A decision support system for institutional support to farmers in the face of climate change challenges in Limpopo province

Priscilla Ntuchu Kephe¹,²,*, Kingsley Kwabenya Ayisi³, Brilliant Mareme Petja¹,²,³

¹ Department of Geography and Environmental Studies, University of Limpopo, Private Bag X1106, Sovenga, 0727, Polokwane, South Africa
² Risk and Vulnerability Science Centre, University of Limpopo, Private Bag X1106, Sovenga, 0727, South Africa
³ Water Research Commission, Private Bag X03, Gezina, 0031, Pretoria, South Africa

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ABSTRACT

Smallholder farmers in South Africa continue to be affected by the changing climate despite the existence of support to improve their adaptive capacity. This study focused on the institutional support systems and support types available to farmers in agro-ecological zones of Limpopo Province and assessed support types best suited to each area. Six hundred farmers were purposively sampled across the agro-ecological zones of Limpopo and interviewed. Support types looked at included monetary, machinery, seeds, educational support and others (irrigation scheme, animals, fertilizer, pesticides). Supporting institutions included Agro finance institutions, DAFF, Banks, and NGOs. Results showed that 70.01% of farmers received support from DAFF 25.60% from NGO’s and 4.39% from Agro finance institutions. The most number of support received was two types 33.3% of the farmers. The result from the ANOVA showed that there were no significant differences in the level of difficulty experienced by farmers in accessing the various support institutions across the agro-ecological zones. In terms of the various support types received, there was a statistically significant difference in seeds (p = 0.002 < α = 0.05) and educational (p = 0.0001 < α = 0.05) support received between the different areas. Furthermore, the support needs varied across zones with farmers in arid-zone needing machinery, education, seeds and lastly monetary support while the semi-arid zone needed machinery, education, others, seeds, monetary and the humid, machinery, education, others, money and seeds. It is therefore recommended that support for farmers should be location-specific in order to enhance the adaptive capacity of an area and not be based only on the availability of certain support. There is a need for proper coordination between institutions in their aim to assist farmers to cope with climate change.

1. Introduction

Institutional support across the Limpopo province needs to be structured in such a way that farmers get the much-needed assistance to continue producing under a changing climate. According to Maponya and Mpandeli (2012), institutional support, both technical and financial (e.g. inputs, technology transfer and capacity building, drought mitigation, historical rainfall distribution information and market trends) are important factors which influence farmers’ productivity. The majority of farmers in the Limpopo province are resource-poor (Maponya and Mpandeli (2012)) who are highly dependent on the services of Agricultural Extension Officers. However, they do not have the required amount of inputs and resources necessary for optimal production. This limitation, coupled with the local effects from climate change (e.g. droughts of 1982/83, 1987/88, 1991/92, 1994/95, 2002/03, 2008/09 and 2015/16, floods: 1923, 1940, 1955, 1967, 1980, 2000, 2011, 2013, 2014, 2016 (Agricultural Disaster Management Policy, 2011; Bureau for Food and Agricultural Policy (BFAP), 2011) as well as bushfires increase the vulnerability of the farmers. Besides climate change other challenges facing farmers in the Limpopo Province have been well documented (e.g. Azan and Besley, 1991; Makhura, 2001). These challenges place the farmers in a difficult situation, where they are unable to produce enough to generate income to undertake various adaptation options. The challenges are not unique to Limpopo province alone, as they have been cited to affect other provinces such as the Eastern Cape, Mpumalanga, Free State as well (Mpandeli, 2006).

Addressing the challenges faced by farmers is paramount if sustainable productivity is to be carried under the current climate stresses.

* Corresponding author.
E-mail address: kprissy@gmail.com (P.N. Kephe).

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Adaptation projects therefore attempt to bring stakeholders operating at different levels into cooperative arrangements (institutions) in order to administer resources that cut across current jurisdictional boundaries (Agrawal and Perrin, 2009; Bulkeley, 2016; Eakin and Lemos, 2010; Stripple and Bulkeley, 2013). While the promotion of cooperative arrangements sounds perfectly reasonable, in many contexts, however according to Nightingale (2017) it is these institutional rules and relationships precisely that are intensely contested. Forsyth (2005) states that even though design principles of institutions are important, the success or failure of the institutions has less to do with them. Rather the success or failure of institution is dependent on the interplay of social and political struggles within them (Forsyth, 2005). This shows that success or failure of the institutions has less to do with them. Rather the success or failure of institution is dependent on the interplay of social and political struggles within them (Forsyth, 2005). This shows that success or failure of institution is dependent on the interplay of social and political struggles within them (Forsyth, 2005). This shows that success or failure of institution is dependent on the interplay of social and political struggles within them (Forsyth, 2005). This shows that success or failure of institution is dependent on the interplay of social and political struggles within them (Forsyth, 2005). This shows that success or failure of institution is dependent on the interplay of social and political struggles within them (Forsyth, 2005).
is to serve the agricultural needs of farmers around areas of access to resources, output markets as well as providing a legal and operational framework (Ortmann and King, 2006; DAFF, 2012). All the support types offered have an intended benefit to be obtained. Thus, if farmers can have access to adequate support services, rainfed agriculture can make a difference by increasing agricultural growth, farm income and improved livelihood.

Studies have been conducted to investigate the negative impacts of climate change on smallholder farmers and their adaptation strategies (e.g. Hosu et al., 2016; Ubisi, 2016) and on institutional support in Limpopo (e.g Mapony and Mpandeli, 2012), however, there is very little information on the support type available to farmers in Limpopo and how accessible these supports are. Sufficient work has not been done with regards to assessing farmer support programmes in practice in South Africa in general and Limpopo in particular, even though R46 billion has been allocated to provincial farmer support programmes from 2010 to 2020 and stated objectives of government programmes set to provide support to 300,000 smallholder farmers. Furthermore, there is very little information on the institutions offering such supports. Therefore, this study aims to explore the types and number of supports available to smallholder farmers from various institutions aimed at bolstering their adaptation strategies towards climate change interventions and support systems in Limpopo province. It further aims to recommend suitable supports that can be geared where they make the most difference.

