTICLE

Livelihood Impacts of Drought: Experiences from Households and Business Organizations in Western Cape Province of South Africa

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Abstract: Drought is a recurring natural phenomenon with significant socio-economic and environmental impacts across South Africa. This research investigates the livelihood impacts of drought on households and organizations in the Western Cape Province of South Africa, utilizing a secondary dataset collected by the Human Sciences Research Council of South Africa. Descriptive statistics were used to describe and explore the dataset. Likewise, heterogeneous choice modeling was applied to investigate the factors influencing the levels of livelihoods impacts of drought among household and organizations. The findings underscored households' greater vulnerability to drought compared to organizations across all the levels of drought impacts. Many households reported considerable and major impacts, which were largely due to differentials in adaptive capacity. While awareness of the drought was widespread, perception varied regarding the government's effectiveness in managing the crisis, as less than half of the population of organizations (43.7%) and households (42.1%) have strong belief that the government was very effective in the management of drought disaster, while 30.9% and 34.6% of the organizations and households respectively, believed that the government was not effective enough with the management of drought crisis. Hygiene, chores, and gardening suffered the most among households, whereas disruption of business and financial burdens were predominant for organizations. Factors that significantly influenced the levels of drought impacts include age, institutional engagement of water restrictions, livelihood areas impacted by drought, and perceptions on water consumption rate. The study recommends heightened awareness of water conservation, compliance with restrictions, investment in infrastructure, and embracing community-based adaptation and disaster risk reduction initiatives. For organizations, emergency response plans, business continuity planning, and stakeholder engagement will be helpful to bolster resilience to drought.

Keywords: Livelihood; Drought; Heterogeneous choice model; Western Cape; South Africa

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1. Introduction

1.1 Background to the Study

Numerous studies at the international, continental, and national levels have examined the impact of drought on people's livelihoods and overall well-being across both agricultural and non-agricultural sectors. For instance, research by Bahta and Myeki ^[1], Lloyd-Hughes ^[2], Shukla et al. ^[3], Oluwatayo and Braide ^[4], Schwalm et al. ^[5], as well as Godfrey and Tunhuma ^[6] have highlighted that the effects of drought and climate change on livelihoods, particularly among vulnerable populations, are severe. The consequences are already being felt globally, regionally, and nationally, with droughts expected to become more frequent and intense in some areas in the 21st century. This situation necessitates actionable government policies and interventions to mitigate the impacts. With increasing pressures on water resources and more intense droughts, a paradigm shift towards well-planned and coordinated strategies to address the impacts of drought is urgently needed. In particular, South Africa is a water-scarce country with a highly variable climate, making it particularly vulnerable to the impacts of droughts ^[1,7], and the adoption of national drought policies, supplemented by drought mitigation plans and water-use restriction measures put in place by the government will have significant ramifications across all key sectors, including agricultural and non-agricultural. Promoting integrated water resource management to ensure the availability and sustainable management of water and sanitation for all can significantly reduce vulnerability to future drought episodes and enhance communities' response plans and coping capacities.

Droughts are complex, multifaceted and have resulted in recurrent natural hazard and/or disasters that have historically affected various areas in many countries around the globe ^[2-4]. Such disasters have profound and long-lasting impacts on human livelihoods, particularly in regions that are highly dependent on agriculture, water resources, and natural ecosystems, causing significant socio-economic and environmental challenges. Severe drought episodes have had profound impacts on water resources, agriculture, and several other areas of livelihoods dependent on many households and business organizations for sustenance, survival and daily operational activities. South Africa's climate is characterized by variability in rainfall patterns, with periodic El Niño and La Niña events exacerbating dry conditions in different regions of the country ^[8]. Given this, the Agricultural Research

Council (ARC) of South Africa oversees the monitoring of climate and vegetation responses, offering timely information and outputs such as maps and bulletins, for policy advice. Complementing this effort, the South African National Space Agency (SANSA) furnishes data regarding vegetation conditions, while the Department of Water and Sanitation (DWS) is responsible for the ongoing surveillance of dam and groundwater levels ^[9].

There is also growing evidence to suggest that climate change is increasing the frequency, severity, and duration of droughts in South Africa ^[10]. Rising temperatures and changes in precipitation patterns are leading to more prolonged and intense drought events. In the same vein, inefficient water management practices, ageing infrastructure, and increasing water demand due to urbanization and population growth, as well as industrial needs and economic development have all contributed to water shortages during drought periods. In particular, the Western Cape Province in South Africa, is one of the Provinces vulnerable to the impacts of drought ^[4,11], due to its Mediterranean-type climate and high dependence on agriculture and tourism. The province has a history of experiencing periodic droughts, with the most recent severe drought occurring between 2016 and 2018, considered to be one of the worst incidences of droughts in the region's recorded history (Human Sciences Research Council (HSRC) ^[12], as cited in Oluwatayo and Braide ^[4]), which consequently impacted on households and organizations across several spheres of human livelihoods. The Province is one of the major agricultural regions in South Africa, contributing substantially to the provincial economy, and a significant portion of the country's GDP ^[4,13]. Bahta and Myeki ^[1] as well as Bahta and Lombard ^[7] reiterated that the incidence of droughts can lead to reduced agricultural productivity and crop yields, as well as livestock losses, thereby threatening food and nutrition security for local communities, as well as income from various livelihood activities. In fact, many rural communities rely on agriculture for their livelihoods, and such drought-induced crop failures and livestock deaths can potentially result in significant income loss for farmers, agricultural workers, and businesses, leading to food shortages, increased poverty and economic hardship. Droughts have also resulted in declining water levels in dams, reservoirs, and groundwater sources, leading to water restrictions, rationing, and challenges in supplying water for domestic, agricultural, and industrial use. This is to say that droughts can trigger vulnerabilities in the water supply infrastructure of any area ^[4], and the environ-

mental consequences of such cannot be over-emphasized. This often leads to land degradation, soil erosion, and loss of biodiversity, impacting on the resilience and productivity of natural ecosystems^[7]. Across different provinces in South Africa, including the Western Cape, droughts can have significant socio-economic impacts. For instance, droughts can impact the tourism industry through reduced water availability, environmental degradation, and negative perceptions of the region, leading to decreased tourist numbers, revenue loss, and job cuts in the tourism sector, which can adversely lead to increased unemployment, and migration as people tend to seek alternative livelihoods and opportunities in other regions^[4]. Droughts can also impact community well-being, social cohesion, and mental health due to stress, anxiety, and social conflicts arising from water scarcity, food insecurity, and economic hardship^[1,14,15]. In addition, many communities in South Africa, and particularly, Western Cape have traditional practices and livelihood strategies that are closely linked to local ecosystems and natural resources, and droughts can equally disrupt these practices, cultural traditions, and social networks, leading to loss of cultural heritage and identity^[7]. All these negative externalities induced by droughts potentially threaten the livelihood, social cohesion, and stability of any households, organizations, and community at large.

