CHAPTER 1

INTRODUCTION

1.1 Background

Over 70% of natural hazards worldwide are weather and climate, or water related hazards (WMO, 2009), which have the risk to develop into disasters. A hazard is defined as a given threat that has the potential to adversely impact on humans or the environment. A disaster, on the other hand, is defined as a serious disruption to the functioning of a community or a society, causing widespread human, material, economic or environmental losses, which exceed the ability of the affected community and/or society to cope when using their own resources (DPLG, 2004; FAO, 2008).

The frequency of natural hazards, such as droughts, over some parts of southern Africa may negatively affect agricultural production (Jury, 2001). In the agricultural sector, hazards have already proved to impact negatively on both livestock and plant production (Jury, 2001). For example, dry conditions could result in reduced production or runaway fires that destroy grazing and above normal rainfall could lead to floods and the destruction of irrigation infrastructure (Jury, 2001; Levira, 2009). This author wants to note that if a livestock farmer, for example, is able to provide additional fodder after veld-fires by using his/her own resources, the situation is not seen as a disaster because the farmer can cope with his/her own resource. Climate variability therefore poses a risk to agricultural production (Salinger *et al.*, 2000; Mukhala and Chavula, 2007; Kgakatsi and Rautenbach, 2014).

A risk is the potential of an event, or chosen action or activity to result in a loss. In general, a risk is the product of a hazard and the subsequent vulnerability associated with the society or area affected (DPLG, 2004; FAO, 2008). Vulnerability may therefore be considered as the degree to which people, property, resources, and societies are susceptible to harm or destruction by being exposed to a hazard (SA, 2005; FAO, 2008). Note that it follows from such definitions that events where hazards strike in areas with low vulnerability are not considered disastrous.

It has been demonstrated that by having effective early warning systems in place, the disastrous impacts of natural hazards on society, such as those often experienced in Africa, could be averted (WMO, 2009). Effective early warning systems are playing an important role in reducing the risk of morbidity and mortality during disasters, and such systems could also contribute in reducing damage to livelihoods and crops in the agricultural sector (AU, 2006; UN, 2006). Seasonal Climate Forecasts (SCFs) have recently been introduced to provide information to early warning services on the risk of droughts to appear in the following months or season (Nicholls, 1999; Kgakatsi and Rautenbach, 2014).

Early warning is defined as the set of capabilities needed to generate and disseminate timely and meaningful services (information) to enable individuals, communities and organizations threatened by a hazard, to prepare and act appropriately and timely to reduce the possibility of harm or loss (ISDR, 2010). In general, early warning systems try to identify and respond to the initial signs of any threats to civil society, and they want to provide a surveillance system that collects information timely on disaster-prone areas in order to trigger prompt public interventions (WCDR, 2005; SA, 2005; ISDR, 2006b; FAO, 2008). This definition does not include reference to the time-scale on which such a warning is given. In reality, SCFs could be associated with early warning services, although many stakeholders still consider early warning as a short-term process (ISDR, 2010).

In this thesis, SCFs and early warning systems are linked in such a way that SCFs are regarded as advisories or services contributing to the coping with disaster-risks within the agricultural sector, which could also be associated with the services of early the warning systems. As a matter of fact, early warnings through SCFs in advisories/services (Stigter *et al.*, 2013) allow for farmers to plan in advance, which again could result in improved production (ISDR, 2010). On a national scale, such early warnings could even contribute to food security.

In general, early warning services consist of four inter-related elements (UN, 2006; ISDR, 2006b), namely:

- **Risk knowledge,** which is knowledge of risks that might arise from both hazards and vulnerabilities. Risk assessments and mapping of the affected areas are used to inform and to motivate society to prioritize early warning needs and to guide preparations for disaster prevention and responses;
- **Prediction, monitoring and warning services,** which refers to a technical monitoring and warning service that is based on a well-documented scientific procedure, as well as the further constant monitoring of possible disasters. A scientific basis for the forecast of hazards is essential for determining the degree of reliability of the forecast or a related early warning. Early warning services for different hazards should be coordinated, where possible, to gain the benefit of shared institutional, procedural and communication networks;
- **Dissemination and communication**, which are the distribution of meaningful and understandable warnings that contain useful advisories/services to those at risk. Useful risk knowledge and warning services are critical to enable proper responses aimed at safeguarding lives and livelihoods;
- **Response capacity,** which is the preparedness to act on a risk, and the capacity of all stakeholders, including the government, to respond (ISDR, 2006b; UN, 2006; FAO, 2008, Stigter *et al*., 2013; Kgakatsi and Rautenbach, 2014).

Early warning services offer advance warnings that could be used to alert communities, such as those of farmers, in advance of impending threats so that the necessary preventative and mitigating actions could be taken. Effective early warning systems are maintained when all the elements mentioned above are effectively implemented (UN, 2006). For an early warning system to be effective, it must be based on sound risk knowledge, understandable, trusted and relevant to/by the communities that they serve. Furthermore, in order to sustain the four elements over a longer period, strong political support and durable institutions are required (Basher, 2006).

Since extremes in climate variability pose a high risk for disasters in the agricultural sector, effective climate forecasting advisories/services communication, dissemination, interpretation and usage may be strengthened by collaboration amongst climate advisories/services producers and users (e.g intermediaries) in order to assist end-users (e.g. farmers), during preparatory planning and in decision-making processes (Walker *et al.*, 2001; Luanda, 2002; RHVP, 2006).

Disaster-risk reduction is defined as long-term or sustainable developmental actions, and it should be a core element of developmental programme planning (SA, 2005; FAO, 2008). With this goes disaster-risk handling, which is a continuous and integrated multi-sectoral, multidisciplinary and ongoing process of planning and implementing measures aimed at preventing or reducing the risk of disasters, mitigating the severity of disasters, facilitating emergency preparedness, ensuring rapid and effective response to disasters and helping in post-disaster recovery and rehabilitation (ISDR, 2004). Such handling being extremely complex, reality may force us to only aim at a better coping with climate risks through better climate services that being new knowledge to farmers (Stigter *et al.*, 2013)

The South African Government has developed, and is currently implementing the Disaster Management Act 57 of 2002 (DPLG, 2004). The emphasis of the Disaster Management Act 57 of 2002 (DMA) is on the development and implementation of disaster-risk reduction strategies in order to prevent and/or mitigate the negative consequences of hazards such as droughts, fires, and floods (DPLG, 2004). This approach differs fundamentally from the requirements of the old Civil Protection Act 67 (of 1977) that placed the emphasis on reactive actions. It is worth noting that in addition to the risk posed by natural hazards to food security, the World Summit on Sustainable Development (WSSD) in 2002 also recognized poverty reduction as a central tenet of achieving food security, and as part of sustainable development.

Agriculture is regarded as the most important sector in the African economy, with 70% of the agricultural output coming from small-scale farmers, while in South Africa only less than 3% of the Growth Domestic Product (GDP) contribution is by the commercial sector (Macaskrill, 2011). In South Africa smallholder farmers are to a large extent poor and therefore vulnerable to the risks posed by natural hazards (UNESCO, 1999). They are also under continued pressure to produce food of high quality for their communities (DoA, 2007b). Currently, planning and decision-making abilities of subsistence farmers appear to be hampered by the conditions of a highly variable climate, amongst other contributing factors, together with an increase in the frequency of extreme weather or climatic events (Hansen *et al.*, 2007; WFP, 2011). Many African farmers, and especially smallholder farmers, are already confronted by challenging technological and environmental constraints, including the effects of global warming that are likely to result in climate changes with a negative impact on food production (IPCC, 2007b; Smith *et al.*, 2007; Schulze, 2010). These impacts may even result in food shortages in some areas, with associated food price increases and food insecurity.

In this introductory chapter, existing viewpoints on disaster-risk reduction focusing on early warning services, based on SCFs, as a means of reducing risk will be discussed. Knowledge and advisories regarding the seasonality of the South African climate, and issues around climate change and agro-meteorological SCF aimed at the agricultural sector are also presented. Emphasis is placed on the risks posed by climate variability on agriculture and food production. The chapter further evaluates the current status and interpretation of climate knowledge. Some aspects considered to be challenges in addressing effective early warning systems are highlighted.

1.2 Seasonality of the South African climate

South Africa, which is located in the subtropics of the Southern Hemisphere where Hadley-cell subsidence dominates, is regarded as a predominantly dry region with a high annual variability in rainfall (Kgakatsi, 1999). The climate of the northern parts of the country is more influenced by tropical weather systems, while the south is mostly influenced by extra-tropical systems (Tennant and Hewitson, 2002:1047).
Most research around southern African climate variability and the potential to predict its inter-annual variability has revolved around either the El Niño Southern Oscillation (ENSO) phenomena or the influence of the Indian Ocean and other oceans on continental rainfall. As a matter of fact the annual variability of rainfall in southern Africa is influenced by several factors, of which the influence of Sea Surface Temperatures (SSTs) is an important one. Most rainfall received over eastern and southern Africa exhibits a strong correlation with both ENSO and SSTs in the Indian Ocean (Jury, 1996; Mason and Jury, 1997). For example, higher than average SSTs in the central and western tropical Indian Oceans are frequently regarded as responsible for local convection and rain over the ocean, with dry conditions over South Africa (Mason, 1995; Jury, 1996; Mason and Jury, 1997), while El Niño and La Niña phases of the ENSO often result in dry and wet conditions, respectively, over South Africa (Lyon and Mason, 2009).

Although seasonal rainfall pattern correlations for southern Africa are often biased towards SST variations in the Pacific and Indian Oceans, studies have also revealed increasing evidence of the importance of Atlantic Ocean SST variability (Reason and Mulenga, 1999; Reason *et al.*, 2006b). For example, it was suggested by Reason and Mulenga (1999) that the Atlantic Ocean might also have an influence on climate variability over large parts of southern Africa. It was shown that the marked annual cycle in winds and SSTs over the south-east Atlantic Ocean are influencing seasonal rainfall, moisture flux and cloud-band location over parts of southern Africa.

Advances in the understanding of ocean-atmosphere teleconnections have given rise to an increasing interest in its application through SCFs for the agricultural sector (Hansen *et al*., 2011). The ability by the international community to forecast seasonal variations in the earth's tropical climate has improved dramatically from the early 1980s to the late 1990s (CLIVAR, 2007). However, further analyses from recent international workshops suggest that after the 1990s the ability to forecast tropical climate fluctuations reached a plateau with little improvement in data quality (CLIVAR, 2007). An improved knowledge and understanding of the seasonality of the South African climate would certainly enhance and improve the ability to produce and interpret seasonal climate forecasts. The careful approach with SCFs that we advocated earlier in this chapter is based on this reality.

1.3 Climate change and the agricultural sector

The degree to which global warming, and eventually climate change, might in future contribute to changes in the frequency, severity and duration of extreme climatic events (droughts and floods), is directly related to the degree of future risks faced by societies in South Africa (Wilhite, 2007). Climate change is therefore very relevant to early warning systems and disaster-risk management. Climate change embodies a long-term change in the statistical distribution of weather patterns (IPCC, 2001). Since inter-seasonal climate variability is linked to the frequency and severity of weather patterns, climate change might also be evident as changes in climate variability.

For many parts of the world climatic change projections are indicative of significant change, and most future scenarios for southern Africa range from wetter conditions in some areas in the east, to drier in the west (IPCC, 2001; Schulze, 2006; Boko *et al.,* 2007). It is also very likely that more extreme weather/climate events might appear in the future (e.g. Stigter and Ofori, 2014a). This includes the risk of more extreme rainfall events associated with floods, as well as longer periods of drought. This poses the risk of increased probabilities of crop and livestock losses, which will certainly affect vulnerable pastoralists and subsistence farmers (Verdin *et al.*, 2005; Levira, 2009; Wang and Huang, 2010). As a matter of fact, scientists worldwide are warning that the negative effects of climate change on agriculture, social structures, forests and economies, as well as ecosystems, could be far reaching (Boko *et al.,* 2007; Stigter and Ofori, 2014b).

Some key development sectors in agriculture, such as the availability of water, are particularly sensitive to climate variability and change. Climate-related disasters, therefore, might have enormous social and economic impacts that could negate years of developmental efforts. As preventative measure in South Africa, climate change adaptation efforts should include disaster-risk assessments aimed at reducing vulnerability and at enhancing resilience. A large part of the South African rural population depends on agriculture as a source of food and income, and livelihoods are often the most vulnerable to the direct impact of adverse climatic events and the indirect impact related to uncertainties in the seasonal prediction of climate (Johnston *et al.*, 2004).

Global climate change, together with its projected local implications, has necessitated the search for adaptation measures to be considered by vulnerable communities in the agricultural sector. Scientists believe that improved climate change projections and SCFs, if reliable (e.g. Stigter and Ofori, 2014c) might benefit society, since they could tremendously facilitate adaptation strategies and actions (Hansen, 2002; Klopper, 2002; Roncoli *et al.*, 2005; Klopper *et al.*, 2006). Climate experts, environmentalists and governments officials have already begun advocating this approach to save the world from the worst effects of climate change (Wang and Huang, 2010).

Research has an important role to play in investigating and implementing mitigation and adaptation strategies in agriculture (e.g. Stigter and Ofori, 2014b). One major problem with climate change projections is the uncertainty associated with these projections, especially as far as local scale rainfall is concerned. Apart from uncertainties as a result of assumptions made in these models, climate GCMs are designed to accept specific future scenarios of greenhouse gas increases, which are also uncertain (UNFCCC, 1992). As a result of all these uncertainties, the average of ensemble members of projections is considered when compiling a climate projection for a specific region (UNFCCC, 1992). These ensembles of climate scenarios are not always consistent, and can sometimes give a range of possible outcomes that are often conflicting (UNFCCC, 1992; DoA, 2006; Kgakatsi, 2006; Schulze, 2006; Schulze, 2007), which makes it difficult to draw conclusions.

Improved future climate projections and probability forecasts of atmospheric variables address only one component of integrated agricultural activities, since an improved understanding of how agricultural practices interact with different climatic conditions, in addition, also is an important aspect to consider (Glantz, 2003).

It is foreseen that rain-fed agricultural activities in the world could be reduced by 50% (agricultural production or yield) by 2020 as a result of climate change, which means higher levels of yield reduction (Vidal, 2007; Wreford *et al.*, 2010). Most developed, and some developing countries, are already making good progress in implementing climate and non-climate-related risk policies associated with sustainable development and the improvement of human-natural environment interaction (Smith *et al.*, 2007). In this regard, most African countries face difficulties, like a lack of financial resources and institutional capacity, in facilitating the integration of climate change concerns into national policies (UNFCCC, 2008).

It is important to globally share new innovative technologies (amongst developed and developing countries) in order to ensure the efficient use of land resources and agricultural practices in an effort to alleviate poverty and malnutrition (Smith *et al.*, 2007). Some suggested ways of assisting farmers in adapting to climate change should include: (1) The promotion of diversification in livelihood options; (2) the encouragement of innovative thinking in farming practices; (3) the establishment of improved social networks to help build capacity and to encourage communities to work together; (4) to capitalize in indigenous knowledge systems; and (5) to improve the accessibility to resources, such as credit, new technologies, inputs and climate service (FARA, 2007; Fraisse *et al.*, 2008; Wang and Huang, 2010; DAFF, 2010b).

It is already accepted to some degree that future changes in climate variability and climate change might have a negative impact on the South African economy, especially when it starts to affect agricultural production, and ultimately, food security (DAFF, 2010a). The Fourth Assessment Report (AR4) of the Inter-Governmental Panel for Climate Change (IPCC) highlights some serious implications for agriculture in the future, such as an increase in competition for agricultural land, an increased demand for water, and subsequently, higher demands for agricultural products, which might in turn also lead to rising in food prices and agricultural input costs (Smith *et al.*, 2007).

To conclude, most climate change reports highlight the importance of introducing tailor-made projections and forecasts aimed at agricultural variables in order to facilitate disaster-risk assessments and to establish more effective early warning services (WMO, 2004; Wreford *et al.*, 2010). Such activities, if successful, will facilitate the implementation of climate change adaptation measures, which will improve agricultural production and food security.

1.4 Atmospheric modelling and seasonal forecasting

Research programmes are conducted throughout the world to gain a better understanding of SCFs and the processes involved in climate change and variability projections and outlooks (Glantz, 2001; Reason *et al*., 2006b; CLIVAR, 2007). Various research programmes, using statistical and dynamic methods, are being undertaken to study the weather and climate of arid, semi-arid, sub-humid and other desert-prone areas with the objective of understanding the forecasting of seasonal to long-term trends, rain-producing atmospheric disturbances, and meteorological drought (Landman *et al.*, 2001; Wilhite, 2007).

The Southern African Regional Climate Outlook Forum (SARCOF), as mandated by the World Meteorological Organization (WMO), produces different types of SCFs. These forecasts are based on information received from meteorological services and university research groups (Johnston *et al*., 2004). In South Africa, meteorological variables, such as rainfall and temperature, are forecast over one to three months in advance. These forecasts, which are also received from various groups, are issued on a monthly basis by the South African Weather Service (SAWS) as the organization mandated by the South African Government to provide weather and climate forecasts to South African citizens (SAWS, 2001). SCFs are mostly presented as probabilistic forecasts for three categories, namely, normal, above-normal and below-normal (Appendix E).

Currently, improvements in SCFs mostly depend on the success of coupled ocean-atmosphere General Circulation Model (GCM) simulations in generating future climate outlooks. This coupling approach was taken after it was found that rainfall forecasts generated by Atmospheric General Circulation Models (AGCMs) that are forced by prescribed SST fields did not provide optimal results (Tennant, 2003). Results from GCMs could also be used as boundary forcing to regional models, or for statistical downscaling applications. The CLImate VARiability and Predictability meeting (CLIVAR, 2007) concluded that there is still scope for substantial improvements in SCF skill in the future and this need to be published. Here, skill refers to the accuracy of a forecast relative to observations, or to a current forecast produced by a standard procedure (Johnston *et al*., 2004).

A major concern in the southern African region, however, is the decline in observations of surface variables, such as rainfall and temperature, as well as atmospheric upper air soundings (DFID, 2004). Good news is that despite these data constraints, there has been a significant improvement in SCF modelling initiatives in South Africa such as SAWS's SCFs (e.g. www.weathersa.co.za; Johnston *et al.*, 2004; Klopper *et al.*, 2006; Landman and Goddard, 2002; Landman and Tennant, 2000; Landman *et al.*, 2012).

1.5 Seasonal agro-meteorological forecasts

Seasonal agro-meteorological forecasts, which are defined as SCFs directed to the agricultural sector, are forecasts of the principal agro-meteorological conditions that affects the growth, development and maturation of crops (Changnon, 1992; Marachi *et al.*, 2004; Gommes, 2010; Stigter, 2011). The need and demand for such agro-meteorological forecasts of rainfall and temperature vary according to the production systems and market forces that determine credit demand and input availability. In order for the response to a forecast to be effective in different regions, one needs to identify feasible adaptive options for farmers within the range of climate extremes (e.g. from dry to wet) in a defined region (Hansen *et al.*, 2011).

The rainy season is, to a great extent, a predictable seasonal cyclic occurrence, although the amount of rain, the timing of the rain and the distribution of rain during such a season is much more uncertain. However, advances in climate science over recent years have contributed to improvements in the predictability of seasonal fluctuations in climate variables. The emerging ability to provide timely, skillful (Johnston, *et al*, 2004) and tailor-made SCFs has created an environment where human vulnerability as a result of agricultural decisions is greatly reduced (Hansen, 2002; Johnston, *et al*, 2004; Motha *et al.*, 2006).

Regional analyses based on historical climate data and crop-simulation models are often used to determine the response options and their associated risks in order to support farmers in their decisions, based on the issue of a SCF (Menzie, 2007).

E.g. SCF knowledge received from the National Meteorological Services is translated into usable knowledge for the agricultural community by the established NAC in South Africa. In consultation with experts in agro-meteorology, crops, livestock and natural resources, agricultural strategies are developed in line with the issued SCFs. A comprehensive advisory document is then compiled containing the SCF and agricultural strategies and is then issued to the farming community. At local level the information is packaged in official languages to be usable for all by the early warning committees.

Tailor-made forecasts rely on the improvement of observations, where end-users can play an important role (IRI, 2001, Roncoli *et al.*, 2009). It is important for user-focused climate services to be readily available and wisely used by decision-makers in the agricultural sector (Hay, 2007). It is almost on a daily basis that farmers are obliged to make such decisions (Fraisse *et al.,* 2008). Useful agro-meteorological forecasts with sufficient skill allow farmers to make decisions regarding particular agricultural practices over the forecast period (Stigter, 2002; Sivakumar and Motha, 2007).

SCFs hold great potential for adequate planning in agricultural activities (Hansen *et al*., 2004a), especially with respect to early warning and response planning. Several studies have evaluated the potential benefits that the use of SCF information holds in supporting decision-making processes in the agricultural sector (Sonka *et al.*, 1986; Stern and Easterling, 1999; Jones *et al.*, 2000; Hansen, 2002; Johnston *et al*., 2004; Ziervogel, 2004; Klopper *et al.*, 2006; Vogel and O'Brien, 2006; Stigter, 2009). Tailor-made SCFs for the agricultural sector can provide valuable information on expected annual rainfall and temperature patterns, and can be employed to adjust seasonal agricultural strategies in order to align them with the expected climate conditions (DAFF, 2011; Gommes, 1998; Jones *et al.*, 2000; Bharwani *et al.*, 2005; Hansen, 2005; Stigter, 2009; Kgakatsi and Rautenbach , 2014).

E.g. the South African's comprehensive advisory document issued by the NAC monthly serves as input in decision making by farmers i.e. decisions on types of crops to plant/diversifying, when to plant, how much to plant, input costs and others. Also, Roving Seminars are conducted to teach the farming community on the benefits of weather and climate in risk reduction resulting in economic benefit. Farmers moreover have study groups where they share knowledge on weather and climate information and risk reduction measure including market trends. Assessment on the uptake of the advisories by farming communities is regularly undertaken with recommendations to address the challenges encountered (DAFF, 2013)

The agricultural sector should participate in the development of climate services, otherwise SCF advisories and services will remain poorly designated for their use (Hansen *et al.*, 2011). Mukhala and Chavula, (2007) highlighted the need for tailor-made forecasts that would make it easier for farmers to cope in a way that would benefit both their farming practices and the natural environment (so call win-win situations). A meteorologist, as a scientific expert of the atmosphere, may provide the necessary information to assist in reducing the negative impacts of risks and uncertainties of adverse weather through agro-meteorological services as structures that strengthen early warning systems (Motha *et al.*, 2006; Motha and Murphy, 2007). It is, however, a challenge to incorporate SCF services, with its uncertainties, into decision-making processes, since end-users always face the risk of making mistakes as a result of uncertainties related to the probabilistic nature of SCFs. Good understandable communication between scientists (who mostly produce data and advisories based on these data), agricultural authorities (who translate data into usable services), and farmers (who interpret the services in order to make decisions) are of utmost importance. This will often change the language of the climate services for farmers (Stigter *et al.*, 2013)

It is difficult to assess the vulnerability of farmers to climate variability without simultaneously addressing the implications of political, social, environmental and economic factors that also have an influence on the decisions made by farmers (Smit *et al.*, 1996). The exposure of farmers to climatic variability and their capacity to cope with its impacts is also influenced by the policy environment and economic context in which they operate (Eakin, 2000; Stigter and Ofori, 2014a).

1.6 The importance of SCF implementation

The complexity, magnitude and costs of disasters have shaped the approach taken to ensure that information is (climate services are, Stigter et al., 2013) relevant and useful to end-users like farming communities (FAO, 2006; Dar and Twomlow, 2007).

The understanding of climate variability is regarded as a key factor in the interpretation and application of SCFs (Klopper *et al.*, 2006; Kgakatsi and Rautenbach, 2014). This concept, for example, was particularly incorporated in various methodological approaches and products developed by the International Research Institute (IRI) in order to provide better SCFs to farming communities. Apart from their SCF communication activities, the IRI is also participating in regional climate forums worldwide (IRI, 2001). A result of such initiatives is that end-users might become more aware of the value that also simple SCFs hold in terms of early planning for anticipated seasonal and inter-annual climate variations (CLIVAR, 2007).

The IRI considers effective partnerships, such as working with other international organisations (i.e. World Meteorological Organisation (WMO), International Strategy for Disaster Reduction (ISDR), World Conference on Disaster Reduction (WCDR), United Nations Framework Convention on Climate Change (UNFCCC), Food and Agriculture Organization (FAO), etc.) and with regional climate centres in Africa (i.e. the Drought Monitoring Centre (DMC) in Nairobi, the African Centre of

Meteorological Applications for Development (ACMAD) in Niger, the Intergovernmental Authority for Development (IGAD), the Climate Prediction and Applications Centre (ICPAC) in Kenya) as vital, as they span the avenues of research, practical engagement in problems, awareness raising, capacity building and resource mobilization. However, despite these efforts, recent advances by IRI in the creation of a range of SCF information and its application value in Africa were found in some instances still to be inadequate (IRI, 2005). This has little changed since (Stigter and Ofori, 2014a; 2014b; 2014c)

In general, it is essential to raise awareness and to build capacity in Africa in order to ensure sustainable avenues through which the risks of climate variability can be managed. This might increase resilience, and reduce the vulnerability of the continent to extreme climate events and change (Washington *et al*., 2004).

There are significant differences in communicating advisories and services from scientists to stakeholders, such as national government and state intermediaries, and to farmers (Johnston *et al*., 2004; Stigter *et al*., 2013). In some countries SCFs are transmitted to user organisations, but these organisations are often unable to provide these forecasts timely to decision makers and end-users. South Africa, like many other countries, also still needs to enhance its capacity to provide quality climate services and advice in this regards.

As far as the value of seasonal forecasts is concerned, the forecasting of the onset of a dry spell is often of greater value to the agriculture sector than the forecasting of seasonal rainfall totals but both are most of the time beyond present forecasting potential unless for a short range as in a weather forecast. Another aspect that might cause confusion is uncertainties related to the probabilistic nature of SCFs (probabilities expressed in percentile categories of below-normal, normal and above-normal) (Kandji *et al.*, 2006). Stigter *et al*. (2013) advocate to use simpler language.

When communicating SCF services, one must also take into consideration that farmers (especially commercial farmers) already have a wide array of risk-controlling measures in place, including forward contracting, crop insurance, alternative seed varieties, genetically modified seed, and more (Harwood *et al.*, 1999; Tadross *et al*., 2003). Education and training should also form an important part of communicating the uncertainties embedded in SCFs, which will improve on the value of such forecasts.

Under this review regarding the importance of SCF implementation, the following two sub-sections yield more clarity on aspects related to the application and assessment of SCFs:

1.6.1 Application of SCF information

SCFs services could play an important role in reducing damage as a result of natural climate hazards (Agrawala *et al.*, 2001). The application of SCF services by both users and end-users involves the inclusion of such information in planning and decision making processes. It is important that SCF services should be scientifically based, even if challenges exist on how marginal groups interpret such services (Vogel, 2000). The challenges faced for the optimum application of SCF services in agricultural planning and operations in the next century have been emphasized by various researchers (Ogallo *et al*., 2000; Archer, 2003; Roncoli *et al.*, 2009; Walker and Stigter, 2010; Hansen *et al.*, 2011).

The agriculture productions processes, and in particular crop growth, are highly depend on climate conditions. This makes agricultural production vulnerable to unexpected climate variability and change. SCF services may therefore be of great value, if of sufficient skill and used correctly, in reducing the risk of production failure (Ogallo *et al*., 2000; Huda and Packham 2004; Maracchi *et al.*, 2004; Archer *et al.*, 2007; WFP, 2011; Stigter *et al.*, 2013).

An analysis on sub-Saharan agriculture for food security highlights the importance of drought preparedness as an integral part of planning for sustainable farming (UNESCO, 1999; Wilhite, 2007). A challenge, however, is that the process of mitigating the impact of drought requires all components within the disaster management cycle, instead of only pro-crisis management that is still prevalent in so many parts of the world (FAO-UN, 2005a; Ongwae and Karanga, 2005; WCDR, 2005).

Some studies (Sonka *et al.*, 1986; Hudson, 2002; Klopper, 2002; Phillips *et al.*, 2002; Johnston *et al.*, 2004; Ziervogel *et al.*, 2006; Walker & Stigter, 2010) have already demonstrated the potential benefits of the application of SCF services. However, SCF services should be understood and correctly interpreted by end-users before it could benefit agricultural practices. Despite the probabilistic nature of SCFs, services need to be reliable for successful implementation (Johnston, *et al.*, 2004; Stigter *et al.*, 2013).

The established structures within the Department of Agriculture, Forestry and Fisheries (DAFF) provide a strong basis for implementing early warning systems in South Africa. This is only possible if credible institutions, such as the Agricultural Research Council (ARC) and the SAWS, are involved.

The research work in the Southern Africa Development Community (SADC) region, as well as over the rest of Africa, is no longer based only on the understanding of SCF modelling, but includes the implementation of SCF services by end-users during planning (IRI, 2005). However, problems are still experienced in decision making processes during the Southern Africa Regional Climate Outlook Forum (SARCOF) meetings. Problems are also still experienced during National Climate Outlook Forum (NACOF) campaigns aimed at encouraging dialogue between SCF producers, users and end-users.

Development activities, the so called farming activities, which range from crop selection to livestock management, often take shorter-term weather forecasts (one to 14 days in advance) into consideration when planning, while longer-term SCFs are neglected (Agrawala, 2006). This again emphasizes the importance of communication to promote the benefits of using SCF services.

1.6.2 End–to-end forecast assessment

Previous studies have investigated the uptake and use of SCFs in South Africa by users and end-users (Klopper, 1999; Vogel, 2000; Archer, 2001; Johnston *et al*., 2004; Archer *et al.*, 2007; DoA, 2007c; DAFF, 2010a). In addition, several detailed assessments on the use of SCFs by the agricultural sector have already been undertaken (Johnston *et al.*, 2004; Hansen *et al.*, 2011), especially during disaster periods in South Africa. Other studies also highlighted the importance of communication during SCF services dissemination (Walker *et al*., 2001; Archer, 2003; Ziervogel, 2004; Ziervogel *et al.*, 2006).

The probabilistic nature of SCFs is one of the most important factors that create confusion. For example, the underestimation of the accuracy (Johnston *et al*., 2004) of a probabilistic SCF often leads to lost opportunities for preparing for adverse conditions, while an overestimation of the accuracy of a probabilistic SCF might lead to excessive responses that could damage the credibility of the forecast provider (Hansen *et al.*, 2004a), which might lead to inappropriate actions that could expose decision-makers to unwarranted risks (Dilley, 2000).

Recent assessments have highlighted the importance of communication and of conducting regular training sessions all along the SCF chain to create a better understanding and interpretation of SCF services (Walker *et al*., 2001; Stigter, 2002; Walker and Stigter, 2010; Hansen *et al.*, 2011).

Preliminary investigations on SCF services distribution from the producer to the end-user have shown that there are both direct and indirect benefits from using such information (Vogel, 1998; Hansen *et al.*, 2011), and the value of SCF services to established farmers cannot be over emphasized (Klopper, 2002; Klopper *et al.*, 2006). Primary and secondary impacts associated with droughts have been identified by Vogel *et al.*, (1999). These authors emphasize the importance of government participation in all hazard-preventive measures in order to holistically address social, environmental and economic impacts.

Human factors, such as culture, history, as well as government policy and market conditions are additional important factors that could affect the use of SCFs. These practices also involve certain disaster-risk strategies (Gibba, 2002; Hudson, 2002).

Several countries have adopted an interdisciplinary approach towards managing disaster-risk reduction by firstly incorporating the most recent advisories possible to deal with natural hazards. This includes useful and relevant advisories/services from research institutions, as well as from decision-makers, the media and local community leaders (Glantz, 2001).

1.7 Uncertainty in SCFs

A challenge, and in many cases an obstacle that needs to be addressed, is the fact that SCFs are intrinsically uncertain. However, effective communication and explanation regarding uncertainties in, more specifically, seasonal agro-meteorological forecasts during the planning and decision-making processes could be to the benefit of end-users. (AMS, 2002; NRC, 2003). The internal non-linear or chaotic character of the atmosphere, coupled with inevitable inadequacies in observations and numerical estimations in computer models, result in SCFs that will always contain a certain degree of uncertainty. These uncertainties generally increase with forecast lead times, and might even vary from location to location (NRC, 2006).

The credibility of a SCF depends on the number of times that a forecast failed to be at least “reliable” in the past, and on the reputation of a forecast communicator. In recent years, some researchers have decided to rather focus on the academic aspects of SCFs, while others pay more attention to the needs of users (NRC, 2006). These two focuses contribute to both reliability and reputation, and the most appropriate approach will be to find a balance between the two. Communicating uncertainties in SCFs is challenging, since users often do not perceive forecasts as being probabilistic (Patt, 2001; NRC, 2003; Motha and Murphy, 2007). By reducing uncertainty, one builds confidence, which might eventually lead to a more successful application of a SCF (Hansen *et al.*, 2004a; Huda and Packham, 2004; Wreford *et al.*, 2010). The partial uncertain or chaotic nature of climate therefore continuously needs to be communicated with users and end-users in order for them to acknowledge the limitations of SCFs, and to generate trust amongst these users (Patt and Gwata, 2002; Menzie, 2007). Broader stakeholder participation can even lead to improved SCF information for disaster-risk management, also changing the scientific language (Stigter *et al*., 2013)

1.8 Disaster-risk management

Disaster-risk management, as defined before in section 1.1, addresses the avoidance and lessening of the adverse effects of hazards through activities and measures of prevention, mitigation and preparedness. Global data indicate that natural hazards have occurred more frequently over the past decade than before, and that these have been more destructive (FAO, 2006; Stigter and Ofori, 2014c), which might also have been the result of a more dense world population. In general, it is widely accepted that weather and climate-related hazards are on the increase, and thus also the number of people reportedly affected by these hazards (FAO, 2006). Preparedness for, and prior knowledge of the potential impact and characteristics of climatic anomalies, effective policies, strategies and recovery plans might be of great value for reducing the damaging impact of natural hazards, such as droughts and floods, which might in turn, lead to better production levels in agricultural yields (Hay, 2007).

The development and promotion of disaster related policy, legislation and regulatory frameworks are crucial for creating an enabling and productive sustainable environment for disaster-risk management initiatives (UNFCCC, 2008). Over the past century, population growth, industrial development and the expansion of irrigated agriculture in some parts of the word has all increased dramatically. All these activities resulted in more land occupation, which brought numerous challenges to disaster-risk managers such as government and priority sectors. More comprehensive planning, policy issues and institutional support, as well as a growing obligation to address poverty and food security, larger areas of land degradation and the increasing focus on bio-fuels in addition to food production (AU, 2006) are only a few areas that had to be addressed.

A major step that was taken by the government of South Africa in order to address disaster-risk management was to promulgate the Disaster Management Act no. 57 of 2002. This act mandates all organs of State to put individual or sector-specific disaster-risk plans into place (DPLG, 2004). In addition to the Disaster Management Act (Act 57 of 2002), the Government of South Africa has developed several other supportive policy frameworks and plans, such as the National Disaster Management Framework of 2005 (DPLG, 2005). To address agricultural disaster-risk management and climate change proactively, the following were put in place: (1) the development of Agricultural Drought Management and Agricultural Flood Management Plans, (2) the 2007 Climate Change and the Agricultural Sector in South Africa document and (3) the comprehensive 2008 Climate Change Sector Plan for Agriculture. Another agricultural disaster-risk and enabling initiative is the DAFF Land Care programme (DoA, 1999; DoA, 2003).

In addressing the mandate of the Disaster Management Act no. 57 of 2002, the DAFF established a disaster-risk unit. In turn, this unit established and chaired disaster-risk management and early warning committees to facilitate the implementation of effective disaster-risk management. All these initiatives aimed at encouraging good decision-making and more effective action to reduce the negative impact of natural hazards, and to make communities more resilient to the impact of these hazards.

As one of the disaster-risk management structures, the National Agro-meteorological Committee (NAC) was established in South African agriculture. The NAC consists of SCF producers from SAWS, the ARC, decision-makers and extension officers in provinces, as well as other potential users. SCF producers from academic and research institutions participate in the NAC meetings or workshops, on invitation, to give scientific advice and to share information. The NAC structure is designed to be "user-friendly", and involves an interactive decision-support system aimed at translating SCFs into usable climate services before they are disseminated.