2. Materials and methods

2.1. Description of the study area

2.1.1. Climate

This study was carried out in the Limpopo province of South Africa. The province is made up of four distinct climatic zones. These are the subtropical plateau characterised by a flat elevated interior area hot and dry with winter rain; a moderate eastern plateau with warm to hot and rainy summers and cold dry winters; the escarpment region with colder weather because of the altitude and rain all year round and the subtropical Lowveld region with hot-rainy summers and warm-dry winters.

Rainfall in the province occurs mostly between the months of October to April and ranges from 200mm in the hot dry areas to 1500mm in the high rainfall areas. There is high annual rainfall variability in the provinces as well as extreme weather events (Tennant and Hewitson, 2002; Cook et al., 2004). The three climatic regions in the province include (i) the Lowveld region characterised by a semi-arid climate(s), (ii) the Middle and Highveld classified as semi-arid, and (ii) Escarpment that experiences sub-humid climate (Limpopo Department of Agriculture (LDA), 2008). The province experiences long sunny days and dry weather conditions on most days. The uneven rainfall distribution and high-temperature regimes in the province results in high evaporative water demand and generally low crop-water-use efficiency (Mzezewa et al., 2010).

2.2. Data collection

A quantitative research method with close-ended questions was employed in this study. The aim was to compare responses across the participants because all participants were asked identical questions in the same order to allow for a significant comparison of responses across participants and study sites (Crossman, 2017). Questionnaires were administered to individual farmers to provide information on the support systems available to them to cope with the climatic and non-climatic challenges.

2.2.1. Sampling technique

The population who participated in this study comprised of farmers residing in Limpopo province. A purposive random sample of 600 smallholder farmers participated in this study in order to cover different agro-ecological zones. 200 participants were targeted from each agro-ecological zone in the province (Figure 1). A criterion to select the participating sample was set as follows: the respondents were individual smallholder farmers, practicing crop production and depended on rainfall. Relevant departments in each local municipality provided a list fitting the stated criteria and smallholder farmers were randomly selected. A stratified random sample was used to ensure that each agro-ecological zone was represented.

![Image](image-url)  
**Figure 1.** Agroecological zones for Limpopo Province and sample sites. Source: Adapted from Harvest Choice, 2010.
selected from bases on agro-ecological zones in Limpopo. The sampling was used to assess uniformity and homogeneous characteristics and to meet the objectives of the study, and it had to adhere to the statistical specifications for accuracy and representatively.

2.2.2. Questionnaires

Questionnaires were used to collect information about climate change interventions and support systems in place in Limpopo and the ease with which they were made accessible to the farmers. The questionnaire was pre-tested in a pilot study so as to minimize errors and format unclear questions. A pilot study was conducted on a sample of farmers in each of the agro-ecological zones. This process helped in structuring the interview procedures and modifying the questions. In the pilot-testing process, space was provided for criticism and suggestions to improve the items. The questionnaire was tested on its usefulness, question clarity, language used, and consistency. After testing, the questionnaire was revised based on field experience and all corrections and advice incorporated. Farmers from the study population who were not included in the pilot study were interviewed to test the reliability of the instrument. All procedures performed in this study involving human participants were in accordance with the ethical standards of the University of Limpopo research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

Farmers were interviewed in their respective languages. An interview was the preferred data collection method for this study because it was anticipated that many farmers in the study area were unable to read and write. A hundred percent response rate was achieved given that interviews were scheduled to accommodate selected respondents in terms of availability and language of communication.

2.2.3. Data analysis

Microsoft Excel 2010 statistical package and its add-on Xlstats 2018.2 were used to analyse the data. Collected data were coded to provide a general overview of which institutional support the farmers were receiving and how accessible they were. Descriptive statistics on the number of institutions giving support and the types of support received across the three agro-ecological zones in Limpopo was carried out. Statistical indicators such as frequencies, percentages, means, standard mean errors and standard deviation were computed. The focus on the descriptive statistics was on counts of farmers receiving supports, how many of the various support types were each farmer receiving and which institutions were doing the most in terms of farmer support as well as the variation in terms of support types and the number of support received per zone. A factor analysis was used to evaluate the support factors which were the most important. An analysis of variance (ANOVA) was done to show the variation between the types of support received per area. A test of significance was done to determine the similarity between zones.

3. Results

Results from this study aimed at answering the question on the types of support types available to farmers across the three agro-ecological zones in Limpopo, which institutions were offering such support and

| Institution | Agro finance | Seeds | Machinery | Education | Others |
|-------------|--------------|-------|-----------|-----------|--------|
| Arid        | 0            | 12.5  | 0         | 0         | 0      |
| Semi-arid   | 0            | 7.5   | 20        | 0         | 0      |
| Humid       | 10           | 28.5  | 37.5      | 0         | 0      |

Table 1. Support institutions and support types received by farmers across three agro-ecological zones in Limpopo.
In Table 3, the number of supports received by farmers across the three agro-ecological zones in Limpopo is presented.

3.1. Support institutions and support types received by farmers

Table 1 and Figure 2 show the various types and sources of support received by the farmers in Limpopo. Support types include monetary supports, seeds, machinery, educational support, and others. The institutions offering support to farmers in the area were Agro Finance institutions, Banks, DAFF, and NGOs. Results showed that DAFF gave 70.01% of support to farmers followed by NGOs (25.60%) and Agro Finance institutions (4.39%). From the supports given by DAFF, 10.44% of the farmers received monetary support, 26.12% seeds, 21.63% machinery, 26.12% educational support and 15.67% from irrigation schemes, livestock and/or fertilizers. A total of 42.85% of the farmers got seeds, 28.57% educational support and 28.57% got other types of supports from NGOs. It can be seen that most support received by farmers was in terms of seeds (66.67%) followed by semi-arid (33.33%) and 25% receiving only one support type. Most farmers receiving all support types were found in the arid area (10.5%) followed by the semi-arid area (3.5%).