In response to the recurrent droughts and their impacts, as well as the strive towards the attainment of the United Nation's Sustainable Development Goal (SDG) 6 which aims to promote availability and sustainable management of water and sanitation for all (United Nations Department of Economic and Social Affairs (UN-DESA)^[16], the South African government, provincial authorities, and various stakeholders have implemented various drought mitigation and adaptation measures, including water-use restrictions and conservation strategies, infrastructure development, and drought relief programs^[12]. Despite the efforts, the Western Cape Province remains vulnerable to future drought events due to ongoing climate variability and change, highlighting the need for continued research, monitoring, and adaptive management strategies to enhance resilience and sustainability in the face of drought risks. Therefore, understanding the impacts of drought on livelihoods is vital for informing policy and decision-making processes, enhancing ecosystem resilience and adaptive capacity, promoting sustainable land and water management practices, as well as improving the well-being and livelihood security of vulnerable communities and populations. Given this

background, the research was motivated to provide answers to the following research questions:

(i) What is the distribution of households and organizations based on the levels of impacts of drought and awareness of the need to save water in the Western Cape Province of South Africa?

(ii) How effective are the Authorities on drought disaster management in the study area?

(iii) What are the factors influencing the levels of livelihood impacts of drought among households and organizations in the study area?

(iv) What coping strategies and resilience mechanisms have been employed by households and organizations in the study area?

2. Literature Review

2.1 Impact of Different Classification of Droughts on Livelihood Activities

Drought disaster is a complex, recurring natural hazard, and a multifaceted natural phenomenon, characterized by a prolonged period of below-average precipitation that leads to water shortages and environmental stress^[2]. As noted earlier, drought can have significant socio-economic, environmental, and agricultural impacts, affecting ecosystems, water resources, food security, and livelihoods of various households and the population at large. Understanding the different types of drought and how such affect households with different livelihood activities are essential for assessing the levels of impact, and the factors influencing the degree of livelihood impacts.

Meteorological Drought

Meteorological drought is characterized by a prolonged period of below-average precipitation in an area, and it is the most commonly recognized type of drought which is typically assessed based on meteorological data such as rainfall patterns, temperature, and evaporation rates^[14]. Of significant note is global climate change which is increasing the frequency, severity, and duration of meteorological droughts by altering weather patterns, increasing temperatures, and changing precipitation distribution^[17], while rising temperatures also accelerate evaporation rates, reducing soil moisture levels, and exacerbate water shortages among the population^[18]. This hitherto contributes to agricultural drought and water stress, which affect crop productivity, reduce farmers' income, and trigger food insecurity conditions.

Agricultural Drought

Agricultural drought speaks to the impact of reduced soil moisture levels on crop production and agricultural productivity. This occurs when there is a lack of moisture in the soil, affecting plant growth, crop yields, and livestock grazing conditions, which are triggered by land use and land cover changes ^[14]. Prolonged periods of below-average rainfall can lead to soil moisture deficits, affecting crop growth and agricultural productivity, while increased temperatures can also accelerate evaporation rates, leading to increased soil moisture deficits and reduced agricultural productivity ^[19]. In addition, land degradation, deforestation, and changes in land use and land cover can simultaneously alter local climate conditions, reduce soil moisture levels, and exacerbate drought conditions. Besides, poor land management practices, such as overgrazing, deforestation, and inappropriate agricultural practices, and urbanization, can exacerbate soil erosion, soil degradation, reduced vegetation cover, which can trigger reduced soil moisture levels, increased agricultural drought, and reduced ecosystem resilience ^[17]. Importantly, poor water management in terms of inefficient irrigation practices, over-extraction of groundwater, and inadequate water storage and distribution infrastructure can potentially exacerbate agricultural drought conditions, leading to a significant decline in agricultural productivity and food insecurity situation among the population.

Hydrological Drought

According to Asad et al. ^[14], hydrological drought refers to the impact of reduced water availability in rivers, lakes, reservoirs, and groundwater sources on water supply, water quality, and aquatic ecosystems, and this occurs when there is a prolonged deficit in water availability, leading to declining water levels and reduced water quality. In addition, poor water resource management and infrastructure can also exacerbate the already worsened situation. For instance, inefficient water resource management practices, limited storage capacity, inefficient water distribution systems, and aging infrastructure exacerbate water shortages, reduce water availability, and contribute to hydrological drought conditions, particularly during periods of reduced rainfall. More so, over-exploitation of water resources (excessive pumping of groundwater for agricultural, industrial, and domestic use) can deplete aquifers and reduce groundwater levels. Consequently, this can significantly contribute to water scarcity and

hydrological drought situation in the Southern African hemisphere ^[18]. Given this impact, households and organizations become vulnerable and struggle to access water, with attendant negative implications on health, households chores, and production activities among the population.

Socio-Economic Drought

Socio-economic drought refers to the impact of reduced water availability and agricultural productivity on human populations, communities, and economies ^[14,15]. When this occurs, it usually translates to water shortages and reduced agricultural productivity which consequently lead to various socio-economic impacts, including food insecurity, poverty, unemployment, and economic hardship. This is to say that, declining crop yields and livestock losses due to agricultural drought can lead to income loss, increased poverty, food insecurity, thereby exacerbating socio-economic vulnerability. Limited access to water for domestic, agricultural, and industrial use due to hydrological drought can also lead to water rationing, reduced economic productivity, and increased competition and conflicts over water resources ^[1,4,14]. It is important to reiterate that high dependence on agriculture for livelihoods and economic development makes communities and regions more vulnerable to the socio-economic impacts of drought. Given that the South African economy is highly dependent on agriculture, the agricultural sector contributes significantly to employment, food security, and largely, economic development ^[9,20].