As part of its mandate, the NAC compiles a monthly climate *Advisory* report that contains climate, SCFs and early warning services (Appendix E) targeted at the agro-meteorological community.

The monthly climate *Advisory* is put together with input from the farming status reports from provincial structures (e.g. PDA units and EWC members), as well as input from SCFs received from producers at SAWS. The monthly climate *Advisory* is then disseminated to end-users through various channels as illustrated in Fig.1.1.

The monthly climate *Advisory* also contains suggested actions or strategies to be considered by farming communities (Appendix C). The ADRM directorate, on behalf of DAFF at national level, also issues daily extreme weather warnings (Appendix D) that contain measures or strategies to consider during planning in order to reduce or minimize risk.

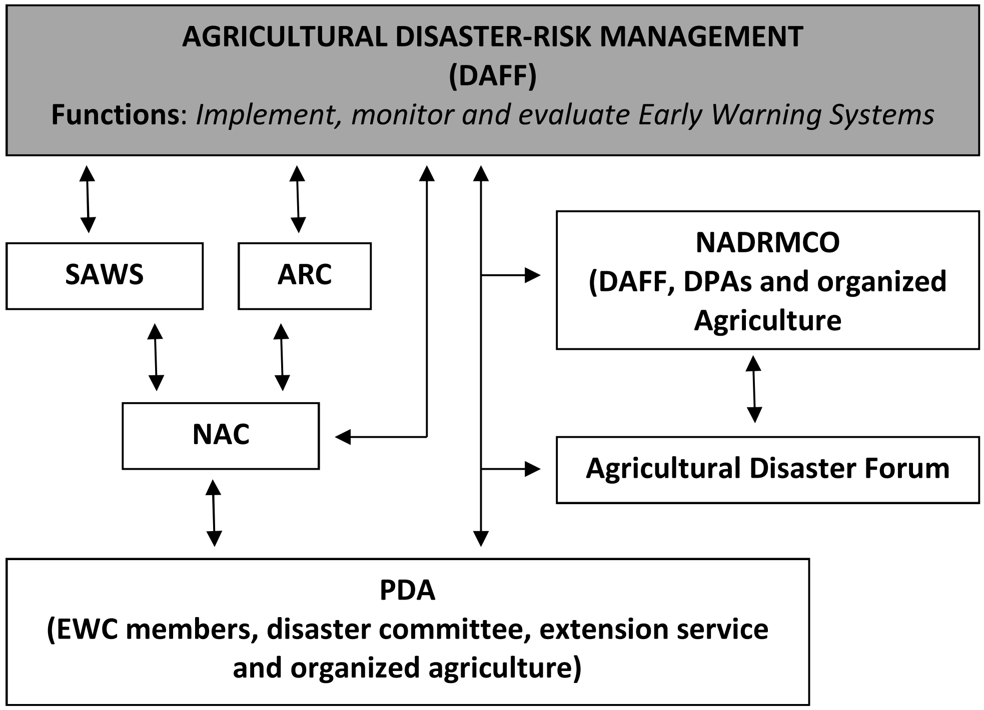

FIGURE 1.1:

The interactions of the Agricultural Disaster-Risk Management (ADRM) advisory information dissemination structures in South Africa. Acronyms: Department of Agriculture, Forestry and Fisheries (DAFF), Provincial Department of Agriculture (PDA), National Agro-meteorological Committee (NAC), Agricultural Research Council (ARC), National Disaster-Risk Management Committee (NDRMCO), Early Warning Committee (EWC) and South African Weather Service (SAWS).

However, a major communication challenge identified by the ADRM directorate during assessment, was the acceptance and use of NAC monthly climate *Advisories/services* by farming communities (DoA, 2007b; DAFF, 2013).

1.8.1 Historical perspective on natural hazards in agriculture

Worldwide, the socio-economic damage resulting from natural hazards has escalated significantly since the 1960s (DMISA, 2005). Likewise, the social, economic and environmental costs and losses associated with droughts are also increasing (DMISA, 2005). Although this might be attributed to climate change, the rapid increase in population density also leaves more people exposed to natural hazards. The trends in losses associated with droughts and other natural hazards (such as heavy rain, floods, hail and fires) in industrialised countries often draw more attention than similar events in developing countries.

The devastating impact of recurrent droughts and floods in southern Africa during the early 1990s and early 2000s, as well as the difficulties experienced by governments to effectively reduce the impacts of these events on society, emphasise the fact that policy-makers have not performed well in the past in developing drought coping programmes. Traditionally, governments and policy-makers tend to view droughts as a transient event caused by climatic aberrations. This view resulted in the implementation of drought mitigation plans while a drought was in progress, while early planning for future droughts were mostly neglected when the rains returned, with political attention being shifted elsewhere (Glantz, 1987).

The impacts of disasters are mostly measured against their influence on the economy (cost to people or business, low crop yields by farmers), their influence on the natural environment (wildlife and plantations destroyed and soil eroded or degraded) and their influence on social society (suffering experienced by vulnerable communities with homes destroyed and a loss of food security) (DMISA, 2005). The impacts of disasters are well documented and known worldwide, although more action should be taken to address the problem (ISDR, 2004; UNDP, 2004; WCDR, 2005). Encouraging is that in recent years a marked change in attitudes towards disasters evolved from various sectors. This is accompanied by a growing recognition of the benefits that prevention and mitigation hold, in contrast with treating disasters on an *ad hoc* basis with relief efforts only implemented during disasters. This new approach is spurring national and international initiatives in disaster-risk reduction (ISDR, 2004; ISDR, 2005). This is reflected by the fact that international, regional (e.g. Famine Early Warning System (FEWS)) and national organisations, as well as research and academic institutions, have embarked on renewed work related to disaster-risk reduction and mitigation measures (ISDR, 2004; ISDR, 2010; Kgakatsi and Rautenbach, 2014).

Before 1994, disaster aid was mainly provided to commercial farmers, while developing farmers were generally excluded (Vogel, 1994a). DAFF financial records from the previous dispensation show that R3.8 billion was the largest amount that was made available for assistance during the 1992 drought, which was mainly targeted towards commercial farmers.

The main focus in the policy shift after 1994 was to put the responsibility of coping with natural hazards, such as droughts and floods, back into the normal production system (DoA, 1998). The government therefore started to assist farmers in their own efforts to deal with various risks, and where possible, to take steps to reduce the likelihood of risks to farmers. This happened, for example, through the promotion of research and extension technologies and practices aiming at reducing risks to the income of farmers, and by providing timely information regarding climate and market trends to farmers.

E.g. another initiative in disaster risk reduction is the establishment of National Agro-meteorological Committee by the agricultural ministry in South Africa since 2002. This committee aims to improve disaster risk management by encouraging incorporation of disaster risk reduction measures in the various sections of agriculture i.e. animal production, crop production including other agricultural activities as well as enhancing knowledge sharing.

In the new dispensation after 1994, all farmers are expected to benefit equally from Government assistance, although commercial farmers still receive a higher percentage of the allocated disaster funds (Kgakatsi, 2007). The total funds that were made available to farm disaster assistance schemes since 1992 until 2007, amounted to approximately R5 billion (DAFF's financial records during those years). This excludes funds for animal health-related disasters, such as Foot and Mouth Disease (FMD), avian influenza, swine fever, and other outbreaks. Between 2004 and 2007 almost R1.435 billion was made available by the Government to assist farmers affected by natural hazards such as droughts, floods, fires, snow and hail (DAFF's financial records during those years). Note that this assistance excluded income losses incurred by farmers during these natural hazards and risk reduction programmes cost put in place to mitigate the hazards.

It is, however, still a challenge for the DAFF to support proactive developmental programmes to farming communities, as large amounts of funds are channeled through disaster reactive programmes. Preventative measures to reduce disaster-risk are proven to be cheaper than acting reactively. For example, buying hay or fodder during or after droughts cost more than investing in early planning measures such as stock number and grazing adaptation, because grazing veld is always the cheapest source of forage to livestock. The early implementation of disaster-risk reduction measures is therefore currently regarded as a high priority (Kgakatsi and Rautenbach, 2014).

1.8.2 Engagement of stakeholders at all levels

Since increased agricultural productivity is highly dependent on the status of the available natural resource base, a region's food and social security are also heavily dependent on how the natural resources are used or misused (Abalu and Hassan, 1998). This is especially relevant to vulnerable communities in Africa. Effective natural resource use and farming practices through collaboration between farmers, stakeholders (governments and Non-Governmental Organisations (NGOs)), and agencies on an international, regional and national level will improve national disaster-risk reduction programmes (Raju and van Niekerk, 2013) and will be to the benefit of food security (DAFF, 2014; kgakatsi and Rautenbach, 2014; McGahuey and Glover, 2013; Scherr, 2013).

E.g. in the South African agricultural sector there is a joint initiative in resources management where the National Resource Management Committee with representatives from national and provincial levels meet regularly to discuss issues on the effective management of natural resources so as to improve food production (DAFF, 2014).

The United Nation (UN) early warning systems encourage the international community to assist governments in organising national collaborative disaster-risk reduction platforms, particularly when no appropriate national authority is in place to take the lead (UNFCCC, 2008). Currently, many countries in the SADC region do not have such platforms in place, and international efforts are required to assist in implementing appropriate technologies and methodologies for system development, and to provide technical assistance in this regard.

1.8.2.1 International involvement

Most people throughout the world are aware of the terrible impact that disasters might have, while an increasing number of people are starting to realize that this is a problem that can partly be addressed in advance (UNDP, 2004), mainly as a result of developments in the fields of preparedness, leaning and forecasting capabilities (e.g. Winarto and Stigter, 2011). As a result, international policy makers are putting pressure on scientists to find methods to predict and project the occurrence, magnitude and impacts of natural and man-induced environmental phenomena, ranging from hurricanes and earthquakes to global climate change, and even the behaviour and treatment of hazardous waste (Pielke, 2006). Funding for such research (e.g. research funding in the United States of America (USA)), is justified to a large extent by the belief by the international community that scientifically based forecasts might be valuable in crafting environmental and related disaster-risk policies (Pielke, 2006).

The ISDR has outlined a major conceptual shift from the traditional emphasis on disaster response towards holistic disaster-risk reduction. This shift will enhance the worldwide objective to integrate disaster-risk reduction measures into policy development (ISDR, 2006b). It is very important to identify various client requirements in order to design appropriate research and communication strategies in addressing disaster-risk reduction (IRI, 2001). An inappropriate response and adaptation option to risks, including risks related to climatic stress, could further undermine any development efforts in the SADC region (Reid and Vogel, 2006). The World Bank is encouraging the international community to make agricultural investments and to develop priorities in disaster-risk reduction, especially those targeted at developing countries.

It is encouraging that international, national and regional research has already led to considerable advances in the science and the application potential of SCFs (IPCC, 2007a; IPCC, 2007b; Smith *et al.*, 2007).

1.8.2.2 A regional approach

On an annual basis, farmers in Africa are facing food production deficits caused by poor agricultural practices, unsustainable production, poor land-use practices, undeveloped markets, vulnerability to natural hazards and poor infrastructure. The development of a resilient smallholder agricultural sector in southern Africa not only requires investments by governments and their partners, but also commitment by farmers to perform better. Preventive measures, such as food security monitoring in sub-Saharan Africa, are essential since they would provide early warnings needed to save lives and livelihoods in the face of a wide range of potential socio-economic and environmental shocks (IDS, 2005).

The establishment of Vulnerability Assessment Committees (VACs) throughout the SADC region has initiated a process that has been at the heart of efforts to understand food security in the region (SADC, 1996). However, their activities have been dominated by the need to provide an analysis for emergency response planning. VACs were first established to contribute to the long-term goal of reducing vulnerability to food insecurity, and they were specifically designed to bring food security and vulnerability information into the developmental sectors. While many information systems exist at national level, none has specifically sought to introduce concepts of vulnerability across the disaster-development spectrum.

Climate monitoring and SCFs are important in Africa, given the large number of rural people who rely on subsistence agriculture (Maracchi *et al.*, 2004). It is important to note that in Africa there is a growing risk of crop and livestock losses, accompanied by a risk of food insecurity in vulnerable pastoralist and subsistence farming communities.

One of the challenges in addressing disaster-risk is the role that climate plays, together with other stressors in the region. This issue is now entering the arena of development action, requiring attention, not only from climate scientists, but also from others, such as governments and developmental practitioners (Vogel and O'Brien, 2006).

Regional bodies, such as SADC and New Partnership for Africa's Development (NEPAD) have a critical role to play in ensuring that national governments do not resort to insular protective policies (RHVP, 2008). The provision of alternative adaptation options for farmers wouldl contribute significantly to the improvement of agricultural productivity and food security, as well as to the reduction of poverty in the region.

1.8.2.3 National approach

In South Africa, the Department of Provincial and Local Government (DPLG) normally assists other sectors in implementing the Disaster Management Act (DMA) (No. 57 of 2002) by establishing governance and implementation structures. The DPLG further strengthens the provincial and local disaster centers in which all relevant stakeholders participate (DPLG, 2005; DAFF, 2011). The ADRM directorate also participates on behalf of the DAFF in most established disaster-risk governance structures.

To improve co-ordination on a national level, the DAFF endorsed the development of guiding principles for effective early warning, along with the establishment of early warning structures (DoA, 2001; Kgakatsi 2007; Kgakatsi *et al.*, 2007, DAFF, 2011). The national agricultural disaster-risk management committee ensures that information systems are in place for monitoring hazard and vulnerability patterns at the national level, and that they can generate low resolution-risk scenarios through hazard forecasts.

In recent years, policy for disaster-risk management in South Africa has progressed significantly to the extent of emphasising self-reliance, maintenance and protection of the sustainability of the environment as constitutional requirements and disaster-risk management (DPLG, 2004; DAFF, 2011). Other nations, frequently confronted with drought, also have similar experiences and challenges with regard to policy (UNISDR, 2013).

1.9 Food security

In South Africa there is a high demand for water to support agricultural production. This also requires large areas of grain-growing land. In 2007, World Bank figures showed that 15% of the world's food supplies are being grown with water drawn from rapidly depleting underground sources or from rivers that are drying up (Vidal, 2007). Developing countries are more vulnerable, as most of them are located in hot climatic zones where more of their citizens lack sufficient food (George *et al.*, 2005). Their economies rely more on climate-sensitive sectors like agriculture, and a greater proportion of the total population in rural areas depends on labour-intensive agriculture with fewer adaptation opportunities (Munasinghe, 2007).

Climate is one of the factors affecting development worldwide, and livelihoods can be strengthened by improving agricultural productivity, providing better access to markets and improving on-and-off farm infrastructure that would reduce poor people's vulnerability to climate variability and extremes. Climate stress in southern Africa could potentially further threaten the livelihoods of rural, resou rce-poor communities (Reid and Vogel, 2006). Food security monitoring in Sub-Saharan Africa provides early warning on food availability needs aimed at saving the lives and livelihoods of millions in the face of a wide range of potential socio-economic and environmental shocks (Verdin, *et al.*, 2005; Walker and Stigter, 2010).

The Integrated Food Security Strategy for South Africa (2002) emphasises food security as a priority objective. However, some challenges to achieve food security are, amongst others, inadequate safety nets and this constitute a weak disaster-risk management system. The increase in vulnerability is due to the growth in poverty in many countries and regions. This leads to settlements and productive activities increasingly relocating to, and expanding into, areas which are at risk (traditional flood areas, steep and unstable hillsides, wet areas, forest areas with vulnerable ecosystems etc). The crop yields of many smallholder farmers who form the bulk of the rural population in southern Africa decline, and farming becomes mainly subsistence, and that has a negative impact on food security (Tadross *et al*., 2003; FAO, 2009). Many of the smallholder farmers lack the capacity to adapt farming practices, and are therefore more vulnerable to climate variability (Tadese, 1998; FAO, 2009).

To improve food security for the greatest number of people at the fastest pace, policies regarding early warning systems must first target people who are the most food insecure (Abalu and Hassan, 1998; FAO, 2010). The use of SCF services by farming communities could enhance agricultural production that would ensure food security in South Africa.

1.10 Early warning information

All disaster emergencies and crises are highly dynamic. They may create physical, emotional and social disorder. In order to address early warning phenomena, climate services need to be made available early in time for planning purposes (ISDR, 2010). An early warning system has been used previously by considering SCF while addressing the changes of risk in malaria prone areas (Thomson *et al.*, 2006). The early warning assists in detection of any diseases that can negatively impact on agricultural production (Connor and Mantilla, 2008).

Communicating or disseminating early warning services about impending emergencies incorporates a wide range of measures that aim at coping with any risks to social society and the environment (ISDR, 2006b). When building improved early warning systems, it is important to understand the network of stakeholders who are already in place in order to identify opportunities and barriers that might affect the flow of SCF services during the dissemination process (Ziervogel and Downing, 2004).

Knowledge on how to effectively communicate uncertainty requires the consideration of the following three factors (Weiss, 2002):

- Effective communication must incorporate an understanding of the end-user's requirements from SCF information, as well as an understanding of how end-users will apply such forecast services. This should be based on social science research and close interactions with end-users (Weiss, 2002; NRC, 2003; NRC, 2006; Stigter *et al.*, 2013);

- Effective communication requires the consideration and prevention of potential user misunderstanding and confusion, which might result from inconsistent communication and the ineffective use of uncertain language and graphics;

- Effective communication of uncertainty requires an understanding of the key roles that dissemination mechanisms, technologies and the media play in conveying SCF services.

In developing societies, forecasters usually focus on food production (for example, the risk of severe food shortages and famine) instead of reducing the number of people in poverty in the country (Glantz, 2003). Through its agricultural disaster-risk management programmes it is the primary goal of the DAFF to establish effective early warning services and support capacity aimed at mitigating and reducing the impacts of natural hazards, with special emphasis on farming communities (Kgakatsi, 2007). Timely and effective warning of natural and related hazards, in conjunction with existing local capacity, can prepare communities to introduce mitigating actions in order to cope with disasters. The response capacity of the users of SCF, as well as both intermediaries and decision-makers, is very important in implementing early warning services.

Teams involved in early warnings are always faced with challenges related to the establishment of services, especially with regard to the issues between the extension services and farming communities (DAFF, 2009; Stigter *et al*., 2013). This situation can become disastrous in itself if an effective method to transmit or communicate early warnings to the poor is absent. This is especially a risk in remote rural areas without any access to the electronic media except rural radios.

The most important aspects of a successful early warning process are (1) the accurate assessment and monitoring of basic information, (2) its communication as services to users like intermediaries, and (3) to some extent to end-users (Walker *et al*., 2001, Johnston *et al*., 2004). This must be accompanied by a feedback process that would assist in improving such early warning services. It is very important to have all information on both the current conditions and the expected future climatic conditions for a specific season at hand before advising/serving users and end-users. Advisory services to the agricultural sector can be improved through proper institutional arrangements amongst relevant agencies and organisations, provincial and national technology transfer officers, national authorities, specialised NGOs and farming communities (Weiss *et al.*, 2000; Luanda, 2002). A boundary organization is very important for all stakeholders from government, scientists, other agencies and institutions dealing with disaster-risk issues to have a platform for knowledge sharing. This will strengthen coping with disaster-risk within the agricultural sector. A boundary organization as defined earlier in the abstract should form part of the governance structures in order to allow for multiple actors to participate and cross institutional or sector relationships to be built (Guston *et al.*, 2000; Morse, 2009). However, the key to all these processes is to ensure that the appropriate early warning services is reliable (at least in terms of verbal probabilities), credible and accessible.

The implementation of effective early warning services that aims to reduce the impacts of future disasters must be an integral part of any sustainable development strategy (ISDR, 2005; Wilhite, 2007). International Federation of the Red Cross / Red Crescent (IFRC) and United Nations World Food Program require SCFs to improve their early warning planning and disaster-risk management strategies (Goddard *et al.*, 2009). Some governments internationally increase funding in developing usable SCF mechanisms to achieve an effective early warning capability (Pielke, 2006).

1.10.1 Interaction between government and end-users

Researchers who previously assessed local SCF services approaches have recently suggested a more flexible and varied communication strategy between a range of actors and end-users (Vogel and O'Brien, 2006).

In the Limpopo Province of South Africa, several communities have been exposed to the use of climate services through donor-funded projects on adaptation to climate change (Archer, 2003; Ziervogel, 2004; Bharwani *et al.*, 2005; Ziervogel *et al.*, 2006). Many of these projects were aimed at supporting women and rural communities in agricultural production of, for example, vegetables. Incorporating Government structures in projects of this nature automatically improves effective communication, which guarantees sustainability through extension services in maintaining all necessary support, such as the production of advice on early warning services, finances and market access. It further enables the government to address equitable access that was identified (Archer, 2003) as a major concern when targeting the poor and those who are food-insecure.

Some programmes were developed on an *ad hoc* basis during the droughts of the 1980s and 1990s to enable response, primarily with relief efforts at the time. These programmes were not linked to national development activities (FAO-UN, 2005b), which was a disadvantage. Furthermore, it often happened that farmers did not have any contact with the service providers or project implementers, such as agencies and NGOs and they, therefore, could not depend on receiving timely advisories (Vogel, 2000; Ziervogel and Downing, 2004). This is precisely where the inclusion of national Government structures could be of great benefit. As a matter of fact, government has a moral obligation to assist its citizens during hardships and deprivation as a consequence of natural hazards. In the case of droughts, government intervention is aimed at preventing communities and infrastructures from disintegrating, thereby avoiding any large scale disruption of agriculture and socio-economic development in the rural areas at risk.

Past reactive responses in South Africa have done little to reduce the risk associated with drought and floods (DoA, 2001; DAFF, 2009). The lessons learned, above all, are that a drought in all its manifestations necessitates a much more planned and developmental approach to reduce damage, instead of only crisis management. Little attention has been given in the past to preparedness, mitigation and early warnings. Such actions could reduce negative impacts and could lessen the need for government intervention.

In the past, and at present, in some areas farmers have relied upon relief progammes from the South African Government as a means of coping with risks and disasters caused by droughts (Vogel, 1994a; Vogel, 1994b). These programmes have, amongst others, reduced the willingness of farmers to take other measures to avoid risk as most such measures like crop insurance entail costs.

The drought of 2002 to 2005, which was similar in intensity to those that occurred in southern Africa in the 1980s and 1990s, but were better predicted, has motivated meteorologists and climatologists to produce improved SCFs of such events. The WMO has implemented the Climate Information and Prediction Services (CLIPS) project to encourage the use of data and services for climate forecast purposes (WMO, 2002).

SCF services may have value, but only if people are guided to change their actions in such a way that they would then benefit from such services. A SCF may be useful, provided it permits more advantageous actions, such as altered choices of crop species, cultivars and timing of tillage (Mjelde *et al.*, 1988b) or altered composition or allocation of herds (Seo and Mendelsohn, 2008).

1.11 Problem statement

Disaster-risk managers are aware of the importance of climate services and it is relevant to incorporate these services into disaster-risk reduction (IRI, 2011). Implementing the four elements of effective early warning services (as mentioned before in section 1.1) requires the contribution and co-ordination of a wide range of individuals, government departments and institutions (ISDR, 2006b).

The main challenge in many countries, including South Africa, is the implementation of effective early warning services that integrates the four elements in addressing disaster-risk management by using SCFs. A particular challenge is to implement such a system so that it is to the benefit of smallholder farmers, of which most are still located in the pre-1994 "homelands" of South Africa. These farmers were previously disadvantaged and are still most vulnerable due their limited ability to mitigate or to respond to disasters. As a matter of fact, since the early 1990s, the frequency of natural hazard based disasters has appeared to increase, and most smallholder farming communities have abandoned their rural agricultural production activities due to crop damage caused by natural hazards (FAO-UN, 2004). In the South African context, it is therefore important for Government to pay more attention to disaster-risk reduction and mitigation in farming communities by introducing and improving early warning services, especially in smallholder farming communities where people depend on food from subsistence farming (DPLG, 2004). Here, the successful development and sustainability of effective early warning services needs to coincide with good governance and institutional support in order to establish, strengthen and maintain the services (ISDR, 2006b).

The WMO has set up an efficient extreme weather and climate warning system that assists in improving climate related disaster-risk management capabilities among nations (WMO, 2005; Golnaraghi, 2012). A recent global survey on effective early warning systems (ISDR, 2006b) indicates that considerable progress has been made in developing the knowledge and technical tools required to assess disaster-risks and to generate and communicate SCFs. This is largely due to a growing scientific understanding on communicating disaster-risk forecasts, and the use of modern information technologies. Several factors such as accuracy, skill, reliability of a SCF, media of communication, target audience, degree of uncertainty of SCF and the needs of users or end-users should be considered by the producers of SCF services (Walker *et al*., 2001; Klopper *et al.*, 2006; Hansen *et al.*, 2011).

It is important to unlock the potential of SCF use in turning early warnings into early actions (Tall *et al*., 2012). It is also important to consider users of SCFs as partners in the task of interpreting and operationalizing such information (Patt and Gwata, 2002).

It is critical for policymakers to consider SCFs during their public policy formulation in agricultural production, disaster-risk management and water management (Lemos *et al*., 2002).

Disappointing, however, is that several studies have shown a fairly narrow group of potential users actually receive SCFs, with an even a smaller number that makes use of these forecasts (Klopper *et al.*, 2006; Hansen *et al.*, 2007; Hay, 2007; Roncoli *et al.*, 2009; Hansen *et al.*, 2011). More efficient and active dialogue among SCF producers, users and end-users could lead to the identification of opportunities for improvement (IRI, 2011). In addition, more effective training and awareness programmes could also contribute to improvements in the application of SCFs (Sivakumar and Motha, 2007; Stigter, 2007; CAgM, 2010; Stigter *et al*., 2013).

The lack of interpretation of SCFs into usable services to end-users by intermediary institutions has also proved to be a barrier to incorporating probabilistic SCFs into practical decision-making (Walker *et al*., 2001; O'Brien and Vogel, 2003; Ziervogel, 2004; Vogel and O'Brien, 2006). It is very important to remove bottlenecks that could prevent users and end-users from obtaining access to SCFs (Tall *et al.*, 2012).

Although it is generally being accepted that SCFs may be useful, many constraints still exist. The most important of these are the way SCFs are understood by end-users, and how the services are applied in the decision-making processes (Klopper *et al.*, 2006). Over the past decade studies (Klopper, 1999; Vogel, 2000; Archer, 2001; Walker *et al.*, 2001; Hansen *et al.*, 2004a, Johnston *et al.*, 2004; Ziervogel, 2004; Klopper *et al.*, 2006; Stigter, 2009; DAFF, 2010b; Walker and Stigter, 2010; DAFF, 2014) have assessed and evaluated services dissemination (Fig.1.2, B1, B2 and B3), from producers (Fig.1.2, A1) to intermediaries at government level (Fig.1.2, A2) to farming community levels (Fig.1.2, A3).

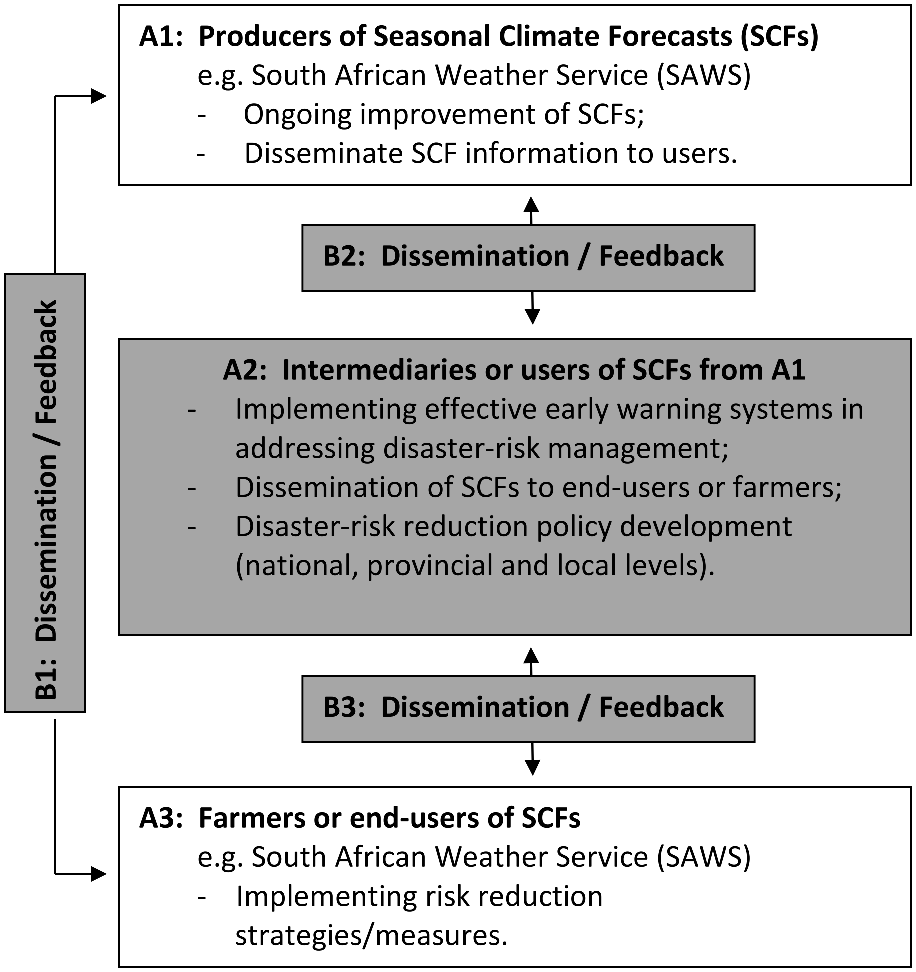

Figure 1.2:

Diagram showing the key role-players involved in the development, distribution and application of Seasonal Climate Forecasts (SCFs). This study addresses the sectors indicated by shaded boxes (A2, B1, B2 and B3).

It was previously found that communication and interaction between SCF producers, all along the SCF dissemination chain, to end-users is critical for early planning and decision-making, as well as for the management of disaster-risks (Klopper, 1999, Roncoli *et al.*, 2009). There is also general agreement that more could be done to improve on these aspects in actual applications, including using more suitable language (Stigter *et al.*, 2013).

The central hypothesis to be tested in this study is therefore:

Improved early warning services and better SCF dissemination lead to more effective and better decision making for subsequent disaster-risk reduction in the agricultural sector.

To test the hypothesis, this study firstly assesses the responsibility of SCF producers (Fig.1.2, A1). Secondly, their roles and way of services dissemination (Fig.1.2 B1 and B2) to intermediaries (Fig.1.2, A2) and end-users (Fig.1.2, A3) are evaluated. The way of how SCFs are received by users and end-users is also assessed. The study also evaluates the information feedback processes (Fig.1.2, B1, B2 and B3). The study further evaluates effective early warning structures at government level, including policies that are in place (in Fig.1.2, A2), in addressing disaster-risk reduction measures.

1.12 Aim and objectives

The overall aim of this study is: to present/propose improved and innovative early warning approaches in order to facilitate better decision-making aimed at disaster-risk reduction in the South African agricultural sector.

The key objectives are to:

1. Assess the processes and strategies followed by intermediaries in addressing SCFs dissemination, and to propose improvements;
2. Analyze and evaluate the roles and functions of both the SCF producers and intermediaries in information dissemination, and to propose improvements;

3. Investigate the preferred media used to disseminate SCFs by both producers and intermediaries to target groups, and to propose improvements;
4. Investigate the types of data and advisories supplied by producers and intermediaries, and to propose improvements;
5. Assess the relevance and effectiveness of institutional structures for early warning services dissemination, and to propose improvements.

These specific objectives should be adequate to test the hypothesis, since they address all the responsible key role-players involved in the development, distribution and application of SCFs as indicated in Fig.1.2.

1.13 Approach of the study

This study was conducted in all nine provinces of South Africa (the Limpopo, North-West, Mpumalanga, Gauteng, Free State, Kwa-Zulu Natal, Western Cape, Eastern Cape, and Northern Cape Provinces). Field work was undertaken in order to address the study objectives. Two types of questionnaires were drafted, namely open questionnaires (allowing interviewees to respond freely) and closed questionnaires (choosing from predetermined answers with a space left for innovative ideas). These questionnaires comprehensively review the knowledge, understanding, interpretation of SCF and early warnings distribution channels. The questionnaires also addressed decision-making processes related to probabilistic SCFs and other SCF products currently in place in South Africa.

The author previously worked at the SAWS as both short-term forecaster and long-term SCF producer. As part of his duties he had to deal with the responsibility of disseminating SCFs. This experience has assisted the author during the course of this study.

1.14 Thesis outline

This thesis is presented in five chapters. In **Chapter one** a literature review with introductory remarks were provided. The seasonality of South Africa's climate, the meaning of agro-meteorological services (i.e. climate services for agriculture), the application of SCFs, uncertainty in SCFs, the importance of disaster-risk reduction and disaster-risk coping in the agriculture sector, and how this relates to the conventional definition of "early warning" were all reviewed. In addition the research problem, the hypothesis, the aim of the research and the research objectives to be achieved was presented.

In **Chapter two** the research methodology used to conduct the study in addressing the objectives is introduced. The communication model, multi-purpose approach, questionnaires, sampling, data collection and statistical analysis are all presented.

In **Chapter three** results obtained from SCF producers (divided into four key groups i.e. managers, researchers, climate forecasters and disaster-risk officers) are presented with discussions around findings.

In **Chapter four** results obtained from intermediaries (divided into four key groups i.e. managers, researchers, extension officers and disaster-risk officers) are presented with discussions around findings.

In **Chapter 5** an overall summary of the thesis, with the key findings is given, followed by a discussion on whether these findings could justify the hypothesis. This is followed by a conclusion on the study.

CHAPTER 2

RESEARCH METHODOLOGY

2.1 Introduction

Short-term (e.g. one to seven days) to seasonal (e.g. one to three months, Appendix E) SCFs are regarded as being very important for agricultural production. In this study SCFs are regarded as an important contribution to early warning services, even though the time of warning is longer in advance than traditional input into early warning services.

Early warning services in the agricultural sector are therefore defined as any services pertaining to any risk, as a result of hazards that might hamper agricultural production, such as in weather forecasts and SCFs. For any early warning services to be effective, it is important to have a good understanding of the needs and demands of end-users - in this case the farmers. Aligning an early warning services to the specific requirements of farmers will lead to improved services dissemination, decision making, coping with risk, and eventually, reduced risks and less damage (Vogel & O'Brien, 2006 but with new terminology).

In the SCF distribution channel, (1) SCF producers (scientists) and (2) intermediaries currently play the most important role. These parties need to make use of the available established channels to communicate SCFs to farmers. Through this process, special care must be taken to ensure that SCFs are presented in such a way that they are understandable, and can be correctly interpreted by farmers. This is of particular importance for the correct interpretation of probabilistic SCFs that should also consider using other terminology than that in percentages (Stigter *et al.*, 2013).

In order to test the hypothesis and to meet the objectives of this study, as stipulated in Chapter 1, the research methodology proposed is based on knowledge communication – firstly through results obtained from questionnaires that were sent out to a wide spectrum of parties involved in the services dissemination channel of SCFs, and secondly through experience collected during meetings and workshops with participants. More specifically, the methodology followed is divided into the following categories:

- the communication of knowledge model;
- multi-method approach;
- questionnaires;
- respondents and sampling;
- data capturing, and
- statistical analysis.

The meaning and application of each of these categories are discussed in more detail in the following sections.

2.2 The communication of knowledge model

Effective communication channels of knowledge are required for disseminating services from the forecast producers, through the intermediaries, to end-users. There are various ways to set up such communication channels, but Walker *et al.*, (2001) suggests that they be based on five fundamentals principles, namely:

- the initiators;
- the recipients;
- a mode or vehicle;
- a message, and

- the effectors.

In the application of these principles there need to be effective communication of knowledge between scientists (meteorologists, climatologists) and intermediaries, as well as between intermediaries and end-users (in our case, farming communities). Both the sender and recipient of knowledge through communication need to understand the knowledge (messages) and communication channels (structures of communication), and must be able to encode (make sure that message transmitted will suite the mode used) the communicated knowledge and decode it (convert encoded message to a form that the receiver will understand). It is therefore important to implement optimal modes or vehicles for knowledge communication in order to provide clear messages.