3.2. Number of supports received

The results in Table 2 indicate that amongst the total number of help types received, an average of 2.2% of farmers was not receiving any type of support. Amongst the three zones, the humid area had the highest percentage of farmers not receiving any form of support. The highest number of support types received was 2 types across the three zones with 33.3% and 25% receiving only one support type. Most farmers receiving all support types were found in the arid area (10.5%) followed by the semi-arid area (3.5%).

3.3. Ease of accessing support institutions

Results in Table 3 show that farmers experience challenges in accessing the support institutions. Only 5.8% of the population can access the Agro Finance institution with ease with the humid area having most of the farmers accessing this institution with ease. All farmers in the area said it was very difficult to access banks, while 67% and 69.5% said it was difficult to access DAFF and NGOs respectively.

3.4. Ease of accessing loans from a financial institution

Table 4 shows the result of the ease with which farmers can access loans from financial institutions in Limpopo. Results indicate it is very difficult for farmers to access such facilities. Across the three regions, above 60% of the farmers cannot access loans from financial institutions. In the arid areas 14% of the farmers can access loans, while in the semi-arid and humid, it showed 16% and 20% respectively.

3.5. Variation in support types across institutions and agro-ecological zones

Tables 5 and 6 show the output of the ANOVA analysis and whether there is a statistically significant difference between the ease with which farmers across the various agro-ecological zones had access to support institutions and support types respectively. Results in Table 5 show a significant of 0.47 for Agro Finance, 0.55 for DAFF and 0.68. Given that these values of significance are greater than 0.05 (i.e., p = 0.05), was low disparity among the respondents concerning the level of access to public agricultural extension and advisory services.

### Table 2. Number of support types received by farmers across three agro-ecological zones in Limpopo.

| Number of Support type | % of farmers receiving support in Arid area | % of farmers receiving support support in the semi-arid area | % of farmers receiving support in Humid area | % of farmers across all three zones receiving support |
|------------------------|------------------------------------------|----------------------------------------------------------|--------------------------------------------|-----------------------------------------------------|
| 0                      | 2                                        | 2                                                        | 2.5                                        | 2.2                                                 |
| 1                      | 17.5                                     | 25.5                                                     | 32                                         | 25.0                                                |
| 2                      | 33                                       | 33                                                       | 34                                         | 33.3                                                |
| 3                      | 20                                       | 23                                                       | 19                                         | 20.7                                                |
| 4                      | 17                                       | 13                                                       | 10                                         | 13.3                                                |
| 5                      | 10.5                                     | 3.5                                                      | 2.5                                        | 5.5                                                 |
| Grand Total            | 100                                      | 100                                                      | 100                                        | 100                                                 |

### Table 3. Ease with which farmers access support institutions in three agro-ecological zones in Limpopo.

| % of farmers accessing support in Arid area | % of farmers accessing support in Semi-arid area | % of farmers accessing support in Humid area | Total % of farmers accessing support |
|--------------------------------------------|-----------------------------------------------|-------------------------------------------|-------------------------------------|
| Agro Finance 5                             | 5                                             | 7.5                                       | 5.8                                 |
| Banks 0                                    | 0                                             | 0                                         | 0                                   |
| DAFF 34                                    | 31                                            | 34                                        | 33                                  |
| NGO 29                                     | 29.5                                          | 33                                        | 30.5                                |

On average, the standard error of the mean was 0.040, which was quite low. The standard deviation was 0.575, which showed that how support types and the total number of support varied across the zones as well the ease to which farmers accessed support types.

### Table 4. Ease with which farmers access financial support from financial institutions in three agro-ecological zones in Limpopo.

| Institutions | Very easy | Somewhat easy | Easy | Not very easy | Not easy at all |
|--------------|-----------|---------------|------|---------------|-----------------|
|              | Arid area | Semi-arid area| Humid area | Arid area | Semi-arid area | Humid area | Arid area | Semi-arid area | Humid area | Arid area | Semi-arid area | Humid area |
| Agro Finance | 0         | 0             | 0     | 0             | 0               | 0       | 35       | 31.5          | 33.5       | 69       | 66.5           | 64.5       |
| Banks        | 0         | 0             | 0     | 0             | 0               | 0       | 41       | 31.5          | 31.5       | 66       | 65             | 65         |
| cooperatives | 0         | 0             | 0     | 0             | 0               | 0       | 14       | 16            | 20         | 17.5     | 21             | 20         |
therefore, there is a statistically insignificant difference in the level of difficulty in accessing the various support institutions across the agro-ecological zones.

Table 6 shows that support types in terms of monetary (.012), machinery (0.09) and other support types (0.62) there was no statistically significant difference between these support types across the different agro-ecological zones given that the values were higher than \( p = .005 \). However, there are a statistically significant difference in seeds (0.002) and educational (0.0001) support types received between the different areas. This is so given that the significance values obtained are than \( p = 0.05 \).

3.6. Support types needed by farmers

The Kaiser-Meyer-Olkin (KMO) (Table 7) was used to assess sampling adequacy and evaluation of any correlations, which is acceptable at values \( >0.500 \). The result from Table 7 shows a KMO value of 0.67, 0.78 and 0.81 for the Arid, Semi-arid and humid areas respectively. This means the sample data could be used to perform a factor analysis. The Cronbach’s alpha was 0.84(Arid), 0.90(Semi-arid) and 0.91(Humid) suggesting that the sample is statistically correlated with high reliability.

As shown in Table 2 it is not always going to be possible for all farmers to receive more than one type of support. But if institutions were to work together, they could make sure that each farmer received some type of support or better still more than one support type. Factor analysis was used to get the most important help type needed by farmers as well as factors that can work together to enhance farmer’s adaptive capacity. Results from the factor analysis, Table 8, show that machinery support was the most important factor towards farmer’s adaptive capacity across all three zones.

