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An assessment of climate-smart agriculture (CSA) practices skills amongst extension practitioners in South Africa

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ABSTRACT

One of the roles of extension services is to link farmers to the developers of technological solutions (research outputs). Extension officers act as facilitators and assist farmers in their decision-making and technology adaptation. With the changing climate threatening production resources, extension officers need to encourage farmers to adopt various climate-smart agriculture (CSA) practices. The paper seeks to reflect on a study by the Agricultural Research Council (ARC) to assess their skills and knowledge about climate change and CSA. The study aimed to conduct a skills audit on CSA and related concepts. Through a stratified sampling method, all extension practitioners (EPs) registered with South African Council for Natural Scientific Professions (SACNASP) were included in the survey. The survey, administered through a user-friendly tool (online google forms), was developed to investigate: familiarity with, and current skills in climate-smart agriculture and collect biographic information, field of responsibility (e.g. cropping, livestock and mixed farming). Both quantitative and qualitative data was sourced through the survey tool to draw generalized conclusion and perceptions of how best to improve the capabilities of EPs on CSA. The results of the survey showed that EPs had a theoretical understanding of climate change and CSA. Generally, EPs across all positions, education levels, age categories and experience could identify the correct definition and cause of climate change, despite the fact that the majority had not received any CSA training. On the contrary, the majority of respondents had little understanding of how best to apply the CSA approach in practice, to assist farmers curb the effects of climate change. A CSA training programme was developed to establish a strong theoretical base, together with an understanding of the challenges presented by climate change and climate variability to sustainable agriculture in South Africa.

Keywords: Climate-Smart Agriculture, skills, agricultural extension services

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1. INTRODUCTION

The agriculture sector has to produce more food to meet the needs of the growing population, as it looks set to be negatively impacted by climate change (FAO, 2013). Agriculture as a sector is most vulnerable to climate change with many threats, including the reduction in agricultural productivity, production instability and limited means of coping with adverse climate impacts. Most estimates indicate that climate change is likely to threaten income amongst societies already suffering from food insecurity, and high rates of poverty (Behnassi, Boussaid & Gopichandran, 2014). To successfully address climate change issues, the agricultural sector must become climate-smart. This includes promoting and adapting to technologies and practices that address the issue of climate change. Climate-smart approaches must be developed to both mitigate and adapt to the effects of climate change on crop production, as well as on livestock production and health as well as to reduce the greenhouse gas production from livestock. FAO (2010) defines Climate-Smart Agriculture (CSA) *"as set of agricultural practices that when applied accordingly will result in an increase in agricultural production and systems resilience while reducing greenhouse gas emission"*. CSA incorporates a wide range of agricultural practices such as crop diversification, the use of drought resistant crop varieties, as well as conservation agriculture (Muriithi, *et al.*, 2021). CSA promotes the transformation of agricultural policies and agricultural systems to increase food production, to enhance food security, to ensure that food is affordable (low input-cost) while preserving the environment and ensuring resilience to a changing climate (FANRPAN, 2014).

One of the roles of extension services is to link farmers to the developers of technological solutions; meaning to researchers. Extension officers act as facilitators and assist farmers in their decision-making and technology adaptation. With the changing climate threatening production, extension officers need to encourage farmers to adopt relevant applicable practices which are reconcilable with CSA principles. Amongst many, CSA practices include precision farming, tillage, mulching, organic fertilization, cultivar selection etc. The extensionist is responsible for providing the knowledge and information that help enable a farmer to understand and make a decision about a particular innovation (Stevens, 2012). This then means since Extension Practitioners' (EPs) role is to disseminate information to farmers in order to influence decision-making, they ought to be lifelong learners by equipping themselves with skills needed for the changing situations and emerging problems. Agricultural extension officers are principal stakeholders for engaging farmers and guiding them on approaches to increase productivity, particularly during unreliable climate conditions caused by climate change (Motlopi, 2019). A study conducted by Simelane, Terblanche & Masarirambi (2019) identified one of the challenges faced by EPs as the lack of rigorous workshops and in-service training to capacitate these officials with skills to keep up with technological developments and emergence of complex challenges. These authors suggested that a solution to this challenge was to assist through further trainings and workshops tailor-made to address emerging challenges.