It was proposed that a good communication model should consider the initiator as the first fundamental factor (Walker *et al.*; 2001, Bowers, 2006). The receiver must understand the sender and the message needs to be packaged in such a way that it can be easily decoded by the receiver, while the most relevant or the most accessible media should be used to transmit the communicated knowledge. In this study, the initiator of SCFs is the forecast producer (scientific meteorologist, climatologist), who is the first sender of knowledge in the SCF communication channel. Knowledge from these scientists is normally communicated to intermediaries or government officials at both national and provincial levels, who are defined as the receivers. Intermediaries or government officials will then become the second senders, from where the services is finally received by (established by) end-users (farming communities).

This study will revolve around the communication of knowledge provided by scientists and received by intermediaries, and then again, the communication of services issued by intermediaries. Note that intermediaries are regarded as both senders and receivers of SCFs, and therefore have a central role to play in SCF knowledge transfer. Intermediaries, as receivers, are expected to act upon the knowledge received by interpreting and understanding it as a service before transmitting it again to the following receiver, who is the end-user or farming community. During this process special care must be taken to avoid services distortion. The mode or vehicle used for channeling messages is important for effective knowledge communication. It would be most appropriate to use popular media (for transmitting the services) that is easily accessible by end-users, but that cannot discuss these services. Dialogues between farmers and intermediaries should complement knowledge transfer in services (Stigter and Winarto, 2012a)

2.3 The multi-method approach

The multi-method approach towards data collection is not only considered useful as a data collection technique, but also as an analytical tool. This allows for a researcher to approach research problems from different methodological viewpoints (Hudson, 2002). The approach will also contribute to the improvement in the data analyses and will portray pertinent study findings (Taylor, 1999). In more detail, it combines quantitative and qualitative methods, thereby allowing for a deeper exploration of the problems under investigation. Note that the qualitative methodology proposed that allowing for human factors to be incorporated differs explicitly from basic scientific quantitative methodologies.

In this study, a combination of methodologies for data and knowledge collection, including participant observation, case-studies and personal interviews, was employed. The most prominent research instrument used was questionnaires. Two separate questionnaires, one for SCF producers, and one for the intermediaries, were prepared. Both these questionnaires contained open and close-ended questions.

Some of the close-ended questions allowed for interviewees to provide additional input, under a category defined as “other”, in response to the question. It also gave interviewees the advantage of having the freedom to respond in their own way, and not to be restricted in their choices.

In addition, personal interviews were regarded as especially appropriate, since it was felt to be necessary to elicit potentially sensitive services. As a matter of fact, because of the comprehensive nature of the interview, and in particular, due to the potential for withholding sensitive knowledge, the names of senior managers, researchers, scientists, disaster-risk officers, extension officers and other interviewees were kept anonymous. This ensured the confidentiality of the respondents, who then could feel free to provide as much knowledge as possible.

Although the methods used were scientifically rigorous, the author acknowledges that some degree of subjectivity was intrinsic. However, every effort possible has been made to minimise subjective biases by using only objectively quantifiable assessment criteria.

2.4 Questionnaires

The questionnaires for researchers and intermediaries (Appendices A and B) were structured in such a way that they included some questions used in previous research (IRI, 2001; Walker *et al,* 2001; Klopper, 2002; Ziervogel 2002), although most questions were relevant to the focus of this study, as defined in the study objectives. The survey instruments were critiqued and reviewed by practitioners and professionals. This was to ensure the content validity of the questionnaires during workshops with researchers.

The two questionnaires were prepared in English. SAWS is regarded as South Africa's national meteorological service, and as such, is the primary weather and climate service provider in South Africa (Johnston *et al*., 2004). SAWS had therefore been identified as the key organization hosting SCF producers to respond to the first questionnaire, while academic institutions involved in producing SCFs were also considered. Since the relationship between the National Meteorological Services (NMSs) and agricultural role-players is critical to effectively implement early warning systems, it was regarded as essential to assess whether they have a similar focus in SCF dissemination, have confidence in each other, and are aware of each other's circumstances and roles (Relationships Foundation, 2004). The second questionnaire was targeted towards intermediaries at national and provincial departments of agriculture, including those from the ARC and organised agriculture. These questionnaires were administered and completed at the workplaces of the interviewees (i.e. at the SAWS, ARC, Provincial Departments of Agriculture (PDAs) and DAFF) or at an appropriate place during disaster-risk meetings and/or workshops. Questions were targeted towards the prediction of summer rainfall, as contained in monthly climate *Advisories* (Appendix E).

The terminologies are amended in the document as well as in the questionnaires (Appendixes A and B) based on Stigter *et al*., (2013).

The questions prepared for SCF producers were aimed at determining the following (Appendix A):

- the gender and occupation of the respondents;
- the confidence that producers have in the SCF they issue;
- the importance of SCF knowledge feedback;
- the value put on the SCFs provided;
- the importance of a boundary organization;
- the preferred medium of knowledge dissemination;
- the groups targeted to receive SCF knowledge;
- the SCF content being communicated to users, and possibly end-users;
- the actions taken to avoid knowledge distortion.

The questions prepared for intermediaries were aimed at determining the following (Appendix B):

- the knowledge communicated to end-users;
- the need for SCF knowledge from end-users;
- the application of SCF knowledge in end-user planning;
- the decisions/actions taken in response to SCF knowledge (Appendix C);
- the importance of effective structures for knowledge dissemination;
- the importance of training or awareness workshops for the end-users;
- the availability and effectiveness of disaster-risk policies and programmes;
- the frequency of discussing monthly climate *Advisories* (Appendix E).

The basic analytical procedure is based on statements that are either positively or negatively worded. This procedure/scale is commonly used in mass-media research (Wimmer and Dominick, 1991). A compiled questionnaire was administered to the random sample group, firstly from SAWS (SAWS, 2001), and secondly, from intermediaries at national and provincial levels.

2.5 Respondents and sampling

The study was undertaken in all nine provinces of South Africa (Fig.2.1). As baseline reference, the map in Fig.2.1 also shows the average annual rainfall of the country as calculated from an 80-year period (1920 to 2000). English was the medium of communication during the interviews, as all participants were conversant in English.

Producers of SCF information were firstly targeted. These producers were identified as employees in the short-term to long-term SCF sections of the SAWS, as well as scientists participating in disaster-risk structures (especially those responsible for information production and dissemination). Twenty-four (24) SCF producers from the SAWS at its head office in Gauteng, North West and the Free State provinces, as well as at the University of Pretoria (UP) (as partners), were interviewed during the study.

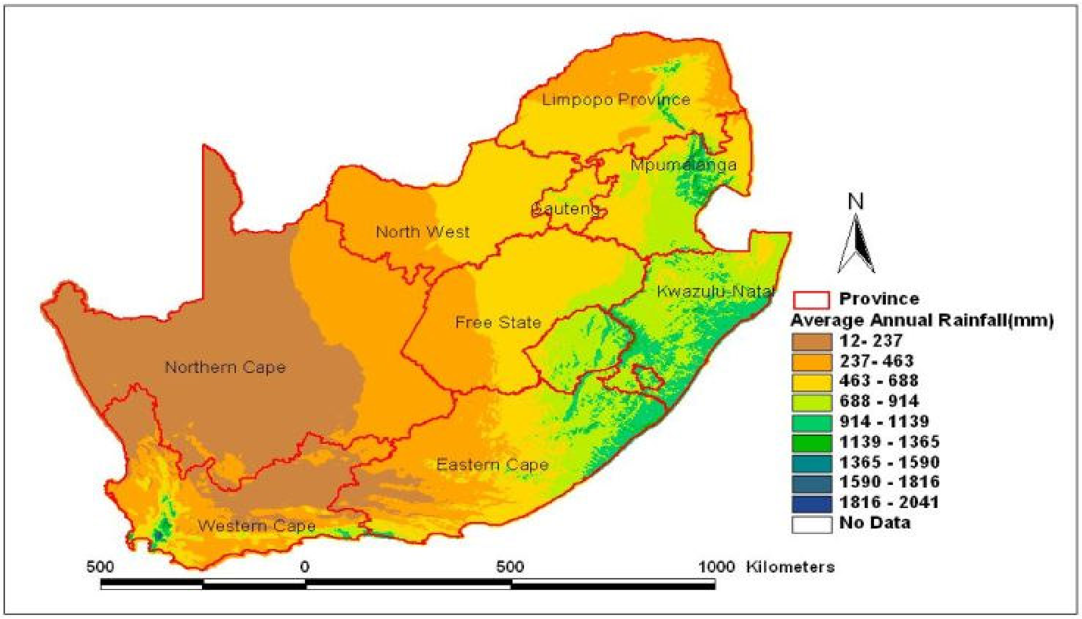

Figure 2.1:
Map of South Africa, which is the study area, with its nine provinces. Annual average rainfall calculated from 1920-2000 is also presented. Source: ARC–ISCW, (2008); see www.arc.agric.za.

Secondly, questionnaires were distributed amongst intermediaries at the DAFF, with the focus on officials involved in disaster-risk management, natural resource management, research and development, agricultural production, animal health, food security and crop estimates. These included PDA representatives of agricultural disaster-risk management from all nine (9) provinces, NAC and provincial Early Warning Committee (EWC) members, officials from the ARC (especially from the ISCW), as well as people responsible for information dissemination and/or for giving advice to farmers. The representatives from PDA and DAFF included senior management (policy makers at Director and Chief Director levels, with various line functions), as well as managers from the ARC and organised agriculture. Hunderd and ten (110) intermediaries were interviewed. The author also met with organised agriculture, namely AgriSA and the National African Farmers Union (NAFU).

In most cases, the respondents were interviewed in their work environment, although interviews also took place during disaster-risk meetings. In some isolated cases, the questionnaires were faxed to respondents, with further elaboration being done through telephone conversations, where necessary. The author made sure that spoiled questionnaire returns were kept to a minimum, usually through regular consultation.

2.6 Data and information captured from producers and intermediaries

General data and information obtained from a large sample of end-users through questionnaires and in-depth interviews are normally required for reliable feedback. Officials from the Agricultural Disaster-Risk Management (ADRM) Directorate within DAFF were therefore asked to assist with administering the distribution of questionnaires, as well as to help with interviews. In these cases, interviewers were trained on how to ask questions, especially with the focus on collecting early warning systems and agricultural disaster-risk management information.

Both SCF producers and intermediaries who were interviewed (completion of open-ended questionnaires) were further requested to identify specific challenges and to make recommendations related to the involvement of the main stakeholders in agricultural disaster-risk management. Participatory exercises facilitated further explanation and understanding of the questionnaire to the interviewees. Special care was taken to ensure that all data and information were correctly captured. Only a few remotely handled questionnaires were faxed back from intermediaries, and only 5 of these questionnaires were spoiled. The spoiled questionnaires accounted for less than 5% of the total questionnaires that were received from intermediaries, and they were not considered during the analysis. In general, the feedback response was exceptionally high, namely 95%.

More generally, disaster-risk management structures, as outlined in Fig.1.1, were considered as important avenues for collecting the relevant data for the study. In this regard, the interviewers made use of platforms such as NAC meetings and or workshops to collect research data.

2.7 Statistical analysis

The questionnaires were mostly quantitatively analyzed. For this, Microsoft Excel data files were prepared, which were imported into the Statistical Package for Social Sciences (SPSS) (see Pallant (2001) and www.spss.com for more information). The SPSS is suitable for the analyses of social science data from virtually any industry, including telecommunication, banking, finance, insurance, manufacturing, consumer packaging, goods, higher education, academic and research institutions, government and market research (SPSS, 2008). As a matter of fact the package is widely used in social sciences research.

The SPSS software is user friendly in order to avoid human error (SPSS, 2008). When using the software, a set of variables is firstly defined, where after data are imported against these variables (SPSS, 2008). Variables are also classified according to types or category. A defined value that describes a 'quality', 'characteristic' or a 'data unit' (ABS, 2012), is allocated to each variable category.

When considering input from climate producers, a categorical variable can contain values that define a category. For example, a categorical variable called "gender" was defined to contain a value 1 for "male" and a value 2 for "female", while the categorical variable called "occupational" was defined to contain a value 1 for "manager", a value 2 for "researcher", a value 3 for "climate forecaster", a value 4 for "disaster-risk officer" and a value 5 to be any occupation other than the first four. The categorical variable called "reduction of forecast distortion" was defined to contain a value 1 for "partnerships during dissemination", a value 2 for "translated information", a value 3 for "awareness and interpretation of the information", a value

4 for “participatory processes” and a value 5 for any other method specified (see Appendix A).

When considering input from intermediaries, a categorical variable called “media-preference” was defined to contain a value 1 for “fax, a value 2 for “print media”, a value 3 for “television”, a value 4 for “radio”, a value 5 for “electronic media”, a value 6 for “gatherings” and a value 7 for any other media, besides the above-mentioned. The categorical variable called “advisory-discussion” was defined to contain a value 1 for “all the time”, a value 2 for “most of the time”, a value 3 for “some of the time”, and a value 4 for “not at all”, while the categorical variable called “effective structures” was defined to contain a value 1 for “very important”, a value 2 for “important”, a value 3 for “unsure” and a value 4 for “not important” (see Appendix B).

Each response from the two questionnaires, following the variables categorisation, was then coded and the code was entered to compile a database. Frequency tables of all variables were calculated, as well as some cross-tabulations on some of the variables. Graphs and charts were generated for further analysis and interpretation according to the selected variables relevant to the study.

2.8 Summary

Research methodologies were specifically designed in such a way that they could address the hypothesis, aim and objectives of this study, as defined in Chapter 1. The methods are scientifically rigorous, yet the author acknowledges that some degree of subjectivity is intrinsic to any assessment methodology of this nature, and every effort possible has been made to minimise subjective biases by using only objectively quantifiable assessment criteria.

CHAPTER 3

ROLES, FUNCTIONS AND INFORMATION DISSEMINATION BY SEASONAL CLIMATE FORECAST PRODUCERS

3.1 Introduction

The scientific community produces SCFs with special care taken to ensure that these forecasts are as "accurate" as possible, and then make them accessible to users for interpretation, application and distribution to end-users or farmers (SCF example on Appendix E). However, despite advances in knowledge-sharing initiatives with users and end-users, as far as SCF interpretation is concerned, the understanding and application of scientifically produced SCFs still remains a challenge (e.g. Stigter and Ofori, 2014a). This is especially relevant to smallholders and subsistence farmers, since SCFs might be of great value to them in reducing vulnerability through disaster risk management.

This chapter addresses the important aspect of improving the efficacy of SCFs when made available as input to early warning services by SCF producers. The study will focus on SCF producers from the SAWS. The chapter is divided into four sections. The chapter is introduced in the first section (section 3.1), while the responsibilities and requirements of SCF producers are assessed in section 3.2. The confidence level assigned to the SCFs provided by SCF producers from the SAWS are also evaluated in section 3.2, as well as efforts and strategies implemented by these SCF producers to obtain forecast feedback from users and end-users. The section further analyses the applicable value of SCFs, as provided by the SCF producers, as well as the feasibility and importance of establishing a "boundary organization".

SCF dissemination channels used by SCF producers, through intermediaries to end-users in the agricultural sector, are reviewed in section 3.3, with an emphasis on the preferred media used to disseminate SCFs in the agricultural sector. The types of knowledge supplied to the agricultural sector by SCF producers, and what measures are being taken to avoid the distortion, misinterpretation or lack of understanding of SCFs disseminated to intermediaries and end-users, are also evaluated. Recommendations made by SCF producers to improve SCF communication, in responding to their open-ended question, are summarized in section 3.4. Since SCF producers, who are making knowledge available to both users (e.g. intermediaries) and end-users (e.g. farmers), are assessed, the concept "users" will be used as reference to both users and end-users.

For structural clarification, four occupation sub-groups were formed from the forecast producing community group, namely: (1) *manager*; (2) *researcher*; (3) *climate forecaster* and (4) *disaster-risk officer*. *Disaster-risk officer*s (also indicated in the figures as *"Disaster Risk Off')* interact with the potential end-users on a more frequent basis than other SCF producer groups (communicating more with users like intermediaries) in terms of risk reduction and disaster-rehabilitation programmes. Besides these four response sub-groups, other respondents that fell outside these four sub-groups were categorised in a fifth sub-group called: (5) *other*. The '*other'* sub-group included weather observers, short-term forecasters and climate information officers. The questionnaire directed to SCF producers is attached as Appendix **A**.

The total number of respondents from the SCF producer group was 24 (N=24), of which 9 were female (N_{ft}=9) and 15 were male (N_{mt}=15) (Fig. 3.1). From the 24 respondents, the number of respondents in the *manager* (N_m) sub-group was 7, the *researcher* (N_r) sub-group was 8, the *climate forecaster* (N_{cf}) sub-group was 8, the *disaster-risk officer* (N_{dr}) subgroup was 1, and the *other* (N_o) sub-group was 1. The respondents had to respond to predetermined categories, while multiple choices were allowed in other categories.

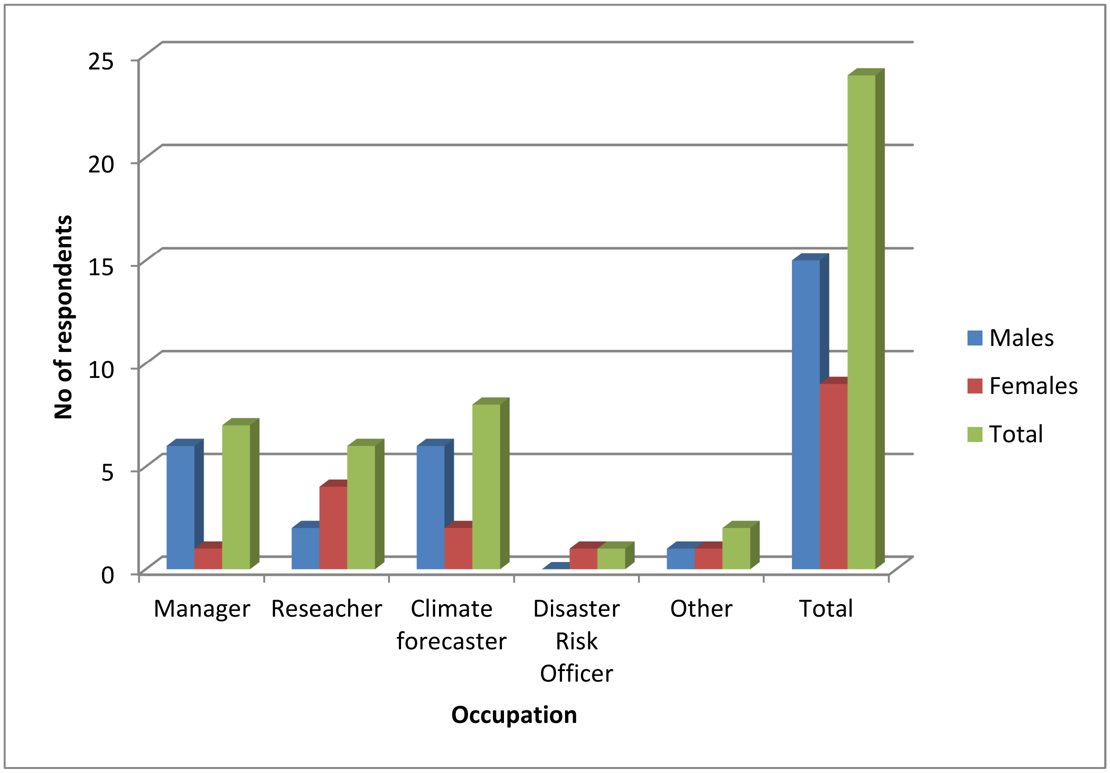

Figure 3.1: *The distribution of the number of respondents in the five occupation sub-groups from the SCF producer community. The total number of respondents was N=24, of which 15 were male (N_{mt}=15), and 9 were female (N_{ft}=9).*

3.2 Responsibilities of and requirements from SCF producers

It was previously recommended that more effort is needed to improve on the delivery of SCF services in South Africa (Walker *et al.*, 2001; Klopper, 2002; Stigter, 2008; Walker and Stigter, 2010). This could only be achieved by upgrading the SCF knowledge and modelling systems, which includes technology improvements as well as enhancing the performance of the scientists who produce SCFs, which again might lead to more confidence in SCFs.

The SAWS are currently issuing short-, medium- and long-term forecasts to the South African public, and uses various systems like super computers and other technologies to collect and analyse data, which are then converted to forecasts before dissemination to users. It is a fact that these forecasts, skilled or unskilled, already have a noticeable influence on the lives and properties of South Africans, and notably on those of farming communities (Walker *et al.*, 2001; Klopper, 2002).

In a survey by WMO (WMO, 2000), media personnel indicated that unfamiliar technology that is too technical and difficult to understand poses challenges in climate services dissemination to the public, and especially to rural household communities. It is therefore important that the transition gap between science, technology and application at the user level be bridged (Fraisse *et al.*, 2006), which is a task which begins with the preparation of SCFs.

3.2.1 Confidence in SCF products

SCF products, as well as tailor-made products, mostly emanate from innovations by SCF producers who are either scientifically qualified meteorologists or climatologists (CAgM, 2010). Probabilistic skill of SCFs of up to one season (in some cases two seasons) in advance have improved substantially over the past two decades (1980s to 1990s), largely in response to climate model development and an increased understanding of SST – South African rainfall teleconnections (e.g. the ENSO phenomenon). It is regarded as imperative that meteorologists and climatologists (including agricultural meteorologists) remain up to date on international development in the field of SCFs in order to deliver the best possible products which will contribute to the confidence that users put in these forecasts. A site for agrometeorologists that helps to remain up to date is that of the INSAM (www.agrometeorology.org).

In order to identify the confidence levels in SCF producers, respondents were asked how much trust (confidence) they had in the SCF provided to the agricultural sector from these producers. The survey showed that most respondents selected a relatively high confidence of more than 60%, while others a moderate confidence (40%-60%)

in the SCFs produced and disseminated to the agricultural sector (Fig. 3.2). A small percentage (less than 20%) of the *manager* sub-group selected the '*other*' category (yellow bar in Fig. 3.2). This '*other*' sub-group expressed concern about the fact that terminology used in the SCF is not understood by the users.

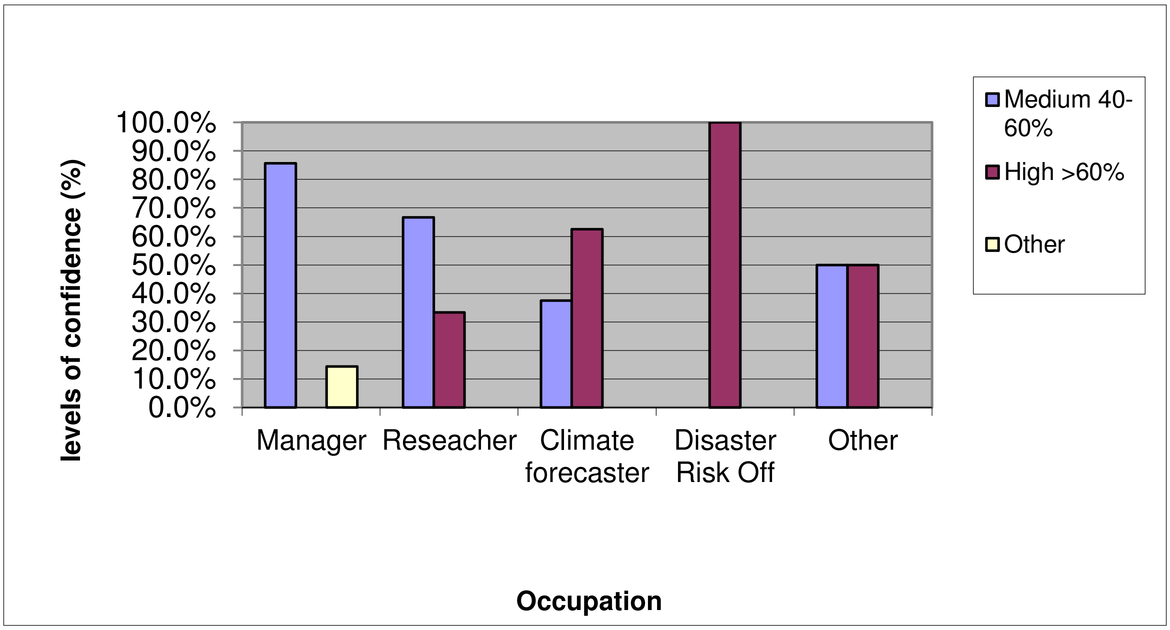

Figure 3.2: *Percentage distribution of feedback on the confidence level in SCFs amongst the five occupation sub-groups of respondents from the SCF producer community (N=24 of which* $N_m=7$, $N_r=6$, $N_{cf}=8$, $N_{dr}=1$ *and* $N_o=2$*).*

SCFs with a low level of skill could still either be good or bad for institutions like the SAWS, as they could encourage improvement in SCF capabilities such as technology and research on model performance skill, which is good, or they could lead to the loss of credibility by users, which would be bad (Klopper *et al.*, 2006).

Results from the analyses (Fig. 3.2) depict moderate to high confidence by SCF producers in SCF products disseminated to users. It is therefore concluded that SCF producers at the SAWS, which is the designated institution for producing SCF in South Africa, have moderate to high confidence in their SCF products.

3.2.2 Obtaining SCF feedback from users

It is important to have regular interaction and feedback between SCF producers, extension services and the end-user community, which includes decision-makers. Emphasis is further directed towards the importance of user and end-user community-training seminars on SCFs, and its application, in order to improve early warning services.

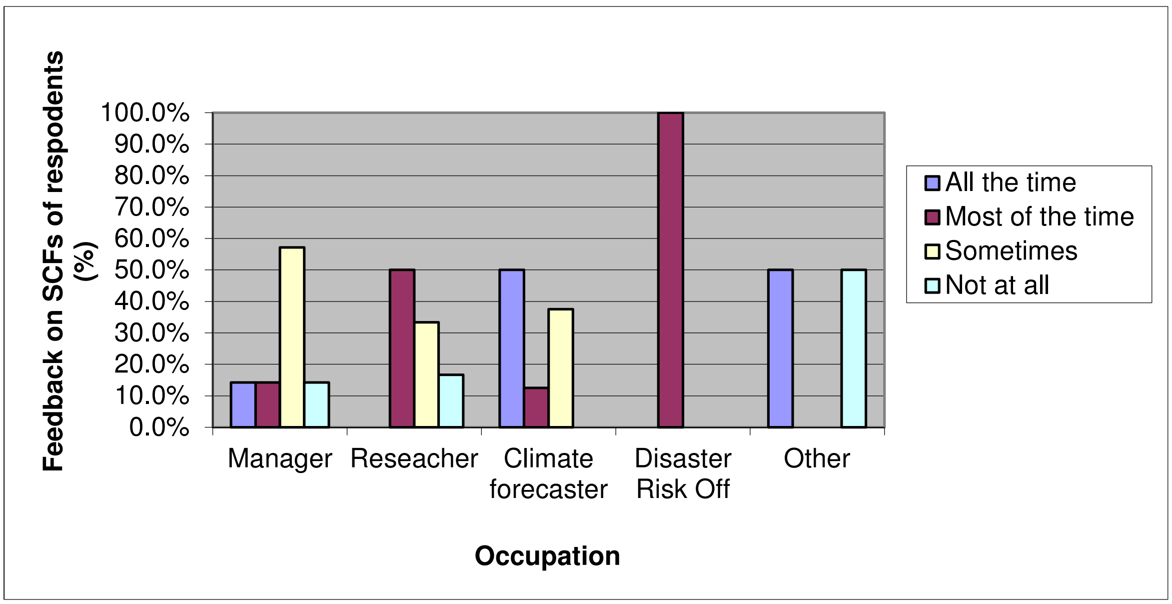

Figure 3.3: *Percentage distribution of feedback on the SCFs received amongst the five occupation sub-groups of respondents from the SCF producer community (N=24 of which* N_m*=7,* N_r*=6,* N_{cf}*=8,* N_{dr}*=1 and* N_o*=2).*

Feedback from users will assist in improving SCFs, and might even lead to immediate response on challenges faced by users, which in turn, might lead to more appropriate disaster prevention actions. Respondents from the SCF producer community were asked how often they obtained forecast feedback from users. As illustrated in Fig. 3.3, the highest percentage of user feedback is received by one respondent in the *disaster-risk officer* sub-group. All respondents from the *climate forecaster* sub-group obtain some feedback, with the exception of 10% who selected a no effort option in obtaining SCF feedback. Respondents from the *manager* sub-group most received feedback from users. With the exception of the managers group regular feedback was received from 50% or more of the respondents. This implies that with the exception of the one and only respondent under *disaster risk officer*, in 50% or less of the cases within the responding groups, contacts with respondents were established more than ‘sometimes’.

3.2.3 Strategies to obtain SCF feedback from users

Different methods and/or strategies could be applied to obtain SCF feedback from users (DAFF, 2010b). Respondents were asked which methods they have used to date to obtain SCF feedback from users, and they were further given the opportunity for strategic suggestions. Compared to the *manager* and the *climate forecaster* sub-groups, the highest percentage of respondents from the *disaster-risk officer* sub-group considered meetings scheduled after the occurrence of a disaster as being the most appropriate way to receive feedback from users (Fig. 3.4). None of the respondents considered questionnaires as a strategy for obtaining SCF feedback from users.

As indicated in Figure 3.4, the survey singled out that the most preferred means for getting valuable feedback from users is through meetings with clients affected by a disaster, and especially through meetings that take place immediately after such a disaster. The ‘*other*’ category of methods suggests events such as workshops, conferences, seminars and surveys during research work. Despite this, it still remains a challenge for SCF producers to continuously obtain feedback from users, not only after disasters, but also when SCF information was applied successfully by users in avoiding damage by a disaster.

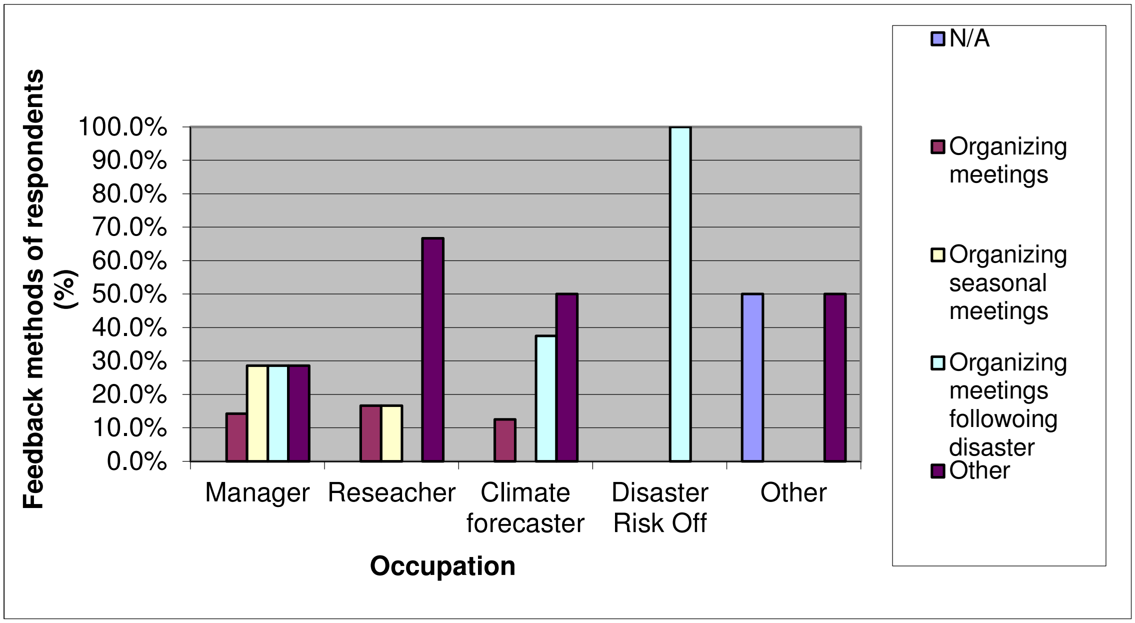

Figure 3.4: *Percentage distribution of feedback on the methods used to obtain SCF feedback amongst the five occupation sub-groups of respondents from the SCF producer community (N=24 of which N_m=7, N_r=6, N_{cf}=8, N_{dr}=1 and N_o=2).*

3.2.4 The value of SCFs

SCF producers need to continuously interact with users in order to refine the needs of users. This would assist in the improvement of the value of SCFs. Here, the value of SCFs is defined as the importance that such SCFs have in the implementation of early warning services, which obviously relates to the "accuracy" of SCFs, even though probabilistic.

The potential value of SCFs issued by SCF producers depends on factors such as the willingness of farmers to adapt their farming operations in accordance with the risks posed by the forecast, the timing and probabilistic accuracy of the forecasts and the effectiveness of forecast-information communication (Hansen, 2002; Klopper *et al.*, 2006; Stigter *et al.*, 2013). The value of SCFs can be increased by improving on these factors. SCFs only have value when it is disseminated in such a way that the users are willing to take action in response to SCFs received (Kgakatsi, 2001; Roncoli *et al.*, 2009). It is, therefore, imperative to effectively bridge the transition gap (knowledge communication channel) between SCF producers and SCF users (Klopper *et al.*, 2006).

The survey determined how valuable SCF producers regard the SCF issued by them. Results revealed that a high percentage (85 – 100%) of respondents from the *manager* and *climate forecaster* sub-groups valued the current SCFs issued as being very important (Fig. 3.5). The *disaster-risk officer* considered the value of SCFs as being important. The two respondents from the '*other*' sub-group indicated that the value of SCFs are either very important, or that they are unsure about the value of such forecasts. The *researcher* sub-group was equally divided between important and very important as the SCFs issued.

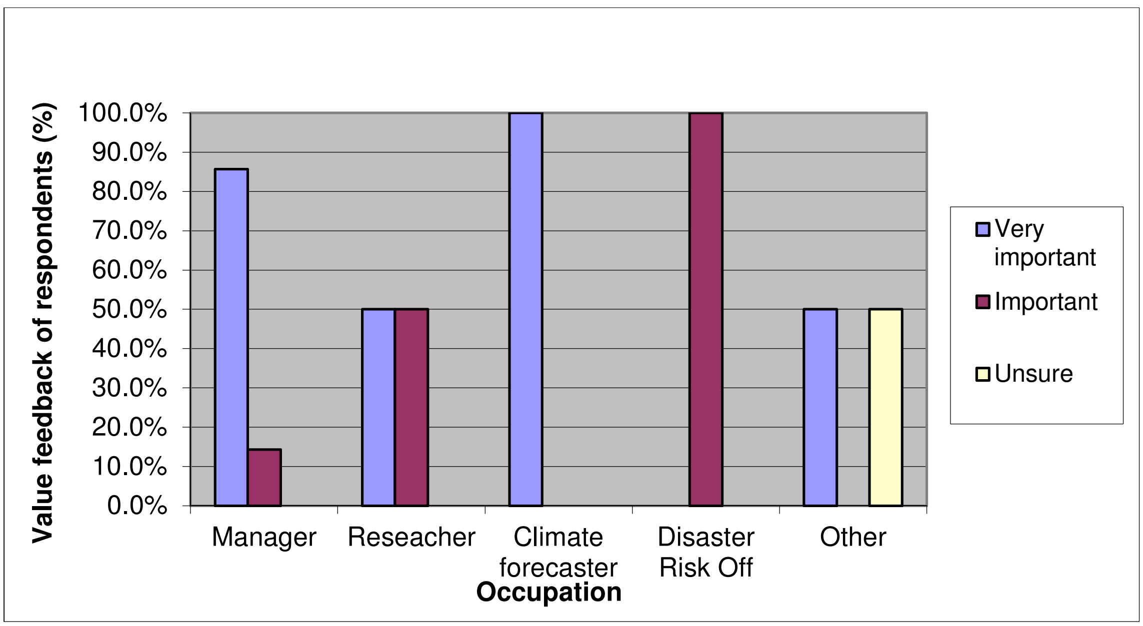

Figure 3.5: *Percentage distribution of feedback on the value of SCFs amongst the five occupation sub-groups of respondents from the SCF producer community (N=24 of which* N_m*=7,* N_r*=6,* N_{cf}*=8,* N_{dr}*=1 and* N_o*=2).*

To address this further, training and capacity building is required, not only to improve the communication between SCF producers and users, but also to improve the knowledge of professionals as well as technology used in the development of these SCFs.