In the arid region, the most important support type is machinery, followed by others, education, seeds and lastly monetary support. In the semi-arid regions, the most important support type for farmers is machinery, followed by education, others, seeds, and money. In the humid area, machinery loaded the highest followed by education, others, money and seeds.

The result from Table 8 further shows that the support needs vary between the agro-ecological zones. It, therefore, means that support has to be site-specific and relevant to the needs of the farmers in that area. Furthermore, it is worthwhile for each of the key players to work together based on their type of support and the area within which they are operating. For example, in the arid area where there is a strong correlation between education and seeds DAFF and NGOs can work closely together so that they pull their resources together and reach many more farmers.

Evidence from Table 9 shows there is a statistically significant difference between the various areas of the different agro-ecological zones. This is seen in the significant value of the chi-square 1 which is greater than the \( \alpha \)-value 0.05. To reiterate this \( p \)-value for Wilks’ \( G^2 \) is compared with the \( \alpha \)-value. With a \( p \)-value of 0.99 (Table 9) which is greater than \( \alpha = 0.05 \), the null hypothesis which states that the means are independent is accepted.
3.7. Discussions

The South African government has dedicated resources for enhancing farmer’s resilience to climate change through various support schemes operating at national and provincial levels. Besides government interventions, the non-governmental sectors also play their role in assisting farmers. However, despite these best intentions, farmers such as those in Limpopo find it difficult to get access to these resources that could make a
Table 7. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of support types in three agro-ecological zones in Limpopo.

| Area          | Support type | Semi-arid area | Humid area |
|--------------|--------------|----------------|------------|
| Arid Monetary| 0.539012     | 0.260437       | 0.358396   |
| Arid Seeds   | 0.70481      | -0.58056       | 0.734206   |
| Arid Machinery| 0.900081    | 0.434636       | 0.876024   |
| Arid Education| 0.764503   | -0.5478        | 0.753925   |
| Arid Others  | 0.869904     | 0.34072        | 0.871943   |
| Semi-arid Monetary| 0.636556  | 0.494949       | 0.405203   |
| Semi-arid Seeds   | 0.754645   | 0.710145       | 0.569489   |
| Semi-arid Machinery| 0.927924  | 0.806316       | 0.861044   |
| Semi-arid Education| 0.869807  | 0.804422       | 0.756564   |
| Semi-arid Others  | 0.863223     | 0.776786       | 0.745154   |
| Humid Monetary| 0.671018     | 0.474638       | 0.450265   |
| Humid Seeds   | 0.507419     | 0.262673       | 0.257474   |
| Humid Machinery| 0.988201    | 0.981714       | 0.976541   |
| Humid Education| 0.981327    | 0.979104       | 0.963003   |
| Humid Others  | 0.959075     | 0.89           | 0.919825   |

Area | Support type | F1 | Initial communality | Final communality | Specific variance |
|------|--------------|----|---------------------|-------------------|------------------|
| Arid | Monetary      | 0.539012 | 0.260437 | 0.358396 | 0.358361 | 0.641638554 |
| Arid | Seeds         | 0.70481  | -0.58056 | 0.734206 | 0.833805 | 0.166195147 |
| Arid | Machinery     | 0.900081 | 0.434636 | 0.876024 | 0.999054 | 0.000946069 |
| Arid | Education     | 0.764503 | -0.5478 | 0.753925 | 0.884553 | 0.115446629 |
| Arid | Others         | 0.869904 | 0.34072 | 0.871943 | 0.872824 | 0.127176191 |
| Semi-arid Monetary | 0.636556 | 0.494949 | 0.405203 | 0.594797 |
| Semi-arid Seeds | 0.754645 | 0.710145 | 0.569489 | 0.430511 |
| Semi-arid Machinery | 0.927924 | 0.806316 | 0.861044 | 0.138956 |
| Semi-arid Education | 0.869807 | 0.804422 | 0.756564 | 0.243436 |
| Semi-arid Others | 0.863223 | 0.776786 | 0.745154 | 0.254846 |
| Humid Monetary | 0.671018 | 0.474638 | 0.450265 | 0.549735 |
| Humid Seeds | 0.507419 | 0.262673 | 0.257474 | 0.742526 |
| Humid Machinery | 0.988201 | 0.981714 | 0.976541 | 0.023459 |
| Humid Education | 0.981327 | 0.979104 | 0.963003 | 0.036997 |
| Humid Others | 0.959075 | 0.89 | 0.919825 | 0.080175 |

Table 8. Factor Analysis of support types in three agro-ecological zones in Limpopo.

Cronbach's alpha: 0.981327 Machinery 0.988201 Education 0.979104 Others (irrigation, animals, fertilizers) 0.963003

Table 9. Test of significance.

| Chi-square (Observed Value) | 2.215 |
| Chi-square (Critical value) | 24.996 |
| DF                          | 15    |
| p-value                     | 1.000 |
| alpha                       | 0.05  |
| Wilks' G² (Observed value)  | 3.151 |
| Wilks' G² (Critical value)  | 24.996 |
| DF                          | 15    |
| p-value                     | 0.999 |
| alpha                       | 0.05  |

3.7.1. Seed support

The availability of seeds to farmers can best be explained through the concept of seed security. This concept, as ingrained in the Seed Security Framework entails the need for a sufficient quantity of seed of target crops within reasonable proximity, and in time for sowing, periods to be made available for farmers (Sperling et al., 2006). Therefore, where farmers receive the needed seed support, they have the potential to improve yield. In the case of Limpopo, the most support received by farmers was in the form of seeds (72.5% of farmers in the arid, 57.5% in the semi-arid and 70% in the humid zones) as seen in Table 1. Looking at the support needs of the farmer, Based on the factor analysis, seeds are not among the most important support types for farmers, as they are ranked 4th in arid and semi-arid zones, whereas they are last in humid zones. This might mean that the farmers have means of which to get seeds and that seeds are not the most important input to booster their level of adaptation.