2.2 Empirical Review on Livelihood Impacts of Drought

Drought has far-reaching and profound consequences and impacts on livelihoods, particularly in regions highly dependent on agriculture, water resources, and natural ecosystems, such as the Western Cape Province in South Africa. The main livelihood impacts of drought in South Africa, with a focus on agriculture, water resources, food security, and health, are explained as follows:

Impacts on Agriculture

Agriculture is a critical sector in South Africa, contributing significantly to employment, food security, and economic development. Drought can have devastating effects on agricultural productivity, crop yields, livestock farming, and rural livelihoods ^[1,4]. Prolonged periods of below-average rainfall and water scarcity

can lead to reduced soil moisture levels, crop stress, and decreased crop yields, affecting staple and cash crops such as maize, wheat, fruits, and vegetables ^[21]. Also, limited water availability and reduced pasture quality can lead to inadequate livestock grazing conditions, livestock stress, and increased mortality rates, affecting livestock farming, milk production, and meat supply ^[1,21]. The declining rate of agricultural productivity and livestock losses due to drought events can equally lead to income loss, increased poverty, and food insecurity, particularly among smallholder farmers and rural communities dependent on rain-fed agriculture for their livelihoods. In fact, reduced agricultural productivity, crop failures, and livestock losses can also lead to food shortages, increased food prices, and reduced access to nutritious and affordable food, exacerbating food insecurity and malnutrition among vulnerable populations.

Impacts on Water Resources

Water resources are essential for domestic, agricultural, industrial, and environmental purposes. Funk et al. ^[22] noted that drought can lead to water shortages, declining water levels in rivers, lakes, and reservoirs, and increased water stress, affecting water supply, water quality, and aquatic ecosystems. In fact, prolonged periods of below-average rainfall and reduced inflows into rivers, lakes, and reservoirs can lead to water shortages, water rationing, and limited access to safe and clean drinking water for domestic, agricultural, and industrial use. More so, limited water availability, increased water demand, and water stress can exacerbate vulnerabilities in water supply infrastructure, water distribution systems, and water storage facilities, affecting water supply reliability, water service delivery, and public health ^[18,22,23].

Impacts on Food Security and Welfare

Food security is a critical concern in South Africa, with many households and communities already facing food insecurity and malnutrition. Drought can exacerbate food shortages, increase food prices, and reduce access to nutritious and affordable food, affecting food security and dietary diversity ^[24,25]. This is to say that declining agricultural productivity, crop failures, and livestock losses due to drought can lead to reduced food availability, food shortages, and limited access to staple and nutritious food, particularly among vulnerable populations. Reduced agricultural productivity, increased production costs, and limited food supply due

to drought can potentially lead to increased food prices, reduced purchasing power, and financial hardship, affecting food access and affordability for households and communities ^[25]. In terms of dietary changes and malnutrition, limited access to nutritious and affordable food can indeed lead to dietary changes, reduced dietary diversity, and increased malnutrition rates, affecting public health, child development, and overall well-being, particularly among children, women, and vulnerable populations ^[23].

Impacts on Health

According to Algur et al. ^[23], drought can have significant public health implications, affecting water supply, sanitation, hygiene, and disease transmission, and exacerbating health risks among humans (particularly vulnerable children and women), as well as animals. This suggests that reduced water availability, limited access to safe and clean drinking water, and deteriorating water quality due to drought can increase the risk of waterborne diseases, including diarrhea, cholera, and other water-related diseases, affecting public health and well-being. Likewise, Bahta and Myeki ^[1] emphasized implications of drought on animal industry in their study conducted in South Africa, where drought was shown to contribute to poor productivity, decreased fertility, poor animal health, and a rise in mortality in the livestock industry. As noted by Bahta and Lombard ^[7], Walz et al. ^[9], Maltou and Bahta ^[20], and Algur et al. ^[23], drought-induced food insecurity, income loss, poverty, and livelihood stress can indirectly lead to mental health issues, anxiety, depression, and psychosocial impacts, affecting community well-being, social cohesion, and overall mental health and resilience.

From the foregoing, one can infer that drought disaster has significant and wide-ranging livelihood impacts in South Africa, affecting agriculture, water resources, food security, and health, which further worsen the vulnerabilities and challenges in these critical sectors of the economy.

2.3 Theoretical Framework (Underpinning Theories)

This research is grounded and supported by a range of theoretical frameworks that help to understand and analyze the complexities of drought impacts on livelihoods of households and organizations. These theories include: the Sustainable Livelihoods Framework, and Climate Change Adaptation Theories.

According to Nasrnia and Ashktorab [26], and Jackson [27], the Sustainable Livelihoods Framework (SLF) provides a suitable approach to understanding the various factors that affect livelihoods, including vulnerability to crisis and shocks like drought and how individuals build resilience against shocks. In terms of drought crisis, the key components of the SLF are: assets, vulnerability context, transforming structures and processes, and livelihood strategies which incorporate the coping and adaptation strategies employed by households and organizations to maintain their livelihoods. As emphasized earlier, drought episodes can lead to depletion of natural assets (e.g., water, land), financial assets (e.g., income loss), and physical assets (e.g., livestock loss), while drought also increases vulnerability due to reduced access to water and food, increased food prices, and health risks [1,7,9,20,23,26]. All these are entry points and pathways to understanding how individuals, be it households and organizations adapt to and cope with drought impacts. Equally important is the climate change adaptation theory and/or action theory of climate change [28-31]. This theory focuses on the strategies and actions that can be taken to reduce vulnerability and enhance resilience to climate-related risks, including drought. The application of the theories has to do with ability to adjust to changing climatic conditions, and measures (coping and adaptation strategies implemented by households and organizations) taken to reduce vulnerability and enhance resilience, as emphasized by Intergovernmental Panel on Climate Change (IPCC) [32,33].

3. Methodology

3.1 The Study Area

The Western Cape Province, located on the South-west coast of South Africa, is one of the country's nine provinces. As noted by Otto et al. [34] as cited in Oluwatayo and Braide [4], the province encompasses an expansive area of over a million square kilometers. The province, which ranks as the fourth largest province in South Africa consists of twenty-five municipalities organized into six districts. The coastal regions of the Western Cape experience a mild Mediterranean climate characterized by wet winters and dry summers. However, as one moves inland and beyond the mountains, the climate transitions to semi-arid and continental conditions [4]. The predominant vegetation in the region is scrubland, a type of vegetation that is both common and prone to fires. This vegetation supports agricultural activities, related businesses, and the area is also home to renowned vineyards [35]. According to Oluwatayo and Braide [4], the Province is susceptible to drought risks, which have been reported to have severe impacts on the livelihood of a significant portion of the population. In particular, the drought and the resulting water crisis have significantly impacted socio-economic conditions of residents, both nationally and locally. The Western Cape province, which contributes approximately 14% to the country's gross domestic product, experienced substantial losses in its agricultural sector, one of the hardest hit due to its heavy reliance on irrigation, amounting to an estimated ZAR 5.9 billion [4,13].



