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# Determinants of Smallholder Livestock Farmers' Household Resilience to Food Insecurity in South Africa

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**Abstract:** This study identified factors affecting livestock farmers' agricultural drought resilience to food insecurity in Northern Cape Province, South Africa. Data of 217 smallholder livestock farmers were used in a principal component analysis to estimate the agricultural drought resilience index. The structural equation approach was then applied to assess smallholder livestock farmers' resilience to food insecurity. The study found that most smallholder livestock farmers (81%) were not resilient to agricultural drought. Assets ($\beta = 0.150$), social safety nets ($\beta = 0.001$), and adaptive capacity ($\beta = 0.171$) indicators positively impacted households' resilience to food insecurity with 5% significance. Climate change indicators negatively impacted households' resilience to food insecurity. Two variables were included under climate change, focusing on drought, namely drought occurrence ($\beta = -0.118$) and drought intensity ($\beta = -0.021$), which had a negative impact on household resilience to food insecurity with 10% significance. The study suggests that smallholder livestock farmers need assistance from the government and various stakeholders to minimize vulnerability and boost their resilience to food insecurity.

**Keywords:** agricultural drought; resilience; food insecurity; assets; adaptive capacity; social safety net

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## 1. Introduction

Agriculture, including the livestock sector, is one of the industries on which drought has a major influence, causing loss of agricultural production. The impact of agricultural drought on livestock production is becoming a significant physical stressor in temperate and humid regions, including South Africa [1]. Agricultural drought impacts livestock production and quality, which is dependent on several factors, such as intensity, recurrent agricultural drought, vulnerability, water stress, and socio-economic factors [2]. Globally, agricultural drought is the costliest natural disaster compared to other natural disasters such as floods, hurricanes, tornadoes, and earthquakes. Loss caused by agricultural drought is estimated to cost from USD 6 to 8 billion annually [3]. An estimated 40 million people have been affected by drought in southern Africa, with a cereal deficit of 9.3 million tonnes recorded at the end of the 2015/16 cropping season [4,5]. The high regional deficit raised staple food prices and constrained the already limited purchasing power of vulnerable families. More than 643,000 livestock deaths were reported in five countries alone due to lack of feed and water and disease outbreaks in southern Africa. In addition, the income sources of many households were diminished due to the loss of crops, livestock, labor, trading, and self-employment activities [4,5]. During 2015, agricultural production in South Africa declined by 8.4% due to drought. The livestock industry, for example, had a 15% reduction in the national herd stock due to the drought [6].

Smallholders are characterized by labor-intensive farming, adoption of traditional production techniques, and inadequate institutional capacity and support [7]. Smallholder agriculture in general and the smallholder livestock sector in particular remain at the center of rural development policy discussions in Africa [8]. Smallholder agriculture plays a significant role and will contribute to feeding approximately 9 billion people worldwide by 2050, although there are still debates about the role of smallholder agriculture. The contribution of agriculture to poverty reduction depends on its own growth performance, its indirect impact on growth in other sectors, the extent to which poor people participate in the sector, and the sector's size in the overall economy. Agriculture is significantly more effective than non-agriculture in reducing poverty among the poorest of the poor (as reflected by the USD 1/day squared poverty gap). It is also up to 3.2 times better at reducing USD 1/day headcount poverty in low-income and resource-rich countries (including those in Sub-Saharan Africa), at least when societies are fundamentally equal. However, when it comes to the better-off poor (reflected in the USD 2/day measure), non-agriculture has the edge [9].

Smallholder livestock farming contributes to improving the livelihoods of the rural poor in South Africa and plays a vital role by providing food and has the potential to strengthen households' economy. Livestock production plays multiple roles in the lives of the poor and meets the various objectives desired by resource-poor farmers [10]. Smallholder agriculture, including the livestock sector in South Africa, has been identified as a notable vehicle to foster poverty reduction, solve household food insecurity, and enhance resilient livelihoods.

Even though smallholder agriculture has the potential to enhance resilience, the decline in average rainfall and rapid population growth have resulted in food insecurity [11]. In Sub-Saharan Africa, smallholder livestock farmers do not produce output beyond household consumption. Their output does not generate enough income nor do they engage in off-farm or non-farm income-generating activities, even in export. The insufficient production is further undermined by factors such as a lack of assets (resources), a lack of adaptive capacity, climate change (agricultural drought), a lack of social safety nets, increasing farm input prices, a lack of information, and inadequate institutional infrastructure [12,13].

International and national studies, such as those of Boukary et al. [11], Melketo et al. [14], Ogunniyi et al. [15], Chamdimba et al. [16], and Galarza [17], focus on the impact of Jatropha cultivation for resilience in food insecurity, pastoral households' resilience, rural households' resilience to food insecurity, drought impact, coping and adaptation, and socio-economic drivers of food security. However, none of the studies empirically assess smallholder livestock farmers' resilience to food insecurity in the livestock sector.

To our knowledge, no studies have specifically focused on smallholder livestock farming households' resilience to food insecurity. Therefore, this study identified factors affecting livestock farmers' agricultural drought resilience to food insecurity in Northern Cape Province, South Africa, using a survey, principal component analysis, and structural equation approach. The findings of this study could help government and policymakers to develop suitable policies and mitigation strategies to build and boost smallholder livestock farmers' resilience to agricultural drought with the alignment of the National Development Plan (NDP) of South Africa and the Sustainable Development Goal of ending hunger and poverty. The NDP considers small livestock producers as a strategy given the role of the livestock sector in food security. This work is original academic research carried out by the authors and part of an MSc dissertation by Vuyiseka A. Myeki [18] entitled "Factors affecting smallholder livestock farmers' agricultural drought resilience to food insecurity in the Northern Cape, South Africa". The University of the Free State, Bloemfontein, South Africa.