3.2.5 Importance of a boundary organisation

A boundary organisation is an organization which crosses the boundary between science, politics and end-users as they draw on the interests and knowledge of agencies on both sides to facilitate evidence base and socially beneficial policies and programmes. It should form part of the governance structures of early warning services in order to allow for multiple actors to participate, and for cross institutional or sector relationships to be built (Guston *et al.*, 2000; Morse, 2009). The importance of a boundary organisation lies in its ability to facilitate interaction between scientists (from both academic and research institutions), users, as well as policy-makers. Discussions in the boundary organisation will allow for immediate knowledge sharing and information feedback across the boundaries of the various role players involved. This in turn, might contribute to the improvement of SCFs, and therefore, early warning systems. Practitioners and scientists involved in boundary organisational structures need to ensure that SCF services are continuously being updated with the best available, and that knowledge communication takes place on a regular basis. The benefit of a boundary organisation is that it will allow for new ways of thinking, brain-storming, communicating and responding to early warning services and disasters. Such actions are necessary in order to ensure that the best product available is delivered.

The survey in this study revealed that a high percentage of respondents from all sub-groups are in favour of the establishment of a boundary organisation (Fig. 3.6), not only amongst SCF producers, but also between SCF producers and users. Such an organization will create an excellent platform from where SCF producers, users and decision-makers could meet. The creation of such platforms will further enhance trust amongst the different sectors, government officials, farming communities and even researchers, and could promote the much-needed inter-sectoral co-ordination and co-operation required amongst all the role players of the SCF process.

All the interviewed sub-groups from the SCF producer's community recommended that a boundary organisation could be an important functional platform to assist with SCF information improvement as well as with better information dissemination to users. These findings support the need for proper communication channels, not only in the agricultural sector, but also across institutional boundaries. Such communication is regarded as essential in the implementation of effective early warning systems.

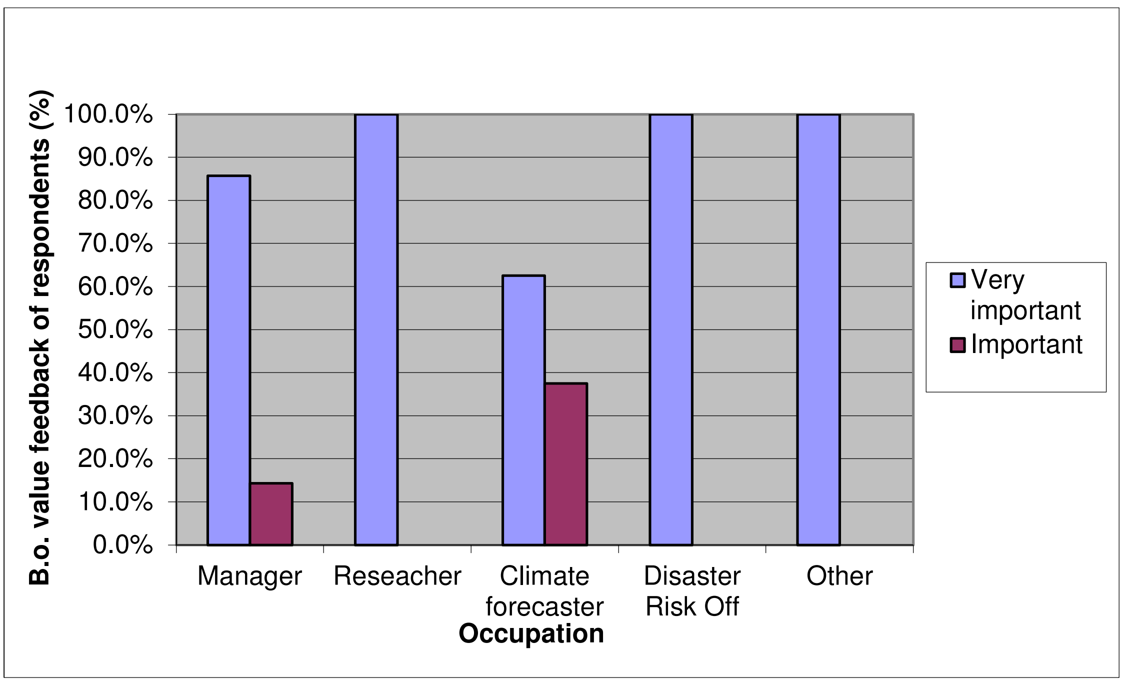

Figure 3.6: *Percentage distribution of feedback indicating the recommendation for a boundary organization (B.o.) amongst the five occupational sub-groups of respondents from the SCF producer community (N=24 of which N_m=7, N_r=6, N_{cf}=8, N_{dr}=1 and N_o=2).*

3.2.6 Summary

To summarise, an analysis on the responsibilities of, and requirements from, the SCF producers community as contained in section 3.2 revealed that, amongst respondents from the *manager, researcher, climate forecaster, disaster-risk officer and 'other'* sub-groups, there is a medium-to-high confidence level in the current SCFs issued to users (Figs 3.2 and 3.5), which indicates that SCF producers are reasonably succeeding in executing their responsibilities. It was also found that SCFs could improve significantly if feedback is received on a regular basis from users which might, in turn, lead to more effective early warning services to be implemented (Figs. 3.3 and 3.4), which is a requirement from SCF producers. It is recommended that SCF producers should make an effort to encourage feedback from users, not only as an integral part of their duties, but as a priority. However, such forward and backward communication along the SCF chain will only work if users find value in SCF products (Fig. 3.5), meaning that SCF should be applicable and those SCFs should be understandable.

Another requirement is that closer interaction between SCF producers and users could also improve confidence and openness amongst the parties involved, and will obviously lead to better information-flow channels (Fig 3.6). This promotes the requirement of establishing a boundary organization with the key function of facilitating cross-institutional communication.

3.3 Information from SCF producers to users

There are several types of media channels available for communicating SCFs to users (Walker *et al.*, 2001). Currently, both the printed and electronic media are employed to disseminate SCF knowledge in South Africa. It is known that through the use of the most appropriate communication medium, SCFs, and even other meteorological products, can easily reach most people in South Africa, except the poorest of the poor (Klopper, 2002; Kgakatsi and Rautenbach, 2014).

However, poor subsistence farmers living in remote rural areas still frequently fail to receive SCFs in time. Since these farmers are the most vulnerable, means of successful communication should be found as a matter of priority also here.

In this section, SCF producers were asked about their views on the most appropriate way of communicating or disseminating SCF information to users.

3.3.1 The use of media channels

Although media channels appear to be the most suitable means available to distribute SCFs to users, they have not yet been effectively employed in linking early warning information to disaster risk managers and users (DoA, 2007c). One main reason is the lack of dialogues (Stigter and Warton, 2012a). It is still a challenge to translate scientifically generated SCFs into understandable early warning SCF services. If such a translation could be established and effectively be discussed with users, intervention measures or early planning could be available in advance, which could reduce damage caused by a natural hazards (DoA, 2007c; DAFF, 2010b; Stigter et al., 2013).

In this section respondents from the SCF producer community were asked to give their view on the most suitable media currently used in disseminating SCF knowledge to users. The survey revealed that a high percentage of the respondents selected email, radio and Television (TV) as the most preferred media channels currently being used to communicate and disseminate SCFs to users (Fig 3.7).

The second most preferred media appears to be the printed media and faxes, followed by communication through meetings or event gatherings at knowledge transfer centers. The most preferred media channels (email, radio, TV, print media and faxes) are all of such a nature that little direct contact between the SCF producers and users actually takes place. This has the disadvantage that direct and mutual communication is reduced, which is certainly not ideal if close interaction is regarded as being important (e.g. Stigter and Winarto, 2012a).

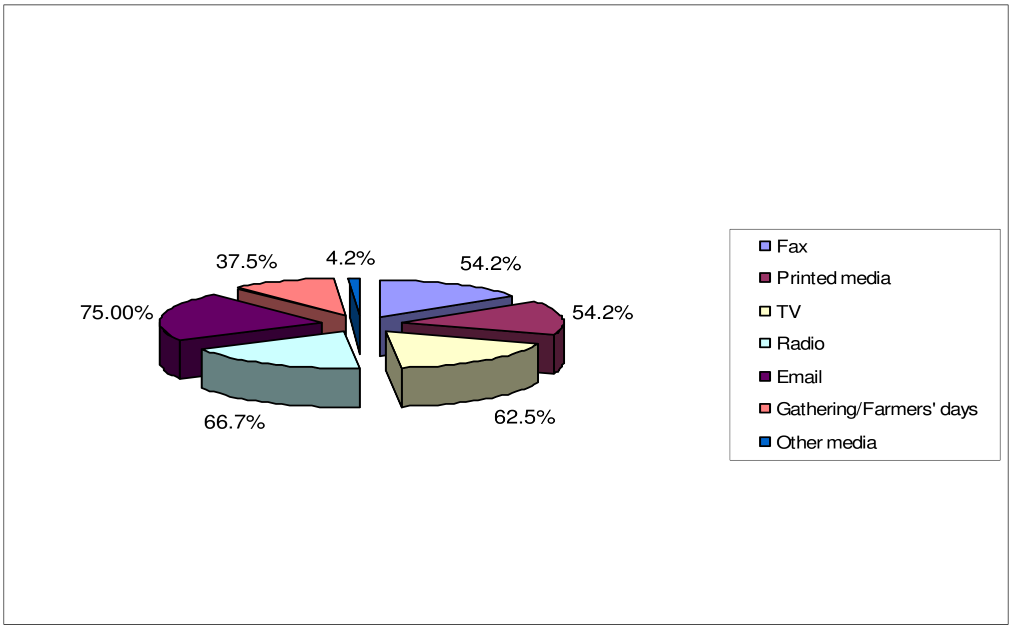

Figure 3.7: *Percentage distribution of feedback from all occupation groups in the SCF producers community on the most preferred media channels currently used for communicating SCF knowledge to users (note: each of the respondents had multiple choices, hence the total percentage is more than 100%, N=24 of which* N_m*=7,* N_r*=6,* N_{cf}*=8,* N_{dr}*=1 and* N_o*=2).*

The survey further indicates that SCF producers feel that they need to be informed on what type of communication media channel is preferred by users. Apart from the electronic media channels mentioned above, there are also professional forums that meet on a regular basis, and that aim to strengthen collaboration at both regional and national levels (e.g. SARCOF and NACOF). Unfortunately, NACOF has become dormant in South Africa, indicating that there is a need to resurrect the national South

African forums that allow dialogues between SCF users and intermediaries and/or produces.

More than 5% of the respondents prefer multiple media as the means to disseminate SCFs to as many users as possible. This is also indicative of the fact that SCF producers regard the dissemination of their products to users as being of high priority.

3.3.2 Identification of target groups

It is suggested that SCF producers (e.g. climatologists, meteorologists and agro-meteorologists) need to refine the identification and profiles of their varied audiences in order for the dissemination of SCFs to become more goal-directed.

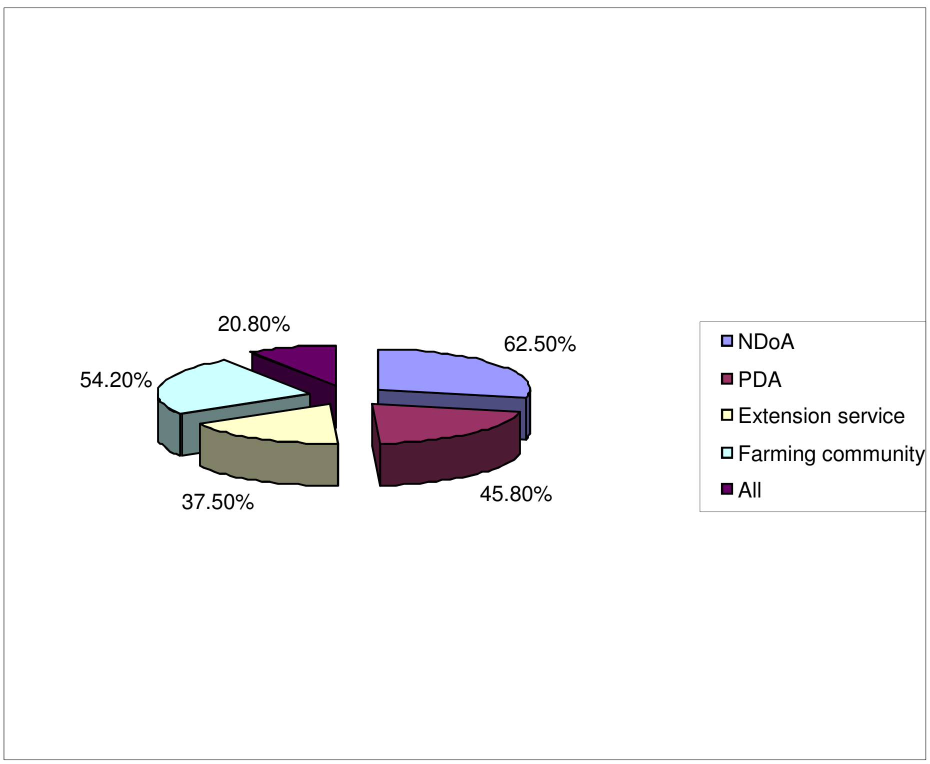

Figure 3.8: *Percentage distribution of feedback from all occupation groups in the SCF producers community on the most preferred receiving audience of SCF knowledge (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=24 of which* N_m*=7,* N_r*=6,* N_{cf}*=8,* N_{dr}*=1 and* N_o*=2).*

That implies that SCF producers who disseminate information to users should understand the needs, characteristics and profiles of the receiving users.

The identified audiences are most relevant and important to the success of the implementation of more effective early warning services based on SCFs in the agricultural sector. SCF producers consider various clients, such as DAFF and PDA officials, extension services and farming communities, as their largest receiving audiences (Fig. 3.8). Interesting to note is that 20% of the respondents have identified all the users listed as being important for receiving SCFs for their planning and decision-making.

3.3.3 What is communicated to users

The response of users in avoiding damage from an extreme natural hazard depends on the design of a SCF message that is sent to users. For example, meteorological or climatological knowledge that are made available need to accommodate vulnerability assessments as part of a threat-recognition plan. And the message also might consider including specific actions to be taken to avoid damage in the event of a severe natural hazard warning. In the survey, SCF producers were therefore requested to identify the most relevant SCF knowledge they think should be made available to users.

The selection of knowledge was classified as: (1) Probabilistic SCFs (Appendix E); (2) warning on extreme natural hazard events such as heavy rain, high temperatures and cold (Appendix D); (3) future climate events such as increased frequency and intensity of droughts and floods; (4) recommended actions/disaster-risk measures; and (5) all-inclusive measures ((1) to (4) above).

The survey showed that probabilistic SCFs and early warnings are regarded by SCF producers as the most preferred communicated knowledge to users, with all respondents selecting probabilistic SCFs at 100%, followed by early warnings at 86%

(Fig 3.9). To a large extent (only 14% in favor), the SCF producer community prefers not to communicate “actions to be taken / measures to be implemented / advice on how to act – all defined as *disaster risk measures* in Fig. 3.9” to users. Because of this preference, the problem of difficult to understand scientific language is not solved (Stigter *et al*., 2013)

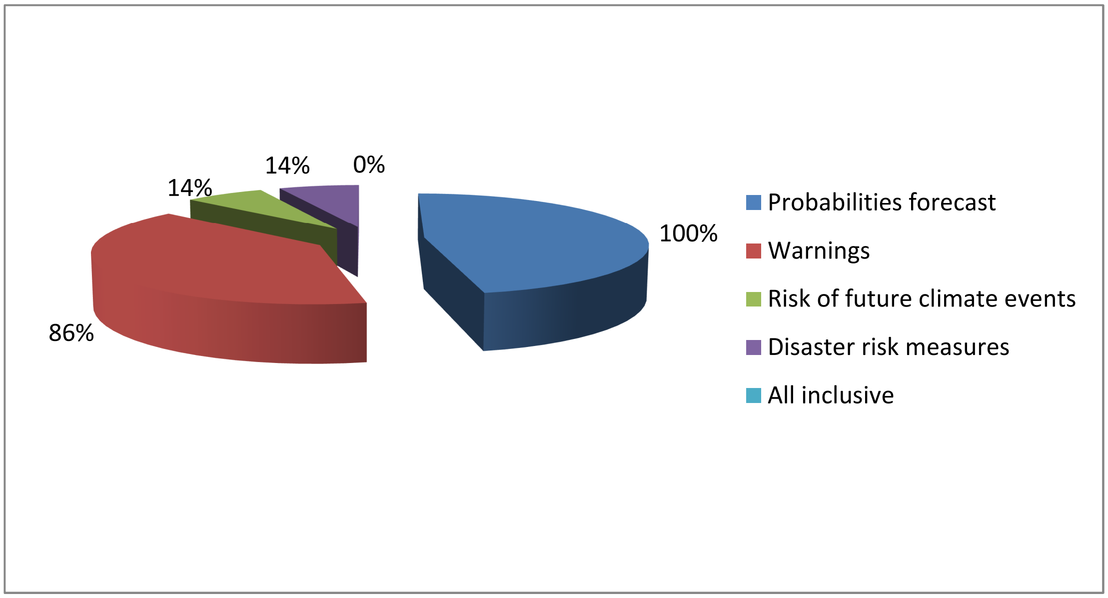

Figure 3.9: *Percentage distribution of feedback from all occupation groups in the SCF producers community on the content of knowledge to be communicated to users (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=24 of which* N_m*=7,* N_r*=6,* N_{cf}*=8,* N_{dr}*=1 and* N_o*=2).*

Communicating the likelihood of future climate events is also not on their priority list. This is in spite of the fact that actions to be taken should be the most important knowledge for users, as this would enable them to respond effectively to any SCF that could pose a risk. Suggestions for action are seen as not being part of the mandate of SCF producers, meaning that now user networks should address this.

3.3.4 Avoiding distortion of SCF information

Effective knowledge communication is often hampered by communication barriers, such as noise (here: information not belonging to the message), different perceptions, knowledge-level, language, inconsistencies, and difference in status, distrust and resistance to change. In some instances, SCF producers assume that users understand meteorological or climatological terms, although this may not be the case. This could result in knowledge being distorted.

Bridging this gap is a major challenge for SCF producers, who need to translate concepts in their knowledge, and end-users, who need to understand the SCF knowledge that is made available to them.

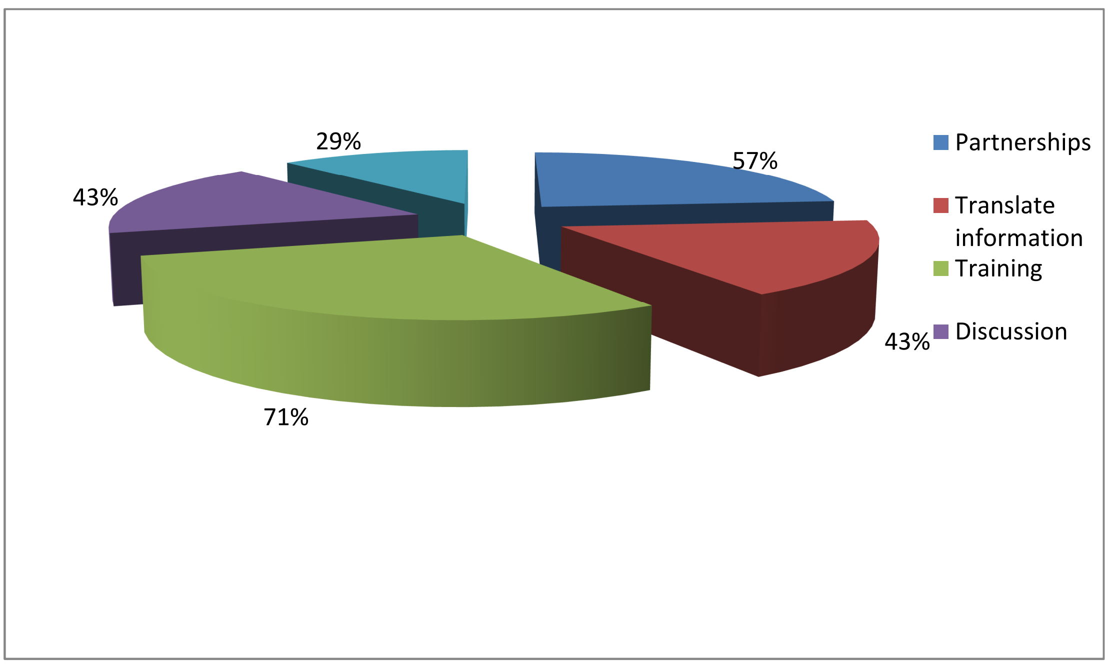

Figure 3.10: *Percentage distribution of feedback from all occupation groups in the SCF producers community on the methods used to avoid knowledge distortion (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=24 of which* $N_m=7$, $N_r=6$, $N_{cf}=8$, $N_{dr}=1$ *and* $N_o=2$*).*

Effective knowledge is therefore very important during the process of SCF dissemination. Respondents from the SCF producer community were requested to identify the method(s) taken to avoid SCF distortion during the dissemination process of such knowledge to users. The survey indicates that all predetermined categories were selected by the respondents, with most respondents choosing training, at 71%, followed by partnerships at 57%, both discussion and translation at 14% and other methods at 29 % (Fig. 3.10).

3.3.5 Summary

The SAWS, in co-operation with the relevant research and academic institutions, are mandated to ensure that all SCF knowledge provided by SCF producers is comprehensible, clear and useful to users, which include intermediaries, decision-makers and farmers. The high priority and commitment currently given by the SAWS by fully participating in disaster-risk structures (e.g. NAC, Provincial Disaster Management Centers (PDMCs) and National Disaster Management Center (NDMC)) as well as chairing the Early Warning Task Team, is expected to improve SCF knowledge communication progressively in future. Renewed efforts to collect knowledge, like in this study, could assist with this improvement, which will eventually lead to a more effective implementation of early warning services to the agricultural sector. This will obviously result in improved coping with disaster risk and more effective early warning services.

In this section it was found that SCF producers assume that they already made SCF knowledge available in an understandable format to users, and mostly through the media channels preferred by the users. However, tailor-made forecasts for identified clients could still significantly improve response and decision-making (e.g. Hansen, 2005). It is also important that care should be taken that SCF should be understandable and easy to interpret.

The information currently disseminated to users is in the form of raw probabilistic SCFs that still need further packaging in order to make them useful to clients (Stigter *et al*., 2013). Any distorted information in the dissemination path could jeopardise the accuracy and the application of SCFs (Kgakatsi, 2001), and more training and closer partnerships were identified as the preferred approaches to improve communication.

3.4 Open-ended response to communicating SCF information

Response to the open-ended questions of the questionnaire highlighted several issues that could improve the use of SCF knowledge in order to create more effective early warning services in the agricultural sector. In essence, it was generally felt that SCF producers should strengthen their relationships with users and seek stronger collaboration with the relevant authorities in the agricultural sector, such as DAFF, PDAs, ARC and organised agriculture (including commodity groups).

A further viable suggestion made was to invite the media to participate in information dissemination workshops. This would furnish them with the relevant scientific knowledge. SCF producers felt that agricultural officials, such as extension officers and the disaster-risk officer group, should be invited on a more regular basis to form part of the monthly SCF discussions and climate-outlook forums that take place in the country. In this way, knowledge could be shared and become more relevant in the packaging of SCF products to users.

It was also felt that the SAWS, as well as research and academic institutions, should collaborate closer in strengthening forecast development and verification programmes in order to ensure greater reliability and value-improvement of SCFs. The SAWS and its partners, such as academic and research institutions, should focus on and invest progressively in, educating the different sectors involved in SCF in order to improve the understanding and application potential of SCFs. Such actions will certainly assist in bridging the knowledge gap between the production and the use of increasingly technical SCF knowledge. Furthermore, efforts need to be made in downscaling SCFs to provincial or even district and community levels (Branscome, 2010; Tabor and Williams, 2010; Yoon *et al*., 2012). Information could preferably be drastically simplified and translated into local languages in order to avoid any misunderstanding and to promote application, especially amongst the poorest of the poor who are not necessarily proficient in English.

Regular information-sharing meetings and workshops with farming communities are found to be of major importance in the learning curve of both SCF producers and users. These would ensure goal-directed, user-friendly and timely information sharing. Closing the gap between SCF producers and users will doubtlessly improve effective knowledge communication, and eventually the value and application of SCFs.

In conclusion, it was generally regarded as very important to strengthen all structures in the SCF development chain, early warning services, and eventually the coping with disaster management framework, with specific emphasis on effective communication. Apart from this, post-processing and feedback through evaluation of SCFs was also found to be important, since it might lead to the improvement of the reliability of SCF products, and can also contribute to better decision- making in the process of coping with disasters.

3.5 Chapter summary

Over recent years, it was found that the availability and effective application of SCF knowledge carries important implications for agricultural production and food security in South Africa. In a dry country like South Africa, with high rainfall variability, climate predominantly dictates the success of sustainable agricultural production. Continuous research aimed at improving SCF skills and channels of SCF knowledge dissemination are two of the most critical activities required from everybody involved in the SCF process.

This chapter has analysed and discussed the value and dissemination of SCF knowledge from the perspective of SCF producers, with emphasis on the evaluation, reliability, value and effective dissemination of SCFs to targeted audiences at different levels in the agricultural sector. It was generally found that South Africa still faces great challenges related to the improvement of the value and use of SCFs. Such knowledge is centrally important for planning purposes, more effective early warning services, and better coping with disasters.

The SCF producing respondents also felt that it is important to establish an environment of credibility and trust in SCF services. The importance of feedback and post-processing to assess communication and forecasting skill cannot be overemphasised. Any new initiatives in improving knowledge of the science of SCFs, and of how to address limitations and uncertainties in SCFs should be welcomed with open arms. In addition, SCF producers should increasingly focus on improving the quality and skill of SCFs in their institutions, without losing perspective of the requirements from users. On the other hand, continuous feedback from users should take place, a process that will contribute to a higher value of SCFs.

An interesting result from interviews was that the use of boundary organisations in research and academic institutions will further improve the performance of the SCF producers, as well as strengthen collaboration with decision-makers for the effective implementation of early warning services.

It was recommended that the SAWS, according to its mandate for public good service, should be more engaged in collecting relevant requirement information from users, and should make informed decisions on moving forward with better product development, focused dissemination and more effective communication.

In support of these recommendations, funding is requested to improve SCF methods, to enhance research and to improve the dissemination of early warnings. Such capacities should be expanded and intensified within research institutions.

CHAPTER 4

ROLES, FUNCTIONS AND INFORMATION DISSEMINATION BY INTERMEDIARIES

4.1 Introduction

In order to ensure improved performance, all users of SCFs, are progressively requiring and expecting more reliable and authoritative information for their decision-making (CAgM, 2010). These users include government (at various levels of authority), academic and research institutions, the private sector and industries, NGOs, and in the case of the agricultural sector, farming communities. Intermediaries, that predominantly form part of government structures in South Africa, receive SCF knowledge from the SCF producers (as defined in chapter 3), from where such knowledge is disseminated in a coordinated fashion to end-users (e.g. farming communities).

This chapter addresses the importance of improving SCF knowledge compilation, and the subsequent dissemination by the intermediary group in order to propose interventions for producing more effective early warning services. A particular emphasis is placed on how SCF usage could contribute to strengthening relationships between intermediaries and farming communities, and how this could contribute to a larger coordination in the coping with agricultural disaster risk in South Africa. The detail content of SCF knowledge is beyond the scope of the study, and more emphasis will be placed on the dissemination of such knowledge. Only the major levels of intermediation are considered, namely intermediation through government officials, at national and provincial levels, and the dissemination of SCFs among farming communities.

Note that the word "intermediaries" refers to any individual or organisation responsible for the communication or dissemination of SCF knowledge received from SCF producers (e.g. SAWS) to end-users (all end-users of SCF knowledge). As mentioned before, end-users in this study are regarded as farmers.

In section 4.1, the total number, gender and occupations of respondents from different intermediary groups that participated in the study, are defined. This is followed by identifying the roles and functions of these intermediaries in section 4.2. Here the confidence of intermediaries in SCFs, as provided by SCF producers and prepared for distribution by intermediaries, as well as the efforts and strategies in place to obtain SCF knowledge feedback from end-users, is explored. In addition, the value of SCFs and the need for establishing a boundary organization is determined, but in contrast to chapter 3, from the view of intermediaries. In section 4.3, access to SCF dissemination channels from the intermediary level to end-users level are explored, as well as the dissemination media preferred by intermediaries. In section 4.4, emphasis is placed on assessing the understanding, interpretation and implementation of SCFs by end-users. An important aspect was to assess how intermediaries communicate to end-users, and what measures are taken to avoid the distortion or misinterpretation of SCF knowledge. In the following sections, the effort taken in addressing SCF use, awareness and capacity building through workshops, are explored. These are regarded as a mechanism to improve the understanding and use of SCF knowledge. The chapter will further assess the importance of such training or awareness workshops in the agricultural sector, and will also look at whether such workshops currently contribute to an improvement in the understanding and application of SCFs. The question of early-warning services feedback is further deliberated. The importance of effective early warning structures in support of coping with disaster-risk is also evaluated. Finally, salient recommendations made by intermediaries, at both national and provincial levels, are documented and interpreted, with a focus on how SCF knowledge is communicated with the view to optimise coping with disaster-risk in the agricultural sector of South Africa.

Four occupation sub-groups of intermediaries were considered during the survey, namely: (1) decision-makers at *management* level; (2) *researchers* within the agricultural sector; (3) people involved in *extension services* (in the figures this is indicated as "*Ext. Service*"); and (4) *disaster-risk officers* in the agricultural sector, at both national and provincial levels. In addition, an *ad hoc* sub-group classified as "*other"* was included. This "*other*" sub-group included respondents such as information officers and other employees, at both provincial and national offices, but with line functions that do not necessarily fall under the four main sub-groups.

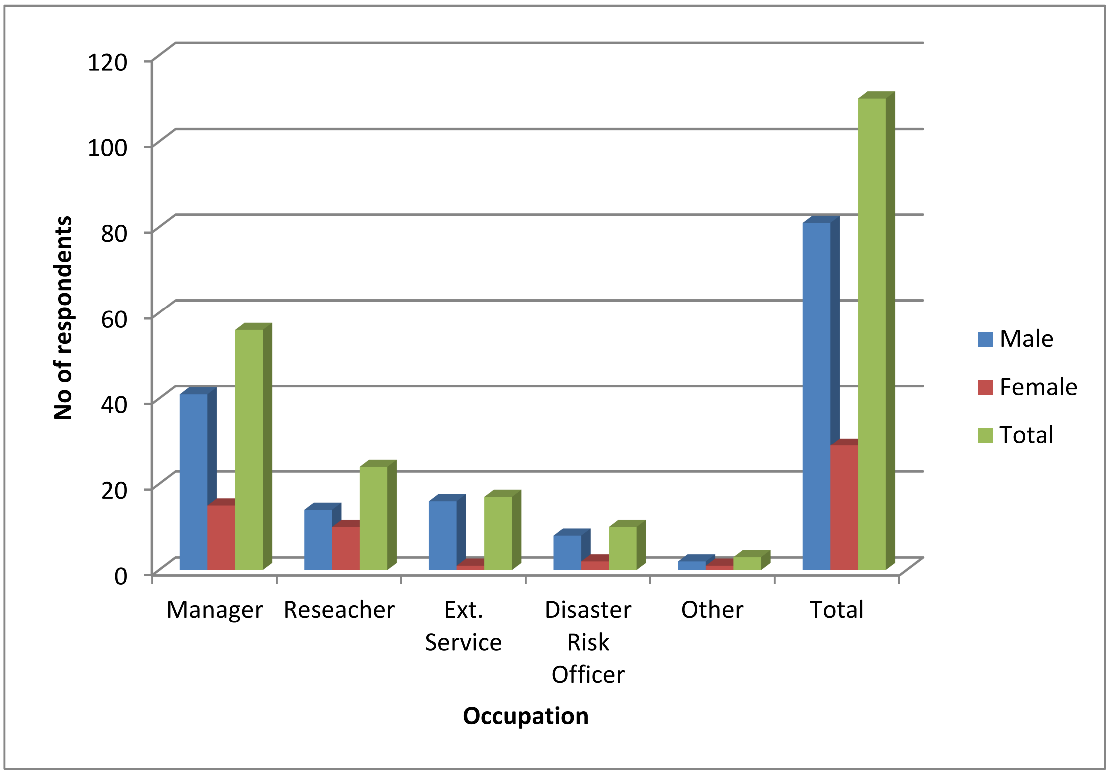

Figure 4.1: *The distribution of the number of respondents in the five occupation sub-groups from the intermediary community. The total number of respondents were N=110, of which 56 were male (N_{mt}=56), and 46 were female (N_{ft}=46).*

In order to identify factors that might have an influence on decision making by intermediaries, and whether SCF knowledge is incorporated in such decisions, a questionnaire was administered to participants responsible for disaster risk management in all nine provinces of South Africa. The administered questionnaires were mostly closed, with additional space allowing for further innovative input to some questions. The total number of respondents from the intermediary group was 110 (N=110), of which 29 were female (N_{ft}=29) and 81 male (N_{mt}=81) (Fig. 4.1).

The number of respondents in the four sub-groups of the intermediary group was 56 in the *manager* sub-group (N_m=56), 24 in the *researcher* sub-group (N_r=24), 17 in the *extension services* sub-group (N_{es}=17), 10 in the *disaster-risk officer* sub-group (N_{dr}=10) and 3 in the '*other'* sub-group (N_o=3). In some cases respondents selected one option per predetermined category, while in other cases respondents were allowed multiple choices. In the cases where there were multiple choices, the percentage total allocated was more than 100.

4.2 Responsibilities of intermediaries

The most important responsibilities of intermediaries are firstly to ensure effective dissemination of SCFs to end-users, and secondly to give advice to SCF producers on how to improve their products. Both these responsibilities are directly linked to achieving effective coping with disaster. Intermediaries, as the link between SCF producers and end-users, therefore provide valuable support in the knowledge dissemination and decision making processes. They further play an important role in assisting end-users with the interpretation and application of SCFs.

As a matter of fact, previous researchers (Archer, 2001; Walker *et al.*, 2001; Stigter, 2002; Huda and Packham, 2004; Ziervogel and Downing, 2004) have identified intermediaries as an important communication link between SCF producers and end-users. Because of this responsibility, it is important that intermediaries from government and scientific organisations are well trained to be specialists in the field of SCF application. By using their knowledge, they also need to assist in training and capacity building down the line.

As a matter of fact, the role of intermediaries in the broader disaster reduction framework is of paramount importance. Farming communities face a number of challenges in their daily operations. These include coping with risks according to early warnings (Hudson, 2002; Mukhala and Chavula, 2007). Mechanisms and management structures must therefore be developed in order to build and maintain strong, persistent and dynamic interaction between the end-users of SCFs and those involved in their production. Such networks are maintained by intermediaries.

4.2.1 The reliability of SCF knowledge

The reliability of SCFs in the agricultural sector still remains a challenge, despite scientific advances in understanding the causes of climate variability and predictability (Sivakumar and Motha, 2007; CAgM, 2010; Stigter *et al*., 2013). This will always be the case as atmospheric propagation is to a large extent non-linear, meaning that SCFs will scientifically always be expressed in terms of the probability of occurrence. Various forms of forecasts are commonly made in the agricultural sector, and many of these forecasts rely on SCFs. For example, decision- makers might forecast required actions and outcomes, and crop managers might issue forecasts on crop yield. It is therefore always good news for the SCF community if respondents express at least some confidence in the reliability of such forecasts. The accuracy of SCFs is determined by comparing them to actual observations over the forecast period, while the reliability is expressed in terms of the number of times that a SCF was correct in terms of climate anomaly categories (e.g. below-normal, normal and above-normal). Since SCFs are scientifically mostly expressed as probabilities, they are mostly evaluated in terms of reliability, instead of accuracy.

Respondents from the SCF intermediary group were requested to rank their impression regarding the accuracy of SCF information provided by SCF producers during the past seasons, when compared to actual climatic conditions (Appendix E). The survey revealed (Fig. 4.2) that the highest percentage of respondents considered the SCFs to be mostly accurate, followed by a ranking of "sometimes accurate". With the exception of 30% of the respondents from the '*other*' sub-group, none of the respondents considered the SCF to be "always accurate". However, this was only one person, as category had only 3 respondents.