This paper seeks to reflect on a study conducted by the Agricultural Research Council (ARC) to assess the skills and knowledge of public sector Extension Practitioners about climate change and CSA.

Why Climate-Smart Agriculture

Agriculture is one of the most important economic sectors especially among rural communities (FAO, 2011). FAO estimates that the sector employs about 60% of the African workforce with an average contribution of about 30 percent to the gross domestic product, while being a major livelihood source especially for the poorest rural communities in Africa (FAO, 2012a). It cannot be overstated that agriculture will experience severe impact especially amongst resource poor farmers, as greenhouse gas emissions increase causing increase in mean temperature, and changes in rainfall patterns. Agriculture will also be affected by increased variability of both temperature and precipitation; as well as increased frequency and intensity of extreme weather events such as droughts and floods (FAO, 2012a; Kurukurasuriya and Rosenthal, 2003; Mendelsohn *et al*. 2006; and Thornton and Cramer, 2012; Steinfield *et al*. 2006;). In fact, with limited adaptation capacity (i.e. finance, social, natural, physical and human capital), the effects of climate change and climate variability will be exacerbated especially among the resource-poor smallholder farmers (FAO, 2012a). The Food and Agriculture Organization of the United Nations (FAO, 2012a) and International Panel of Climate Change (IPCC, 2007), projects that severe reductions in crop yields are expected especially in Africa where rural households are highly dependent on rain-fed agriculture. Furthermore, the FAO (2012a) estimates that the number of undernourished people (globally) already exceeds one billion. With the current and projected reduction in yields, feeding the world now and in the future will therefore require more than incremental changes in yields (FAO, 2012a). Climate change and the rising food consumption demands driven by global population growth, equally demand great commitment and innovative approaches to water management and conservation as a production recourse for the agricultural systems.

In South Africa, numerous challenges persist among smallholder farmers who are generally less organized and do not possess the necessary human, financial and physical capacity to cope against climate induced risks and shocks (Frank and Buckley, 2012). Climate change and climate variability introduce a relatively new set of challenges to the smallholder agriculture sector in South Africa, threatening a further decline to an already compromised rate of productivity. Indeed, while agriculture is significantly vulnerable to climate change, equally, the sector is a major contributor to global greenhouse gas emissions as well as a major driver of deforestation and land-use change (IPCC, 2007; Steinfield *et al*. 2006). According to Vermeulen *et al*. (2012), the bulk of the estimated 19 to 29 per cent of global greenhouse gas emissions is contributed by food systems across the developing world. Consequently, farmers need to adapt and adopt innovative and sustainable agricultural production systems and practices that reflect an appreciation of the current and projected future climate. Since South Africa's ratification of the United Nations Convention for Climate Change (UNFCCC) in 1997 (UNFCCC, 1997) and the Kyoto Protocol in 2002 (UNFCCC, 1992), the country has made

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recommendable strides relating to climate change mitigation and adaptation. The UNFCCC and the Kyoto Protocol call for governments to develop appropriate policies and action plans and to share best practices and information on climate change mitigation and adaptation with national and international partners (UNFCCC, 1992; Kyoto Protocol, 1998). This has translated into numerous national and local climate change adaptation planning and action initiatives involving multiple actors in South Africa. For example, the establishment of the Adaptation Network in 2009 as a creative platform to share experiences, practical approaches and frameworks relating to climate change adaptation by individuals, civil society, government, parastatals, academia and business. Noticeably however, a great deal of challenges persists at the grassroots level, especially for the smallholder agricultural sector. Climate-smart agriculture (CSA) has recently been identified as one of the most innovative and comprehensive solutions for climate change mitigation and adaptation while ensuring sustained productivity and resilient livelihoods. CSA includes agricultural practices and interventions that simultaneously adapt to climate change and contribute to mitigate climate change, while also promoting sustainable food systems that are efficient, using less land, water, and inputs (FAO, 2010). CSA effectively builds on the justification that it can simultaneously achieve the triple-win benefits of mitigation, adaptation and food security (FAO, 2012b).