## 2. Literature Review and Conceptual Framework

The definitions and conceptual framework used to identify factors affecting livestock farmers' agricultural drought resilience to food insecurity in Northern Cape Province, South Africa, were adopted from international and national studies/literature.

There are different definitions for resilience with shared characteristics [19–22]. However, nearly all definitions stress the common elements of resilience: ability, mitigation, adaptation, coping, recovery, withstanding shocks, resistance, and bouncing back against shocks. Resilience in this study is considered to be the ability of a household to "bounce back" after exposure to livelihood threats, shocks, or stressors (such as agricultural drought and vulnerability to food insecurity).

Household resilience to food insecurity is defined as the ability of a household to maintain a certain level of well-being (food security) when faced with agricultural drought, and depends on the options available to make a living, and on the ability to handle agricultural drought. Therefore, it refers to ex ante actions aimed at reducing or mitigating agricultural drought and ex post actions to cope with agricultural drought. Thus, the options available for a household to make a living and cope with agricultural drought will determine the resilience of the household [23]. In scenarios where the ecosystems that communities depend on during shocks are vulnerable and exhibit eroding resilience, it is evident that the coping and adaptive strategies tend to overlap. Therefore, the concept of resilience stresses the dynamic nature of agricultural drought and usefully categorizes resilience into absorptive, adaptive, and transformative capacities. Absorptive capacity highlights the ability to show an initial "persisting" response to cope with agricultural drought. Adaptive capacity reflects the ability to function consistently as before in the face of incremental changes in climate change shocks, including agricultural drought. Transformative capacity reflects the ability to show a substantial changing response to agricultural drought or prolonged disturbance, including value systems, regimes, financial systems, technological systems, and biological systems [24,25].

Further, it might involve improving infrastructure, supporting social protection mechanisms, providing basic social services, or developing institutional capacity. These changes might be voluntarily chosen or forced (such as conflict forcing people to flee their country). To be successful, these transformational changes typically require shifts in economic and social policies, land use legislation, and resource management practices, as well as inclusion of various institutions and social practices [24,25].

Food insecurity is defined as a household's inability to meet target consumption levels in the face of shocks, such as agricultural drought [14]. In this paper, the concept of resilience to food insecurity refers to the adaptive capacity of smallholder livestock farmers in Northern Cape Province of South Africa.

Rockstrom [26] highlighted that social, economic, situational, and institutional preparedness to cope with stresses and shocks as well as their effects are the core mechanisms of household resilience to food insecurity. In addition, numerous studies have documented several factors determining the means and processes of achieving household resilience [27–31].

Various resilience analysis frameworks have been suggested [32]. However, Hoddinott [33] argues that the plethora of frameworks for resilience analysis have similar components. These include highlighting the broader environment in which a household (or individual or some other unit of observation) resides; the resources available to that household; how that household uses those resources; how the economic returns on those uses are affected by shocks that the household experiences; and how the outcomes of those uses lead to consumption of food and other goods and services, savings, health, nutritional status, and other such outcomes.

Therefore, resilience frameworks commonly guide studies on household resilience to food insecurity [14,34,35]. This study adopted an updated framework developed by Alinovi et al. [22,36]. Figure 1 presents the conceptual framework applied in this study. The selection of the framework is justified, because it is mainly proposed for analysis (Equations (5)–(7)) of households' resilience to food security shocks such as agricultural drought. This framework elicits the extent of resilience-building variation from one household to another and that the variation is determined by diverse factors. Factors include assets (herd/flock size (HFS); agricultural assets (AA); non-agricultural assets (NAA)), adaptive capacity (perception; source of income (Incsource); migration; credit), social safety nets (cash; training; food support; water rights; garden equipment; sanitary latrines, farm input), climate change (occurrence and intensity of drought). The factors are associated with the outcome variable of the agricultural drought resilience index (ADRI) as illustrated in Figure 1 and Equations (5)–(7).