Figure 1. Map of western Cape province, South Africa.

Source: Oluwatayo and Braide [4]

3.2 Data and Data Analytical Strategies

This research utilized a secondary dataset provided by the HSRC from 2019. The dataset captures the behaviors and perceptions of respondents during the severe drought experienced in the Western Cape Province between 2016 and 2018. As noted by HSRC [12], the data comprises of 311 respondents with 240 households (family units) and 71 business organizations from various locations in the Western Cape Province of South Africa.

Several analytical techniques were applied to describe and analyzed the dataset. First, exploratory analysis was conducted through a contingency table approach, which was used to profile the respondents (households and organizations) based on the levels of impacts of drought experienced. Descriptive statistics such as frequency counts and percentages were applied to describe the respondents' awareness of the need to save water, and their perceptions on the water restrictions measures instituted by the government. Frequency counts and percentages were also used to: describe the respondents' perception of the effectiveness of the authorities (government) on drought disaster management, identify the areas of impacts of drought disasters, and describe the coping strategies and resilience mechanisms employed by the respondents in the study area. Likewise, heterogeneous choice model (estimated via ordinal generalized linear model estimator) was applied to investigate the factors influencing the levels of livelihood impacts of drought among the respondents in the study area.

3.3 Modeling Strategy: Heterogeneous Choice Model

The choice of heterogeneous choice model for this study, as against other competing econometrics techniques is governed by two reasons. The first one is because few other closely related studies, such as Bahta and Myeki [1] and Bahta and Lombard [7] simply described their variables through line graphs, chat, percentiles, and frequency distributions, while Oluwatayo and Braide [4] applied ordered logistic regression model (which cannot account for possible heterogeneity, and incorrectly assumes that error variances are the same for all cases) to investigate the determinants of households' vulnerability to drought. However, heterogeneous choice model has the ability to correct for this heterogeneity bias [36,38,39]. The second reason bothers on the availability of relevant and sufficient variables in the HSRC dataset to implement other

econometric techniques, such as endogeneous switching regression, and propensity score matching to estimate the impact. Given the highlighted limitations of the approaches used in previously related studies, and the available variables in the HSRC dataset [12], this research applied heteroskedastic ordered logistic regression (an heterogeneous choice model) to investigate a variety of factors that influence the levels of impact of drought disasters in Western Cape Province of South Africa. As emphasized by Williams [36] citing Yatchew and Griliches [37], when a binary or ordinal regression model incorrectly assumes that error variances are the same for all cases, the standard errors are wrong, and unlike ordinary least squares (OLS) regression, the parameter estimates are biased; thus, heterogeneous choice models (also known as location-scale models or heteroskedastic ordered models) explicitly specify the determinants of heteroskedasticity in an attempt to correct for it [38,39]. According to Williams [36], suppose there is an observed variable "y" with an ordered response categories; 0, 1, 2,..., k, one of the rationales for the ordered logit and probit models is that "y" is actually a collapsed version of a latent variable, y^* . As respondents cross thresholds on y^* , their observed values on y change, such equations (1)–(4):

$$y = 0 \text{ if } -\infty < y^* < \kappa_0 \tag{1}$$

$$y = 1 \text{ if } \kappa_0 < y^* < \kappa_1 \tag{2}$$

$$y = 2 \text{ if } \kappa_1 < y^* < \kappa_2 \tag{3}$$

$$y = 3 \text{ if } \kappa_2 < y^* < \kappa_3 \tag{4}$$

According to Williams [36], the model for the underlying latent y^* can now be expressed as equation (5):

$$y_i^* = \alpha_0 + \alpha_1 x_{i1} + \dots + \alpha_k x_{ik} + \sigma \varepsilon_1 \tag{5}$$

where:

y^* = ordered dependent variable; that is; no impact = 0, a small impact = 1, considerable impact = 2, and major impact = 3

x 's = the fitted explanatory variables, α 's = coefficients that give the effect of each x on y^* ,

ε_1 = residual term often assumed to have either a logistic or normal (0, 1) distribution, and;

σ = a parameter that allows the variance to be ad-

justed upward or downward.

Now, because y^* is unobserved, we do not actually estimate α 's, but we estimate the parameters called β 's. Therefore, Allison [40] as cited in Williams [36] states that the α 's and the β 's are thus related as equation (6):

$$\beta_k = \alpha^k / \sigma \tag{6}$$

where $k = 1, \dots, K$

This now leads us to a potential problem of homoscedastic (when σ is the same for all cases) and/or heteroskedasticity (when σ differs across the cases) with the ordered logit or probit model [36], as the case may be. Therefore, heterogeneous choice model provides a way to deal with such econometric problems, where the σ can differ across cases, but the model will correct for any potential heteroskedasticity issue. The model accomplishes this by simultaneously fitting two equations: one for the determinants of the outcome, or choice (in this case, levels of drought impacts), and the other for the determinants of the residual variance [36].

Given the aforementioned explanation, the choice equation can be written as equation (7):

$$y_i^* = \sum_k x_{ik} \beta_k + \epsilon_i \tag{7}$$

The location or choice equation gives the value of the underlying latent variable. In the equation above, x is a vector of k values for the i^{th} observation. The x 's are the explanatory variables and are said to be the determinants of the choice, or outcome. The β 's show how the x 's affect the choice,

Also, the variance equation can be written as equation (8):

$$\sigma_1 = \exp \left(\sum_j z_{ij} \gamma_j \right) \tag{8}$$

The scale or variance equation indicates how the underlying latent variable is scaled for each case; that is, it reflects differences in residual variability that, if left unaccounted for, would cause values to be scaled differently across cases. In the equation above, z is a vector of j values for the i^{th} observation.