3.7.2. Machinery support

Agricultural productivity is closely related to machinery and investments in all aspects of agricultural activity (Andriy and Prokopenko, 2017). In its Least Developed Countries Report, the United Nations indicated the level of mechanization in agricultural production as one of the major indicators of agricultural productivity (2015). According to Sims and Kienzle (2006) mechanization is a key input in any farming system. The aim of mechanization amongst others is to increase productivity per unit area through improved timeliness of farm operations; expansion of the areas under cultivation where land is available as well as the improvement of the quality of work and products. This might explain why in Table 9, machinery loaded the highest with regards to support type the farmers needed across all the three zones. Studies such as Agarwal (1981); Clare Bishop-Sambrook (2005) and Faleye et al. (2012) show that mechanization helps not only in increasing productivity but also in improving the quality of all the farm operations and final products. Furthermore, the FAO and World Bank (2009) reporting on agricultural production in the Kyrgyz Republic showed that lack of mechanization amongst other factors negatively affects aggregate agricultural production output.

Nevertheless, acquiring agricultural machinery alone cannot ensure productivity as well as climate change mitigation and adaptation without additional measures. This is seen in the study of Faleye et al. (2012) who
posit that a number of minimum conditions of mechanization have to be in place in order to ensure efficient small farm functioning. These conditions include aspects of farm suitability, simple design and technology, affordability and accessibility and the provision of support services from the government. Unfortunately, amongst the smallholder farmers in Limpopo, most of these conditions are not met. Firstly as seen in Table 1, very few farmers had support in terms of machinery from the government. Secondly, the success of mechanization is dependent on the inclusion of agricultural extension and advisory efforts which are essential for the operationalization of any mechanization and sustainable farming system, mitigation and adaptive measures. However, this aspect is minimally met given that in terms of educational support only 66.5% of farmers in the arid, 48.5% in the semi-arid and 37.5% in the humid zones are supported. This means only a small percentage of farmers are getting educational support and the majority would not have been able to function with machinery had they been given since they would have been lacking in knowledge on operating them. It is essential that investment is made in terms of agricultural machinery with an aggregate support system given that it has been proven to be effective and highly advantageous for agricultural and economic development in general (e.g. Stavrytsky and Prokopenko, 2017).

3.7.3. Educational support

Nelson and Phelps (1966) posit that a better-educated farmer is quicker to adopt profitable new processes and products given that they are aware that the expected payoff from innovation is likely to be greater. Education enhances a farmer's ability to know his alternatives, to know when and where to buy and sell, proper farm management procedures specific to the crops cultivated such as tillage, fertilizer application. Most farmers in rural areas such as those in Limpopo are not privy to the most up-to-date information on efficient food production, cost-effective means of as well as the proper implementation of adaptation techniques to a changing climate. The question which arises with cases such as the resource-poor farmers in Limpopo is how they get the necessary education needed for optimum production and adaptive capacity to a changing climate. A possible solution that has also been cited by Rosegrant and Cline (2003) will be that of enhancing their understanding of new techniques and technologies and also providing them with any physical resources necessary for implementation. From that perspective, a look at the Strategic Plan for South African agriculture (National Department of Agriculture (NDA), 2001) shows that the national and provincial departments of agriculture are committed to the provision of extension support to land reform beneficiaries. Extension services are particularly necessary where plots are intensively farm because they cannot be expanded easily (Machethe and Mollel, 2000). In South Africa, agricultural extension services serve as an important link between small-scale farmers and the Department of Agriculture (Jacobs, 2003). This might explain why in Table 1, most support received by the farmers is from DAFF. Table 1 further shows that of the 600 farmers surveyed, only 58.33% of the farmers were receiving educational support. Across the zones, DAFF is supporting less than half of the population (46.5% in the arid, 28.5% in the semi-arid and 27.5% in the humid zones) and NGOs provide additional educational support (20% in the arid, 20% in the semi-arid and 10% in the humid zones). Furthermore, Table 6 shows there is a significant difference in the total number of farmers receiving educational support amongst the zones. Granting the South African government promotes access to agricultural extension and advisory services by the farmer, lack of access is still a reality at the grassroots level as seen in Limpopo. This situation can be as a result of vast numbers of people requiring assistance, the relatively few and inadequately trained and resourced extension workers (DAFF, 2012) thereby increasing officer to farmer ratios. DAFF estimates that the percentage of small-scale farmers reached through the extension service grew from 8% in 2010, but was still at just 14% in 2012/13 (DAFF, 2015). Also given that there is no regulatory framework within which the delivery of extension and advisory service takes place (DAFF, 2014) extension and advisory services face major challenges in the areas of relevance, efficiency, accountability and sustainability in South Africa (DAFF, 2014).

Given that extension is the conscious communication of information to help people form sound opinions and make good decisions (Van den Ban and Hawkins, 1996; facilitates the access to knowledge, information, and technologies by farmers, farmers organizations and other market actors; facilitates farmer’s interaction with research partners, educational institutions, agribusiness, and other relevant institutions; and further assists them in the development of their own technical, organizational and managerial skills and practices (Christopoulos, 2010) then smallholder farmers in Limpopo are disadvantaged because they are not able to adequately benefit from educational support services through extension as has been seen by the low number of farmers receiving such support.

With regards to its importance to farmers in Limpopo, agricultural educational support services ranked third in the arid zone, second in the semi-arid and humid zones. Hence Extension programs aimed at increasing knowledge have the potential to increase the adoption of technology (Sasa, 2009; Oni et al., 2011). Furthermore, an increase in the frequency of extension visits to impart information could result in increased productivity and income generation (Ackello-Ogutu, 2011).