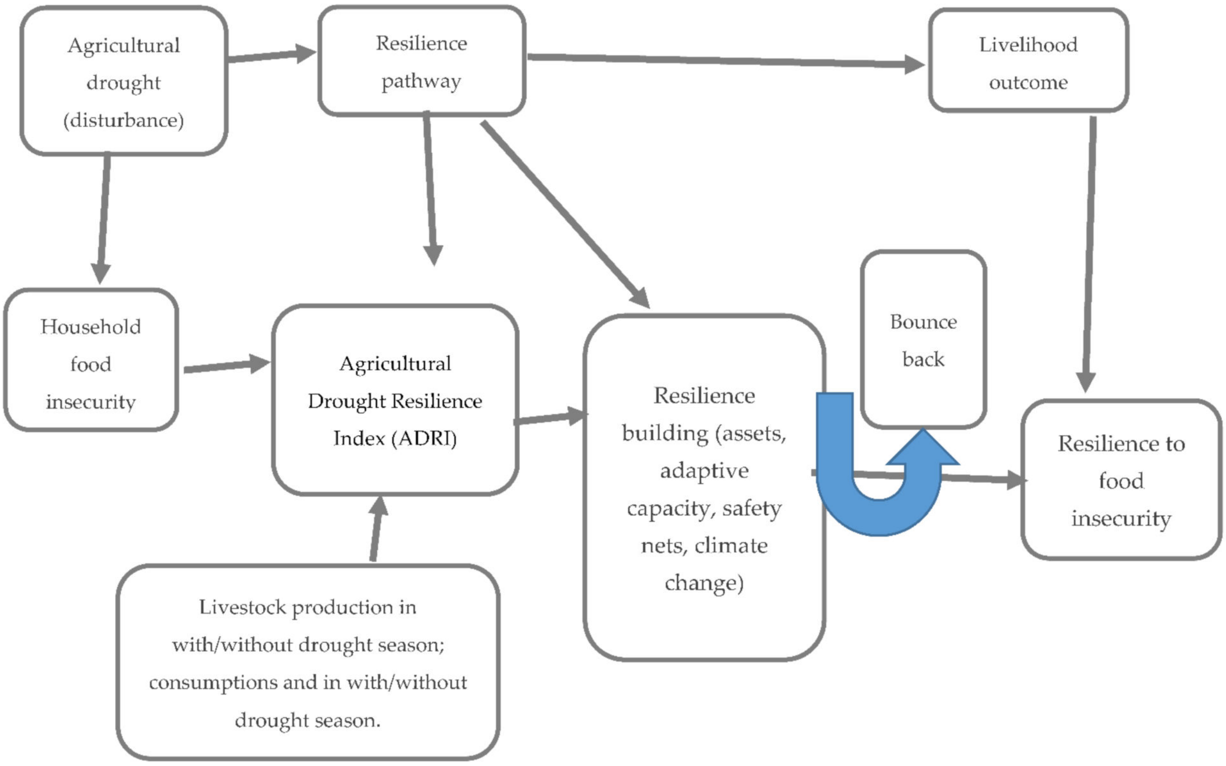


**Figure 1.** Conceptual framework of the study. Source: Authors' work from observations of various studies.

As shown in Figure 1 and Equation (5), the ADRI is calculated using principal component analysis (PCA) and variables related to livestock production and consumption with or without a drought season. Furthermore, as demonstrated in Figure 1 and Equations (6) and (7), the ADRI is determined using a structural equation model against independent variables as aggregate and disaggregate variables of assets, adaptive capacity, social safety nets, and climate change.

## 3. Materials and Methods

### *3.1. Description of the Study Area*

This study was conducted in Northern Cape Province of South Africa, in the Frances Baard District Municipality. The municipality's total geographical area is 12,384 $km^2$ and accounts for 3.4% of the total area of Northern Cape Province [37]. The study was conducted in the following four local municipalities: Sol Plaatje, Dikgatlong, Magareng, and Phokwane (Figure 2).

### *3.2. Sampling Procedure and Sample Size Determination*

A multiple-stage sampling procedure was employed. Firstly, Northern Cape Province was chosen from the nine provinces of South Africa, because most households were involved in livestock production, and the province was declared a disaster zone by the South African Government due to agricultural drought. Secondly, four district municipalities in the province were randomly selected using balloting and included Dikgatlong, Magareng, Sol Plaatje, and Phokwane.

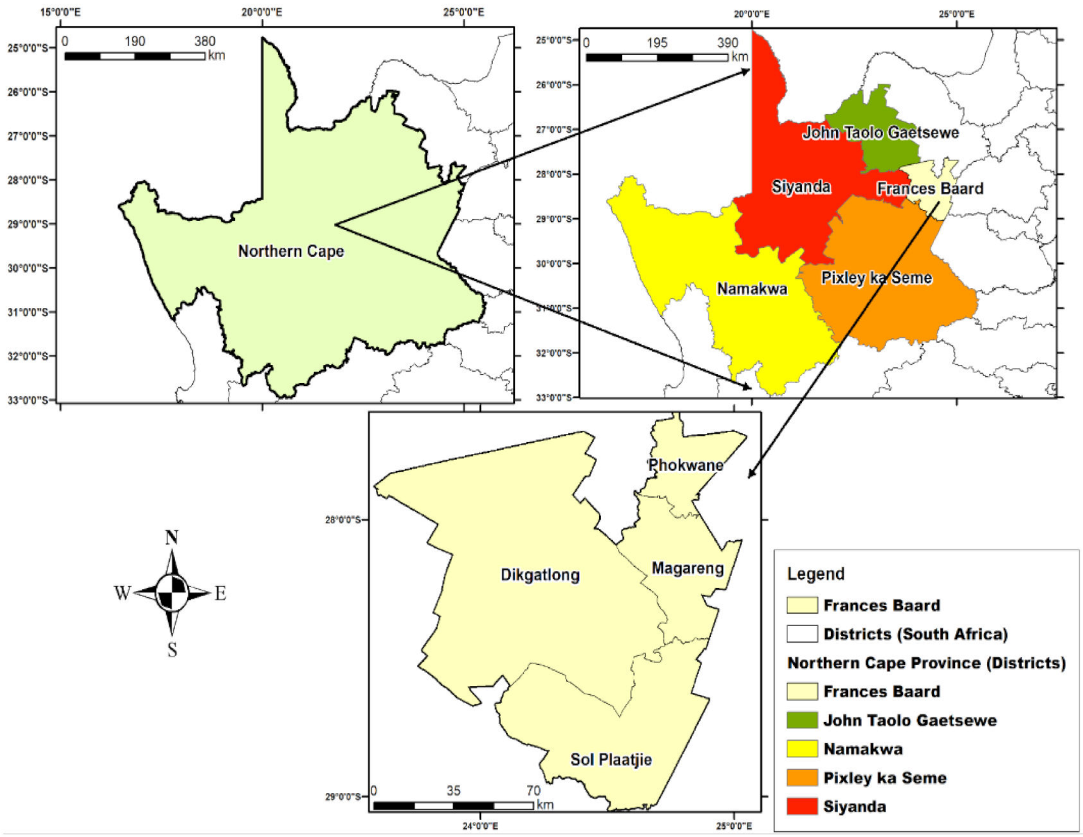


**Figure 2.** Maps of South Africa highlighting Northern Cape Province, district municipalities of the Northern Cape, and the four local municipalities of Frances Baard District Municipality. Source: FBDM [38].