For an ordered dependent variable y with M -categories coded 0 to 3 (as indicated in equations 1 to 4), the full heterogeneous choice model (using logit link) is expressed as equation (9):

$$P(y_1 > m) = \text{invlogit} \left\{ \frac{\sum_k x_{ik} \beta_k - k_m}{\exp \left(\sum_j z_{ij} \gamma_j \right)} \right\} \\ = \text{invlogit} \left(\frac{\sum_k x_{ik} \beta_k - k_m}{\sigma_1} \right), \\ m = 1, 2, \dots, M - 1 \tag{9}$$

In essence, the full model shows how the choice and variance equations are combined to come up with the probability for any given response. From the foregoing, it can be seen that heteroskedastic ordered logistic regression model allows the distribution of unobserved factors to differ, providing a more realistic and flexibility situation than an ordered logistic regression model.

Table 1 summarizes the important variables included in the model, their definitions, measurement and their hypothesized directions of movement.

Table 1. Hypothesized variables were included in the model.

Variables	Definition	Measurement	Expected Sign
Levels of impacts	Subjective level of impacts experienced by the respondents	Ranking-4 levels	
Business organizations/ households	Belonging to organization or households	Binary (1, and 0)	±
Gender	Sex of the respondent	Male = 1, 0, otherwise	±
Age	Age of the respondent	Continuous	±
Awareness of drought risk	Awareness on the need to save water	Recorded in binary form	+
Institutional engagement on water restriction	Authority's communication on water restriction	Recorded in binary form	+
Communication channels (index)	Index of all sources and channels of communication.	Continuous	+
Livelihood areas impacted by drought	Areas of people's livelihood & existence that were impacted by drought episode	Recorded in continuous form	±
Household size	Numbers of persons in a given household	Continuous	±
Perception on water consumption rate	Subjective opinion on water consumption rate in the past 2 years.	Recorded in binary form	±
Perception on water restriction measure	Subjective opinion on water restriction measure put in place by the government.	Recorded in binary form	±

Source: Authors' compilation, 2024.

4. Results and Discussion

4.1 Distribution of Households and Organizations Based on the Levels of Impacts of Drought Risks

The results from the contingency analysis in Table 2 showed the relationships between the levels of impact of drought from the perspective of the two groups (business organizations and households) of respondents in question.

The first value in each panel speaks to the number of observations for each level of impact, while the second value in each panel speaks to the row percentages for the variables attached to each level of impact. Also, the third value in each panel speaks to the column percentages for the variables attached to each level of impact. However the interpretation will be restricted to the row and column percentages only, which are also in tandem with the number of observations recorded for each level of impact.

Therefore, in the first panel, 35% and 65% of the respondents who belong to ‘business organizations’ and ‘household’ respectively, reported “no level of impact”, while across the board, 7.4% of the respondents experienced “no level of impact” of drought in the study area. Likewise, in the second panel, the results indicated that only 20 percent of the respondents from the business organization, and the majority (80%) from households reported a “small level of impact”, while across the board, about 32.2% experienced “small level of impact”. In the third panel, very few (about 17%) of the respondents from business organizations reported a “considerable level of impact”, and approximately 83% from households also reported the same level of impact. Across the board, about 31% experienced a “considerable level of impact”. For the fourth panel, the findings revealed that the majority (71%) of the respondents who are from households experienced a major impact, while only 29 percent from business organizations reported a similar level of impact. On both counts, nearly 30% of the respondents experienced a major impact of drought in the study area. In all, the results revealed a similar pattern of drought impacts across each of the levels of impact, showing that nearly one-third of the respondents experienced either small, considerable or major impacts of drought. Apparently, with the metrics indicated in Table 1, the results indicated that households compared to the business organizations, were most impacted by the drought disaster across all the levels of drought impacts.

On the other hand, the findings also revealed the

Pearson- X^2 and LR- X^2 values, and these values test for the relationships between variables of interest. Given the Pearson- X^2 value, hypothetically, the null hypothesis (H_0) is that of no relationship between the variables, and to reject this, the X^2 (chi^2) is expected to be significant, statistically. The same null hypothesis and interpretation also holds true for the likelihood ratio test. Given the statistical significance of the two chi-square tests ($p < 0.1$), the study concludes that there is a relationship (though differentiated) between the levels of impact of drought among the business organizations and households in the study area. Likewise, the output- Cramer’s V signifies a measure of the strength of the association (which ranges from 0 to 1) between the levels of impact of drought among the two groups of respondents in question, meaning that the higher the output value, the stronger the relationship, and vice-versa. Therefore, the Cramer’s V output value of 0.1421 suggests a small or weaker association, which also reinforces the earlier submission of differentiated levels of impact of drought between the business organizations and households in the study area.

Table 2. Contingency Table: Levels of impacts of drought risks by organizations and households.

Levels of Impact of Drought	Organizations	Households	Total
No impact	8	15	23
	34.78	65.22	100.00
	11.27	6.25	7.40
Small impact	20	80	100
	20.00	80.00	100.00
	28.17	33.33	32.15
Considerable impact	16	79	95
	16.84	83.16	100.00
	22.54	32.92	30.55
Major impact	27	66	93
	29.03	70.97	100.00
	38.03	27.50	29.90
Total	71	240	311
	22.83	77.17	100.00
	100.00	100.00	100.00

Note: The first value in each panel is the number of observations for each level of impact, while the second value in each panel is the row percentages for the variables attached to each level of impact. Pearson chi^2 (3) = 6.2838; Pr = 0.099. Likelihood-ratio chi^2 (3) = 6.1484; Pr = 0.105. Cramér’s V = 0.1421. Gamma = -0.0621; ASE = 0.111. Kendall’s tau-b = -0.0315; ASE = 0.056. Fisher’s exact = 0.097.

Source: Data analysis, 2024.

4.2 Distribution of Households and Organizations Based on Awareness of the Need to Save Water, and Public Cooperation and Perceptions on Water Restriction

The results from Table 3 revealed the distribution of respondents and their disposition vis-à-vis their awareness of the need to save water as a result of drought disaster in the study area. From the findings, most (80.3% and 80.5%) of the respondents (organization and households, respectively) appeared to be aware of the need to save water. This seemed to be driven by their awareness of climate change impacts, which thus aligns with the findings reported by Thinda et al. ^[41] in their related study in South Africa. While 14.1 percent and 10 percent of both groups appeared indifferent to people’s awareness, only a very few proportions (5.6% and 9.6%) of the business organizations and households respectively, disagreed on this position. Considering the pooled results, the implication is that most people are aware of the drought disaster and the need to save water in the study area.

Table 3. People’s awareness of the need to save water because of drought risks.