3.7.4. Fertilizer, irrigation schemes

Fertilizers are commonly believed to be as important, and contribute up to 50% of the growth in output (Tomich et al., 1995). It is advocated that the fundamental ways in which agricultural productivity can be improved, especially in sub-Saharan Africa are to increase the productivity of agriculture through the use of farmer consultations and providing inputs, such as seeds, fertilizers, pesticides and the use of modern agricultural technology (Wanyama et al., 2009). Afzal and Ahmad (2009) show that stable fertilization leads to improved crop yields and agricultural income. However, these support factors are not adequately distributed amongst farmers in Limpopo. Of the farmers surveyed only 31.5% received these support types in the arid zone, 30% in the semi-arid and 34.5% in the humid zones respectively. In terms of support types needed, this support type loaded highly as seen in Table 9, loading as the second most important need in the arid, third most important in the semi-arid and humid zones respectively. The need for these type of support especially irrigation can be because of the climatic stresses especially drought which plagues this area as well as deficiencies in infrastructures and poor institutional support which (e.g. Machethe et al., 2004; Tlou et al., 2006; Van Averbeke et al., 2011; Fanadzo, 2012) involved in irrigation projects across South Africa.

3.7.5. Ease of accessing support institutions and credit facilities

There is no consensus on the extent to which monetary support as well as financial service provision such as credit, can help farmers adapt to a changing climate. This may be caused by the difficulty in measuring the impact of credit on poverty reduction. However, it is generally accepted that monetary support and financial services may assist farmers either directly or indirectly thereby having a spill down effect on the challenges faced by farmers in a changing climate. Zeller and Sharma (1998) believe that credit facilities may assist smallholder farmers to tap financial resources beyond their means thereby taking advantage of potentially profitable small business opportunities.

In Limpopo, the ease of getting support and accessing financial institutions is quite daunting to farmers. Table 2 shows that most farmers (33.3%) received two types of support. This is low considering that there are non-governmental and governmental institutions committed to supporting farmers in the area. From their responses as seen in Table 3, DAFF was the easiest institution to get support from followed by NGOs. Amongst the zone, the farmers experience similar levels of difficulties in getting support from the institution, showing that there is a problem various with role players carrying out their responsibilities adequately.
Table 4 shows that cooperatives are the easiest to access in terms of obtaining loans. However, only 14%–16% of the farmers were able to access and obtain loans from cooperatives. Banks and microfinance institutions were not easily accessible. This situation might be as a result of farmers having to comply with certain requirements prior to receiving support. For example, the support criteria outlined in the Limpopo Department of Agriculture and Rural Development’s (DARD) Farmer Support Policy provide a sense of the requirements when applying for and receiving grants (Limpopo Department of Agriculture and Rural Development (DARD), 2016). Small-scale farmers need to show proof of secure tenure, a completed farm assessment report and feasibility study, proof of business registration, operational records, a detailed business plan, proof of tax registration, and market contracts or letters of intent to buy. On the other hand, Department of Rural Development and Land Reform’s (DRDRL) One Household, One Hectare initiative, requires the farmer’s production plan with cash flow projections before they are considered for financial support (DRDRL, 2016).

The inability to get adequate types and financial support places significant constraints on these farmers in both the opportunities forgone and their inability to mitigate risk and adapt to climate change. Furthermore, this constraint has proved to impede on the farmers’ ability to innovate (Griffin et al., 2002, 2017) and hence can be concluded that they will not be open to suggestions of adaptation. According to Kandlinkar and Risbey (2000) since most farmers in Africa are operating under resource limitations: (a) Lack of credit, (b) Subsidies, and (c) Insurance will accelerate farmers’ failure to meet transaction costs necessary to acquire adaptation measures as a result of unexpected weather patterns.

Studies such as that of Deressa et al. (2009) and Maddison (2007) have cited the difficulty of obtaining credit by farmers, as a crucial factor in determining the ability of farmers to adapt to climate change. In other settings, for example, credit markets are an important feature of Pakistan’s rural agricultural economy owing to the range of different types of lenders that offer credit (Aleem, 1990). Therefore, easy access to credit may offset the effects of climate and play a crucial role in making the difference between being vulnerable and not. Improved access to agricultural credit and savings may help those with limited assets to invest in agricultural technology or land improvements, such as high-yielding seeds and chemical inputs that increase incomes. This opinion has been echoed by Asiedu and Fosu (2008) who think credit is a very important component in the modernization of agricultural activities. Furthermore, credit is seen as the backbone of any business, especially for agriculture, which has traditionally been a non-monetary activity for the rural population (Abedullah et al., 2009). Modern agricultural technology is necessary for national and economic development, and the use of such technology in rural economies is only possible when farmers are provided with credit for the purchase of modern technological inputs (Schultz, 1980). Hence agricultural credit is an integral part of the process of the modernization of agriculture.

Both commercial and subsistence farming is subject to climatic effects, but compared to commercial agriculture, smallholder farmers are more vulnerable to climate change and usually do not have access to financial instruments such as credit and insurance to hedge against climatic risk. As has been shown by studies such as Wild and Zivertogel (2012) and Nhemachena and Hassan (2007), farmers with access to credit and markets have greater chances of adapting to changing climatic conditions. This is because being able to access affordable credit, farmer’s financial resources are increased as well as their ability to meet transaction costs associated with the various adaptation options they might want to take. With more financial and other resources at their disposal farmers can change their management practices in response to changing climatic and other factors and will be able to make use of all the available information they might have on changing conditions both climatic and socioeconomic factors. For instance, with financial resources and access to markets, farmers can change their cropping calendar, chose appropriate cultivars, crop varieties, invest in new irrigation technologies, and change their practices to suit the forecasted and prevailing climatic conditions. At individual farm levels, adaptation will involve a combination of various individual responses and assumes that farmers have access to support infrastructures, alternative practices, and technologies available in the region. The support types available in Limpopo and the departments providing such supports appear good on paper but in implementing their stated objectives to a certain degree, they have failed.