Appropriate sample sizes were calculated using the simple random sampling formulae of Cochran [39] and Bartlett et al. [40]. Subsequently, 217 smallholder livestock farmers were selected from 878 farmers registered for government and local government assistance during the 2015/2016 production season (Table 1); this season was the worst drought season in South African history [41]. The assistance from the government included feed and medication for livestock, strengthening access to agricultural credit and farm input, and enhancing smallholder farmers' involvement in agricultural drought resilience activities by giving training and disseminating information.

**Table 1.** Number of farmers who received assistance from the government and sampling procedure.

| Local Municipality | Number of Smallholder Farmers | Share of Farmers (Number of Farmers/Total) % | Number of Samples (Percentage × Total Sample Size [217]) |
|---|---|---|---|
| Dikgatlong | 351 | 40 | 87 |
| Magareng | 120 | 14 | 30 |
| Sol Plaatje | 141 | 16 | 35 |
| Phokwane | 266 | 30 | 65 |
| Total | 876 | 100 | 217 |

Note: The "×" represents multiplication. Sources: Northern Cape Department of Agriculture, Forestry and Fisheries (NDAFF) [41], beneficiaries of drought relief program.

A sample of 217 smallholder livestock farmers were interviewed. Cochran's [40] sample size formula was applied to determine the correct sample size (Equation (1)):

$$\text{Sample size} = \frac{(y)^2 * (f)(g)}{(z)^2} \tag{1}$$

where y is the level of confidence/alpha level, f and g are the estimates of the variance of the population, and z is the margin of error (5% (0.05)). Therefore (Equation (2)):

$$\text{Sample size } = \frac{(1.65)^2 * (0.515)(0.515)}{(0.05)^2}\text{Sample size} = 288.3 \quad (2)$$

Resulting in a sample size of 288.3. Note that, if the sample size exceeds 5% of the population, the Cochran's correctional formula should be applied (Equations (3) and (4)):

$$\text{N1} = \frac{\text{Sample size}}{1 + (\text{N0}/\text{population})} \quad (3)$$

$$\text{N1} = \frac{288.83}{1 + (288.83/878)}\text{N1} = 217 \quad (4)$$

### 3.3. Data Collection

This research was qualitative and quantitative. Data were collected using a structured questionnaire and face-to-face interviews. The questionnaire included continuous and categorical data, which comprised socio-economic characteristics, livestock production, assets, adaptive capacity, climate change, social safety net, and other variables. Face-to-face interviews were conducted from October to December 2020 using a structured questionnaire (part of the questionnaire is available in Appendix A). Ethical clearance was obtained from the University of the Free State.

### 3.4. Analytical Procedures

#### 3.4.1. Agricultural Drought Resilience Index (ADRI)

Principal component analysis (PCA) was used to construct the agricultural drought resilience index (ADRI). Production of livestock in a normal year ($W_nP_n$), production of livestock with agricultural drought ($W_dP_d$), the number of months a household consumes food produced by the household in a normal year ($W_{cn}M_n$), and the number of months a household consumes food produced by the household in agricultural drought ($W_{cd}M_d$) were aggregated in PCA to develop the ADRI. The ADRI formula is expressed as (Equation (5)):

$$\text{ADRI} = W_nP_n + W_dP_d + W_{cn}M_n + W_{cd}M_d \quad (5)$$

where W represents each component as a weighted linear combination of the variables and is determined from the component loadings from principal components with a zero mean and unit variance.

The four variables, production of livestock produced in a normal year (Pn), livestock produced in a year with agricultural drought (Pd), the number of months a household consumes food produced by the household in a normal year (Mn), and the number of months a household consumes food produced by the household in drought (Md), were analyzed using Bartlett's test of sphericity and Kaiser–Meyer–Olkin (KMO) using SPSS software.

#### 3.4.2. Structural Equation Modeling

A structural equation model was applied to the determinants of smallholder livestock farming households' resilience to food insecurity (Table 2). The model applies a factor analysis-type model to measure the latent variables via observed variables, simultaneously using a regression-type model for the relationship among the latent variables [36,42]. The structural equation model for a household *i* is illustrated as (Equation (6)):

$$\text{ADRI}_i = f(\text{ASS}_i, \text{ADC}_i, \text{SSF}_i, \text{CH}) \quad (6)$$

**Table 2.** Description of variables used in structural equation modeling.

| Variables | Descriptions |
|---|---|
| Dependent variable | |
| Agricultural drought resilience index (ADRI) | |
| Explanatory variables | Sub-variables and description |
| Assets (ASS) | Herd/flock size (HFS) (cattle, sheep, and goats), agricultural assets (AAs) (tractors, feeding equipment, livestock trailers, water tanks, and corral systems), non-agricultural assets (NAAs) (house, television, chairs, radio, and bed) |
| Adaptive capacity (ADC) | Perception, source of income (Incsource), migration, credit |
| Social safety nets (SSF) | Cash, training, food support, water rights, garden equipment, sanitary latrines, farm input |
| Climate change (CH) | Drought occurrence and intensity |

Source: Authors' observation (2020).