2. RESEARCH PROCESS

2.1. Development of the survey tool

A survey questionnaire was developed as the primary data collection tool. The questionnaire was designed to collect both quantitative and qualitative information including biographic information, CSA conceptualisation information; CSA competency skills as well as the application of CSA skills to understand climate change and climate variability, adaptation and mitigation. The areas of focus in the study included, cropping, livestock, fisheries, agroforestry, and water management as the foundational framework to assess the EPs' CSA skills. Within the questionnaire, three distinct forms on crops, livestock and mixed farming were developed, to help channel the respondents to questions addressing their work focus and expertise. Furthermore, and as part of the project scope, the skills matrix was also benchmarked against the Extension Norms and Standards (DAFF, 2005). It was noted however that the extension Norms and Standards do not cover areas of climate change and climate-smart agriculture in particular.

A national workshop for validation of the desktop analysis and final review of the research tools was hosted with national stakeholders. This stakeholder workshop (attended by government, civil society, private sector, research, universities, development partners, extension, etc.) was to aid in the validation of the literature review findings and the draft skills matrix emanating from the survey. The outcome of the national workshop was a comprehensive skills framework against which the audit was conducted to determine the gaps and opportunities as well as the survey questionnaire as the data collection tool.

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2.2. Testing and improving

The survey questionnaire was further developed into both an online (google forms) and hard copy. The questionnaire was then sent out for testing among a small group of project steering committee members and other stakeholders including EPs from a non-participating province. The testing was meant to pre-test the framing of questions, nature of the response induced by each question, the ease of understanding and weak points in the survey. The information acquired from the pre-testing process was then used to improve the survey prior to broadcasting through to the targeted extension practitioners (EPs).

2.3. Distribution of the questionnaire

As stated in the project scope, the target participants of the skills audit were to be registered with the South African Council for Natural Scientific Professions (SACNASP) or at least with a pending application for registration. As such, the survey questionnaire was distributed to 1372 EPs, including 948 active members and 424 pending registration with SACNASP. The survey was distributed electronically through email by the ARC, the SACNASP registration office, as well as directly through the Department of Agriculture, Forestry and Fisheries (DAFF).

2.4. Analysing and validation survey results

The results were consolidated and coded as they were received. The ARC Biometry team assisted with the data analysis. The analysis employed a strong element of qualitative analysis also assisted by the stakeholder validation workshops hosted at national and provincial levels (Limpopo, KwaZulu Natal and Free State Provinces). The validation workshops were also used to collect inputs for the proposed training plan.

3. RESULTS

3.1. Extension practitioners’ demographic information

Various demographic profile elements related to the surveyed Extension practitioners are presented in Table 1. The findings in Table 1 show that, more than 90% of the participants in the survey fall between the age group of 26 to 55 years, with the highest percentage (34%) in the age group of 36-45 years, that is considered the working age. The study also comprised only 4% in the elderly group (56-65), this could be because most people retire or were promoted after the age of 56 years. The young generation group (18-25 years) contribute only 1.7% of the respondents, understandable as other fellow age mates are still at school or university or just entering the working environment. There were more male participants at 56.2%, while the females contributed 43.5% of the sample size (Table 1).

TABLE 1: Extension practitioners' demographic information (n=299)

Profile	**Classification**	**Frequency (%)**
Gender	Female	43.5
	Male	56.2
	Non-disclosure	0.3
Age (in years)	18-25	1.7
	26-35	30.4
	36-45	33.8
	46-55	30.1
	56-65	4
Qualifications	Advanced Diploma	1.7
	Bachelors	51.5
	Honours	14.4
	Masters	12.7
Experience	0-3 years	17.7
	3-6 years	14.4
	6-10 years	19.7
	More than 10 years	48.2
Registration with SACNASP	Yes	83
	No	17

Majority of the study respondents (48%) had more than 10 years' experience working in extension (Table 1), a factor that could make the adoption of CSA easier or more difficult. Easier in that, the respondents have a higher level of trust by their farmers, aiding in the adoption; more difficult in that the officials may be averse to changing farming practices in favour of CSA. The study also indicates that the majority of the participants have a bachelor's degree qualification (Table 1). Lastly, at least 83% of survey participant are registered with SACNASP.