4. Conclusion

The study revealed that both public and private institutions have significant roles to play in supporting farmers’ adaptive capacity to a changing climate in the Limpopo Province. These roles include generation of appropriate educational, timely information and technology, ensuring that information and technology are available to the intended party for use, assistance with production inputs, facilitate access to financial institutions as well as supplying the adequate number of supports towards farmer’s sustainability. Furthermore, with properly tailored policies and implementation of such policies, smallholder farmers can adapt to climate change and improve their crop production. To do this, policies need to factor in potential adaptations methods to climate change when farmers are given adequate support as well as taking into consideration what support types are relevant to a particular area. In this regard, interventions of the South African government should focus on the needs of farmers and not a one size fits all model for institutional support.

Hence, planning and financing adaptation to climate change requires an understanding of current conditions of what is available to farmers in the form of support in each area, how many support types are available to each farmer and how accessible these support institutions are. It also requires an understanding of how the various levels of governance enable or hinder local actors to improve their wellbeing. Knowing the what, how, when and where of climate change and the options for support towards adaptation, will allow for well-informed decision-making by farmers, policymakers and practitioners. These spatiotemporal dimensions and multi-actor perspectives promise relevant insights for achieving sustainability less haphazardly. Institutional frameworks and actions can thus hinder or facilitate adaptations (Dolan et al., 2001). In the case of Limpopo, institutions are falling short of their intended objectives of farmer support.

Based on the findings of this study the following recommendations can be put forward with regards to the various support factors:

- Given the current poor reach of extension services in Limpopo, better public-private partnerships should be developed and improve better coordination in such partnerships so that every farmer gets the necessary educational support.
- • The government needs to implement a coherent extension policy to advance a varied system of extension providers. Given that climate change impacts are diverse, vulnerability is place-specific and adaptation requirements are diverse, there are various benefits from having various providers. This will mean the delivery of advice, technology, and innovations as well as facilitating services will be available from varied sources. Such a strategy requires putting in place of new and appropriate mechanisms for financing and/or co-financing the needs of farmers. Also, most importantly, it will require putting in place adequate mechanisms that will enhance the quality of services provided by diverse institutions. To effectively pursue such a strategy, the government needs to better understand the nature of the existing support services to design policies that will be supportive of a pluralistic system. It is also necessary that the government conducts a survey that will help in creating an inventory of key players and stakeholders, what they provide, whom they provide, assess the quality of the services they render before deciding on the type of reform necessary.
• Moreover, the success in fulfilling the public-private sector partnerships potential in South Africa is dependent on the creation of new ways to break down barriers to support systems through which the farmers can benefit such as less stringent rules for accessing support institutions or obtaining loans from financial institutions.

Declarations

Author contribution statement

P. N. Kephe: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

K. K. Ayisi, B. M. Petja: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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The authors declare no conflict of interest.

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References

Abdulai, N., Mahmood, N., Khalid, M., Kouser, S., 2009. The role of agricultural credit in the growth of livestock sector: a case study of Faisalabad. Pakistan Vet. J. 29 (2), 81–84.

Ackello-Ogutu, C., 2011. Managing food security implications of food price shocks in Africa. J. Afr. Econ. 20, 100–141.

Adger, W., Dessai, S., Goodland, M., Hulme, M., Lorenzoni, I., Nelson, D., Wreford, A., 2009. Are there social limits to adaptation to climate change? Climatic Change 93 (3–4), 335–354.

Afzel, N., Ahmad, S., 2009. Agricultural input use efficiency in Pakistan: key issues and reform areas. Manag. Nat. Resour. Sustain. Pract. Agric. Res. Brief. 1 (3), 1–12.

Agarwal, B., 1981. Agricultural mechanisation and labour use: a disaggregated approach. Int. Lab. Rev. 120, 115–127.

Agarwal, A., Ferrini, N., 2009. Climate adaptation, local institutions and rural livelihoods. In: Adger, W., Lorenzoni, I., O'Brien, K. (Eds.), Adapting to Climate Change: Thresholds, Values, Governance. Cambridge University Press, Cambridge, pp. 350–367.

Aleem, I., 1990. Imperfect information, screening, and the costs of informal lending: a study of a rural credit market in Pakistan, World Bank Econ. Rev. 4 (3), 329–349.

Asiedu, E., Fou, K.Y., 2008. Importance of agricultural credit in Ghana’s credit sector: a logit model analysis. In: Paper Presented at World Bank and ADB Conference European Journal of Political Economy, Vol. 5, pp. 331–343 (PDF Download Available). Available from: https://www.researchgate.net/publication/269687523_C onstraints_and_Challenges_Facing_the_Small_Scale_Farmers_in_Limpopo_Province_South_Africa; (Accessed 30 April 2018).

Azan, J.P., Besley, T., 1991. Peasant Supply Response under Rentioning: the Role of the Food Market. BFAP, 2011. The Contribution of the Agro-Industrial Complex to Employment in South Africa. BFAP, Pretoria.

Biglari, B., Bierbaum, R., Stults, M., Dobardzic, S., McNeely, S.M., 2014. A typology of adaptation actions: a global look at climate adaptation actions financed through the Global Environment Facility. Global Environ. Change 25, 97–108.

Bishop-Sambroof, C., 2005. Contribution of Farm Power to Smallholder Livelihoods in Sub-saharan Africa. Food and Agriculture Organization of the United Nations, Rome, Italy, p. 87.

Bryan, E., Desera, T.T., Geibhubo, G.A., Ringler, C., 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. Environ. Sci. Pol. 12, 413–426.

Bulkeley, H.K., 2016. Accomplishing Climate Governance. Cambridge University Press.

Christopoulos, L., 2010. Mobilizing the Potential of Rural and Agricultural Extension. Neuchatel Group.

Cook, C., Reason, C.J., Hewitson, B.C., 2004. Wet and dry spells within particularly wet and dry summers in the South African summer rainfall region. Clim. Res. 26 (1), 17–31.