Equation (6) is disaggregated in detail as (Equation (7)):

$$\begin{aligned} ADRI_i = f(&ASS_i(_{\text{herd/flock size (HFS); agricultural assets (AA); non-agricultural assets (NAA)}}), \\ &ADC_{i\ \text{(perception; source of income (Incsource); migration; credit)}}, \\ &SSF_{i\ \text{(cash; training; food support; water rights; garden equipment; sanitary latrines, farm input), herd/flock size (HFS);}} \\ &CH_{\text{(drought occurrence and intensity)}}) \end{aligned} \quad (7)$$

# 4. Results

## 4.1. Socio-Economic Characteristics of the Respondents

Table 3 depicts the socio-economic characteristics of the respondents. When it comes to farming, age is a debatable topic; the average age of the farmers was 52 years. The average formal education of smallholder livestock farmers was eight years (Table 3). The results show that 54% of the respondents had primary education, 42% secondary education, and only 4% had tertiary education.

An average of 11 years of farming experience was observed. As indicated in Table 3, the minimum length of farming experience was half a year, and the maximum was 60 years. The average number of household members was five, with a minimum of one and a maximum of 25 members. From the study's findings, 61 (28%) of the respondents were women, while 156 (72%) were men.

The majority of the respondents were married (57%), 27% single, 9% widowed, 2% divorced, 1% separated, and the remaining respondents (4%) noted other (Table 3). The findings indicated that 51% of the respondents used their family savings to support their farming business, while 8% borrowed money and 41% used other ways of supporting their farming business. Farming is considered a business entity, and thus the majority of the smallholder livestock farmers (86%) depended solely on farming, and 14% owned additional businesses. In addition, only 5% of the respondents owned additional property as a source of income besides livestock farming.

## 4.2. Respondents' Agricultural Drought Resilience Profile

As indicated, a PCA was applied to construct the outcome variable of the ADRI. Table 4 shows the communalities, component factors, and correlations of variables utilized when constructing the ADRI. All the initial commonalities were above 0.30, which was good. The component variance explained 94% of the total variance. The variables used in PCA were not inter-correlated, and Bartlett's test of sphericity and Kaiser–Meyer–Olkin (KMO) were applied. Bartlett's test of sphericity was significant ($p$-value = 0.000 with chi-square = 2224.837). As a result, the variables were suitability correlated, warranting the application of PCA, because the inter-correlation matrix did not derive from a population. The KMO was 0.64, which was above 0.5, showing that KMO was suitable for PCA. Therefore, the data set met both KMO and Bartlett's sphericity test requirements and was considered suitable for dimension reduction using PCA.

**Table 3.** Socio-economic characteristics of the respondents ($n$ = 217).

| Variables | | Frequency | Percentage | Average | Min | Max | St.dev |
|---|---|---|---|---|---|---|---|
| Age | 21–50 | 102 | 47 | 51.66 | 21.00 | 85.00 | 14.16 |
| | 51–85 | 115 | 53 | | | | |
| Education | Primary | 118 | 54.38 | 8.01 | 0.00 | 16.00 | 4.31 |
| | Secondary | 91 | 41.94 | | | | |
| | Tertiary | 8 | 3.68 | | | | |
| Farming experience | 0.5–20 | 196 | 90.32 | 10.96 | 0.50 | 60.00 | 8.85 |
| | 21–60 | 21 | 9.68 | | | | |
| Household members | 1–10 | 204 | 94 | 5.19 | 1.00 | 25.00 | 2.88 |
| | 11–25 | 13 | 6 | | | | |
| Gender | Female | 61 | 28.1 | 0.72 | 0.00 | 1.00 | 0.45 |
| | Male | 156 | 71.9 | | | | |
| Marital status | Single | 59 | 27.2 | 2.05 | 1.00 | 6.00 | 1.09 |
| | Married | 123 | 56.7 | | | | |
| | Widowed | 19 | 8.8 | | | | |
| | Divorced | 4 | 1.8 | | | | |
| | Separated | 2 | 0.9 | | | | |
| | Other | 9 | 4.1 | | | | |
| Source of farm funding | Family Savings | 111 | 51.2 | 1.92 | 1.00 | 3.00 | 0.96 |
| | Borrowings | 18 | 8.3 | | | | |
| | Other Sources | 88 | 40.6 | | | | |
| Other businesses | No | 187 | 86.2 | 0.14 | 0.00 | 1.00 | 0.35 |
| | Yes | 30 | 13.8 | | | | |
| Property owned | No | 207 | 95.4 | 0.05 | 0.00 | 1.00 | 0.21 |
| | Yes | 10 | 4.6 | | | | |

Source: Authors' compilation based on survey (2020).

**Table 4.** Correlation matrix used for agricultural drought resilience index (ADRI).

| Variables | Communalities | | Component Factors | Corr. ADRI |
|---|---|---|---|---|
| | Initial | Extraction | | |
| PN | 1 | 0.935 | 0.967 | 0.894 |
| PD | 1 | 0.958 | 0.979 | 0.995 |
| Mn | 1 | 0.280 | 0.963 | 0.890 |
| MD | 1 | 0.955 | 0.977 | 0.984 |
| Eigenvalue variances (%) = 94.402 | | | | |
| Cumulative (%) = 94.402 | | | | |
| KMO test of sampling adequacy = 0.636 | | | | |
| Bartlett's test of sphericity is significant at $p$ = 0.0000; chi-square = 2224.837 | | | | |

Source: Authors' compilation based on survey (2020).