3.2. Perceived causes of climate change

The respondents were asked what causes climate change according to their knowledge, and majority understood it to be caused by growing accumulation of greenhouse gases in the atmosphere (Fig. 1). A concerning observation about these results is that some respondents perceived three wrong answers as correct; and this is worrying as it implies that wrong information may be given to the farmer, should they ask the officials concerned. The majority of EPs with Bachelor's degrees appeared to have a better understanding about the causes of climate change than the other groups (Fig. 1b). These results prove that both qualifications and years of experience may have an influence on ones' knowledge in ensuring correct information is transferred to farmers. A project conducted by Motlopi (2019) argued that most Extension Officers went through their formal training during a time when climate change education was not taught as a subject or even a topic in curriculum. The extension officers in the study were therefore trained to enhance their knowledge and awareness of climate change.

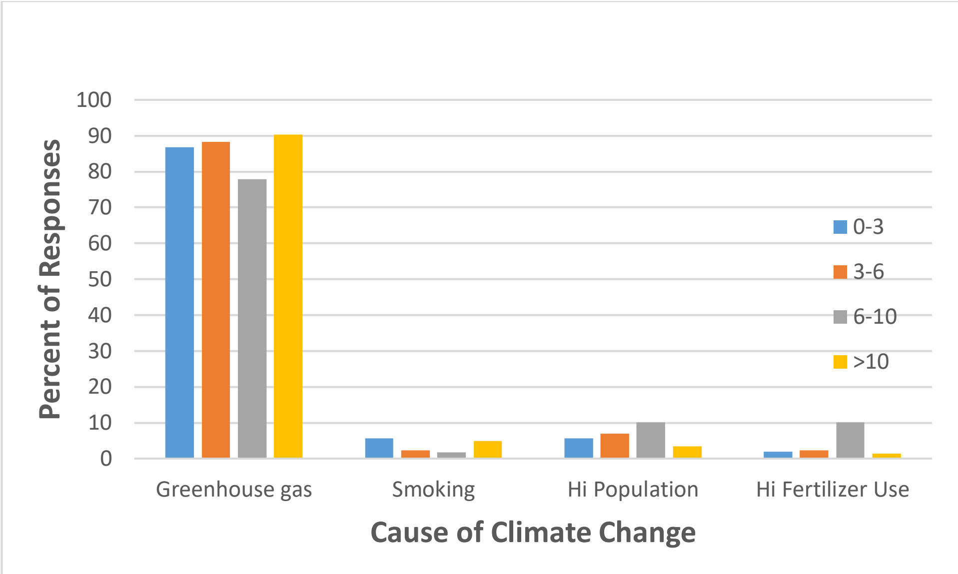

FIGURE 1A: Extension practitioners' knowledge about causes of climate change according to year of experience (categories 0-3 y; 3-6y; 6-10y & more than 10years experience).

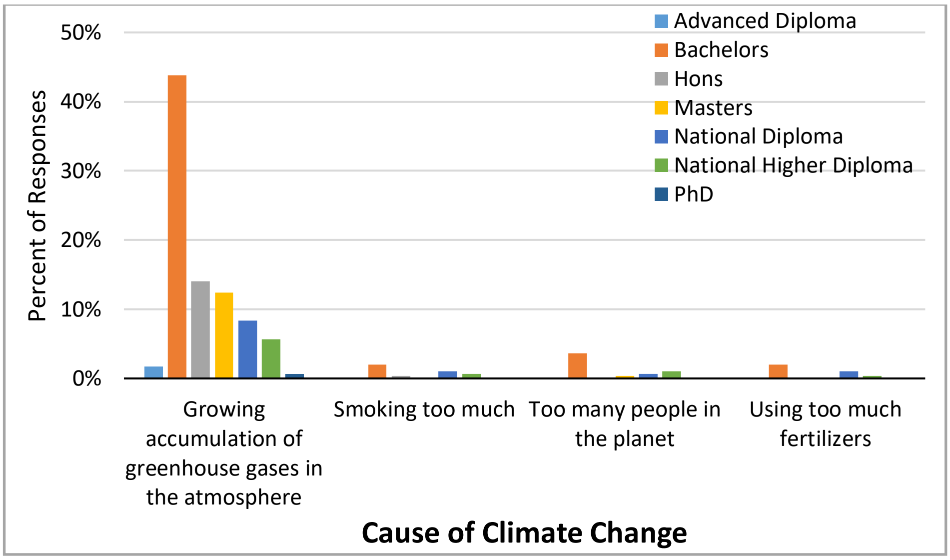

FIGURE 1B: Extension practitioners' knowledge about the causes of climate change according to their highest qualification.