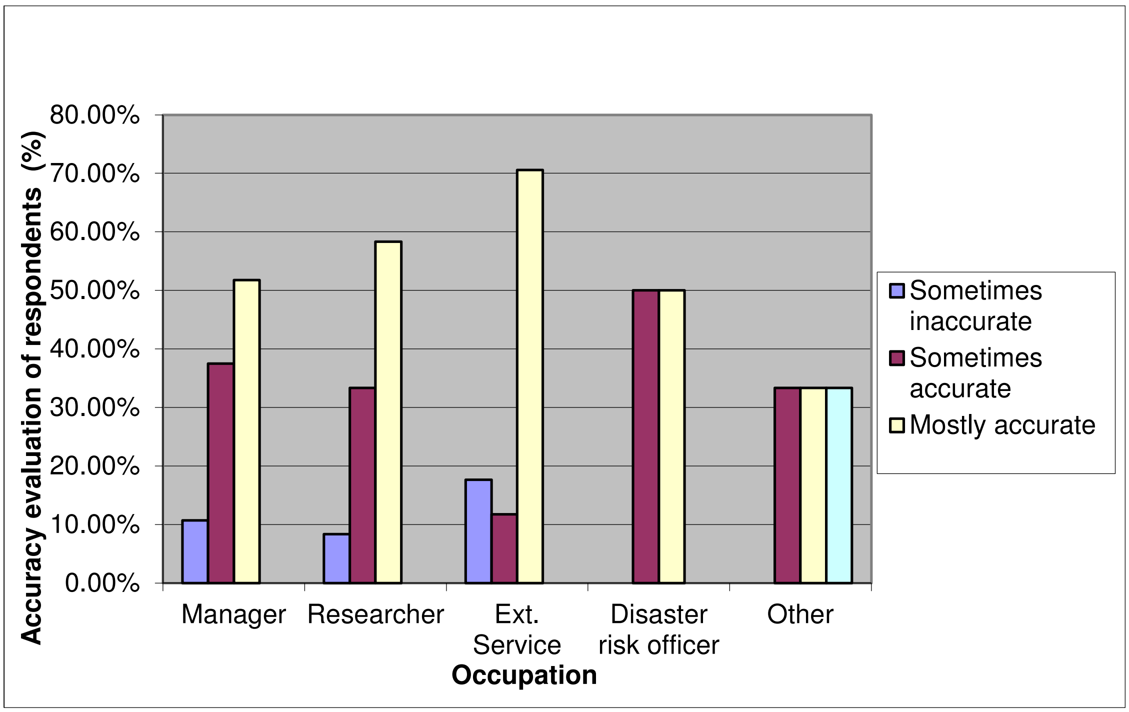

Figure 4.2: *Percentage distribution of feedback on SCF accuracy amongst the four occupation sub-groups of respondents from the intermediary community (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

The outcomes in Fig. 4.2 are encouraging with more than 50% of all sub-groups in the intermediary group consider SCFs to be generally accurate, although the challenge to increase the reliability of SCFs still remains.

4.2.2 Obtaining feedback from end-users

As mentioned in chapter 3, feedback from end-users could help in improving the products provided to such users. As far as SCFs are concerned, the knowledge services by intermediaries should therefore always strive to improve customer service by evaluating the needs and recommendations from end-users, and then to incorporate these, where possible, into SCF products and services (Stigter, 2002).

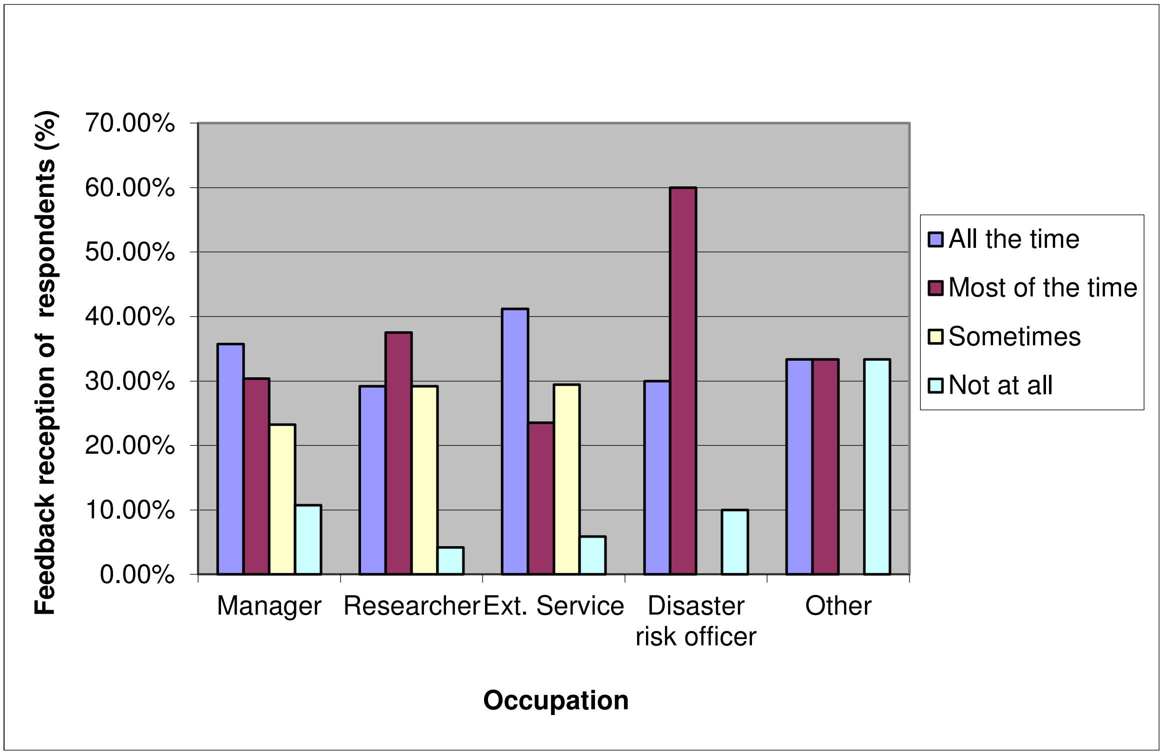

Figure 4.3: *Percentage distribution of feedback on efforts to obtain feedback from end-users amongst the four occupation sub-groups of respondents from the intermediary community (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

In order to establish whether intermediaries managed to obtain SCF feedback from end-users, respondents were asked about how often they make an effort to obtain such feedback. There are here no indications on whether such feedback was positive or negative. Most respondents from all the intermediary occupation sub-groups ranked their efforts in obtaining SCF feedback under the following positively orientated categories: (1) “all the time”, and (2) “most of the time” (Fig. 4.3). It was found that a not negligible number of respondents of the first three groups of respondents reported to obtain feedback “only sometimes” while a small percentage of respondents did not obtain any SCF feedback. Almost 60% of the *disaster-risk officer* sub-group reported that they indeed obtained such feedback “most of the time”. This high percentage of feedback from end-users should lead to a good work relationship between intermediaries and end-users, and should eventually not only improve the quality of SCF products, but also the service delivery in addressing disaster risk coping in the agricultural sector. It should of course be assured that these intermediaries report this feedback obtained to the SCF producers.

4.2.3 The value of SCF knowledge

It is important to ensure that the full SCF knowledge flow chain (dissemination and feedback) in the agriculture sector is fully implemented and undertaken, since the value of SCFs can only be established if the knowledge provided improves the decision-making and response process (Klopper, 2002; Maynard *et al.*, 2004; Hansen *et al.*, 2011). As a matter of fact it has been found that the economic value of weather and climate services products appears to have steadily increased over the past years due to public awareness and demand (Hooke, 2013; Katz and Murphy, 2005; Klopper, 2002;). It is known that the ideal way to assess the value of SCF knowledge flow is through intermediaries, as they are central between SCF producers and end-users.

In order for SCFs to be of value to end-users, there must be a level of confidence in such knowledge by the end-users. Communication, and therefore knowledge flow between scientists and policy-makers is sometimes difficult. So is communication between policy-makers and end-users. Such obstacles may distort the knowledge, which in turn, could compromise the value of SCFs, particularly when the media interpose themselves as primary interpreters of SCF knowledge (Luanda, 2002).

With their experience in dealing with both SCF producers and end-users, respondents from the intermediary group were therefore asked to assess the value that they assign to SCFs. The survey (Fig. 4.4) revealed that a highest percentage from all the participating occupation sub-groups of respondents ranked the value put on SCFs as generally very important.

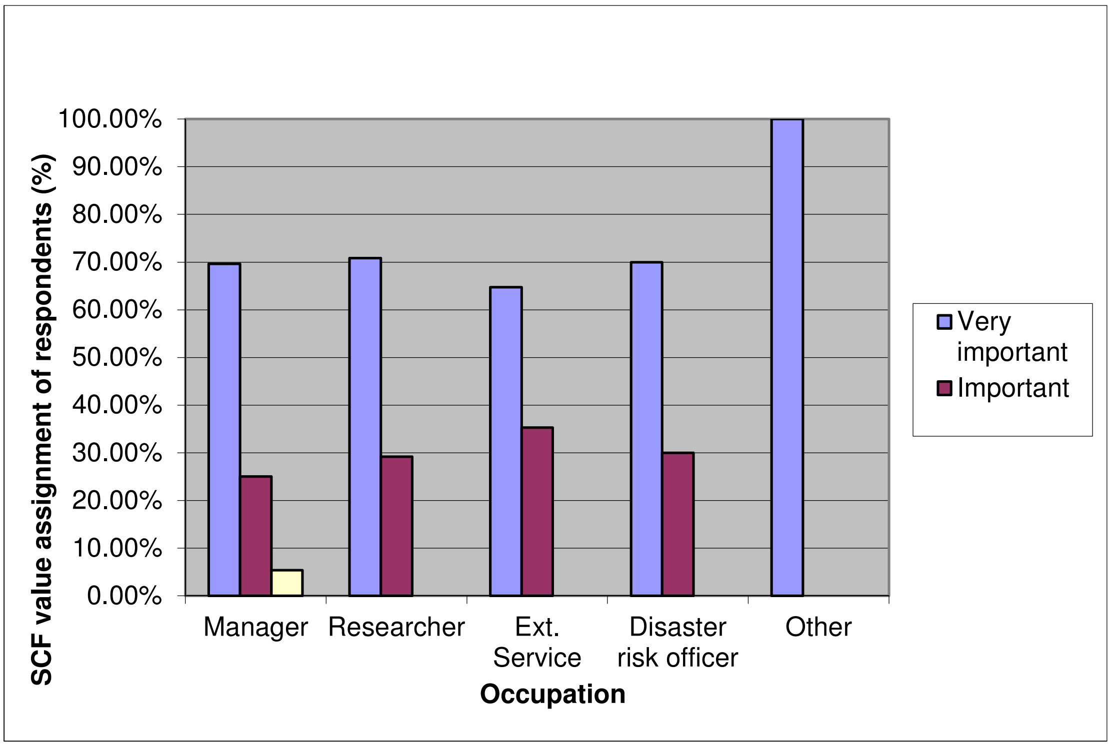

Figure 4.4: *Percentage distribution of feedback on the value assigned to SCFs amongst the four occupation sub-groups of respondents from the intermediary community (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

A moderate percentage (between 20% and 40 %) of the respondents considered the value of SCFs as being "important", while a very small percentage (5%) of the *manager* sub-group had indicated that they were not sure about the value of SCFs. A concern is that when end-users receive knowledge from this 5%, they might appear to be not too interested in the knowledge, which might influence the impact of such knowledge on end-users. Fortunately it was found that, in general, intermediaries assigned high value to the SCFs that they received and disseminate to end-users.

4.2.4 The importance of disaster-risk policies

It is known that relevant SCF research findings and outputs could not only assist policy-makers, but also guide them in identifying where actions need to be taken in order to implement disaster-risk measures (Yodmani, 2001). Disaster-risk coping policies could also assist government in implementing effective early warning services for the agricultural sector (Gibba, 2002; Hartmann *et al.*, 2004).

Figure 4.5: *Percentage distribution of feedback on the importance of disaster-risk policies amongst the four occupation sub-groups of respondents from the intermediary community (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

As climate knowledge is essential for successful agricultural enterprises, as well as for sustainable agricultural production, it is desirable to assess the application of SCFs in the agricultural sector (Mjelde *et al.*, 1997; Munasinghe, 2007). Such assessment might contribute to the formulation of policy directives in agricultural (and water) management, the implementation of disaster-risk reduction measures, as well as in emergency disaster-relief provision.

The uncertainty about the importance of disaster-risk policies, as expressed by a portion of the *extension service* sub-groups (Fig.4.5) is negligible. This is indicative of a absence of transition gap that has been suggested between policy development and implementation, which would needs to be bridged. Researchers often warn policy-makers that the cost of future disasters is likely to increase due to more frequent and intense extreme climate events (DMISA, 2005; Kgakatsi, 2007; Stigter and Ofori, 2014c)). If this is the case, good disaster-risk policies will result in more effective implementation of early warning systems, which might significantly curtail post-event costs (Kgakatsi, 2007). In short, good disaster-risk policies will eventually help to improve coping with disasters through effective early warning systems. The results of Fig 4.5 show that the respondents think the same way.

4.2.5 Importance of a boundary organisation

A boundary organization, as defined in chapter 3, may serve the purpose of bridging the gap between SCF producers and end-users with respect to encouraging useful communication as far as climate, weather and water knowledge and services are concerned. An important task of a boundary organisation should be to identify relevant dissemination channels that are easily and timely accessible by end-users within the agricultural sector. Because of their position between SCF producers and end-users, intermediaries could obviously also form part of such a boundary organization.

In order to investigate the potential role that a boundary organisation could play, respondents were asked to assess the importance of its establishment in the agricultural sector. A high percentage of the respondents (Fig. 4.6) considered a boundary organisation to be a very important platform from where direct interaction between SCF producers (including producers from research institutions and universities), end-users and policy-makers can take place. A smaller percentage (less than 11%) of the respondents from the *extension service* and *disaster-risk officer* sub-groups remained unsure about the value that a boundary organization could bring to the SCF community. However, the majority of respondents (more than 60%) from all the sub-groups valued the importance of introducing a boundary organisation.

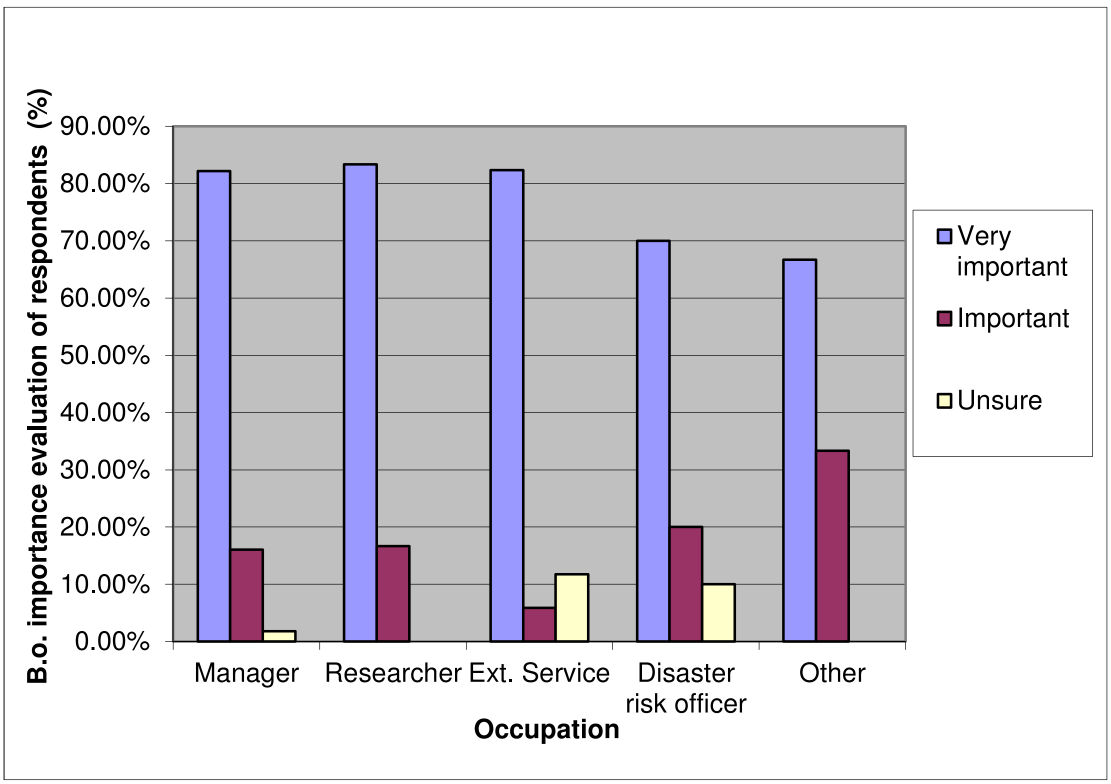

Figure 4.6: *Percentage distribution of feedback on the importance of a boundary organization (B.o.) amongst the four occupation sub-groups of respondents from the intermediary community (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

4.2.6 Summary

In summary, it was found in section 4.2 that not only the availability, but also the accuracy and reliability of SCFs are regarded as important factors in the agricultural sector. Intermediaries in general appear to feel comfortable with, and are confident about various aspects of SCFs. However, it still remains a large challenge for both scientists and government officials at all levels to still convince a relatively large percentage of end-users on the benefits of the correct implementation of SCFs. Feedback from end-users could play an important role in this process, since it could assist intermediaries in improving SCFs and their effective communication and dissemination.

One of the findings was that many respondents from the intermediary group felt that the establishment of a boundary organisation would improve knowledge sharing and SCF interpretation, and that such organisations would also be able to play a major role in identifying the most relevant channels for the dissemination of SCFs within the agricultural sector (see for example Morse, 2009).

4.3 Dissemination of SCF knowledge

SCF knowledge communication in the agricultural sector could be defined as a "communication transaction" in which agriculture-related knowledge is transmitted and interpreted with the view to share the meaning, and eventually, the benefit of such knowledge (Blench, 1999; Mukhala *et al.*, 2000; Luanda, 2002; Weis, 2002). Radio is commonly found to be the preferable medium selected to communicate SCFs to already trained end-users. As a matter of fact it is foreseen that radio communication will remain a primary means of communication in future, bearing in mind the number of poorly literate/illiterate people in rural areas who do not have access to more advanced communication technology (Walker *et al.*, 2001; Hansen *et al.*, 2011).

The advantages of considering radio as a communication medium are that it is cheap, that it is easy to operate, and that it is a highly acceptable communication medium amongst farmers (DAFF, 2010b; Stigter *et al*., 2014). Radio listeners could be categorised into two groups, namely: (1) radio-listening groups that prefer further discussion around radio messages (see Stigter *et al*., 2014) and (2) more informed radio-listening groups that could directly make collective informed decisions on what is heard from the radio. These two groups are of notable importance in view of awareness and early warnings.

However, in this section various means of information dissemination are considered, and the most appropriate media preferred by intermediaries within the South African context is explored.

4.3.1 Frequency of *Advisory* discussions

It is important for intermediaries, at all levels of government, to discuss their local periodicals issued on SCF knowledge with all the relevant role players. As mentioned in chapter 1, the most relevant periodicals, as far as SCFs are concerned, is the monthly climate *Advisory* compiled by NAC (DAFF, 2009; DAFF, 2010b).

Historically in South Africa, farming communities have often relied on indigenous knowledge in order to forecast seasonal events. These forecasts were mostly based on observations of plants/trees, animals, insects and bird behavior (Patt, 2001; DAFF, 2009; Zuma-Netshiukwi *et al*., 2013)), which are all associated with a change in season. However, in a modern society such forecasts are regarded as becoming less reliable (Patt and Gwata, 2002; Zuma-Netshiukwi *et al*., 2013). This is partly due to anthropogenic disturbances in the balance of nature and because of the loss of biodiversity as a result of unsustainable agricultural and land-use practices, climate variability and even climate change.

In recent years, scientifically produced SCFs have been gaining momentum in popularity among farming communities, also in South Africa (e.g. Zuma-Netshiukwi et al., 2013). For this trend to also benefit small-scale farmers, SCF information should be prepared in a language or style that is easily understood and can be correctly interpreted by these farmers (e.g. Stigter *et al*., 2013). As a matter of fact, all end-users and policy-makers who use SCF knowledge as a risk-reduction tool must at least have an appropriate understanding of the meaning of a probabilistic forecast to enable them to interpret information correctly, although it is possible to simplify this (Stigter *et al*., 2013)

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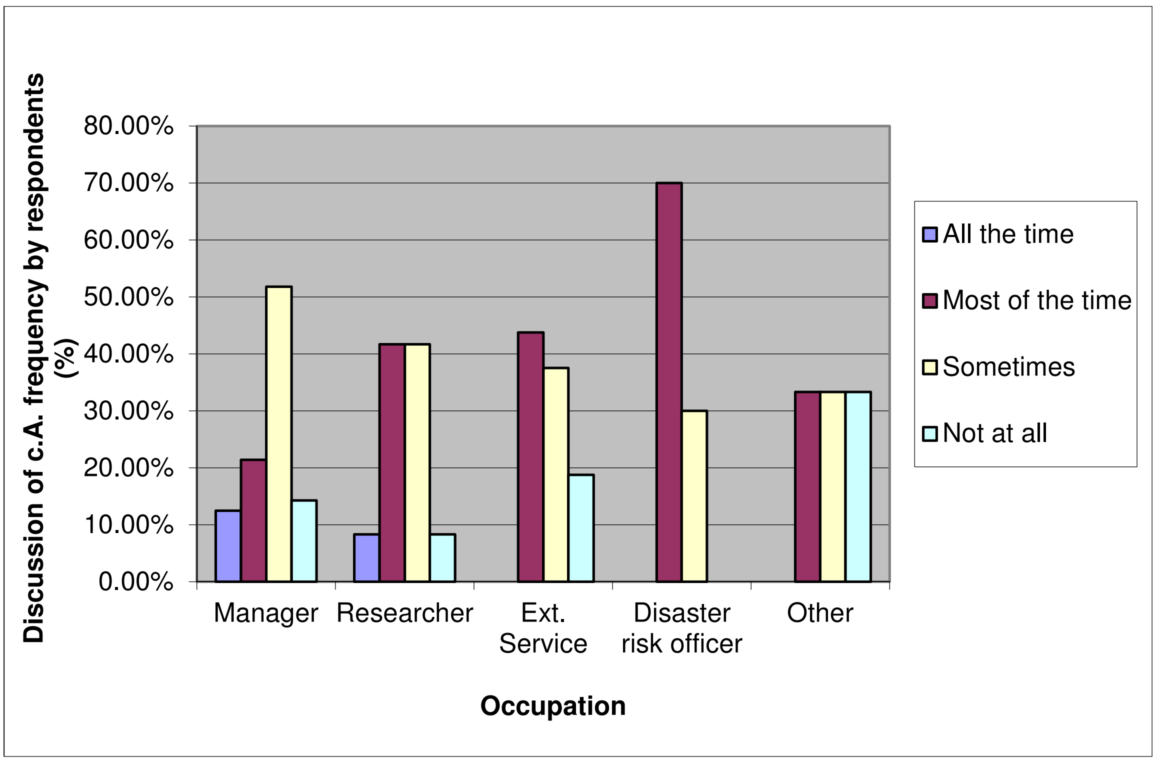

Figure 4.7: *Percentage distribution of feedback on the frequency of discussing the climate Advisory (c.A) amongst the four occupation sub-groups of respondents from the intermediary community (N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

Respondents from the intermediary group were asked about their view on the frequency of discussing monthly climate *Advisories* as a means of communicating SCFs. The most significant responses (Fig. 4.7) were from the *disaster-risk officer* sub-group, followed by the *researcher* and *extension service* sub-groups, as they frequently discuss monthly climate *Advisories*. The next significant response by the smallest '*other*' sub-groups (between 30% and 50%), indicated that they only sometimes discuss monthly climate *Advisories*.

It was felt that regular discussions of SCFs through programmes such as participatory and roving seminars could improve the understanding and interpretation by end-users, especially those from poor communities. It is encouraging that more than 80% of the respondents per group have indicated that they at least use and discuss the Climate Advisories. It is therefore important that the needs of end-users should be determined and prioritised at all times through Climate Advisories, so that relevant and usable knowledge is disseminated through the appropriate channels.

4.3.2 Most preferred communication media

Intermediaries should use all the relevant media of communication available when disseminating SCF to end-users (Blench, 1999). Media can also be targeted for further knowledge dissemination within the sector (Mukhala, 2000; Walker *et al.*, 2001; Luanda, 2002). Fortunately, there are currently various channels of knowledge communication available for consideration. These include radio (as mentioned before), the electronic media, newsletters, local civic meetings, reports, village Chief meetings, farmer gatherings and educational materials. Previous studies have shown that radio and fax are the most frequently used media for communication (Walker *et al.*, 2001; Luanda, 2002). During the survey, respondents from the intermediary group were asked which media they would prefer to use. As one of the choices, cellphones form part of 'other media'.

The predetermined media of knowledge communication were considered to be mostly relevant to disseminate SCFs. The response showed a strong bias towards the use of electronic media – as demonstrated in the exploited segment in Figure 4.8. Note that most interviewees were from the *government official* sub-group that has regular access to the electronic media, such as the internet, computers and faxes. Given the need for dialogues between end-users and intermediaries (Stigter and Winarto, 2012a; Winarto, *et al*., 2013) the final choice may be influenced by such a need. Indonesian farmers endorsed so called Science Field Shops where they could interact with scientists and extension on SCFs and other new knowledge (Stigter and Winarto, 2012a; Stigter *et al*., 2013).

It was further found that respondents selected different types of preferred SCF dissemination media (Fig. 4.8). These include cellphones and text messages. The electronic media, as the most preferred media, assumes the fact that both senders and receivers are mostly in an office environment, and have access to computers and emails. For farmers this of course does not apply. Gatherings, such as those during farmers' days, with full participation of extension officials, were ranked in the second place as the most desired means of knowledge communication. Extension officers provide an interactive source of communicating knowledge to end-users during farmers' days, as end-users could ask direct questions on how to put SCFs into practice. The third most preferred medium by intermediaries was radio communication. Intermediaries are aware of the fact that most farming communities, including the poorest, have access to a radio. Radio is, however, a one-way transfer of information, and it is known that one-way communication is not exactly conducive to mutual discussions, and could therefore be of less value from the view of intermediaries.

Media play a central, but not always an informative role in the dissemination of SCFs. This is especially the case rural villages, where the scale tends to be broad, data resolution is coarse, and where media resources are not widely or frequently available.

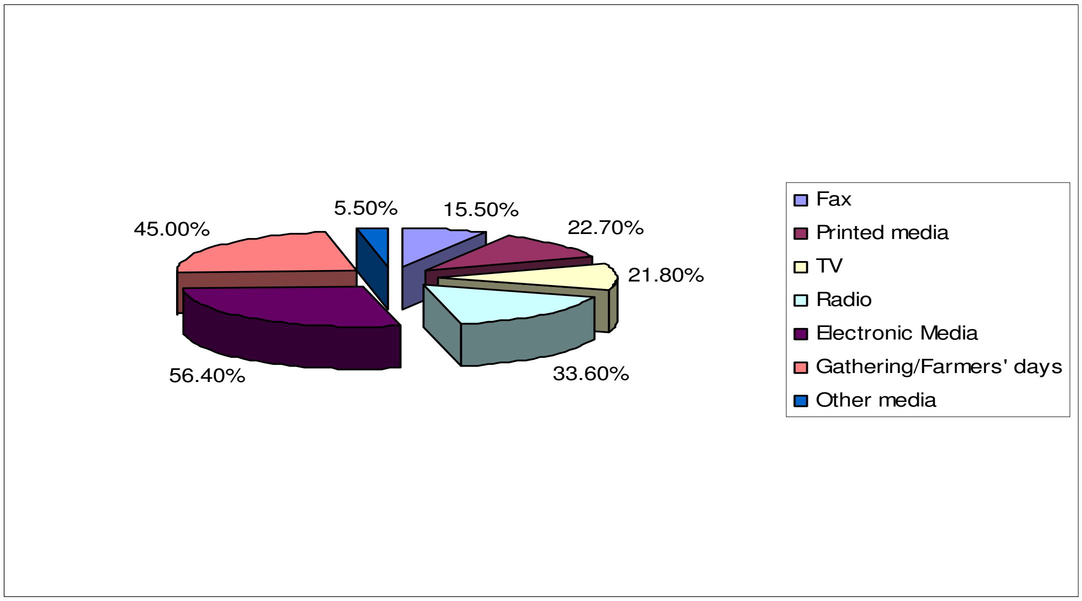

Figure 4.8: *Percentage distribution of feedback from all occupation groups in the intermediary community on the most preferred media channels currently used for communication of SCF knowledge to users (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

Inadequate communication, or even a communication breakdown, is becoming a risk if the preferred communication medium is not accessible by end-users. The preferred communication medium by intermediaries, namely the electronic medium, emphasises the importance of having a reliable electronic communication infrastructure in place in their work environment.

4.3.3 Communication to end-users

It is important that intermediaries distribute understandable knowledge to end-users that can easily be incorporated into decision-making processes (Klopper, 2002; Mukhala, 2000; Stigter *et al*., 2013). Climate knowledge could be of great value in helping farming communities to cope with uncertainty during decision-making times (e.g. during droughts or the prospects of a drought) (Mukhala *et al.*, 2000). It is even regarded as important for individual farmers to be able to make such decisions. If farmers believe solely in traditional forecasting as a result of cultural practices, it might be required to explain the benefit of scientifically orientated SCFs to them in more detail, particularly with respect to how scientific indicators might be used in tandem with traditional indicators (Patt, 2001; Zuma-Netshiukwi *et al.*, 2013). Intermediaries should therefore not only be aware and informed about the needs of end-users (Stigter, 2009), but should also take the initiative to introduce new knowledge to end-users.

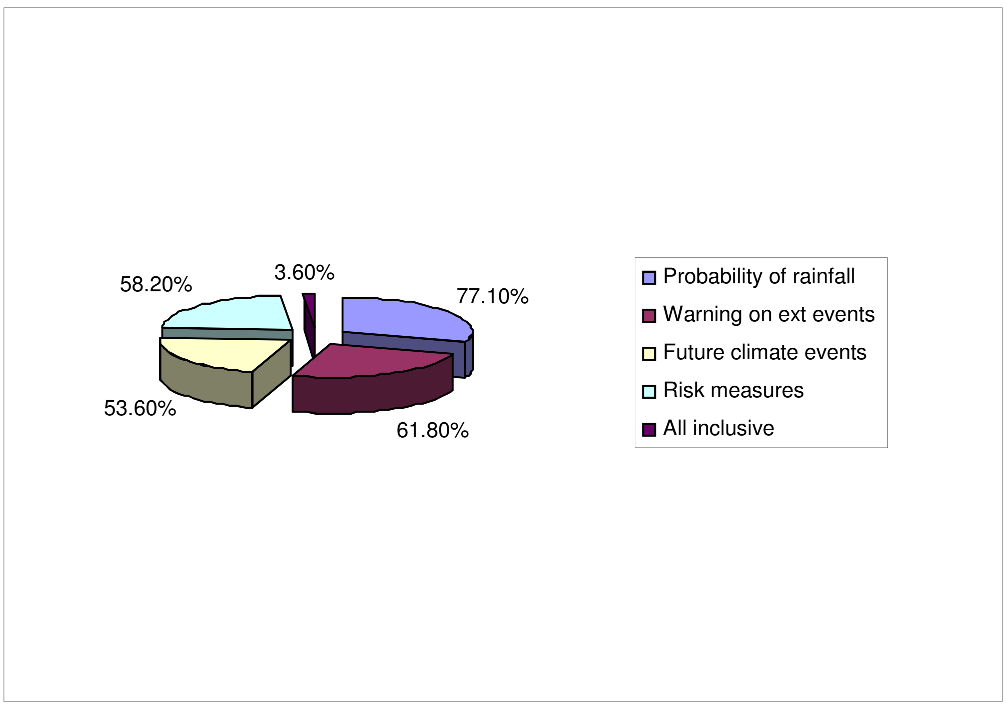

Figure 4.9: *Percentage distribution of feedback from all occupation groups in the intermediary community on the content of knowledge communicated to end-users (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

In the interviews predetermined relevant knowledge, such as the probability of rainfall (Appendix E), warning on extreme events (Appendix D), future climate (long-term scenarios) and risk reduction measures were identified. From these, respondents were requested to select the type of knowledge they normally communicate to end-users.

More than 50% of the respondents (Fig. 4.9) indicated that they communicate all products available to end users, even knowledge related to planning indicators, warnings, risk reduction measures, in addition to SCFs and the most likely future climate events.

Intermediaries should be kept informed on new developments in the field of SCF, in order to continuously improve service delivery (Walker, 2005; Walker and Stigter, 2010). It is also felt that the probabilistic nature of forecasting needs to be adequately communicated by intermediaries, and correctly interpreted by end-users before they can make decisions on how to act. Simplifying the messages is believed to assist the communication of SCF knowledge (Stigter *et al.*, 2013)

4.3.4 Ensuring the correct interpretation of SCF knowledge

Knowledge intended to improve farming practices should not be packaged in the same way as knowledge for scientific use, especially when dealing with poor communities who are not conversant with scientific terminology (Patt, 2001). Translating scientifically produced SCFs into more understandable or useful knowledge provides *ex ante* evidence of benefiting by advanced knowledge, and supporting efforts to improve management responses.

Predetermined categories were identified to be the most relevant ways of ensuring correct knowledge reaches the end-users (see Fig.4.10). The respondents were asked to select the means that they normally use to avoid distortion during the knowledge dissemination process.

Intermediaries considered open and direct discussions as being the most appropriate method (Fig. 4.10) used to avoid distortion. It was preferred by most *extension services*, and '*other*' specialised intermediaries. This was followed by training and awareness programmes. The next highest percentage of respondents identified partnerships and translated knowledge as a means to reduce distortion. However, it was felt that all methods selected need further improvement to allow for more direct participation and interaction with the end-users. See also Stigter *et al*., 2013 and Zumz-Netshiukwi *et al*., 2013)

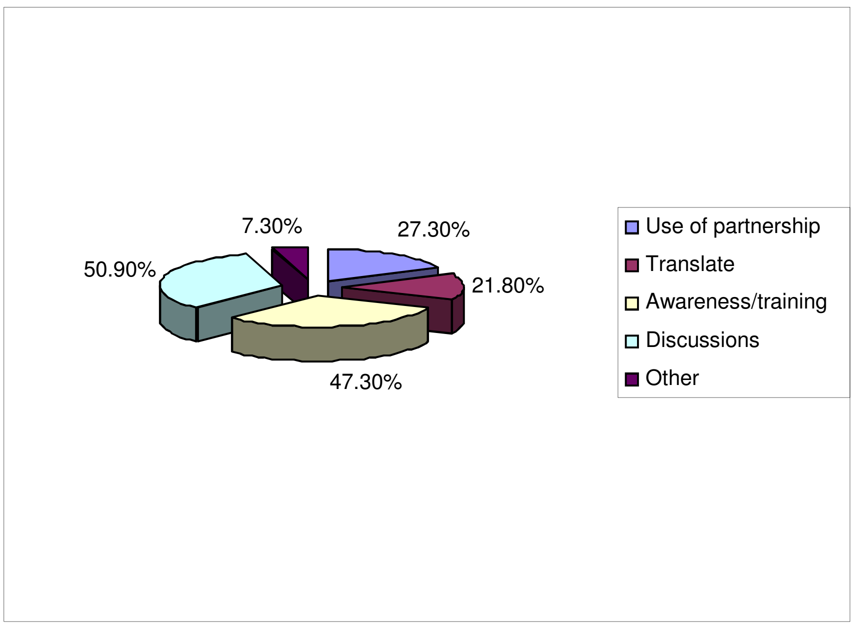

Figure 4.10: *Percentage distribution of feedback from all occupation groups in the intermediary community on methods used to ensure credibility and correct knowledge distribution to end-users (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

4.3.5. Summary

In summary, little or no discussion on the disseminated knowledge, for example knowledge that is only available through the printed monthly climate *Advisories*, might lead to misinterpretation and inadequate application by end-users. The survey has shown that more efforts are still required to improve the packaging of SCFs, so that such knowledge is understood and correctly interpreted. End-users, especially small-scale farmers, should also provide input in order to give guidance towards the final communication channels and infrastructure required for effective early warning services. See for organizing such possibilities the innovative approach in Stigter and Winarto (2013).