As a result, Equation (5) is rewritten to estimate the ADRI (Equation (8)):

$$ADRI = PN * 0.967 + PD * 0.979 + Mn * 0.963 + Md * 0.977 \quad (8)$$

Based on the findings using Equations (5) and (8), Table 5 presents the ADRI of the study area. An ADRI greater than zero represents households that were resilient to drought, while ADRI less than zero represents households that were not resilient. An estimated 81% (176) of the farming households were not resilient to agricultural drought.

**Table 5.** Agricultural drought resilience index (ADRI) of Northern Cape Province of South Africa.

| | Number | Percentage |
|---|---|---|
| ADRI > 0 | 41 | 19 |
| ADRI < 0 | 176 | 81 |
| Total | 217 | 100 |

Source: Authors' estimation (2020).

### 4.3. Econometric Results (Structural Equation Modeling)

The ADRI as an outcome variable was regressed using Equation (6) at the aggregate level (general) and Equation (7) at disaggregate level against the explanatory variables to the determinants of smallholder livestock farmers' household resilience to food insecurity. A structural equation modeling approach was applied to empirically assess smallholder livestock farmers' resilience to food insecurity in Northern Cape Province of South Africa. The results in Table 6 (aggregated) and Table 7 (disaggregated) show that assets, adaptive capacity, safety nets, and climate change indicators significantly impacted households' resilience to food insecurity. ADC (β = 0.171), ASS (β = 0.150), CH (β = 0.053), and SSF (β = 0.001) contributed to the regression model. Asset, SSF, and adaptive capacity indicators positively impacted households' resilience to food insecurity and were significant at 5%. The variance inflation factor (VIF) statistics indicated that there was no multicollinearity problem in the analysis.

**Table 6.** Structural equation modeling results (aggregated).

| Variables | Unstandardized Coefficients | | Standardized Coefficients | Sig. | VIF |
|---|---|---|---|---|---|
| | B | Std. Error | B | | |
| Constant | 11.366 | 2.086 | | | |
| Assets (ASS) | 0.007 | 0.003 | 0.150 | 0.036 ** | 1.86 |
| Social safety nets (SSF) | −0.005 | 0.319 | 0.001 | 0.987 | 1.46 |
| Adaptive capacity (ADC) | 0.910 | 0.360 | 0.171 | 0.012 ** | 1.72 |
| Climate change (CH) | 0.095 | 0.127 | −0.053 | 0.454 | 1.65 |

** Significant at 5%. Source: Authors' estimation based on survey (2020).

Households' resilience to food insecurity in the Northern Cape was empirically assessed in detail (Table 7). The results indicated that HFS (β = 0.333), AA (β = 0.089), and NAA (β = −0.019) influenced households' resilience to food insecurity. Herd/flock size (HFS) and AA indicators positively impacted households' resilience to food insecurity. The HFS was the most crucial dimension compared to the other components of assets. Smallholder farmers used livestock as a coping and adaptation mechanism, because they sold livestock during agricultural drought to enhance their resilience.

Four dummy variables were used to estimate the resilience impact of adaptive capacity on food insecurity. The results in Table 7 showed that migration indicators positively impacted households' resilience to food insecurity. Migration (β = 0.037), credit (β = −0.250), perception (β = −0.181), and income source (β = −0.122) contributed to the regression model.

The results in Table 7 showed that all the social safety net indicators had a positive and significant impact on households' resilience to food insecurity. Cash (β = 0.044), training (β = 0.124), food support (β = 0.075), water rights (β = 0.111), garden equipment (β = 0.195), sanitary latrines (β = 0.037), and farm input (β = 0.145) contributed to the regression model.

The two variables that were included under climate change, focusing on drought, namely, drought occurrence and drought intensity, had a negative and significant impact at 10% on household resilience to food insecurity (Table 7). Drought occurrence (β = −0.118) and drought intensity (β = −0.021) contributed to the regression model.

**Table 7.** Structural equation modeling results (disaggregated).

| Variables | Unstandardized Coefficients | Standardized Coefficients | Sig. | Variables |
|---|---|---|---|---|
| | B | Std. Error | B | |
| Constant | 11.366 | 2.086 | | |
| Assets (ASS) | | | | |
| Herd/flock size (HFS) | 3.435 | 0.676 | 0.333 | 0.000 *** |
| Agricultural assets (AA) | 37.494 | 27.567 | 0.089 | 0.175 |
| Non-agricultural assets (NAA) | −2.795 | 9.997 | −0.019 | 0.780 |
| Social safety nets (SSF) | | | | |
| Cash | 0.038 | 0.059 | 0.044 | 0.524 |
| Training | 0.096 | 0.057 | 0.124 | 0.092 * |
| Food support | 0.060 | 0.057 | 0.075 | 0.297 |
| Water rights | 0.114 | 0.079 | 0.111 | 0.147 |
| Garden equipment | 0.271 | 0.106 | 0.195 | 0.012 ** |
| Sanitary latrines | 0.040 | 0.077 | 0.037 | 0.607 |
| Farm input | 0.118 | 0.055 | 0.145 | 0.032 ** |
| Adaptive capacity (ADC) | | | | |
| Perception | −0.154 | 0.057 | −0.181 | 0.007 *** |
| Source of income (Incsource) | −0.235 | 0.132 | −0.122 | 0.077 * |
| Credit | −0.541 | 0.155 | −0.250 | 0.001 *** |
| Migration | 0.059 | 0.113 | 0.037 | 0.603 |
| Climate change (CH) | | | | |
| Drought occurrence | −0.052 | 0.030 | −0.118 | 0.090 * |
| Intensity | −0.007 | 0.032 | −0.021 | 0.825 |

*** Significant at 1%; ** significant at 5%; * significant at 10%. Source: Authors' estimation (2020).

## 5. Discussion

The socio-economic variables, such as age, gender, sex, marital status, access to credit, and assets, were the main factors determining the enhancement of resilience to agricultural drought. It is concerning that the average age of farmers was relatively high. It meant that fewer young people were farming and mostly joined other industries. This could be due to a lack of funding for start-up farmers and the negative stigmas surrounding agriculture as a career choice. This finding is supported by Meterlerkamp et al. [43], who found that one-third of young people show a positive attitude towards farming and choose agriculture as a career.