3.3. Extension Practitioners' perceptions of the effect of climate change

The knowledge of the effect of climate change and variability on crop production was compared relative to the EPs age and highest qualification (Fig. 2). The results show that most EPs know that crop production will be affected through the reduction in crop yields due to heat

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stress. Respondents further reasoned that one could expect an increase in the frequency of droughts, although there is no trend in the status of knowledge according to either age nor qualification (Fig. 2). Furthermore, it was noted that most EPs did not consider the risk of new pests and diseases as a potential impact of climate change. This shows that, for all age levels of EPs, there is a need to attend further training courses on climate change and its effects and impacts on agricultural systems.

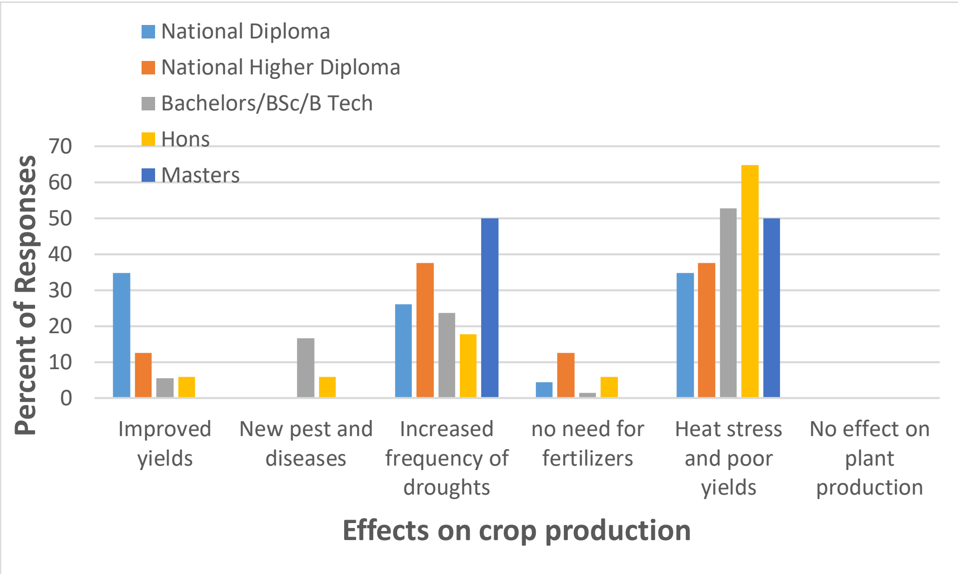

FIGURE 2: Extension practitioners' knowledge about the effects of climate change on crop production according to their highest qualification.

Concerning the knowledge about the effect of heat stress on beef cattle production, it was seen that the EPs with less years of experience were more familiar with this information (Fig. 3). It could perhaps be argued that EPs who have most recently completed their studies may have received more exposure to the issues of climate change and climate variability, as recently emerging problems globally. Contrary to expectation, results show that methane produced due to high temperatures scored lower, than the effect of heat on beef production as an option. This further asserts the view that training to help EPs make these types of links on these and similar phenomenon is warranted.