Perception on People’s Awareness on the Need to Save Water	Business/Organizations	Households	Pooled
Strongly disagree	0 (0.0)	11 (4.6)	11 (3.5)
Disagree	4 (5.6)	12 (5.0)	16 (5.1)
Neutral	10 (14.1)	24 (10.0)	34 (11.0)
Agree	30 (42.3)	103 (43.0)	133 (42.8)
Strongly agree	27 (38.0)	90 (37.5)	117 (37.6)
Total	71	240	311

Note: Figures in parentheses are percentage values.
Source: Data analysis, 2024.

In the same vein, the results in Table 4 indicated the perception of the business organizations and households on the water restriction measures put in place by the government authorities. The results suggest that more than half (57.7% and 58.3%) of both groups agreed with the water restriction measure and thought that the move was in the right direction. A relatively few proportion (17% and 18.3%) in both groups seemed indifferent to the move while less than one-third (25.3% and 23.4%) of both groups’ population totally disagreed with the water restrictions moved by the authorities. In agreement with what Mamba ^[42] and Martey and Kuwornu ^[43] reported in their respective studies in Swaziland and Ghana respectively, the pooled results from this study also indicated that the

majority of the respondents (business organizations and households) have a strong perception about climate change, which induced the need to save water, as most agreed with the water use restriction measure. This outcome is not surprising because there cannot be compliance with water use restrictions without people’s awareness of the negative impacts of climate change as highlighted earlier. This informs their understanding of the need to save water due to the incessant drought disaster.

Table 4. Public cooperation/perception on water restriction by the government.

Perception on Public Cooperation on Water Restriction	Business/Organizations	Households	Pooled
Strongly disagree	2 (2.8)	15 (6.3)	17 (5.5)
Disagree	16 (22.5)	41 (17.1)	57 (18.3)
Neutral	12 (17.0)	44 (18.3)	56 (18.0)
Agree	28 (39.4)	86 (35.8)	114 (36.7)
Strongly agree	13 (18.3)	54 (22.5)	67 (21.5)
Total	71	240	311

Note: Figures in parentheses are percentage values.
Source: Data analysis, 2024.

4.3 Effectiveness of the Authorities on Drought Disaster Management

The perceptions of the organizations and households on the effectiveness of the authorities (government) on drought disaster management are revealed in Table 5. From the findings, 30.9 percent and 34.6 percent of the business organizations and households respectively, believed that the government was not effective enough in the management of the drought crisis. About one-quarter (25.4% and 23.3%) of the population in each of these groups appeared indifferent to government effectiveness, while 43.7 percent and 42.1 percent of both groups firmly believed that the government was very effective in the management of drought disasters. The pooled results also revealed a nearly similar pattern of outcome, which ultimately suggests mixed feelings on respondents’ perceptions of the government’s effectiveness on drought disaster management in the study area. The results highlight the importance of providing clear, sufficient and timely information about the restrictions on water usage as a result of drought disasters. This is because information gaps can create negative perceptions in the minds of citizens about the government’s intentions. This was also reiterated by Phikolomzi, Ziervogel and Enqvist ^[44], as well as Oluwatayo and Braide ^[4] in their respective

related studies carried out in South Africa.

Table 5. Effectiveness of the authorities on drought disaster management.

Effectiveness of the Authorities on Drought Disaster Management	Business/Organizations	Households	Pooled
Strongly disagree	7 (9.8)	28 (11.7)	35 (11.3)
Disagree	15 (21.1)	55 (22.9)	70 (22.5)
Neutral	18 (25.4)	56 (23.3)	74 (23.8)
Agree	25 (35.2)	76 (31.7)	101 (32.5)
Strongly agree	6 (8.5)	25 (10.4)	31 (9.9)
Total	71	240	311

Note: Figures in parentheses are percentage values.

Source: Data analysis, 2024.

4.4 Areas of Impact of Drought in Organizations and Households

The impact of drought disasters on different areas of human existence cannot be over-emphasized. The consequences of drought can be manifested as a direct and/or indirect impact. Therefore, the distribution of the respondents based on the areas of impacts of drought is hereby presented in Table 6. The results in Table 6 showed that 19.7 percent and 11.7 percent of the organizations and households respectively, did not report any impact in any areas of their livelihood means. The findings also indicated that approximately 9 percent and 16 percent of the organizations and households respectively, reported the impact in the aspect of gardening, while about 11 percent and 29 percent, respectively in both groups were also impacted in the areas of hygiene and chores. Similarly, relatively few proportions (1.4% and 7.9%) of the respondents in both groups were impacted in terms of health, while disruption of business/financial burden was also reported to have impacted organizations and households, which account for 38.0 percent and 10.8 percent

of the population, respectively. Unlike the households who were most impacted in the areas of hygiene and chores, and gardening, as expected, organizations were most impacted in the areas of disruption of business/financial burden, and hygiene and chores. This result implies that the organizations and households in the study area were disproportionately impacted by the drought disaster.

4.5 Factors Influencing the Levels of Livelihoods Impacts of Drought Disasters

The estimates of heteroskedastic ordered logistic regression model (heterogeneous choice model) applied to investigate the factors that influence the levels of livelihood impact of drought disasters in the Western Cape Province of South Africa are presented in Table 7. Overall, the results showed a significantly differentiated impact of drought on organizations and households, while age of respondents, institutional engagement (communication by the government/authorities) on water restrictions, areas of livelihood impacted by drought, as well as respondents' perceptions on water consumption rate significantly drive the levels of impact of drought in the study area.

The estimates shown in the first panel of Table 7 revealed the average marginal effect for being an organization and/or belonging to a household in terms of experiencing considerable impact ($p < 0.1$) of drought disaster was 7.3%, suggesting that, on average, the likelihood of organizations and households experiencing a considerable impact of a drought disaster in the study area is higher by 7.3% points. The results also indicated that the average marginal effect for age in terms of no impact and small impacts of drought were 1.9% and 4.4% points, respectively. All else equal, this implies that on the average, the probability of older organizations and households experiencing no impact and small impacts is lower by 1.9% points and by 4.4% points respectively, compared with the younger farm-

Table 6. Areas of impacts of drought in the organizations and among the households.