The male household heads spent more years in school than their female counterparts. This implied that the more educated and higher-skilled individuals were likely to be the least vulnerable to climate shocks such as agricultural drought. This is consistent with the finding of Brenda [44], who highlighted that, commonly, the more educated and higher-skilled individuals of a household are likely to be the least vulnerable to climate shocks such as agricultural drought and have more adaptive capacity than less-educated farmers, because they could obtain information about climate change to assess their situation.

Gender and its impact on social and economic aspects are essential for decision making. It is clear that there is a gender imbalance in farming, agreeing with the study of Matlou and Bahta [45]. Marital status is critical in the determination of the level of involvement in farming. Married household heads can make better decisions during agricultural drought with the assistance of their partners. This finding is in line with a study by Ngeywo et al. [46], who found that the youth who dedicate their energy to farming as a business are denied a chance to do so, because they believe they are not responsible enough if they are not married.

Access to credit or funding is the main challenge for smallholder farmers in Africa, including South Africa. The findings indicated that only a few respondents had access to credit. This finding is in line with the study of Bahta et al. [47]. They highlight that access to credit enhances the working capital of households and resilience to agricultural drought. The majority of the respondents depended on farming. Diversification of income helps to enhance the resilience of smallholder farmers when shocks (such as agricultural drought) occur. However, a minority of farmers owned additional property; this indicated that most smallholder farmers were not resilient to shocks such as agricultural drought. These findings concurred with the findings of Maltou and Bahta [45].

Results from the ADRI indicated that the majority of the respondents were not resilient to agricultural drought. This suggests that smallholder livestock farmers need assistance from the government and different stakeholders in industry to enhance their resilience. The assistance could be feed for livestock (fodder), medication for livestock, strengthening access to agricultural credit and farm input, as well as enhancing smallholder farmers' involvement in agricultural drought resilience activities by giving training and disseminating information. This finding is in line with the study of Matlou and Bahta [45].

The structural equation modeling result indicated that assets, adaptive capacity, safety nets, and climate change indicators significantly impacted households' resilience to food insecurity. This implied that the more assets a farming household owned, the higher the resilience to agricultural drought. These findings are consistent with literature stating that having more assets may increase a household's resilience to food insecurity [11,13–16,48]. Further, the literature also indicates that resilience is the key to enhancing adaptive capacity [49].

The social safety net refers to benefits and protects vulnerable households from the risk of food insecurity. All the social safety net indicators (cash, training, food support, water rights, garden equipment, sanitary latrines, and farm input) had a positive and significant impact on households' resilience to food insecurity. The finding indicates that benefiting from the social safety net provides support for individual households. Our findings concurred with Mane et al. [50], Boukary et al. [11], Szabo et al. [48], and Shah and Dulal [51].

Climate change (drought occurrence and intensity) had a negative and significant impact on household resilience to food insecurity. Indeed, the Northern Cape climate is characterized by hot summers (between 34 °C and 40 °C) and cold winters (below zero nightfall temperatures and frost). Coupled with low rainfall (mean annual precipitation of 200 mm), the climate is consistently dry, which leads to the reduction of livestock production. The findings concur with Shah and Dulal [51], who indicated that a climate shock such as agricultural drought affects food production.

## 6. Conclusions

This study identified factors affecting livestock farmers' agricultural drought resilience to food insecurity in Northern Cape Province, South Africa. A principal component analysis was applied to estimate the agricultural drought resilience index. A structural equation model was then applied using a survey of 217 smallholder livestock farmers.

The study found that most (81%) smallholder livestock farmers were not resilient to agricultural drought. The study also showed that asset, social safety net, and adaptive capacity indicators positively and significantly impacted households' resilience to food insecurity. However, climate change indicators had a negative and significant impact on households' resilience to food insecurity. This implied that the more assets a farming household owned, the higher the resilience to agricultural drought. The findings further indicated that benefiting from the social safety net provided support for individual households. Indeed, the Northern Cape climate is characterized by hot summers (between 34 °C and 40 °C) coupled with low rainfall (mean annual precipitation of 200 mm). The climate is consistently dry, which leads the reduction of livestock production. As a result, the government needs to strengthen the drought relief program for affected smallholder farmers by supplying fodder, medication, and farming inputs, and strengthening access to agricultural credit.

The study suggests that smallholder livestock farmers need assistance from the government and various stakeholders to minimize vulnerability and boost their resilience to food insecurity. They should target disadvantaged smallholder farmers to build their resilience by enhancing their persistence and adaptability. The government may help smallholder livestock farmers to gather resources to acquire more assets and reduce vulnerability to food insecurity via strengthening access to agricultural credit and farm input. Additionally, the government should address viable off-farm employment as a source of income, and strengthen social safety nets, which include smallholder farmers' involvement in agricultural drought resilience activities by giving training and disseminating information.