4.4 Improvement in SCF application

The effective application of SCFs requires integrating a number of factors, such as (1) limitations in forecasting skills, (2) appropriate understanding of the vulnerable sector, (3) the needs of intended end-users, (4) communication barriers, and (5) limitations on the availability of appropriate SCF knowledge. Opportunities to improve the application of SCF in agricultural production in a wider sense than the existing operational applications of climate knowledge for decision-makers, is based on the understanding of conditions in which end-users need to operate, as well as its correct and timely application (Stigter, 2002; Huda and Packham, 2004).

4.4.1 Awareness and training workshops

Agricultural extension systems are the main conduit for disseminating SCFs that are required by farmers for planning purposes. For the extension services to continue with their contributions, they must continuously sharpen their skills through formal or informal training.

It was already found that two possible causes of the difficulty of understanding SCFs are (1) the probabilistic nature of SCFs and (2) the complex format in which SCF knowledge is presented (Klopper, 2002; Hansen *et al.*, 2011; Stigter *et al.*, 2013). A way to address these is to introduce training on a variety of skills development components in order to fully capacitate the spectrum of end-users. It should also include the development of transferable skills, such as communication and information technology.

Figure 4.11: *Percentage distribution of feedback from all occupation groups in the intermediary community on the importance of awareness and training programmes (Aatps) (N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

Agricultural meteorology is an applied science that combines the effects of weather and climate on the production of crops and livestock, as well as on market planning (Walker, 2005). To fulfill its vision and mission, it is felt that the DAFF should significantly increase its capacity by employing agro-meteorologists at both provincial and local authority levels. This additional capacity could enhance the quality and quantity required for the effective implementation of the Disaster-Management Act 57, of 2002 (DPLG, 2004), which could be of great benefit to South Africa.

Respondents from the intermediary group were asked about their view on the importance of awareness and training workshops in improving the interpretation and understanding of SCFs. The survey revealed that a high percentage of respondents from all occupation sub-groups regarded awareness and training workshops to be very important. A few respondents representing the *manager* and *disaster-risk officer* sub-groups considered awareness and training workshops as not too important (Fig. 4.11). A small portion of 2% of the *researcher* sub-group was unsure about the value of these workshops, most probably because they are SCF producers and do not interact with end-users on a regular basis.

According to feedback it is regarded as important by the intermediary group to carry out awareness and training initiatives in order to improve the interpretation and understanding of SCFs. This could take place using extension training officers throughout the country (Midgley, 2008; DAFF, 2010b; Stigter et al., 2013).

4.4.2 Improvement on the understanding of SCFs

Intermediaries, as knowledge providers, should understand the SCFs that they receive from SCF producers. In their assistance to farmers, they must remain up-to-date in the advanced knowledge around SCFs, and even climate change, as also Africa's climate is generally influenced by a number of off-shore factors (Walker *et al.*, 2001) and a good number of dangers (Stigter and Ofori, 2014a; 2014b; 2014c). Intermediaries therefore need to receive in-service training and be able to attend short courses to sharpen their skills and become conversant with new techniques and technology in the generation of SCFs. They should, simultaneously, ensure that they capacitate extension and other officers working at grassroots level with farming communities.

As indicated in Fig. 4.12, the largest proportion of respondents using SCFs indicated that they have noticed some significant improvement in the understanding and interpretation of SCFs after training and awareness workshops. However, most respondents indicated further, and even more consistently, that training is needed for end-users to be capacitated adequately in order to respond more effectively to SCF knowledge.

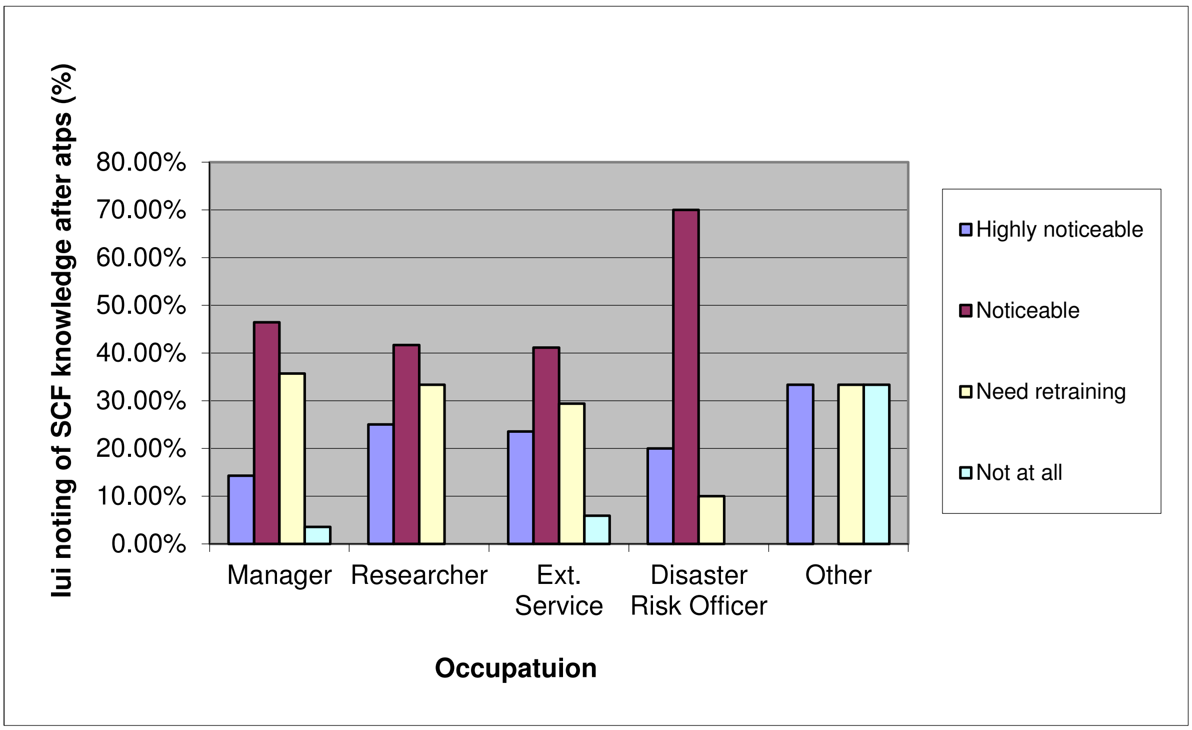

Figure 4.12: *Percentage distribution of feedback from all occupation groups in the intermediary community on the improvement of the understanding and interpretation (Iui) of SCF knowledge after awareness and training programmes (atps) (N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

In more detail, with the exception of the '*other*' sub-group, the survey showed that the highest percentage of respondents from all the occupation groups in the intermediary group reported a noticeable improvement in the understanding and interpretation of SCF after training took place, while very few respondents from the *manager* and *extension service* sub-groups reported that they did not observe any improvement in the understanding and interpretation of SCF knowledge after such training. Most respondents further propose that further consistent training is important. The survey analysis therefore emphasises the need for further investments in awareness and training programmes by the organisations involved, or government departments, in order to enhance the knowledge and understanding of SCFs by end-users.

4.4.3 Improvement of SCF knowledge dissemination

Improvement in the dissemination of SCF knowledge depends on well-trained and informed personnel. Such training should encompass formal training to scientists, to interpreters of SCFs with advanced university degrees, as well as to managers or end-users of SCFs who may have already attended diploma or certificate courses (Stigter, 2007). Such end-user training could be facilitated through the preparation and distribution of explanatory and tutorial knowledge, such as training manuals, booklets, pamphlets, taped or live radio, videos and interviews with experts (Walker, 2005).

The interviewees were asked to express their feeling about the improvement of SCF dissemination after training programmes were attended. As depicted in Fig. 4.13, the highest percentage (between 60% and 70%) of respondents from the '*other' sub-*group did not see any improvement of information dissemination after training. However, these are only two people. Between 20% and 50% of the respondents from the *manager, research, extension service* and *disaster risk officer* sub-groups, with a higher percentage from *manager* sub-group, indeed noticed an improvement in SCF dissemination after training had taken place. Furthermore, 10% to 35% of the respondents from all the occupation groups noticed highly visible improvements in SCF dissemination to end-users after training.

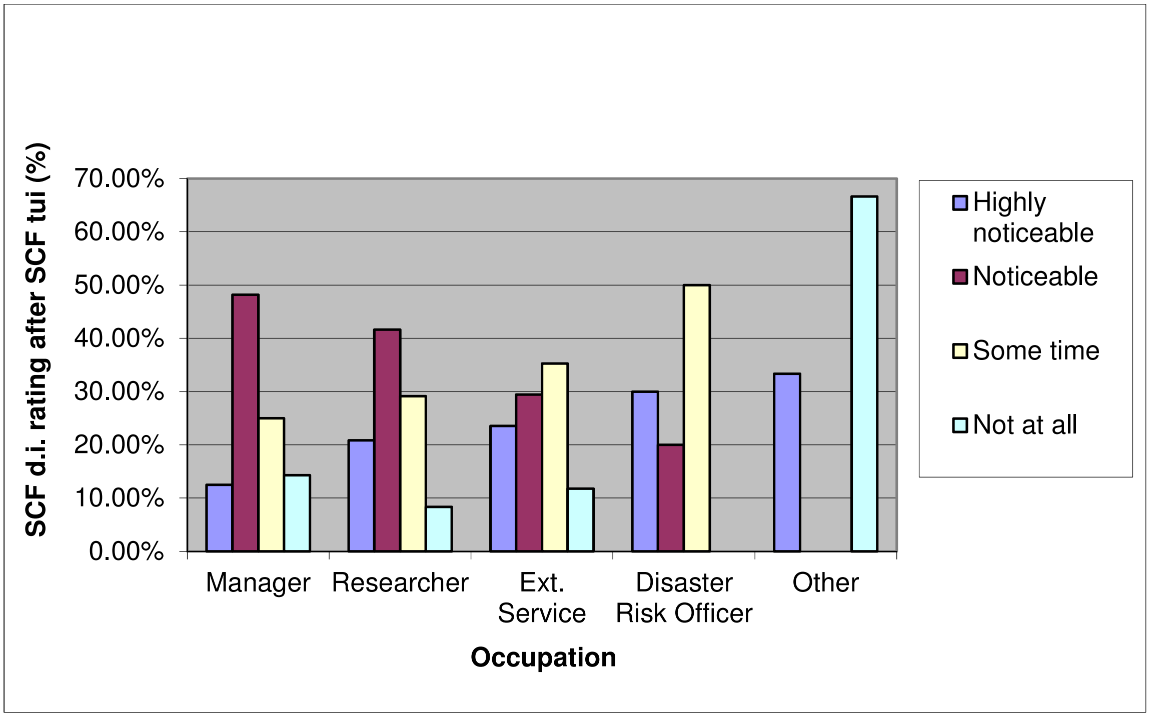

Figure 4.13: *Percentage distribution of feedback from all occupation groups in the intermediary community on SCF dissemination improvement (d.i) following training on the understanding and interpretation (tui) of SCF knowledge (N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

With the exception of the *disaster risk officer* sub-group, only a few respondents from all the other sub-groups did not observe any improvement after training. All sub-groups further sometimes noticed improvement after training.

4.4.4 Use of SCFs in planning

The potential benefits of using SCFs in decision-making processes in the agricultural sector have been evaluated in several studies (Kgakatsi, 2001; Klopper, 2002;

Hudson, 2002; Ziervogel *et al.*, 2006; Zuma-Netshiukwi *et al.*, 2013). Some of these studies explored the difficulty that people have in interpreting and applying SCFs in practice, and argued for the necessity of systematically examining knowledge communication practices in order for the agricultural sector to take greater advantage of the potential benefits of SCFs (Hansen, 2002; Luanda, 2002; CAgM, 2010; Stigter and Winarto, 2013).

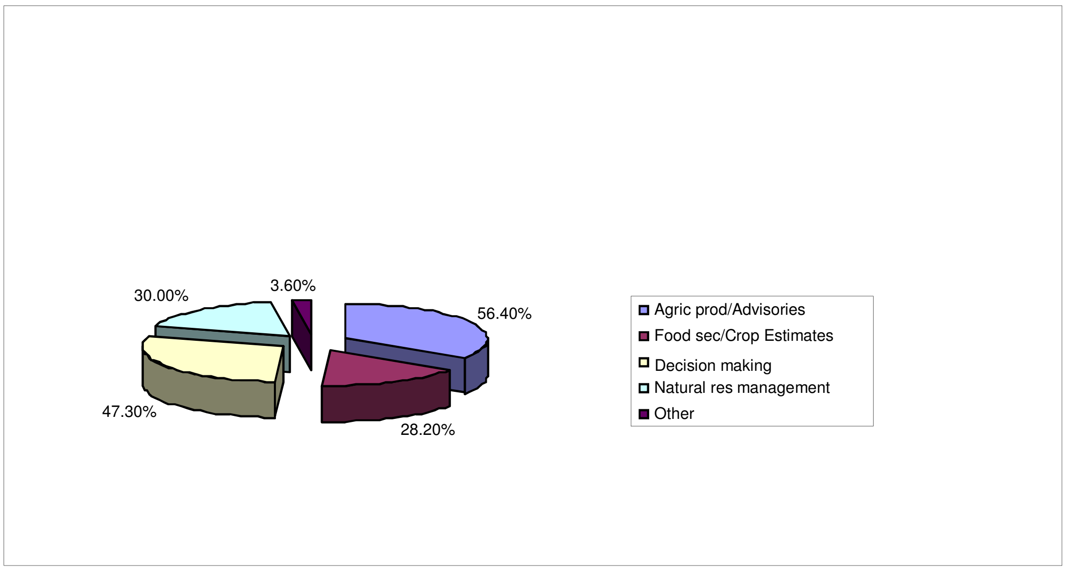

Figure 4.14: *Percentage distribution of feedback from all occupation groups in the intermediary community on the use of SCFs during planning (note: each of the respondents had multiple choices, hence the total percentage is more than 100, N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

The survey revealed (Fig. 4.14) that a higher percentage of respondents from all the occupation sub-groups makes use of SCFs in: (1) agricultural production and advisories (decision and planning based on SCFs and the introduction of relevant strategies according to that knowledge), than in (2) other decision- making processes (e.g. to set aside funds for alternative use), while even a smaller percentage makes use of it in (3) natural resources management (incorporate SCF knowledge in soil, land, water and biodiversity planning) and (4) food security (the use of SCFs in analysing the food security status). According to Fig. 4.14, only a small percentage of respondents from all the sub-groups regarded other activities as compared to the above four in the use of SCFs as being essential in their planning.

4.4.5 Actions taken after a hazard SCF

In reality farming communities need more than SCF knowledge for effective response. They also need resources and manpower to effectively respond to a possible future risk. Farmers should have access to these resources in order to provide them with strategic alternatives amongst which they could select the best solution. Studies (Stigter, 2002; Ziervogel, 2002; UNFCCC, 2008) have suggested that the response of poor farmers to SCF knowledge might be inadequate without supportive resources, and that the capacity of farmers to respond might even be negatively affected by poor access to the necessary support input.

Respondents were requested to indicate whether they had made any adjustments to their activities once they received SCFs indicative of a potential hazard. The findings showed that the highest percentage of respondents from the *manager* sub-group had responded to such SCFs, either ‘most of the time’ or ‘all of the time’ (Fig. 4.15). ‘Most of the time’, the *extension service* and *disaster-risk officer* sub-groups indicated that they made adjustments in their planning according to risky SCFs received.

However, a small number of respondents from all the occupational sub-groups indicated that they never adjusted their planning, or took any action in response to a hazardous SCF received because it was accepted that the farmers, as end-users, are the final decision-makers, while the function of intermediaries is only to communicate between SCF producers and end-users.

It was felt that disseminated SCFs should enable all end-users to respond to the advice. Despite this almost 18% of the respondents from the *extension service* and *researcher* sub-groups have indicated that they are not taking any action on a projected hazard. Extension is one of the components responsible for informing end-users so that they could respond to a potential hazard. However, a prerequisite is to ensure that end-users receive the warning of a hazard in a format that is easily understandable by them.

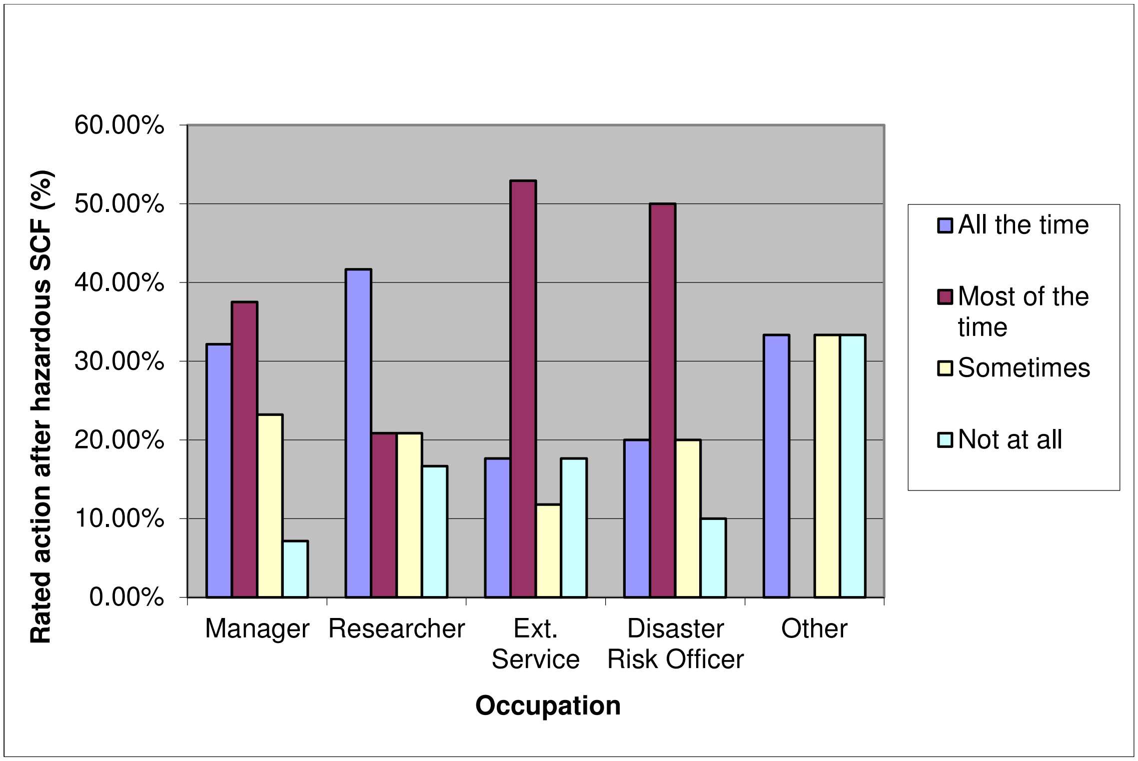

Figure 4.15: *Percentage distribution of feedback from all occupation groups in the intermediary community on actions taken after a hazardous SCF (N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

4.4.6 Obtaining feedback from end-users

As emphasised in the previous section, feedback should involve organised interaction amongst all the role players in the SCF process. Feedback is the only way to verify application results. Such feedback could not only enhance the skills and knowledge of end-users, but also the understanding of SCF knowledge which finally could empower end-users to make their own decision on how to respond to SCFs.

The survey showed (Fig. 4.16) that high percentages (between 33 and 40%) from the *other, disaster-risk office, researcher* and *manager* are having feedback from the users only 'sometimes'. And the second most given reply (from 23% (*extension service*) till 33% (*other*) is 'not at all'. But a most of time reply comes not far behind the later within between 19% (*extension service*) till 33% (*other*).

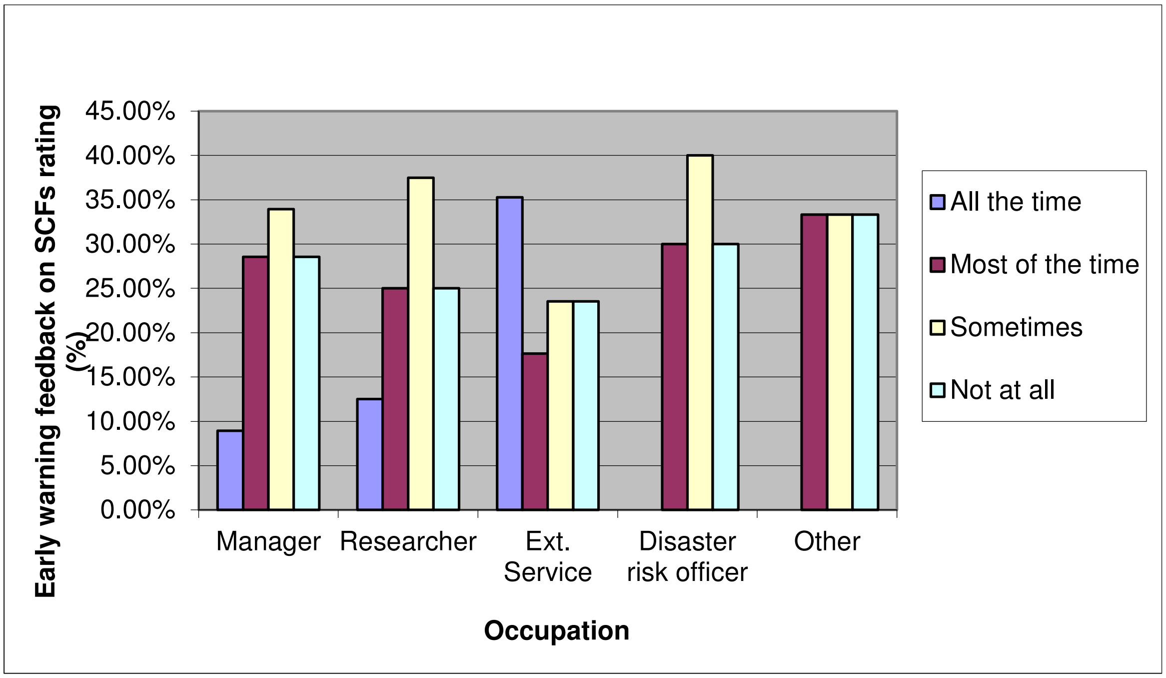

Figure 4.16: *Percentage distribution of feedback from all occupation groups in the intermediary community on efforts taken to obtain early warning feedback from end-users (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

However, a significant percentage of respondents from the *extension service* (35%) replied that they got this feedback 'all the time'. But the next highest in that category was only 12% (*researcher*). In general, as can be calculated from Fig. 4.16, 62% of respondents had ‘sometimes’ or ‘not at all’ receive SCFs (early warning) feedback reply and only 38% had a ‘most of the time’ or ‘all the time’ feedback reply.

4.4.7 Understanding climate change

Climate variability on the seasonal scale could be influenced by anthropogenic global warming, and therefore forms part of anticipated future changes in climate. It is therefore important that all role players in the SCF process are at least aware of the risk that climate change poses to the agricultural sector in Africa (e.g. Stigter and Ofori, 2014a; 2014b; 2014c). Apart from increasing temperatures, one of the biggest risks posed by global warming is the projected increase in the intensity and frequency of extreme events, such as droughts and floods, with all the associated consequences to the agricultural sector (UNFCCC, 2008; FAO, 2010; Schulze, 2010). Understanding climate change will entail making adjustments and changes at all levels, including mitigating and adapting to climate change (WMO, 2002). Implementing climate change mitigation and adaptation programmes will, in turn, reduce the impacts on vulnerable communities and thus enhance coping with disasters.

Respondents were asked to what extent they understand the concept of climate change as a result of global warming. In Fig. 4.17, a higher percentage in the ‘*other’*, *disaster-risk officer* and *manager* sub-groups indicated that they understand climate change, but some respondents from the *extension service* and *researcher* sub-groups have indicated that they need some further explanation.

A bigger challenge for the respondents is that the current discussions on climate change are globally or continentally orientated, and that there is a great need for regional level information in the agricultural sector in Africa (e.g. Stigter and Ofori, 2014a; 2014b; 2014c).

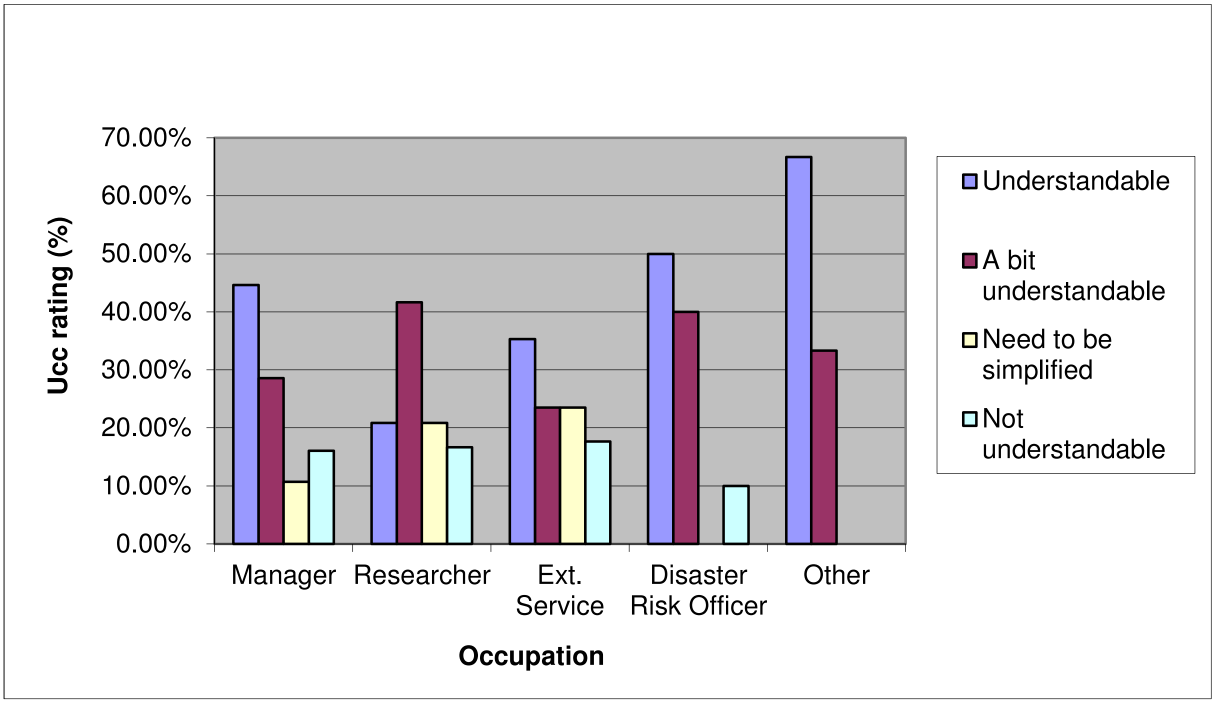

Figure 4.17: *Percentage distribution of feedback from all occupation groups in the intermediary community on the level of understanding of climate change (Ucc) (N=110 of which* N_m*=56,* N_r*=24,* N_{es}*=17,* N_{dr}*=10 and* N_o*=3).*

The positive response on understanding of climate change by intermediaries effectively benefits the development and implementation of mitigation and adaptation strategies aimed at reducing the negative impacts that might occur because of climate change. As far as climate is concerned, challenges to farming opportunities are to embrace conservation agriculture practices to minimise greenhouse gas emissions (mitigation) by agriculture, and to encourage farmers to adapt to climate change. It is important to take actions that could enable adaptation to climate-change risks in order to create opportunities in promoting sustainable development (Schneider *et al.*, 2007).

4.4.8 Structures for SCF dissemination

It is crucial that the established structures of coping with disasters within the agricultural sector function optimally to assist in the effective implementation of early warning, mitigation and adaptation systems (DoA, 2001; Kgakatsi, 2007; DAFF, 2009). The application of SCFs to manage risks generally focus on its impact on agricultural production, such as crops and livestock production, and not so much on climate *per se*. Yet, the most critical opportunities and challenges for end-users in addressing both climate variability and climate change risks have more to do with institutional and financial support, as well as structural co-ordination (FAO, 2008; UNFCCC, 2008; Schulze, 2010).

Several field studies (Kgakatsi, 2001; Hudson, 2002; Klopper, 2002; Ziervogel *et al.*, 2006) on the benefits of SCFs in southern Africa suggested that there still exists a considerable gap between the knowledge needed by farmers and that provided by the SCF producers. However, the established early-warning services assist in educating farmers in the interpretation and understanding of SCFs, thereby empowering them to respond accordingly (DoA, 2001).

In this study, such services are strongly represented by the network involved in SCF dissemination, such as the NAC and the EWC at national and provincial levels, respectively. Unfortunately these structures are currently not functioning well due to challenges such as sporadic participation by members and the lack of support by managers at both national and provincial levels. Effective structures enable fruitful discussions, more effective early warnings, improved communication and more trust and knowledge-sharing between the participants. Effective structures within the coping with disaster fraternity could improve decision-making in the agricultural sector.

Respondents were asked to express their views on the importance of established structures for early warning services and monthly climate *Advisory* dissemination. More than 80% of the respondents from all occupation sub-groups considered early warning structures to be very important and of a high priority in the agricultural sector (Fig. 4.18).

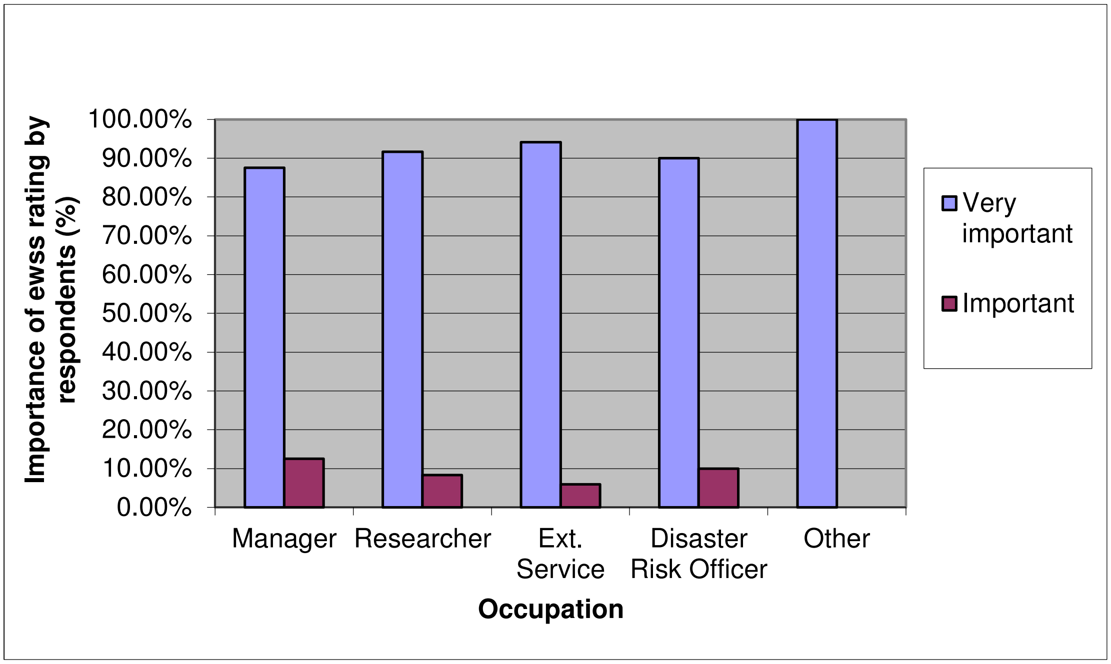

Figure 4.18: *Percentage distribution of feedback from all occupation groups in the intermediary community on the importance of early warning structures (ewss) (N=110 of which N_m=56, N_r=24, N_{es}=17, N_{dr}=10 and N_o=3).*

More than 75% of the respondents considered the importance of early-warning structures as being very high. They generally felt that the established structures, at all levels of government, are expected to further improve the effective implementation of disaster-risk principles in the agricultural sector.

4.4.9 Summary

In summary, the study has shown that sufficient attention is still needed in improving climate understanding and the use of this knowledge by intermediaries. It is essential to increase the frequency of presenting training and awareness programmes to all end-users, not only so that they could understand and interpret SCFs, but also to empower them to apply SCF knowledge during their planning. The understanding and correct application of SCF knowledge, as well as the effective response to SCFs, will ensure risk reduction in farming practices, as well as higher production yields.

According to the study it is regarded as important to strengthen the existing structures that promote the support of knowledge flow from the SCF producers down to end-users (Phillips *et al*, 2002; Ziervogel, 2002). As a matter of fact, improved early warning structures might even provide a vehicle through which SCF knowledge could be discussed and debated, and from where a consensus SCF could be prepared and released to the agricultural sector (Vogel and O'Brien, 2006). These actions preferably need to take place within government structures.

4.5 Open-ended responses from intermediaries

In open-ended questions, the respondents commented on risk reduction efforts that are taking place in the agricultural sector, with some recommendations for further consideration during the implementation of effective early-warning services. The open-ended questions allows for respondents to propose innovative ideas in addressing disaster-risk reduction.

In the consolidated response on policy development and implementation, it was emphasised that disaster-risk reduction functions require close collaboration between policy-makers, management and extension services at ground level, including farming communities (UNDP, 2004; WCDR, 2005; USDA, 2006; Hay, 2007; Menzie 2007; Mukhala and Chavula, 2007). Provincial departments of agriculture and rural development should also include disaster risks as a key component of individual provincial strategic action plans aimed at implementing disaster-risk reduction measures (DPLG, 2004; Kgakatsi, 2007). Furthermore, other policy issues of notable importance are the government policy on gender, which is to be cascaded to all the departments, as well as the consideration of indigenous knowledge in policy formulation and programme implementation (SA, 1999b; Zuma-Netshiukwi *et al*, 2013). The presentation of the SCF and its modes of communication to policy-makers and farmers are found to be critical to the success of SCF knowledge application (Gibba, 2002; Stigter *et al*, 2013).

Suggestions from respondents on effective communication were: (1) to improve and strengthen communication channels, as well as awareness campaign programmes within the agricultural sector (2) to improve communication infrastructure for SCFs, especially for knowledge communication towards smallholder farmers and (3) to regularly communicate, evaluate and monitor climate knowledge to end-user in understandable local languages (Mukhala *et al.*, 2000; Luanda, 2002). It was felt that the translation of terminology requires capacity-building in communicating science-based knowledge to those mandated to communicate such knowledge to end-users (Walker *et al.*, 2001). The fourth suggestion by respondents was to establish provincial disaster-risk management units to address the effective implementation of early-warning services in support of disaster-risk reduction.

The establishment of a knowledgeable boundary organisation to collect data, and to disseminate and share knowledge, was also found to be important. To ensure consistence, provincial departments of agriculture should be strategically aligned with national structures in order to minimise or avoid SCF distortion and misinterpretation, as well as in enhancing the value of SCF knowledge (ISDR, 2004; FAO, 2008). Provincial and district extension officers form an important part of effective dissemination structures. It was suggested that more support is needed, from both national and provincial departments of agriculture, for the effective implementation of early warning services. A participatory approach of involving organised agriculture and communities at ground-level was regarded as very important in enhancing their resilience towards disasters.

Lastly, the respondents suggested that institutional arrangements at provincial, district and local level could assist in improving the communication of SCFs, ensuring that all end-users receive them timeously and in understandable format. For example, the SAWS should collaborate with other institutions to focus their efforts on developing new technologies for efficient and needs-driven data collection in order to improve the reliability of SCFs. Institutional arrangements should be strengthened to foster cohesive linkages, to respond to barriers of SCF usage and to collaboration on climate-related issues of mutual interest, such as decision-making and policy directives (DPLG, 2004). Better co-operation between the different institutions involved was regarded as important to ensure that the best available SCFs reach the end-users. This will again enable end-users to make informed decisions during their planning and adaptation processes.

4.6 Chapter summary

This chapter deliberated on the challenges faced by the entire climate- information chain. The following were the most important findings:

- *Sub-optimal use of SCF knowledge*

  The underutilization of SCFs knowledge is a significant hindrance in establishing their value. It is suggested that socio-economic, political and cultural conditions should be taken into consideration, as these could compromise the use of SCFs by both end-users and policy-makers. The availability of reliable SCF knowledge for the agricultural sector was found to be important in enabling a better approach in dealing with the complex agricultural production problems and challenges facing South Africa in addressing poverty reduction and food security.