Areas of Impacts of Drought	Business/Organizations	Households	Pooled
None	14 (19.7)	28 (11.7)	42 (13.5)
Hygiene and chores	8 (11.3)	69 (28.8)	77 (24.8)
Gardening activities	6 (8.5)	38 (15.8)	44 (14.2)
Health status	1 (1.4)	19 (7.9)	20 (6.4)
Disruption of business and financial burden	27 (38.0)	26 (10.8)	53 (17.0)
Others	15 (21.1)	60 (25.0)	75 (24.1)
Total	71	240	311

Note: Figures in parentheses are percentage values.

Source: Data analysis, 2024.

ers. In tandem with the findings of Olabanji et al. ^[45], age is an important household characteristic that has great implications on farmers' adaptive capacity. In fact, the effect of age may sometimes be location-specific and the expected relationship has been a subject of empirical debate because if the relationship appears negative (lowering the probability of being in a moderate or a high adaptive response category), such may be attributed to the risk-averse nature and less flexibility of the older farmers ^[46]. Meanwhile, if the relationship is positive (increasing the likelihood of being in a moderate or higher adaptive response category), one may argue that older farmers have sufficient farming experience.

The findings also revealed that the probabilities of experiencing no impact ($p < 0.1$) and small impact ($p < 0.05$) of drought disaster respectively, with respondents' positive perceptions of the institutional engagement (communication by the authorities-government) about the water restrictions measure is lower by 2.3% and 5.3% points, while it is also higher by 1.1% and 6.5% points for considerable ($p < 0.1$) and major impacts ($p < 0.05$) of drought disaster, respectively. This result reinforces the need for proper and clear communication with the citizenry about any government action. Provision of clear, sufficient and timely information about the restrictions on water usage is important to bridge information gaps which can further create a negative perception about government actions, as emphasized by Phikolomzi et al. ^[44] in a related study conducted in South Africa. In terms of areas of livelihood affected by the drought disaster, the findings indicated that the likelihood of experiencing small impact ($p < 0.01$) is lower by 3.4% point, while the probability of experiencing major impacts ($p < 0.01$) is higher by 4.4% point. The implication of this is that the chances of people's livelihood being affected greatly are higher across different various areas of livelihood endeavors. This could perhaps be associated with their low adaptive capacity, especially on the part of households.

Concerning the perceptions on water consumption rate, the results indicated that on average, the chances of the respondents experiencing no impact ($p < 0.05$) and small impact ($p < 0.01$) of drought disasters are lower by 2.8% and 6.4% points, respectively. The findings also indicated that the likelihood of the respondents experiencing considerable impact ($p < 0.1$) and major impact ($p < 0.01$) of drought disasters are higher by 1.4% and 7.9% points, respectively. By implication, the respondents seemed to be highly vulnerable to drought disasters, and a plausible reason for this could

be linked to the poor perception of limiting their water consumption rate, which by extension could also affect their compliance with the water restriction measure put in place by the authorities. A similar finding was also reported by Oluwatayo and Braide ^[4] in a related study conducted in Western Cape Province of South Africa, where approximately 41% of households reported both unchanged and increased rates of water consumption over the past years.

The output from the fitted heterogeneous choice model in the second panel of Table 7 also indicated that the standard deviation of the residuals is $e^{(\gamma)} = e^{(-0.3519)} = 0.7034$ times lesser for business organizations than households, while the result also indicated that the standard deviation of the residuals is $e^{(\gamma)} = e^{(0.0401)} = 1.0409$ times larger for those who are affected by drought in various aspects of life than those who experienced minimal effect and those who are not affected at all in any ways. Likewise, the results produced a residual variance; $e^{(\gamma)} = e^{(0.0143)} = 1.0144$ times larger for men than women respondents in the study area. In essence, the variance in the choice and variance equations' error terms was parameterized to be a function of business organization/households, areas of life of affected by drought episode, and gender. The use of these variables in the variance specification was premised on the fact individuals of different gender orientations are disproportionately affected by shock episodes across various areas of life. If these are not taken into consideration, it may distort the conclusion and inference made from the findings. Given this position, of the three fitted variables, the results indicated that variable business organization cum households have an inverse relationship with the levels of drought impact in both the choice and variance equations, but only have significant effect in the latter. By implication, the negative coefficient of this variable in the variance equation suggests that business organization was less variable in their vulnerability to drought than were the households. This result appears plausible and in line with a-priori expectation because organizations potentially have greater adaptive capacity than the households in terms of coping with the impacts of drought, perhaps due to their financial advantage, compared to the households.

In addition, the model delineates three distinct cut-points or critical thresholds, each associated with estimated values of -0.6134, 0.7298, and 1.5674, as presented in the third panel of Table 7. These cut-points serve as threshold parameters, elucidating the presence of three separate equations within the model.

Table 7. Factors influencing the levels of livelihoods impacts of drought among households and organizations in Western Cape.

Variables	Average marginal effects (dy/dx)			
	No Impact	Small Impact	Considerable Impact	Major impact
Business organizations/households	-0.0448 (-1.42)	0.0517 (0.96)	0.0734 (1.91)*	-0.0803 (-1.15)
Gender	0.01425 (0.58)	0.0260 (0.79)	-0.0091 (-0.30)	-0.0311 (-0.72)
Age	-0.0195 (-2.04)**	-0.0443 (-2.23)**	0.0096 (1.74)*	0.0542 (2.21)**
Awareness of drought risks	0.0145 (1.00)	0.0328 (1.04)	-0.0071 (-0.93)	-0.0402 (-1.04)
Institutional engagement on water restriction	-0.0238 (-2.11)**	-0.0538 (-2.34)**	0.0117 (1.77)*	0.0659 (2.31)**
Communication channels (index)	0.0030 (0.72)	0.0069 (0.73)	-0.0015 (-0.71)	-0.0084 (-0.73)
Livelihood areas impacted by drought	-0.0075 (-1.25)	-0.0345 (-2.91)***	-0.0021 (-0.29)	0.0442 (2.93)***
Household size	-0.0012 (-0.38)	-0.0028 (-0.38)	0.0006 (0.38)	0.0035 (0.38)
Perception on water consumption rate	-0.0286 (-2.31)**	-0.0649 (-2.65)***	0.0141 (1.87)*	0.0794 (2.62)***
Perception on water restriction measure	0.0087 (1.36)	0.0197 (1.41)	-0.0043 (-1.20)	-0.0241 (-1.42)
Variance (Insigma)				
Business organizations/households	-0.3519 (-2.07)**			
Livelihood areas impacted by drought	0.0401 (0.99)			
Gender	0.0143 (0.11)			
Threshold				
/cut1	-0.6134 (-1.03)			
/cut1	0.7298 (1.09)			
/cut3	1.5674 (1.78)***			

Note: Figures in parentheses are z-values; *, ** and *** indicate $p < 0.1$, $p < 0.05$, and $p < 0.01$ probability levels, respectively. Source: Data analysis, 2024.