Furthermore, the government could improve water rights and access to boost the resilience of smallholder farmers to agricultural drought. This could be achieved through collaboration and coordination among all stakeholders. This includes coordination between monitoring agencies in terms of reliable early warning data, communicated in a comprehensive way to decision makers, farmers' organizations such as the African Farmers' Association of South Africa (AFASA; AFASA is very active in Northern Cape Province of South Africa), and the private sector, such as banks, to strengthen the resilience of farmers against shocks.

Collaboration with national and provincial governmental departments should also be strengthened. This includes collaboration with the Department of Agriculture, Forestry and Fisheries (DAFF), provincial Departments of Agriculture, National and Provincial Disaster Management Centres (NDMC and PDMC), the Department of Water Affairs (DWA), and the South African Weather Service (SAWS).

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## Appendix A

**1. Socio-economic characteristics of the respondents**

| | |
|---|---|
| 1.1 How old is the household head (age): | |
| 1.2 Gender: | Female = 0 and Male = 1 |
| 1.3 Marital Status: | Single = 1, Married = 2, Widowed = 3, Divorced = 4, Separated = 5 and Other = 6 |
| 1.4 Educational level (years spent at school) | |
| 1.5 How long have you been farming/farm experience? | |
| 1.6 Where do you get funding for your farm business? | Family savings = 1, Borrowings = 2, and Other = 3 |
| 1.7 How many household members are staying in the household? | |

**2. Assets at household home and farm.**

Do you own any of the following assets? How many of the following assets do you own (specify the number)?

| Asset | | Number of Assets |
|---|---|---|
| **2.1 Herd/Flock Size (HFS)** | | |
| 2.1.1 Cattle | No = 0 and Yes = 1 | |
| 2.1.2 Sheep | No = 0 and Yes = 1 | |
| 2.1.3 Goat | No = 0 and Yes = 1 | |
| 2.1.4 Chicken | No = 0 and Yes = 1 | |
| 2.1.5 Pig | No = 0 and Yes = 1 | |
| 2.1.6 Others | | |
| **2.2 Agricultural Assets (AA)** | | |
| 2.2.1 Tractor | No = 0 and Yes = 1 | |
| 2.2.2 Feeding equipment (feed mixer) | No = 0 and Yes = 1 | |
| 2.2.3 Livestock trailer | No = 0 and Yes = 1 | |
| 2.2.4 Water tank | No = 0 and Yes = 1 | |
| 2.2.5 Corral system | No = 0 and Yes = 1 | |
| 2.2.6 Others | No = 0 and Yes = 1 | |
| **2.3 Non-Agricultural Assets (NAA)** | | |
| 2.3.1 House | No = 0 and Yes = 1 | |
| 2.3.2 Television | No = 0 and Yes = 1 | |
| 2.3.3 Chairs | No = 0 and Yes = 1 | |
| 2.3.4 Radio | No = 0 and Yes = 1 | |
| 2.3.4 Bed | No = 0 and Yes = 1 | |
| 2.3.5 Others | No = 0 and Yes = 1 | |

**3. Social Safety Net**

Do you or did you receive any of the following benefits?

| Support Type | Response | | Support from where? |
|---|---|---|---|
| 3.1 Cash | No = 0 and Yes = 1 | | |
| 3.2 Training | No = 0 and Yes = 1 | | |
| 3.3 Support for food | No = 0 and Yes = 1 | | |
| 3.4 Vegetable gardening equipment | No = 0 and Yes = 1 | | |
| 3.5 Sanitary latrine (toilet) | No = 0 and Yes = 1 | | |
| 3.6 Farm inputs (feed, medication, etc.) | | No = 0 and Yes = 1 | |
| 3.7 Water rights | | No = 0 and Yes = 1 | |
| 3.8 Others | | | |

**4. Adaptive Capacity**

| Adaptive capacity<br>4.1 Credit | Questions | Response |
|---|---|---|
| 4.1.1 Institution (financial institution) | 4.1.1.1 Do you have access to credit? If yes, how effective is the support from the institutions? | No = 0 and Yes = 1 |
| 4.2 Perception | | |
| 4.2.1 Perception of risk | 4.2.1.1 Do you believe that the climate is changing to the extent that it will affect your livestock production? | No = 0 and Yes = 1 |
| 4.3 Income source | | |
| 4.3.1 Employment | 4.3.1.1 How many members of your household are employed?<br>4.3.1.2 How do they contribute during the drought? | |
| 4.3.2 Business | 4.3.2.1 Is there any other business the household is doing besides farming? If yes, please specify<br>4.3.2.2 How does the business contribute to your farm during drought year? | No = 0 and Yes = 1 |
| 4.4 Migration | | |

| Adaptive capacity<br>4.1 Credit | Questions | Response |
| --- | --- | --- |
| 4.4.1 Migration<br>4.2.2 Other options | 4.1.1.1 Is migration is an adaptive option during the drought?<br>4.4.1.2 If no, do you have any other options available? What are they? | N0 = 0 and Yes 1 |

**5. Climate change**

Do you usually experience agricultural drought in your community? (Yes/No), if yes.

| Climate change | Questions | Response |
| --- | --- | --- |
| 5.1 Drought occurrence | When was the last time drought occurred? (less than 12 months = 1, less than 5 years = 2, and more than 5 years = 3) | |
| 5.2 Drought intensity | Do you think the intensity of this drought is: (worse than the previous droughts = 1; similar to the previous droughts = 2; better than previous droughts = 3) | |

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