- *SCF requirements*

It is suggested that intermediaries (and SCF producers) need to become more aware of the needs of end-users, whereas end-users need to become more aware of the limitations of SCF knowledge. Effective product development involves the determination of critical climate aspects for various applications, and for intermediaries to focus on preparing and distributing tailor made knowledge to ensure climate-smart agricultural production. Intermediaries should make special efforts to train end-users in understanding the intricacies of climate and SCF information.

- *SCF application*

It is suggested that end-users should integrate SCF knowledge into their risk-reduction frameworks on a regular basis - similar to the application of all the other pieces of knowledge that are taken into consideration during decision-making. It was felt that a prerequisite for the application of SCFs is user satisfaction. User satisfaction depends on the confidence in products supplied to end-users. This confidence is dictated by the reliability (timely, consistent and dependable knowledge) of SCFs, as well as the ease with which SCFs could be incorporated into routine operations. Users of SCF knowledge should have confidence in the information produced and communicated.

- *Adoption of the use of SCFs*

It was found that the incorporation of SCFs in farming activities is still slow. This could largely be ascribed to a lack of a clear understanding by end-users. The DAFF has already developed and implemented annual uptake assessment programmes in provinces to monitor adoption of the use of SCFs, and to bridge the transition gap between SCF producers and end-users, which is the mandate of intermediaries. These assessment programmes should improve in future. The adoption of the use of SCF knowledge and the level of confidence in SCFs are of equal importance to policy and investment in the disaster-assistance domain. It was suggested that improved data on post-disaster experience should inform investment and policy-decisions at government level, and thus help secure more appropriate levels and forms of disaster prevention, mitigation and preparedness. This is of notable importance for DAFF in its agricultural mandate. As a matter of fact, decreasing the vulnerability of the agricultural sector to natural hazards through more informed policies could greatly assist DAFF in implementing more effective early warning services.

To conclude, it is recommended that additional policies and other measures be developed or revised in order to assist intermediaries, and to reduce the impact of natural hazards, and especially extreme climate variability, on the agricultural sector. This could be achieved through more effective disaster-risk reduction, and through a progressive strengthening of adaptive capacity.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

In general, this study has focused on assessing the potential contribution of SCFs to agricultural disaster-risk reduction in South Africa, with particular emphasis on how SCFs could be employed by SCF producers and intermediaries to improve the chain of knowledge flow to end-users. This was done to achieve improved early warning services and by better SCF dissemination, which was assumed to result in better disaster-risk decision making. The research focused on the following key areas: (i) the effectiveness of current SCF knowledge systems; (ii) the availability (or unavailability) of SCFs distributed to intermediaries and end-users; (iii) the integration of SCFs into early warning services; and (iv) the co-ordination, networking, training and partnerships, which might result in a effective holistic approach towards agricultural risk-reduction mechanisms.

The hypothesis assumed in the study was that an improved early warning services supported by better SCF dissemination will lead to more effective and better decision-making for subsequent disaster risk-reduction in the agricultural sector.

In order to address the hypothesis, the aim of the study was therefore to present improved early warning approaches, which could lead to better decision making, since it was envisaged that improved early warning approaches could contribute to better planning, disaster-risk management, and eventually better performance by the South African agriculture sector. The aim was pursued by using a multi-method research approach, which allowed for an in-depth exploration of the problems related

to effective risk-reduction mechanisms in order to decrease the vulnerability of end-users, or farming communities, to climate-related agricultural production risks.
The specific objectives of this study were to:

1. Assess the processes and strategies followed by intermediaries in addressing SCFs dissemination, and to propose improvements;
2. Analyse and evaluate the roles and functions of both the SCF producers and intermediaries in knowledge dissemination, and to propose improvements;
3. Investigate the preferred media used to disseminate SCF by both SCF producers and intermediaries to target groups, and to propose improvements;
4. Investigate the types of data and knowledge supplied by SCF producers and intermediaries, and to propose improvements;
5. Assess the relevance and effectiveness of institutional structures for early warning dissemination, and to propose improvements.

The approaches followed to address the aim and objectives were to analyse the status of the current SCF environment (from the original generation/issuing, through to the distribution chain, to eventually the transfer of SCFs to end-user), and to investigate the importance of SCF-based early warning services as a contributing factor in disaster-risk reduction. To achieve this, the investigation focused on the four inter-related elements of early warnings (ISDR, 2006b; UN, 2006), namely, (1) Risk knowledge, (2) Prediction, monitoring and warning services, (3) dissemination and communication, and (4) Response capacity.

The study was conducted through multiple interviews. A multipurpose approach, as outlined in Chapter 2, proved to be the most suitable for assessing how improved and effective SCF-based early warning services could be achieved.

5.2 Key findings

In the following sections, the key findings from this study are summarized with reference to each one of the study objectives, and *recommendations* are made on how to achieve improved early warning systems supported by better SCF information dissemination:

OBJECTIVE 1:
Assess the processes and strategies followed by intermediaries in addressing SCFs dissemination, and to propose improvements:

It was found that discussions (e.g. through discussion forums) and training and/or awareness making initiatives (e.g. through training seminars and workshops) are the strategies by intermediaries from all occupation sub-groups to ensure effective communication, and they are also aimed at reducing knowledge distortion. *It is therefore recommended that the Government, and in particular the DAFF, should invest more productively in these strategies which appear to work well, to strengthen effective communication between SCF producers, intermediaries and end-users. The DAFF should also consider to strengthen the capacity of intermediaries, for example through more suitable SCF communication channels, better equipped and located teaching facilities and technologies, and also to encourage intermediaries to improve their own knowledge in their duties to make end-users aware of the benefits that SCFs might hold.* Such investments will eventually contribute to improved early warning services by creating a better understanding and correct interpretation of SCFs by end-users.

It was found that there was a significant improvement in the understanding and interpretation of SCF knowledge by intermediaries shortly after training or awareness programmes. Intermediaries were also more motivated in executing their duties after such training meetings. *To expand on this it is recommended that the DAFF should* *further invest in more frequent training (or re-training) of intermediaries, in order to build further knowledge capacity, and to ensure that intermediaries are always up to date with the latest developments in SCFs, so that they are more motivated in their duties.*

According to feedback from intermediaries it was felt that the DAFF should consider categorizing disaster-risk reduction strategies according to various types of natural hazards, such as below-normal rainfall (risk of droughts), above-normal rainfall (risk of floods), and extreme temperature events (risk of frost or heat waves). Each of these hazards poses specific challenges, and a more focused approach should result in better planning and response. Such strategies should be made available in all the official languages of South Africa so that they can be communicated effectively to end-users in all sectors of agriculture.

The analysis indicated that the use of SCFs amongst intermediaries from some occupation sub-groups during the management of natural resources was moderate, which was a disappointment. However, the *Management* occupation sub-group, located in the DAFF, uses SCF information more frequently for planning, and mostly for putting together the monthly climate *Advisory*, which is distributed to other occupation sub-groups and end-users. *It is recommended that the content of* monthly climate *Advisories should be used by all occupation sub-groups, and that other sub-groups (other than Managers – especially Extension services), be drawn in to give feedback, or even to contribute to the content of* monthly climate *Advisories.* These advisories are regarded as an important source of knowledge, but should be used by a wider proportion of people involved in disaster-risk reduction in the agriculture sector. This will further strengthen strategies and measures incorporated into decision-making for better response. *The DAFF should also look at ways to communicate* monthly climate *Advisory* contents *to a wider audience through all 11 official languages*.

OBJECTIVE 2:

Analyze and evaluate the roles and functions of both the SCF producers and intermediaries in information dissemination, and to propose improvements.

Interviews amongst SCF producers showed a confidence level of moderate to high in SCF knowledge issued to end-users, although there was consensus that SCFs could still improve in future. *It is recommended that the SAWS should continuously invest in the modeling facilities and research capabilities of SCF producers*. This will lead to improved and more reliable products, which will put more confidence into the application of SCFs.

There was a strong feeling that SCF producers should improve on their efforts in obtaining SCF knowledge feedback from intermediaries and end-users. This study showed that less than 20% and 50% of the respondents from the *Manager* and *climate forecaster* occupation sub-groups, respectively, made some effort to get feedback. Such feedback could lead to an immediate improvement in the use and application of SCFs. *The SAWS should therefore strengthen feedback mechanisms in order to consistently improve the value of SCF products*.

Mixed responses were received from the intermediary group on the reliability of SCFs. It was noted by the *Manager* and *Extension-service* occupation sub-groups that SCFs are frequently inaccurate. This is a concern since the *Manager* and *Extension-service* occupation sub-groups form part of the support structures responsible for SCF dissemination, and therefore, for the implementation of effective early-warnings.

It was found that a significant percentage of respondents from the *extension service* intermediary group (35%) replied that they got a SCFs (early warning) feedback 'all the time', but they were an exception. It was calculated that slightly more than 60% of respondents had 'sometimes' or 'not at all' SCFs (early warning) feedback replies and slightly less than 40% had a 'most of the time' or all the time feedback reply. *An* *effective feedback programme is critical to strengthen answering the needs of users and end-users, and it is recommended that feedback should be obtained on a much more regular basis.* Such interaction will provide a platform/opportunity to engage, and to understand any shortcomings or challenges faced by users and end-users.

It is recommended that a variety of approaches is applied in obtaining feedback, which could not only encourage broader participation, but could also further bridge gaps between SCF producers, users and end-users. Such an approach could also improve the application of SCF knowledge by farming communities.

It is recommended that disaster-risk policies be developed and implemented to address the benefit of SCF based early-warnings and to ensure that everyone within the agricultural sector understands and endorses the implementation programmes from such policies. Government needs to strengthen the compliance mechanisms by developing and implementing sound disaster-risk reduction policies, strategies and regulations for South Africa, especially for the agricultural sector.

Encouraging is the finding that most occupation sub-groups from the intermediary group respond actively after a SCF is issued, with more than 70% taking responsibility to act on the advice issued. However, it was felt that the reliability of such SCFs still needs to improve.

It is recommended that SCF producers should therefore put more emphasis on improving SCFs, as well as the communication or dissemination of knowledge to users and end-users, using tailor-made approaches to improve the value of their products. To address this, the SAWS should develop clear and useful guidelines on the application value of agro-meteorological products in order to ensure the development of tailor-made products. The SAWS should also constantly evaluate and address factors that might have positive or negative impacts on the value of their SCFs.

It is recommended that the strengthening of early-warning services for the agricultural sector, with the associated technical and strategic inputs, should be considered. Effective early-warning services for the agricultural sector require timely, accurate and reliable SCFs, as well as feedback knowledge on how warnings are to be understood and interpreted by vulnerable farming communities that are at risk.

By constructively addressing the responsibilities of both SCF producers and intermediaries in the dissemination of SCFs, one might achieve a better contribution to the coping with agricultural disaster-risks – as stated in the study hypothesis.

OBJECTIVE 3:

Investigate the preferred media used to disseminate SCFs by both SCF producers and intermediaries to target groups, and to propose improvements.

SCF producers use various media to disseminate SCF information to end-users. This study indicated that they mostly prefer the printed media, radio and TV, above any other media, with gatherings/meetings being the least preferred. The medium used for SCF dissemination should be suitable for, and accessible by the targeted audience and within the timely and in reach by all end-users, including farmers in remote areas. *It is therefore recommended that SCF producers and intermediaries should develop more appropriate communication plans to allow wider distribution of SCF knowledge in order to ensure wider application. This should include frequent dialogues with the end-users.*

Study results indicated that the current most targeted audience or recipients of SCFs from the SCF producers is intermediaries, at both national and provincial levels, and farming communities (also through intermediaries), especially from the commercial sector. *It is recommended as a priority that this should be expanded to ALL farmers, including subsistence farmers and smallholder farmers in rural areas.* Other recommendations above outline how this could be achieved. With a growing population it is expected that all farmers must contribute to food security in South Africa, and it is important to reduce the risk of failure for all farmers.

The electronic media constitute the most highly preferred medium for communication by intermediaries in disseminating SCFs to end-users, followed by gatherings/meetings and radio, while faxes are the least preferred. A prerequisite is that all relevant media identified and used should be accessible by everybody in the agriculture sector, including vulnerable farming communities. A challenge is that these farming communities are often isolated from access to electronic media. Experience elsewhere has recommended dialogues with particularly the smaller farmers. *It is recommended that communication channels for SCF dissemination should acknowledge the literacy levels and vulnerability of end-users as a result of language preference and socio-economic conditions, and should proactively act to ensure that information is disseminated to all farmers through the most appropriate communication media.*

The study has indicated that intermediaries and SCF producers prefer the printed media and radio when disseminating SCFs. *It is recommended that these should be aligned with the media preferred by end-users*. As a matter of fact, the understanding of and suitable access to SCF knowledge through the most preferred media of communication will allow for better response to disaster-risks, with explanatory meetings where in demand.

OBJECTIVE 4:

Investigate the types of data and knowledge supplied by SCF producers and intermediaries, and to propose improvements.

It was found that the most frequently communicated advice by SCF producers is probabilistic SCFs of rainfall and temperature, followed by extreme climate warnings, such as droughts, floods and hail. Results indicate that SCF producers hardly ever communicate recommended actions to be taken or disaster-risk measures to be implemented to farming communities, possibly because such actions are rather the responsibility of disaster-reduction managers. *However, SCF producers could consider providing better tailor-made knowledge about agricultural uncertainties that might arise from SCFs, which will assist disaster-reduction managers and end-users in their decision-making*.

To achieve effective early-warning services, SCF producers should ensure that the SCF knowledge provided is clear, is understandable and will be correctly interpreted by end-users. *It is recommended that the communication model currently used is improved, especially by strengthening the relationship between senders and receivers of SCFs. Such relationships could be improved through the establishment of dialogues and boundary organisations, as also earlier recommended in the study.*

However, it was found that more that 60% of respondents from all occupation sub-groups in the intermediary group are satisfied by (highly valued) the SCFs received from SCF producers.

Discussions of monthly climate *Advisories* are occasionally taking place, especially at provincial department levels, where the implementation of disaster-risk reduction measures is discussed. Non-adherence to scheduled discussions will have a negative impact on knowledge-sharing, understanding of SCFs, and finally, on the application of SCF knowledge in practice. *It is therefore recommended that more frequent discussions around the* monthly climate *Advisories take place on a more regular basis (as scheduled), and across the SCF communication chain*. Note that monthly climate *Advisories* are currently discussed on a frequent basis by 40% of the Managers occupation sub-group amongst intermediaries.

Encouraging is that probabilistic SCFs (rainfall and temperature: Annexure E) are widely communicated by intermediaries to end-users, since more than 70% of respondents from all occupation sub-groups prioritised this during interviews. Communication includes warnings on extreme events (61% of respondents), risk measures (58% of respondents) as well as future climate (53% of respondents). It should also be considered to simplify the probabilistic language.

It is very important that both SCF producers and intermediaries consider the needs of end-users when compiling and packaging SCFs. The SCF knowledge supplied to end-users should be packaged in such a way that it is understandable, easy to interpret and useful for application in disaster-risk reduction.

OBJECTIVE 5:

To assess the relevance and effectiveness of institutional structures for early warning dissemination and to propose improvements.

The study has emphasised the importance of a boundary organisation in the research fraternity. Such a boundary organisation could, for example, assist in improving knowledge sharing amongst those involved disaster reduction. *It is therefore recommended that the SAWS, as well as research and academic institutions, should engage in collaborative efforts in such a boundary organization.* Such engagement should include the presentation of SCFs in discussion forums, and the encouragement of good working relationships and team-work amongst different sectors (including government officials and the research fraternity).

All respondents from the intermediary group put a high value on the importance of implementing a boundary organisation to encourage good collaboration among all stakeholders. *It is recommended that Government and research institutions establish and support effective early-warning structures, such as the NAC and disaster-risk committees, to enhance the effective implementation of early-warning services.* The

DAFF and other Government departments involved need to strengthen institutional collaboration with all relevant stakeholders, including research and academic institutions, SAWS, organised agriculture, agricultural unions, co-operatives and farming communities throughout the country. This should notably involve those in remote rural areas, where the poorest of the poor, often without access to electronic media, live.

It was found that effective early-warning services and capacitated early-warning structures are of crucial importance for the effective implementation of disaster-risk reduction in agriculture. Collaborative efforts among meteorologists, agro-meteorologists and extension services should be maintained and strengthened in view of the importance of SCFs and the knowledge involved.

Decision support for stakeholders is regarded as critical, which involves a process in which scientists, government and potential end-users of SCFs engage in an interactive dialogue during which trust and confidence are built simultaneously, with the SCF knowledge being shared. *It is important to convene forums such as disaster risk committees and boundary organisations comprising farming communities, farmer representatives, scientific communities, co-operatives, commercial companies and government, in order to find ways to promote particular sub-sectors and to remove obstacles in addressing disaster-risk reduction in a holistic way.*

5.3 Summary and contribution of the study

Early warning services associated with SCFs (i.e. knowledge, warning and predictions, communication and response) were addressed by the first four objectives of the study, especially as they are interrelated. The last objective emphasised the importance of structures to assist with the effective implementation of the early warning services. Results from these objectives, as collected during interviews, emphasise the importance of considering improved early warning approaches in creating improved disaster-risk reduction structures, which confirms the study hypothesis.

The outcome of the study provides a basis from where SCF-based early warning services can be successfully accommodated in the implementation of disaster-risk reduction. Many system components are already in place, but could be improved through the recommendations made from findings in this study. A more effective implementation of early warning services will benefit a number of stakeholders, such as extension services, disaster-risk reduction practitioners (in government on national and provincial levels) decision-makers, agricultural organisations, farming communities (with a greater focus on vulnerable/poor farmers in remote rural areas), the SAWS as well as both research and academic institutions. Furthermore, the implementation of disaster-risk reduction measures remains the responsibility of all within the agricultural sector, such as government, farmer associations and organisations, all types of farmers (and their communities) and the private sector, which could also benefit from improved SCF-based early warning services.

Despite encouraging developments in the South African agriculture sector in implementing the Disaster Management Act 57 of 2002, there are still a number of challenges, particularly related to inadequate funding for staffing and training of disaster-risk reduction practitioners throughout the country. This applies especially in the remote parts of the country, and to the ongoing shift in mindset of farming communities from reactive to proactive disaster risk reduction (DPLG, 2004; SALGA, 2011). Moving away from crisis management to risk reduction, in accordance with the Disaster Management Act 57 of 2002, requires a paradigm shift in the agricultural sector (DPLG, 2004).

The complex, multi-factor adoption process, as advocated in this study, will have to be expedited to ensure effective disaster-risk reduction as part of the planning process and application in practice. However, there is some notable progress that was made in national and provincial risk-reduction structures in the agricultural sector. The

Provincial Disaster Management Centers (PDMCs) have also made encouraging progress towards implementing mitigation, preparedness and prevention measures despite the lack of financial resources to fully implement the Disaster Management Act 57 of 2002. The SAWS, both nationally and provincially, has shown commitment in improving SCF and to more efficiently disseminate early-warning of all hazards in collaboration with the National Disaster-Management Centre (NDMC) at the Department of Co-operative Governance and Traditional Affairs (DCoGTA), of which the agricultural sector forms part.

Agricultural disaster-risk reduction strategies are aimed at enabling farming communities and societies at risk to become engaged in the conscious coping with risk and the reduction of vulnerability. It is argued in this thesis that risk-reduction approaches should be seen as a comprehensive process that goes beyond traditional responses to the impact of individual natural hazards. Structures such as NAC, National Agriculture Disaster Risk Management Committee (NADRMCO) and National Disaster Management Advisory Forum (NDMAF) could improve on communication and trust within the disaster-risk reduction programmes. These can further ensure the usefulness of SCFs to the end-users, such as farming communities and government policy-makers in reducing the negative effects and socio-economic impacts of extreme weather/climate events in the agricultural sector.

5.4 Conclusions

The results of this study have highlighted ways to strengthen and improve early-warning services in order to prevent and mitigate the impacts of natural hazards in South Africa, especially in the agricultural sector. It is concluded in this study that an improved early warning approach should have the following general features to support the hypothesis:

- A SCF knowledge feedback programme should be implemented by both SCF producers and intermediaries in order to improve on all four elements of early warning services (as defined earlier);
- It is important to assess the needs of users and end-users on a regular basis in order to improve on dissemination and communication channels of SCFs;
- It is regarded as very important for SCF producers to package knowledge according to the targeted audience and their needs;
- Intermediaries should at least discuss SCFs on a monthly basis to enhance knowledge sharing, interpretability and understanding;
- The Government (especially the DAFF) should develop sound disaster risk reduction policies that will ensure compliance within the agricultural sector when implementing early warning services; and
- It is important to create boundary organizations that include at least government officials and research institutions in order to improve on knowledge sharing.

The following critical elements of early warning services need to receive focused attention:

- **Risk knowledge –** The Government should increase the capacity in the disaster risk reduction field and prioritise training and awareness programmes so that knowledge about a potential hazard and usage of SCFs could improve;
- **Prediction, monitoring and warning services** – SCF producers should continuously improve modeling and research capabilities in order to improve on SCF accuracy and to ensure their usefulness. SCF producers should even consider creating platforms where users and end-users can form part of SCF application discussions;
- **Dissemination and communication** - multiple media used by both SCF producers and intermediaries in disseminating of SCFs should be accessible by all users and end-users. SCF producers and intermediaries should include recommended actions on the SCF knowledge provided to users and end-users,

avoid knowledge distortion and communicate weaknesses and uncertainties (that is skill) on SCFs to users and end-users; and

Response capacity - The Government should ensure that farming communities are educated, trained and well equipped to respond to risks from natural hazards.

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Appendix A

QUESTIONNAIRE ON COMMUNICATION OF WEATHER/ CLIMATE FORECAST

Adapted IRI, (2001); Walker *et al*, (2001) and Klopper, (2002).

ONE ON ONE INTERVIEW WITH PRODUCER

MARK IN THE BLOCKS MARKED 1,2,3….

1. Gender

(a)	Male	1
(b)	Female	2

2. What is your age?

(a)	under 25 years	1
(b)	26 – 46 years	2
(c)	47 – 59 years	3
(d)	Above 60 years	4

3. What is your occupation?

(a)	Manager/Decision maker	1
(b)	Researcher/ Scientist/Economist	2
(c)	Climate forecaster	3
(d)	Disaster risk officer	4
(e)	Other Specify ………………………………………….	5

4. In what activities are you involved?

(a)	Producer of weather/ climate forecasts	1
(b)	Climate information service	2
(c)	Participate in the NAC/ IDMC Management meetings	3
(d)	Participate in other forums/meetings	4
(d)	Other Specify ………………………………………….	5

5. Through which media do you disseminate the seasonal climate forecasts?

(a)	Fax	1
(b)	News paper/printed pamphlet	2
(c)	Television	3
(d)	Radio	4
(e)	Electronic media/ Email	5
(f)	Gatherings/Farmers' days	6
(g)	Other Specify ………………………………………	7

6. Who is your current focus group/target group of weather/ climate information in the agricultural sector?

(a)	National Department of agriculture	1
(b)	Provincial Department of agriculture	2
(c)	Extension service	3
(d)	Organized Agriculture/Farming community	4

7. What is being communicated?

(a)	Probabilities for rainfall/temperature	1
(b)	Warning(s) on extreme events	2
(c)	Risk of future climate events e.g. climate change	3
(d)	Recommended actions/ disaster risk measures	4
(f)	Other	5

Specify……………………………………………………………………………………………………

………

8. How do you reduce or avoid the distortion of seasonal climate information?

(a)	Usage of partnerships during dissemination	1
(b)	Translated information to other officials languages	2
(c)	Training/awareness on the understanding/interpretation of climate info by users	3
(d)	Discussion in groups/ meetings/workshops/participatory processes	4
(e)	Other	5

Specify….…………………………………………………………………………………………..

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9. How often do you make a deliberate effort to obtain forecast information feedback from users?

(a)	All the time	1
(b)	Most of the time	2
(c)	Some time	3
(d)	Not at all	4

10. How do you go about obtaining seasonal climate forecast information feedback from users?

(a)	Organising meetings/forums when forecasted climate conditions is proved unreliable	1
(b)	Quarterly questionnaires	2
(c)	Organising meetings/workshops/forums seasonally	3
(d)	Organising meetings or workshops following extreme weather events	4
(e)	Other Specify …………………………………………	5

11. How much confidence/skill do you have in seasonal climate forecasts provided?

(a)	Below 40%	1
(b)	Medium 40% - 60%	2
(c)	High – above 60%	3
(d)	Other Specify …………………………………………	4

12. How much value do you put on seasonal climate forecasts you provide?

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4
(e)	Other Specify	5

Specify………..

……..

13. Do you trust weather/ climate forecasts you provide?

(a)	All the time	1
(b)	Most of the times	2
(c)	Some times	3
(d)	Not at all	4

14. Importance of Boundary Organization (a platform were scientists and decision makers can share information)

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4

15. Any other comments or challenges or recommendations when considering institutions such as ARC, Universities, seasonal forecast producers such as SAWS, DoA and PDA especially in line with the goals of communicating climate information for the benefit of farming communities in addressing disaster risk management:-

………
………
…………………………..…………………………………………………………………………………

Advisory : Monthly advisory compiled by the Directorate, there is information about the current climatic conditions, seasonal climate forecasts and some strategies to be followed by farming community

Forecast information feedback: The SCF information is disseminated to users on monthly basis through different types of media. The SCF information feedback from the users will assist in further improvement on the product.

Boundary organization: Boundary organization among all stakeholders from scientists, policy makers and intermediaries including end users are created to enhance knowledge and effective communication among users of SCF information in addressing disaster risk management.

Avoid information distortion: SCF information needs to be effectively communicated to the users so the sender needs to protect this through the media channel used as a way of avoiding information distortion.

SAWS : South African Weather Service

ARC : Agricultural Research Council

DoA : Department of Agriculture

PDA : Provincial Department of Agriculture

IPCC : Intergovernmental Panel on Climate Change

Appendix B

QUESTIONNAIRE ON COMMUNICATION OF WEATHER/ CLIMATE FORECAST

Adapted from IRI, (2001); Walker *et al*, (2001) and Klopper, (2002).

ONE ON ONE INTERVIEW WITH INTERMEDIARY

MARK IN THE BLOCKS MARKED 1,2,3….

1. Gender

(a)	Male		1
(b)	Female		2

2. What is your age

(a)	under 25 years		1
(b)	26 – 46 years		2
(c)	47 – 59 years		3
(d)	Above 60 years		4

3. What is your occupation

(a)	Manager /Decision maker		1
(b)	Researcher/Scientist/Economist		2
(c)	Extension Service		3
(d)	Disaster risk officer		4
(e)	Other		5

Specify………

……

4. Through which media would you prefer to disseminate the seasonal climate or early warning information?

(a)	Fax		1
(b)	News paper/printed pamphlet		2
(c)	Television		3
(d)	Radio		4
(e)	Electronic media/ Email		5
(f)	Gatherings/Farmers' days		6
(g)	Other		7

Specify……………………………………………………..…………………………………………………………..

5. What is being communicated to users?

(a)	Probabilities for rainfall/temperature forecasts	1
(b)	Warning on extreme events	2
(c)	Risk of future climate events e.g. climate change.	3
(d)	Recommended actions/ disaster risk measures	4
(e)	Other	5

Specify………..
……..

6. Are you able to use the seasonal climate forecasts in planning the following activities?

(a)	Agricultural Production/Advisories	1
(b)	Food security/Crop estimates	2
(c)	In other decision making process e.g. disaster risk, climate risk, etc.	3
(d)	Natural resource management	4
(e)	Other	5

Specify………..
……..

7. How do you reduce or avoid distortion of seasonal climate or early warning information?

(a)	Usage of partnerships during dissemination	1
(b)	Translated information to other languages	2
(c)	Training/awareness on the understanding/interpretation of climate info by users	3
(d)	Discussion in groups/ meetings/workshops/participatory processes	4
(e)	Other	5

Specify………
…….

8. How often do you discuss advisories (climate forecasts with strategies) within organization?

(a)	All the time	1
(b)	Most of the time	2
(c)	Some time	3
(d)	Not at all	4

9. How often do you make a deliberate effort to obtain weather and climate forecast information?

(a)	All the time	1
(b)	Most of the time	2
(c)	Some time	3
(d)	Not at all	4

10. How do you make a deliberate effort to obtain early warning information feed back from users?

(a)	All the time	1
(b)	Most of the time	2
(c)	Some time	3
(d)	Not at all	4

11. How accurate do you think the Weather Service's seasonal climate forecasts are?

(a)	Always inaccurate	1
(b)	Sometimes inaccurate	2
(c)	Sometimes accurate	3
(d)	Mostly accurate	4
(e)	Always accurate	5

12. How much value do you put on the weather/ climate forecast/early warning information?

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4

13. Importance of disaster risk policies/strategies/plans climate change risk reduction?

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4

14. Indicator to measure disaster risk policies/strategies/plans within the organization

(a)	Has little or no understanding of the relevance and importance of disaster risk plans	1
(b)	There is general awareness within the organization	2
(c)	Has a conceptual framework for disaster management	3
(d)	Has a policy/plans on disaster risk reduction	4

15. Importance of a boundary organization (a platform where scientists and decision makers can share information)

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4

16. If a drought/flood is forecasted or fire warning issued, do you make adjustments to your planning/decision as per advice or strategies issued?

(a)	All the time	1
(b)	Most of the time	2
(c)	Some time	3
(d)	Not at all	4

17. Importance of training/awareness on the understanding and interpretation of climate information

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4

18. Any improvement on the understanding and interpretation of climate information following the training/awareness?

(a)	Highly noticeable	1
(b)	Noticeable	2
(c)	need retraining	3
(d)	Not at all	4

19. Any improvement on information dissemination following the training/awareness on climate information?

(a)	Highly noticeable	1
(b)	Noticeable	2
(c)	Some time	3
(d)	Not at all	4

20. Do you understand the climate change issues within your field of work e.g. UNFCCC or contents of the IPCC assessment reports

(a)	Understandable	1
(b)	A bit understandable	2
(c)	Need to be simplified	3
(d)	Not understandable	4
(e)	Other	5

Specify…….
………..

21. Importance of effective structures for early warning information dissemination

(a)	Very important	1
(b)	Important	2
(c)	Unsure	3
(d)	Not important	4

22. Any other comments or challenges or recommendations when considering institutions such as ARC, organized agriculture, seasonal forecast producers such as SAWS and Universities, as well as Department of agriculture at national and provincial especially in line with the goals of communicating climate information for the benefit of farming communities in addressing disaster risk management:-

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Advisory : Monthly advisory compiled by the Directorate, there is information about the current climatic conditions, SCFs and some strategies to be followed by farming community

Forecast information feedback: The SCF information is disseminated to users on monthly basis through different types of media. The SCF information feedback from the users will assist in further improvement on the product.

Boundary organization: Boundary organization among all stakeholders from scientists, policy makers and intermediaries including end users are created to enhance knowledge and effective communication among users of SCF information in addressing disaster risk management.

Avoid information distortion: SCF information needs to be effectively communicated to the users so the sender needs to protect this through the media channel used as a way of avoiding information distortion. SAWS : South African Weather Service

ARC : Agricultural Research Council

DoA : Department of Agriculture

PDA : Provincial Department of Agriculture

IPCC : Intergovernmental Panel on Climate Change

UNFCCC : United Nations Framework Convention on Climate

Appendix C

agriculture

Department:
Agriculture
REPUBLIC OF SOUTH AFRICA

STRATEGIES THAT COULD BE FOLLOWED DURING DROUGHT

1. INTRODUCTION

South Africa is characterized by a wide variety of climatic zones which allows diversity in agricultural production. However, the country is generally arid/semi- arid as it receives an average rainfall of 500mm per year compared to the world average of 800mm per annum. Climate variability is a natural phenomenon, but research has shown that over the past century there has been an increase in the concentration of greenhouse gases due to human activities such as industrialization, deforestation, etc. The findings of which lead to global warning through the greenhouse effect much more focused research on climate variability in Southern Africa indicate that the mean air temperature over South Africa will increase with an estimated 1,5-4º C over the next century. This is a serious threat to sustainable development, affecting human well-being, global economy and environmental integrity as it means a high frequency of extreme weather conditions such as droughts and floods amongst others.

South Africa is divided into three main rainfall regions: winter rainfall region in the southwest, an area with rainfall throughout the year along the southern coastal region and summer rainfall area over the remainder of the country. The decrease in rainfall from the eastern to the western parts of the country has been observed. South African rainfall is extremely variable and results in the country to having limited agricultural production.

Agriculture includes all economic activities from provision of farming inputs to value adding and it remains an important sector in the South African economy despite its small contribution to the gross domestic product (GDP). Farm workers, farmers and their families also contribute to the economy when they spend their wages and salaries on consumer goods and services, or when they buy inputs for production. In this way agriculture becomes a sector contributing significantly to growth and development. The effects of extreme weather and climate conditions will have negative impacts on agricultural production through water logging of soils and frequency of dry spells amongst other disasters that would make it impossible to realize good yields and hence poverty to the households which depends entirely on farming.

The drought that Southern Africa has been experiencing since 2002 to date is a foretaste of the impacts of climate change in years to come and could mean less agricultural production among others. The Disaster Management Act (Act No. 57, 2002) also urges that the emphasis be put more on prevention and reduction of disasters by using the weather and climate information.

ADRM is compiling the monthly advisories which have the strategies for farming community to apply given the current climatic conditions. It was realized that these strategies must be strengthened and be produced in all official languages to be understood by all users.

The following are the strategies that farmers can consider and apply during drought:

2. CROP PRODUCTION

2.1 Soil choice:

- Choose the correct soil type for the crop being planted e.g. sandy soil for maize and clay soil for sorghum etc, if at all possible.

- Choose fields with lower gradients to minimize water run-off.

2.2 Land preparation:

- Avoid, where possible, soils with pronounced plough pans.
- Use a ripper to break plough pans and increase access of roots to stored water and nutrients.
- Do not expand land under crop production unnecessarily.
- Roughen the soil surface to minimize evaporation.
- Practice conservation tillage methods e.g. zero tillage, minimum tillage, fallowing etc.
- Minimize compaction by reducing the passing of heavy machinery in the field. This can be partly achieved through utilization of appropriate equipment for specific soil type.

2.3 Crop choice and planting:

- Choose drought resistant cultivars.
- Plant shallow especially for maize as seedlings of deep planted seed will take longer to emerge than shallowly-planted seed.
- Provide flexibility and diversification in the cropping system by using mixed cropping systems rather than mono-cropping, e.g. plant maize and dry beans in the same field. This will help the farmer to benefit from the other crop should one fail.
- Stick to the normal planting window if appropriate and follow the weather and climate forecast regularly. Make plans for short season crops e.g. sunflower.
- Consider staggered planting-spreading over weeks.
- Do not experiment with new and unknown cultivars and also avoid unnecessary capital investments.
- Always practice crop rotation.

2.4 Crop management:

- Adjust planting density accordingly.
- Consider planting cover crops and mulching to minimize evaporation.
- Control weeds regularly.
- Consider a conservative fertilizing strategy.
- Consider organic fertilization.
- Regularly scout for pests and diseases.
- Practice water harvesting techniques e.g. construction of basins, contours, ridges.

The farmers who are planting maize should note the following stages of maize:

- **Planting to emergence:**
  - Plant shallow as deeply planted seeds emerge below the soil-surface and die off.
  - Avoid too much fertilizer close to the seed as this may cause burning.

- **Vegetative growth stage**:
  - After emergence, the plant will get into the leaf unfolding stages. For the maize plant to complete this vegetative stage, it has to unfold from four leaves to sixteen leaves.
  - Nutrients and water stress at this point may not cause permanent damage, however silk development can be affected as well as the number of kernel per ear.

- **Reproductive growth stage**: Critical period of water need.
  - The first and critical stage of reproductive growth is the appearance of silk at the tip of the ear. Enough water is required during this period as water stress will reduce the time of pollen shedding and delay silk development and hence loss of yield.

- Planting dates should be chosen effectively so as to ensure that this stage coincides with normally favourable conditions.
- The blister, soft dough and hard dough stages are also critical in reproductive growth. Water stress during these stages can lead to poor grain quality and huge crop losses.
- The full dent stage follows immediately after hard dough stage and this is the correct time to cut silage. Enough moisture is still important but not crucial, but severe water stress can still reduce yield and grain quality.