However, due to the ordered nature of the dependent variable, the model’s output appears to manifest as a single equation model, as also justified by Ender^[47].

4.6 Coping Strategies and Resilience Mechanisms have been Employed by Households and Organizations

Building resilience to drought through adequate awareness of preparedness, response capacity and recovery mechanisms is important for maintaining and improving the well-being and livelihoods of the population. Given the results in Table 8, the majority (25.4% and 22.5%) of the organizations reported usage of less water, perhaps driven by the water restriction measures put in place by the authorities, as well as recycling of water, respectively. About 19.7 percent and 1.4 percent of the organizations reported storage of water and fixing of leakages in pipes, respectively as coping and adaptive strategies mechanisms, while only 8.5 percent reported they did not save water. The same goes for the households group as nearly one-third (32.5% and 31.6%) of them reported usage of less water and recycling of water, respectively. Approximately 16 percent and 2 percent of the households also stored water and fixed leakages in pipes as coping mechanisms respectively, while about 3 percent did not save water. On both counts, most of the organizations and households

reported the usage of less water and recycling of water as water-saving strategies against drought disasters in the study area.

Table 8. Coping strategies and resilience mechanisms against drought (Water-saving strategies).

Water-saving Strategies	Business/Or- ganizations	House- holds	Pooled
Recycling of water	16 (22.5)	76 (31.6)	92 (29.6)
Storage of water	14 (19.7)	39 (16.3)	53 (17.0)
Usage of less water	18 (25.4)	78 (32.5)	96 (30.9)
Fixing of leakages	1 (1.4)	5 (2.1)	6 (1.9)
Did not save water	6 (8.5)	7 (2.9)	13 (4.2)
Others	16 (22.5)	35 (14.6)	51 (16.4)
Total	71	240	311

Note: Figures in parentheses are percentage values. Source: Data analysis, 2024.

5. Conclusions

The research on the livelihood impact of drought on households and organizations is supported by a range of theoretical frameworks, most importantly, the Sustainable Livelihoods Framework, and Climate Change Adaptation Theories. The study has demonstrated through various findings from the dataset analyzed, how households and organizations in the study areas are vulnerable to the various degrees of impacts of

drought. Given livelihood dependence on water on the part of the households and organizations, most households are more vulnerable to the impacts of drought, compared to the organization's counterparts due to their limited adaptive and coping mechanisms. The spillover effects of this ugly situation are manifested by water and food shortages and reduced resilience and adaptive capacity, limited access to essential services such as health care. This also caused an upsurge in households' vulnerability to drought by affecting the living conditions, and reducing livelihood opportunities, especially on the part of households, as demonstrated by the implications of the research findings. In addition, respondents' perceptions of the government's effectiveness in drought disaster management are fairly good, while most of the organizations and households reported the usage of less water as well as recycling of water as water-saving strategies employed against drought disasters. Significantly differentiated impacts of drought were also observed among organizations and households, while the age of the respondent, institutional engagement (communication by the government/authorities) on water restrictions, areas of livelihood impacted by drought, and perceptions on water consumption rate also significantly influenced the levels of impacts of droughts among the respondents in the study area.

The following policy statements are of importance, considering the findings from this study:

There is an urgent need to increase people's awareness by intensifying enlightenment campaigns and engagements on the need to conserve water by adhering to the water restriction measures put in place, and by cultivating the habit of sustainable use of water. This can contribute to both households' and organizations' resilience to drought.

In addition to the need to comply with the regulatory authorities on the water-use restriction measure, proper institutional engagement in terms of providing clear, sufficient and timely information about the restrictions on water usage as a result of drought disasters. This is because information gaps can create negative perceptions in the minds of citizens about government intentions.

Another important dynamic is investment in infrastructure development such as the provision of sufficient irrigation facilities. Access to such resources can indeed enhance resilience to drought as this will further assist the smallholder farmers in the food production system which by extension can improve the health and well-being of the citizenry.

Participation in community-based adaptation and disaster risk reduction initiatives, capacity-building programs, and awareness-raising activities can enhance resilience to drought by improving knowledge, skills, and practices, fostering innovation, and promoting community empowerment and self-reliance.

Given the economic vulnerability from the organization's perspective, owing to their dependence on agricultural resources, and natural resources for their operations, and services, emergency response plans, and business continuity planning should be developed to enhance resilience to drought. This can also improve preparedness, response capacity, and recovery mechanisms, and reduce operational disruptions and financial losses that can result from drought disasters.

An equally important factor is stakeholder engagement and collaboration. It is therefore important for organizations to implement corporate social responsibility initiatives, sustainable development practices, and environmental, social, and governance strategies. This can ultimately enhance resilience by improving corporate reputation, stakeholder relationships, and organizational performance, and promoting sustainability, responsible business practices, and long-term value creation.

Author Contributions

Conceptualization: Seyi Olalekan Olawuyi and Abbyssini Mushunje; Data curation: Seyi Olalekan Olawuyi; Methodology: Seyi Olalekan Olawuyi and Abbyssini Mushunje; Data analysis: Seyi Olalekan Olawuyi and Abbyssini Mushunje; Writing: original draft preparation, review and editing: Seyi Olalekan Olawuyi; Supervision: Abbyssini Mushunje.

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Data Availability

Human Sciences Research Council (HSRC). Adaptation to the Western Cape drought of 2016-18 (WCD),

2019: Household and business survey. [Data set]. WCD 2019. Version 1.0. Pretoria South Africa: Human Sciences Research Council [distributor] 2020. DOI: <http://doi.org/10.14749/1570105897>

Conflict of Interest

The authors declare no conflict of interest.

Ethical Considerations

The dataset used were collected in line with global research ethics, as outlined in WHO (2001)'s Helsinki declaration on research protocol. The research also followed the University of Fort Hare Research Ethics Committee (UREC)'s protocol on research: "anonymity, informed consent, privacy, confidentiality, as well as professionalism". This research obtained ethical clearance with the number: REC-270710-028-RA Level 01, with project number: SEY001-22 (Project).

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