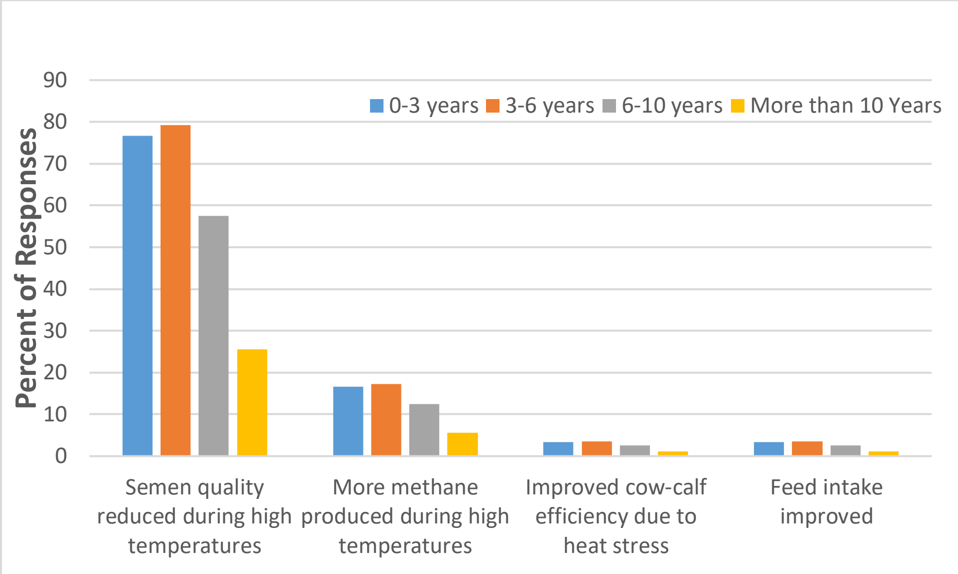

FIGURE 3: Extension practitioners' knowledge about the effects of heat stress on beef production according to their experience.

3.4. Application of Climate-Smart Agriculture practices

Various questions were asked to assess respondents' knowledge on the application of CSA practices for both adaptation and mitigation for both livestock husbandry and crop production. According to figure 4 the majority of majority of respondents between the ages of 18-25 with less years of experience indicated no difficulties of application of approaches as compared to their older counterparts. This could be explained by the fact that, with climate change as an emerging area of interest and growth knowledge, younger graduates could possibly have had more exposure to climate change and CSA related concepts. Those who consider these practices difficult are in the minority, as the majority of respondents 26 years and older indicated that the application of CSA practices is manageable. This is a positive and encouraging response as this opens room for improvement and for more training opportunities. The implication here is that, if an effective intervention is to be designed then it would have to emphasise more practical applicability over and above the theoretical elements of climate change and CSA for agricultural production. Findings by Yusuf, Lategan and Masika (2014) confirmed that an effort toward capacity development of Agricultural Development Technicians on scavenging chicken production needs to be made with special focus on practical training.

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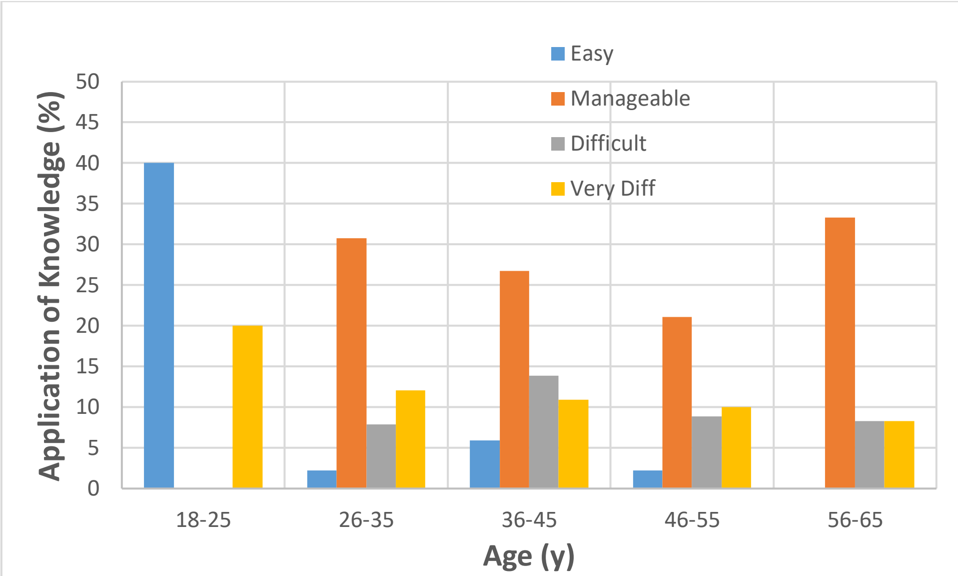

FIGURE 4: Application of CSA into practice according to age (in years)

Majority of respondents had little understanding of how best to apply the CSA approach in practice, to assist farmers curb the effects of climate change (Fig. 5a & 5b). For example, when asked about possible mitigation strategies applicable for livestock production, only 50% were able to select the option of methane collection and manure treatment. Regarding theoretical application, a number of respondents when asked about adaptation and mitigation practices such as *"planting of drought tolerant varieties"*, *"adopting appropriate tillage practices like zero tillage/minimum tillage, and the use of cover crops"*, and so on were correctly selected concerning crop production.