Crossman, A., 2017. How to Conduct a Research Interview: A Brief Introduction to the Research Method. ThoughtCo. Retrieved from: https://www.thoughtco.com/in-de pth-interview-3025355.

Department of Agriculture, Forestry and Fisheries (DAFF), 2011. National Framework For Extension Recovery Plan. Communications Directorate, Pretoria.

Department of Agriculture, Forestry and Fisheries (DAFF). 2012. A Profile of the South African Chevon Market Value Chain, the Year Book 2011/12. DAFF, Pretoria.

Department of Agriculture, Forestry and Fisheries (DAFF), 2014. Norms and Standards for Extension and Advisory Services in Agriculture.

Department of Agriculture, Forestry and Fisheries (DAFF). 2015. Strategic Plan 2015/16 to 2019/20. DAFF, Pretoria.

Desresa, T.T., Hassan, R.M., Ringler, C., Alemu, T., Yesuf, M., 2009. Determinants of farmers’ choice of adaptation methods to climate change in the Nile Basin of Ethiopia. Global Environ. Change 19, 248–255.

Dolan, A.H., et al., 2001. Adaptation to Climate Change in Agriculture: Evaluation of Options. University of Guelph, Department of Geography, Guelph (Occasional Paper 26); online: http://adaptation.uanrc.ca/projdb/pdf/3b_e.pdf.

Department of Rural Development and Land Reform (DRDRL), 2016. Policy on One Housewel, One Hector Initiative. DRDRL, Pretoria.

Eakin, H., Lemos, M.C., 2010. Institutions and change: the challenge of building adaptive capacity in Latin America. Glob. Environ. Change 1 (20), 1–3.

Eakin, H.C., Pant, A., 2011. Are adaptation studies effective, and what can they enhance their practical impact? Wiley Interdiscip. Rev. Clim. Change 2 (2), 141–153.

Eriksen, S.H., Nightingale, A.J., Eakin, H., 2015. Reframing adaptation: the political nature of climate change adaptation. Global Environ. Change 35, 523–533.

Faleyre, T., Adejija, J., Faroussi, A., 2012. Improving small-farm productivity through appro–private partnerships in Nigeria. Int. Res. J. Agric. Sci. Soil Sci. 2 (9), 386–389.

Available at: http://www.interjournals.org/IJIAS.

Fanadzo, M., 2012. Revitalisation of smallholder irrigation schemes for poverty alleviation and household food security in South Africa: a review. Afr. J. Agric. Res. 7 (3), 1956–1969.

FAO & World Bank, 2009. The Kyrgyz Republic: Farm. Mechanization and Agricultural Productivity. FAO Investment Centre; Food and Agriculture Organization of the United Nations, Rome, Italy, p. 74.

Ferris, S., Robbins, F., Best, R., Seville, D., Buxton, A., Shriver, J., Wei, E., 2014. Linking smallholder farmers to markets and the implications for extension and advisory services. MEAS Brief 4 (10), 13–14.

Forstyh, T., 2005. Building deliberative public–private partnerships for waste management in Asia. Geoforum 36 (4), 429–439.

Griffin, K., Khan, A.R., Ickowitz, A., 2002. Poverty and the distribution of land. J. Agrar. Chang. 2 (3), 279–293.

Griffin, T.W., Miller, N.J., Bergtold, J., Shanoan, A., Chardia, A., Ciampiati, L.A., 2017. Farm-scale’s sequence of adoption of information-intensive precision agricultural technology. Appl. Eng. Agric. 33, 521–527.

Hoss, S.Y., Gaba, E.N., Luswazi, P.N., 2016. Vulnerability to climate change in the Eastern Cape province of south Africa: what does this future holds for smallholder crop farmers? Agron Res 55 (1–2), 133–167.

Jacobs, P., 2003. Support for Agricultural Development. Institute for Poverty and Environment Studies (PLAES).

Kabuho-Mariara, J., 2008. Global warming and livestock husbandry in Kenya: impacts and adaptations. Ecol. Econ. 68, 1915–1924.

Kandlinkar, M., Risby, J., 2000. Agricultural impacts of climate change: if adaptation is the answer, what is the question? Climatic Change 45, 529–539.

Limpopo Department of Agriculture, 2008. Background [Online] Available: http://www.limpopo.gov.za/index.php?option=com_content&view=article&id=60&Itemid=55.

Limpopo Department of Agriculture and Rural Development (DARD), 2016. Farmer Support Policy. Limpopo DARD, Polokwane.

Macthee, C., Molle, N., 2000. Extension and support services for smallholder agricultural development in South Africa who is the smallholder farmer? In: Cousins, B. (Ed.), At the Crossroads: Land and Agrarian Reform in South Africa into the 21st century. Programme for Land and Agrarian Studies, University of the Western Cape/ND(C)ional Committee, Cape Town/Johannesburg, pp. 340–348.

Macthee, C.L., Molle, N.M., Ayisi, K., Martinola, M.B., Anim, F.D.K., Vanasche, F., 2004. Smallholder Irrigation and Agricultural Development in the Olifants River Basin of Limpopo province: Management, Transfer, Productivity, Profitability and Food Security Issues. Report to the Water Research Commission on the Project “Sustainable Local Management of Smallholder Irrigation in the Olifants River Basin Limpopo Province.” Pretoria, South Africa.

Maddison, D., 2007. The perception of and adaptation to climate change in Africa (No. 4308), policy research working paper, Pretoria, South Africa. Available at: http://econ.worldbank.org.

Mackay, M.T., 2001. Overcoming Transaction Costs Barriers to Market Participation of Smallholder Farmers in Limpopo Province of South Africa. Published Ph.D. Thesis, University of Pretoria.

Maponya, P., Mpandeli, S., 2012. Climate change and agricultural production in South Africa: impacts and adaptation options. J. Agric. Sci. 4 (10), 48–60.

Måleksa, T.K., 2009. Economic and distributational impacts of climate change: the case of Ethiopia. Global Environ. Change 20, 278–286.