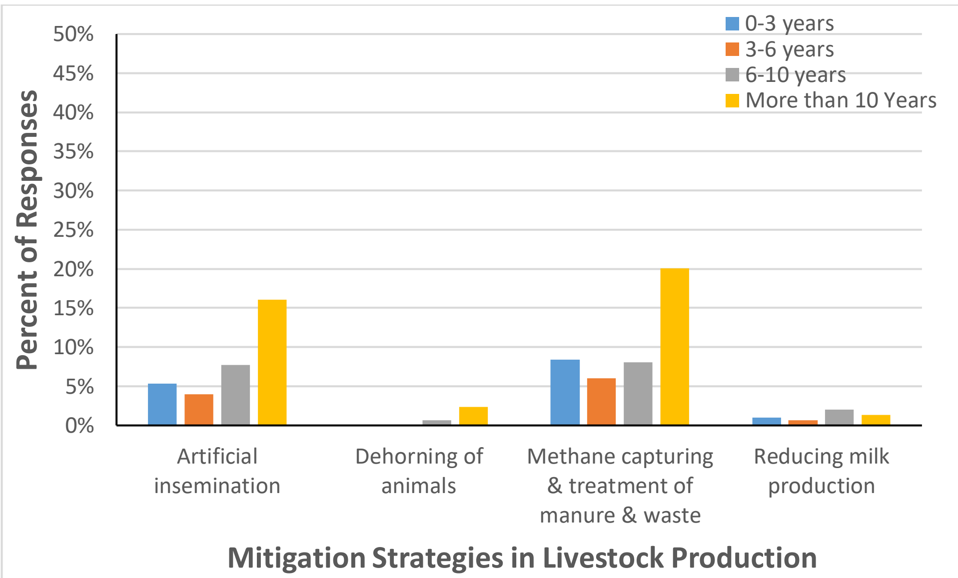

FIGURE 5A: Mitigation strategies in livestock production

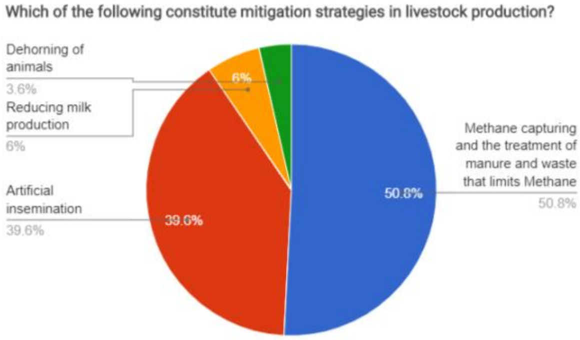

FIGURE 5B: Mitigation strategies in livestock production.

4. CONCLUSION AND RECOMMENDATIONS

The study established that EPs had a good grasp of climate change and were clear on the theoretical concept of climate-smart agriculture. Worrisome was the fact that this understanding did not translate to informed advice for farmers and consequently to improved adoption of CSA practices on the ground. The respondents did not perform well in their knowledge of CSA interventions and applications of the theoretical concepts. The survey results suggest that future interventions need to be designed to emphasize more practical applications to address climate change effects and introduce CSA for resilient agricultural production systems. Therefore, as a recommendation, a CSA training programme has been developed to establish a strong theoretical base, together with an understanding of the challenges presented by climate change and climate variability to sustainable agriculture in South Africa. This would ensure a grounded understanding of the implication of climate change and climate-smart agriculture for agricultural production. Such a training course can establish a good understanding of CSA among EPs with its application in practice; with CSA-focused skills to ensure climate-smart and sustainable food production systems (crop, livestock and fisheries) in the face of a changing and highly variable climate.

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