- **Physiological maturity and harvesting:**
  - Physiological maturity is the last stage of maize development.
  - A farmer should monitor the moisture content of the grain to start harvesting as soon as the crops have reached biological maturity and this is when the moisture content of the grain is below 15%. The diseases that should be taken care of during this period are stem and root rot as well as the cob diseases.

2.5. Pests and diseases

In general, integrated pest management should be practiced throughout the cropping season. These include the following:

- Preventive control: this method is effective, however, not at a very high infection levels as it may not be effective and also cause large losses.
- Cultivation control: this method includes soil cultivation during winter, eradicating volunteer plants, choosing cultivars and adapting planting times.
- Biological control: this occurs where natural enemies attack all the life-stages of insect pests. The natural enemy complex can be protected to a certain extent by using insecticides which are more environmentally friendly and which are not very toxic to non-target organisms.
- Insect-resistant crops: this occurs when you use cultivars that are resistant to insects. Cultivars differ in their susceptibility to diseases such as ear rot, maize streak virus, grey leafspot, rust, cob-and tassel smut, stem rot as well as root

rots. In order to avoid or minimize the impact of these diseases, select cultivars with the best levels of resistance or tolerance where a specific disease occurs.

2.6. VEGETABLE MARKETING

Vegetable production involves higher costs than many other crops. Amongst the reasons are volatile market risk and the need for optimum levels of appearance, consistent supplies and qualities in the marketplace. Moreover, many vegetable crops have high water needs. Developing marketing strategies is important in trying to attain profitability in vegetable crop production whether drought conditions prevail or not. When drought conditions are anticipated, it is important to develop buyers and outlets for lower grade products. Reduce harvest, packaging, and marketing costs when possible. Drought-damaged produce of certain commodities may be useful to certain vegetable processing companies. These options may be limited, but some sales may be possible. Contact potential outlets early to investigate these arrangements.

3. LIVESTOCK MANAGEMENT

- Keep well adapted animal breeds and do regular veld inventories and adjust stocking rate (herd/flock size) accordingly.
- Work out the minimum number of breeding cows that can be kept under the worst conditions and keep this as the nucleus herd. These are the best breeding cows selected for functional efficiency and past performance, using all the aids at your disposal e.g. (Records, evaluation for functional efficiency).
- Maintain young best females and cull old and unproductive animals.
- Market surplus stocks and cull poor producers when feed resources run out.
- Provide suitable licks, and other forms of supplementary feed to maintain nutritional requirements as drought-stricken natural pastures have generally low nutritional value.

- Use crop residues or drought-damaged crop for emergency feed supply. In these cases, use special care to ensure that animal-toxic pesticide residues are not present on the crop residue as this could impair the health of your livestock.
- Alter animal management practices to include creep feeding or early weaning of the calves, and raise young animals intensively.
- During worse conditions, take animals to the camps and provide feeds.
- Use products from indigenous woodlands (e.g. pods) and cut the feeding material above the browsing line (e.g. below the 1.5 m stratum for goats) and feed to browsers in camps.
- Regularly control animal diseases and parasites.
- Feed pregnant and lactating animals better.
- Postpone the mating period during extremely dry conditions.
- First graze areas where vegetation is still good.
- Spread water points evenly through grazing areas to avoid over grazing near the water point.
- Plant hardy trees or shrubs for browsing animals.
- If the onset of rainfall season is late, consider sowing quick growing fodder crops such as teff, babala or millet for extra feed in dry times.
- Eradicate invader plants at all times.

3.1. DROUGHT FEEDING STRATEGIES

In drought conditions you need to develop a plan of action to care for your livestock.

- Determine the amount of energy supplement needed by the availability of pasture or the energy value of stored forages then start looking for alternative feed sources.
- Other by-products from wheat, citrus, peanut can be used as feeds, even stale bread and brewer's grains. Ask Extension office for more information on by-product feeds and remember to do cost/analysis comparisons before buying to ensure that you pay a reasonable price for emergency feedstuffs.

- Provide correct mineral supplementation for the cow herd. “Salt, calcium and phosphorus will be most important”.
- Energy may be the most limiting nutrient during a drought. Grain, hay, and by-products can be used to provide the energy. A general rule of thumb is not to feed more than 2.5% body weight as supplemental grain. More than this will affect forage digestibility.
- When it does rain, rotate the cows on the pastures as much as possible to take advantage of available grass.
- Drought dormant pasture may be deficient in protein. Reduced pregnancy rates can occur at this time and sunflower meal as well as other protein meals can then be used.
- Poultry litter is an economical and safe source of protein, minerals and energy for beef cattle. Grain and poultry litter (40-45% of mix) can reduce the pasture demands by 20-40% for cows
- If possible lease additional pasture land and reduce the stocking rate of your fields.

3.2. LIVESTOCK MARKETING

The timing of selling stock and the condition of the stock at sale is critical. Past market information is available to assist in determining livestock value changes during and after the drought. Selective reduction of stock numbers early in a drought is nearly always an attractive proposition.

3.2.1. Selling stock

- If stock is sold early in the drought, prices received are likely to be better because the stock should be in a reasonable condition and the market firm. Also, feeding costs are avoided.
- Keep stock that is easy to handle during drought and which is going to be most productive or give the best returns after the drought. Sheep, for example, have consistently given a higher percentage return to livestock capital invested than cattle. The longer the drought lasts, the more effective this strategy will prove.

- If the drought is short and a small percentage of stock has been sold, the remaining stock will probably compensate through increased performance per animal as a result of reduced stocking rate. It may not even be necessary to repurchase stock.
- With a longer drought and a higher percentage of stock sold, the critical factor becomes the ability to re-purchase livestock at reasonable prices when conditions improve.
- Livestock prices in the post-drought phase do not always rise dramatically, because the financial reserves are depleted.
- Early sale of stock will generate liquidity to sustain the farm's equity position or generate interest, which will assist in the longer-term survival of the business.
- As the drought progresses, sell stock until you are left with a nucleus of young, sound, breeding females, which are likely to be most valuable when the drought breaks and most capable of the best production at that stage.
- Castrate males during a prolonged drought to avoid multiplication of stock.

4. WATER USE MANAGEMENT

4.1 Domestic and home garden water use:

- Conserve existing water supplies.
- Eradicate water weeds.
- Limit water waste and losses.
- Repair leaking pipes to avoid unnecessary water losses.
- Additional sources of water must be used at this stage e.g. harvesting water at home during rainy days.

4.2 Irrigation farming

- Irrigate during cool conditions to minimize evaporation, mainly in the evenings.

- Remove all weeds containing seeds but keep other vegetative materal on the land surface to minimize evaporation.
- Obtain the relevant seeds to be planted considering the climate forecast.
- Check and repair all tools and machinery that are necessary for irrigation.
- Consider the levels of earth dams and adhere to the water restrictions at all times.

4.3 Drinking water for livestock

- Spread water point evenly at all grazing areas to avoid spreading of diseases.
- Ensure that enough water is available throughout that particular season and conserve where possible.
- Use water effectively and if all water sources have dried out, report urgently to the local Department of Water Affairs.

1. VELD MANAGEMENT

- Evaluate the carrying capacity of the available grazing area (i.e. drought vulnerability assessment: both the condition and slope of the pasture land) and keep suitable stocking rates. Highly erodible land can be adversely affected by overgrazing during drought conditions and maintaining adequate grass cover should be a priority on lands susceptible to erosion.
- Find out / determine the potential of the grazing area by choosing a system that best suits the conditions, for example, weaner versus ox production, depending on Veld type and average rainfall.
- Ensure that your grazing area is divided into camps and rotate the animals between the various camps (*i.e.* apply rotational grazing); and always monitor the grazing animal, maintaining the "graze half and leave half" principle in order to avoid overgrazing.
- Always avoid overgrazing as it is deteriorates the veld. This is caused by overstocking.

- Do an inventory of edible shrubs and trees; these can be cut and milled for feed supply in emergency situations.
- Control invader species and weeds as they compete with fodder plants for the available soil moisture and rooting space.
- Reinforce natural pastures by incorporating quick-growing legumes to improve the crude protein content and growing-vigour of sward, and the overall carrying capacity.
- Avoid veld fires by always checking the weather forecast and putting fire breaks in place.
- The firebreaks must be continuously revisited to avoid unnecessary fire damages especially during the burning season. Those who are burning the veld for ecological purposes are advised to consider National Forest Fire Act No. 101 of 1998 which states that an owner of the land is obliged to prepare and maintain a firebreak and must ensure that , with due regard to weather, climate, terrain and vegetation of the area, the following is taken care of in terms of installing the firebreaks (chapter 4 of National Veld and Forest Fire Act No. 101 of 1998):
  - It has to be wide enough and long enough to have a reasonable chance of preventing a veld fire from spreading to or from neighboring land.
  - It does not cause soil erosion and
  - It is reasonably free of inflammable material capable of carrying a veld fire across it.

The Disaster Management Act (Act No 57 of 2002) urges Provinces, individuals and farmers, to assess and prevent or reduce the risk of disasters using early warning information among others.

The farmers are encouraged to check the agro-meteorological advisories from the Department of Agriculture and the extended weather forecast from the South African Weather Service on a monthly basis. The farmers are also advised to share this information with others.

The Agricultural Risk and Disaster Management Directorate would like to thank the following directorates: Plant Production Systems, Animal and Aqua Production, Water Use and Irrigation Development, Animal Health, Plant Health as well as the Agricultural Research Council and South African Weather Service for their valuable inputs in compiling this booklet.

Appendix D

agriculture

Department:
Agriculture
REPUBLIC OF SOUTH AFRICA

EXTREME WEATHER WARNING

Dear All,

Kindly receive the warning below and disseminate widely as stipulated in the NAC and EWC terms of reference.

In the light of this warning as produced by the South African Weather Service (SAWS) and other centres, the following advisory guidelines are suggested. It is emphasized that these advisories are broad guidelines and should be interpreted considering the local aspects of the region such as soil types, cultural preferences and farming systems. Depending on the particular region, the prioritization of the guidelines will differ. The basic strategy to follow would be to minimize and diversify risk. The province should further simplify, downscale and package the information according to their language preference and if possible use local radio stations and farmers' days in disseminating the information.

National warning issued by SAWS valid for Tuesday, January 25, 2011:
Heavy rain is possible over places of Free State, over places Gauteng, over places in the southwestern part of Limpopo, the western part of Mpumalanga and over places of the North-West Province.

The provinces should further disseminate the information according to their language preference and if possible use local radio stations.

Heavy rainfall raises the water level. When the water level is higher than the river banks or the dams, the water comes out from the river and flooding occurs.

Preventive measures

1. Improve drainage efficiency,
2. Construction of structures,
3. Increase areas serve as retention basins,
4. Mitigation measures,

What to do when heavy rainfall is forecasted:
avoid-

- Cutting grass in the rainy season (nutrient depletion),
- Appling fungicides and pesticide (plants and animals),
- Applying N fertiliser (burning of plants). Nitrogen loss is higher when a heavy rain immediately follows a surface application of fertilizer, especially on sloped areas. Dumping fertilizer in one spot can cause the roots below the fertilizer to be burned and die.
- Irrigation (waterlogging can occur, nutrient depletion),
- Cover Urea licks to prevent them from becoming toxic,
- Provide shelter for animals (young ones die easily),
- Leave cultivated areas coarse,
- Relocate/ Move animals to a safe place,

Following are a number of concerns and recommendations:

- Be extra cautious for pest and diseases after rain has fallen, as high moisture content and the high temperatures may trigger these.
- Assume that flood water contains sewage and might be harmful for human and livestock consumption.

- Before leading livestock across a river, check whether the water level is rising. This is especially necessary if it is already raining, but remember that there could be a storm further upstream and floodwaters could be on the way.

For more information contact: -DoA, Directorate: Agricultural Disaster Management
Private Bag X250
Pretoria 0001
Tel:012 319 7955/56; Fax: 012 319 6711
Email: PA.DADRM@nda.agric.za

agriculture
Department:
Agriculture
REPUBLIC OF SOUTH AFRICA

Appendix E

agriculture, forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

National Agro-meteorological Committee (NAC) Advisory on the 2010/11 Summer Season

Statement from the Agricultural Disaster Risk Management

06 DAFF 2011

21 February 2011

In the light of the seasonal outlook as produced by the South African Weather Service (SAWS) and other centres, the following advisory guidelines are suggested. It is emphasized that these advisories are broad guidelines and should be interpreted considering the local aspects of the region such as soil types, cultural preferences and farming systems. Depending on the particular region, the prioritization of the guidelines will differ. The basic strategy to follow would be to minimize and diversify risk, optimize soil water availability and to manage the renewable resources (rain water and grazing) to uphold sound farming objectives. Long-term mitigation strategies should be considered by implementing techniques to enhance in-field water harvesting by reducing run-off and improving infiltration. Reduced tillage methods are very important in this regard, as is basin tillage, to capture rainwater in the drier areas. **The provinces should further simplify, downscale and package the information according to their language preference and if**

possible use local radio stations and farmers' days in disseminating the information.

I. <u>CURRENT CONDITIONS</u>

Figure 1

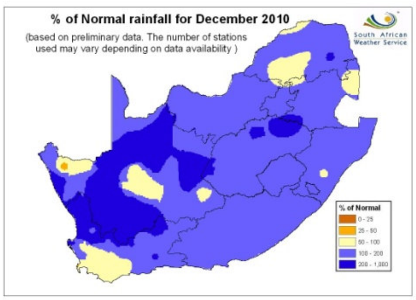


Figure 2

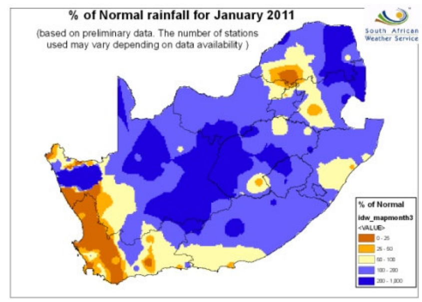


Figure 3

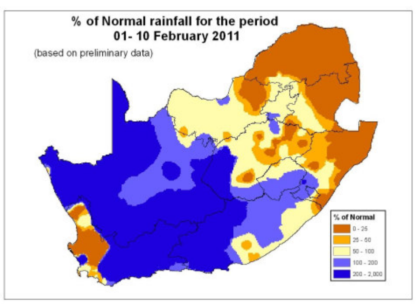
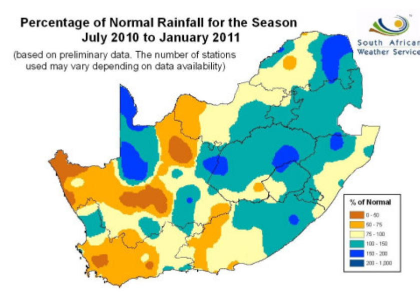
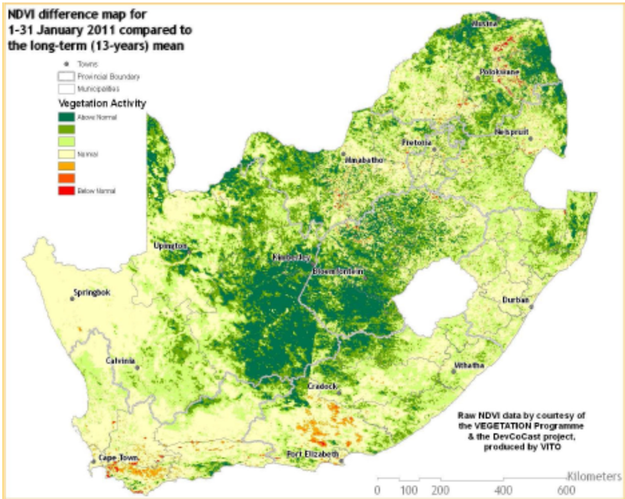


Figure 4



Copious **(Figure 1)** amounts of rain fell during December resulting in above normal rainfall countrywide. The above normal rainfall continued into January over most summer rainfall areas **(Figure 2)**. The first dekad of February **(Figure 3)** received above normal rainfall over the western half of the country except the West Coast District. The remainder of the country experienced normal rainfall but below normal over Provinces in the east. The season July - January 2011 **(Figure 4)** received normal to above normal rainfall over the central and eastern parts but below normal towards the west.

NDVI difference map for January 2011 compared long-term mean



Vegetation conditions were above normal throughout most of the country. Lower vegetation activity can be seen in small areas of the Eastern Cape Province.

II. <u>CONDITIONS IN THE PROVINCES DURING JANUARY 2011</u>

Eastern Cape

Good rains have been received except for the western areas (Cacadu). Signs of severe drought are still evident in parts of Cacadu and Chris Hani. The good rains resulted in good quality crops but mainly maize is poor due to water logging in most planted fields in Alfred Nzo. A few incidents of hail storm damages were reported in parts of Amathole, Alfred Nzo and where maize fields were damaged. The veld is recovering except where there was less rain. Generally, all regions have reported good conditions of livestock. Even in areas where minimal rains have been recorded, livestock has improved. An outbreak of Rift Valley Fever was reported in the Kei Mouth area of Buffalo City in the Amathole region. However, there was swift response from relevant authorities to quarantine the area and put the disease under control. In totality the level of dams remained low but is higher as compared to the previous year during the same period (66% in 2011; 63% in 2010).

Free State

Above average rainfall was received that resulted in floods in some areas. The condition of veld and livestock exceed above average but the excess rainfall is not advantageous to sheep as it could lead to foot-rot and the development of other diseases. Most dams are above 100% capacity. At the end of January the level of dams in general was higher as compared to the previous year (110% in 2011; 97% in 2010).

Gauteng

Above normal rainfall was experienced which resulted in flooding in most of municipalities. This had a negative effect on crop production in most of the farming areas. In Sedibeng Municipality; maize, soyabean and sunflower have been severely affected. Flooding also created conditions that are conducive to the possibility of animal diseases such as Rift Valley Fever. Veld is in good condition with good grass for grazing. All major dams are over 100% full. The level of dams is at 102% similar to the previous January.

KwaZulu-Natal

Above normal rainfall was received. Flooding was experienced where infrastructures such as fences were destroyed and there was damage to the late planted maize and soybean crops. Veld and livestock are in good condition. A number of community owned cattle were struck by lightning. The level of dams has slightly decreased as compared to the previous year during the same time (88% in 2011; 89% in 2010).

Limpopo

Below normal rainfall was received southeast of the province but elsewhere it was above normal. Grazing conditions are improving due to the rain but will need time and follow up rains for good recovery. The condition of livestock is fair. Cash crops were badly damaged by hail, thunderstorms and floods. The flooding occurred in Vhembe, Mopani, Sekhukhune and Capricorn which resulted in waterlogging on some farms. Access to a number of roads has been cut off resulting in farming activities coming to a halt. Some infrastructure has also been washed away. Majority of dams are overflowing. As compared to the previous year, the level of dams has increased (89% in 2011; 81% in 2010).

Mpumalanga

Normal to above normal rainfall was received which caused flooding in some areas. Crops are in reasonable condition but where there was flooding water logging resulted and farmers are unable to cultivate weeds. Other crops were completely damaged and infrastructure was also affected. Irrigated winter wheat has been harvested. Vegetation conditions are normal and livestock is in reasonable to good condition. Farmers are advised to remove livestock from low lying areas when heavy falls are anticipated. A few cattle were struck by lightning in the Volkrust area of Gert Sibande. Overall the level of dams has slightly increased as compared to the previous year at the same time (101% in 2011; 100% in 2010).

Northern Cape

Normal to above normal rainfall was received except in parts of Namakwa where it was below normal. Crops in the summer rainfall areas were damaged by floods and some completely destroyed. The quality of those that survived will be low while others were cut off from the irrigation system as pipes were removed from the river, which will result in low yields. In Namakwa yields will also be low as a result of the low rainfall. The veld and livestock are in good condition except in areas that received low rainfall. Ostrich mortalities were reported in Pixley KaSeme and in John Taolo Gaetsewe goats, lambs and cattle. A case of Rift Valley Fever was reported in the Calvinia area. In general the level of dams is slightly higher than in the previous year during the same period (117% in 2011; 114% in 2010). Although the overall level is high some dams are critically low i.e. Calvinia dam is at 7%.

North West

Above normal rainfall was received, resulting in flooding for most parts of the province where crops were affected and some destroyed. Overflowing of the Bloemhof Dam due to flooding also affected the crop farmers in Bloemhof and Christiana. Livestock is reported to be in good condition despite the fact that some grazing areas are covered by water. The level of dams has increased as compared to the previous January (88% in 2011; 79% in 2010).

Western Cape

Rainfall received was near normal in the east but below normal elsewhere. Due to low rainfall the northern parts of the West Coast District and the drought stricken Central Karoo experienced poor sub-soil water levels. In the remainder of the province veld conditions improved and livestock are in reasonable to good condition. Where rain was low farmers supplied fodder to livestock. Overall temperatures were above normal and heat waves resulted in severe damage to apples and pears in the first week in January. Dam level were reported to be at 64%, which lower as compared to 69% of 2010.

Information on level of dams is obtained from the Department of Water Affairs
Available: http://www.dwa.gov.za/Hydrology/Weekly/Province.aspx
Accessed on 14/02/2011

III. AGRICULTURAL MARKETS

Major grain commodities

According to FNB Agri-Weekly yellow maize and white maize domestic prices are expected to remain strong due to the weakness of the Rand. Domestic wheat prices continued to trend higher on the back of a weaker Rand. The wheat market will maintain an upward trend due to the global supply constraints in the short to medium term. The tight international supply situation coupled with strong demand will continue to support the oilseed market.

Domestic prices per Safex (R/t)

	Futures prices as at (2011/02/11)				
Commodity	**2011/03**	**2011/05**	**2011/07**	**2011/09**	**2011/12**
White maize	R1655.00/t	R1687.00/t	R1716.00/t	R1747.00/t	R1787.00/t
Yellow maize	R1715.00/t	R1734.00/t	R1764.00/t	R1791.00/t	R1825.00/t
Wheat	R3391.00/t	R3420.00/t	R3453.00/t	R3450.00/t	R3210.00/t
Sunflower	R4835.00/t	R4660.00/t	R4740.00/t	N/a	N/a
Soybeans	R4135.00/t	R3785.00/t	R3836.00/t	R3885.00/t	R3907.00/t
Sorghum	N/a	N/a	R1550.00/t	N/a	N/a

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Livestock domestic markets

FNB Agri-weekly mentioned that the beef prices bottomed out and strengthened on the back of tight supplies across most markets. Beef prices are expected to trade at current levels in the short term with additional upside potential towards Easter. Lamb and mutton prices maintained a firmer trend due to tight supplies. The prices are expected to remain at current levels with further upward potential due to tight supplies. Local porker and baconer prices bottomed out and ended firm to higher on improved uptake. Prices are expected to move sideways in the short term.

Producer prices for selected livestock commodities	**Beef**	**Mutton**	**Pork**	**Poultry**
Open market: Class A / Porker / Fresh whole birds (R/kg)	27.12	46.21	16.25	18.48
Open market: Class C / Baconer / Frozen whole	22.51	36.00	16.00	13.75

birds (R/kg)				
Contract: A2/A3* / Baconer/ IQF (*includes fifth quarter) (R/kg)	26.62	46.03	15.67	12.58
Import parity price (R/kg)	18.39	26.43	16.11	10.03
Weaner Calves / Feeder Lambs (R/kg)	18.78	21.50		

FNB AgriCommodities: 11/02/2011

NB: Users are advised that these are just indicative prices therefore it is imperative that clients investigate their own individual basis value when marketing their products (livestock and grain).

IV. SADC REGION

The January – June 2011 FEWS NET report states that currently most of the region remains generally food secure. Nonetheless, as the lean season peaks, access is becoming a problem, especially for poorer households many of whom have depleted on farm stocks and have turned to markets. The situation is more worrisome for households in areas currently facing moderate levels of food insecurity as a result of failed/poor crop production last season. Increased demand for food in local markets is putting upward pressure on prices, a trend that is expected to continue until the next harvest. Although most of the region received normal to above normal rainfall during the first half of the season, below normal rains have been received in the northern parts of the region (northern Mozambique, Tanzania, and parts of northern Zambia). In line with the La Nina phenomenon, extremely wet conditions have been reported in the areas where above normal rains have been received. Heavy downpours between December and January in affected areas have resulted in widespread flooding which has negatively impacted crop production. These downpours have also raised river levels to alert levels where flooding risks are elevated. Bimodal Tanzania however received below normal short season (*vuli*) rains and many areas have recorded crop failure for the short season.

Summary of the reports

Above normal rainfall was received over most summer rainfall areas during the month of January which resulted in flooding in some areas. Consequently crops were severely affected i.e. water logging and some completely destroyed. Livestock in general is in reasonable condition but cases of Rift Valley Fever were reported in the Eastern Cape and Northern Cape. Mortalities of cattle, lambs and Ostrich were also reported in the Northern Cape. Cattle were struck by lightning in Mpumalanga and KwaZulu-Natal. Fruit crops were damaged by heat waves in the Western Cape. Over the SADC region most regions remain food secure but as the lean season peaks, access is becoming a problem, especially for poorer households many of whom have depleted on farm stocks and have turned to markets.

V. MONTHLY CLIMATE OUTLOOK

Seasonal Rainfall and Temperature Forecast: March to July 2011

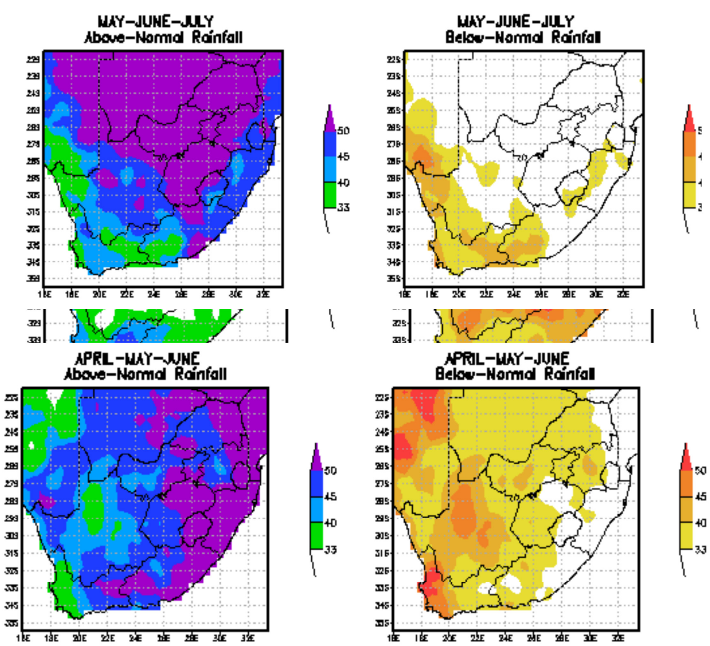


Figure 1- Rainfall

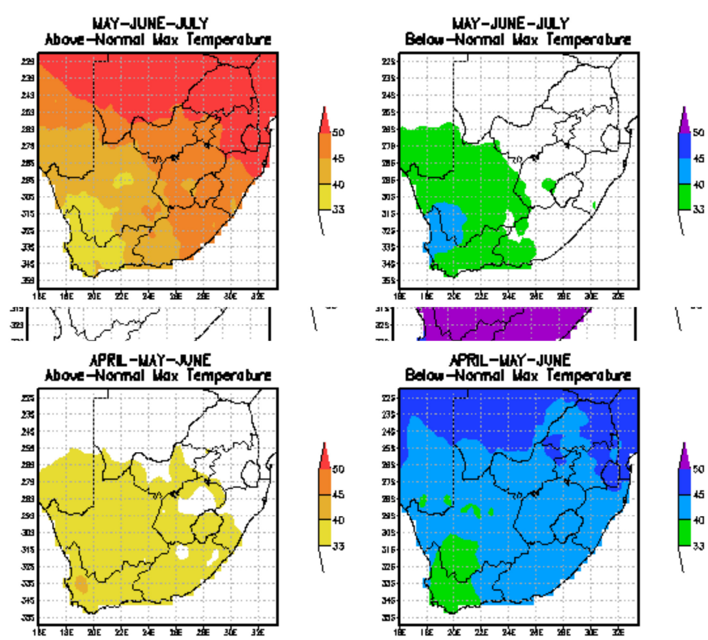
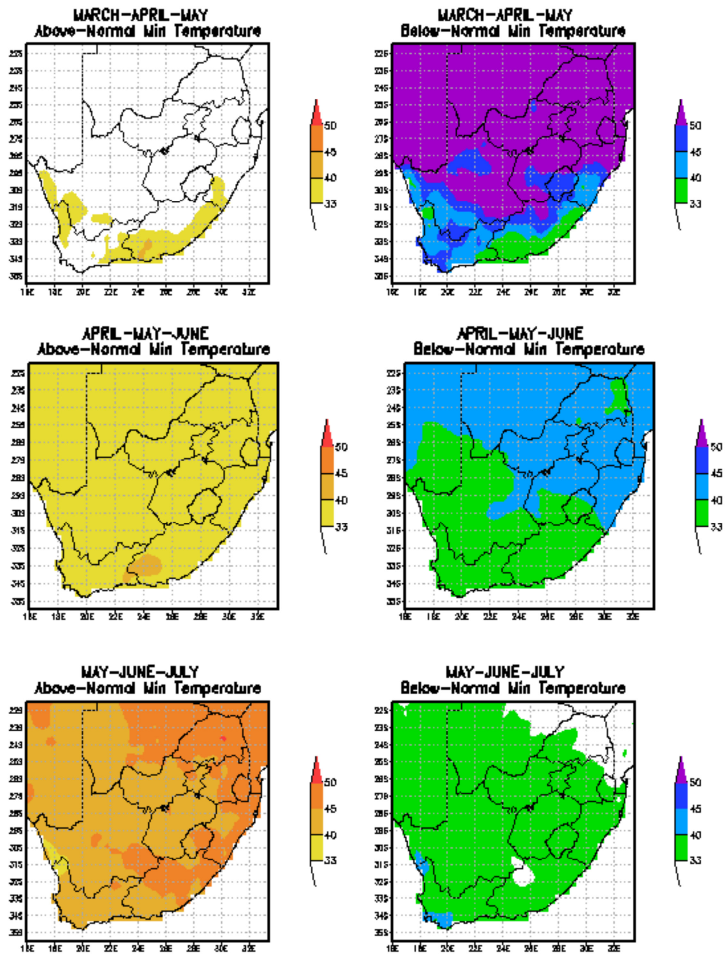


Figure 2- Maximum temperatures

Figure 3- Minimum temperatures



How to interpret the forecast maps:

- There are three sets of forecast maps: the rainfall, maximum and minimum temperatures.
- Each set consists of maps showing the probabilities for above-normal (left panels) and below normal (right panels) conditions to occur.
- For each forecast map a probability percentage is given on a scale of 0-50% and above (the colour bars on the right hand side of each map) for the rainfall or temperatures for the season, i.e. MARCH-APRIL-MAY 2011.
- The forecast probabilities indicate the ***direction*** of the forecast as well as the amount of ***confidence*** in the forecast.

For further clarification using MARCH-APRIL-MAY 2011 rainfall (**Figure 1**) as an example:

the Western Cape Province for the above normal category is shaded mainly in green over the winter rainfall areas **(33-40%)** with a patch of light blue **(40-45%)**, while for the below normal category it is shaded in yellow and light orange **(33-40%** and **40-45%).** The eastern half is shaded in light blue and dark blue **(40-45% and 45-50%)** for above normal and for below normal in yellow **33-40%.**

Comparing the two:-

winter rainfall areas - above normal: 33-40% , 40-45%, while
- below normal: 33-40% , 40-45%

eastern half - above normal: 40-45% , 45-50%, while
- below normal: 33-40%

Neither above normal nor below normal dominates the winter rainfall areas, whereas above normal dominates the eastern half. This means there is a higher probability that the eastern half will receive above normal rainfall. However when percentages are less than 45% the forecast is considered uncertain and is then unusable. When the forecast is unusable farmers are advised to plan in accordance with weather conditions usually associated with that particular period/ season in their areas.

Seasonal Forecast Overview for SOUTH AFRICA

1. <u>ENSO Discussion</u>

ENSO conditions have been shown to be the single most determining factor in South African summer rainfall which can also be effectively forecasted. Other local ocean basins such as those from the Atlantic and Indian oceans have also shown to have very strong influences to South African rainfall, but remain very difficult to forecast for various reasons. Because of this fact, we look at ENSO forecasts to give an indication of whether the seasons ahead would be abnormally wet (La Nina) or dry (El Nino). Below are some forecasts from international and local centers:

European Centre for Medium-Range Weather Forecasts (ECMWF) [http://193.63.95.1/products/forecasts/d/charts/seasonal/forecast/seasonal_range_forecast/nino_plumes_public_s3/]

Climate Prediction Center – National Centers for Environmental Prediction (CPC-NCEP)
[http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/lanina/images3/nino34SSTSea.gif]

International Research Institute Climate and Society (IRI)
[http://iri.columbia.edu/climate/ENSO/currentinfo/QuickLook.html]
Risk & Vulnerability Atlas (RAVA)
[http://rava.qsens.net/themes/climate_template/seasonal-forecasts/NINO34_FCAST.jpg/view]

ENSO is currently in the La Nina phase and is predicted to persist to at least the April-May-June (AMJ) 2011 season.

2. Rainfall Forecast (March to July 2011)

Enhanced Probabilities is considered to be more than 45% probability for a specific category. If there are areas that do not show an indication of more than 45% probability, then the forecasts for that area is considered to be uncertain.

March-April-May

Enhanced probabilities for above-normal rainfall totals are expected for parts of Western Cape. Enhanced probabilities for below-normal rainfall totals are expected for parts of Limpopo, Mpumalanga, Gauteng, Free State, North-West, KwaZulu-Natal, Northern Cape and Eastern Cape.

April-May-June

Enhanced probabilities for above-normal rainfall totals are expected for most parts of South Africa. Enhanced probabilities for below-normal rainfall totals are expected for parts of Northern Cape and Western Cape.

May-June-July

Enhanced probabilities for above-normal rainfall totals are expected for most parts of South Africa.

3. Minimum Temperature Forecast (March to July 2011)

Enhanced Probabilities is considered to be more than 45% probability for a specific category. If there are areas that do not show an indication of more than 45% probability, then the forecasts for that area is considered to be uncertain.

March-April-May

Enhanced probabilities for below-normal minimum temperatures expected for most parts of South Africa.

April-May-June

No Enhanced probabilities, uncertain forecast.

May-June-July

Enhanced probabilities for above-normal minimum temperatures expected for parts of Limpopo, North-West, Gauteng, Mpumalanga, Kwazulu-Natal, Northern Cape and Eastern Cape.

4. Maximum Temperature Forecast (March to July 2011)

Enhanced Probabilities is considered to be more than 45% probability for a specific category. If there are areas that do not show an indication of more than 45% probability, then the forecasts for that area is considered to be uncertain.

March-April-May

Enhanced probabilities for below-normal maximum temperatures expected for most parts of South Africa.

April-May-June

Enhanced probabilities of below-normal maximum temperatures expected for most parts of South Africa.

May-June-July

Enhanced probabilities of above-normal maximum temperatures expected for Limpopo, North-West, Gauteng, Mpumalanga, Free State, Kwazulu-Natal and Eastern Cape.

In summation, going into autumn the rain is expected to dry out over much of the country. The winter rainfall areas will neither be favored by above or below rainfall meaning farmers in these areas should plan their activities according to weather conditions usually associated with that particular period/ season. Both minimum and maximum temperatures are expected to be below normal countrywide over the said period. With the above forecast in mind, the following strategies are recommended:

VI. SUGGESTED STRATEGIES:

A. Rain-fed crop production

Crop management:

- Control weeds regularly.
- Consider organic fertilizers.
- Scout for pests and diseases regularly and control where necessary.

B. Irrigation farming

- Remove all weeds containing seeds, but keep other vegetative rests on the land because that will reduce evaporation.
- Check and repair all tools and machinery.
- Irrigate during cool conditions to avoid evapotranspiration.
- Avoid over irrigation because that can create problems e.g. water logging and diseases.
- **Adhere to the water restrictions when issued.**

C. Domestic and home garden water use

- Conserve existing water supplies.
- Eradicate water weeds.
- Limit water waste and losses.
- Repair leaking pipes.
- Re-use water and retain high quality.
- Harvest water during rainy days.

D. Stock farming (very important)

- Provide lots of drinking points.
- Provide phosphorous licks freely
- If grazing is in danger, herd animals into pens where different animals can be segregated and fed separately.

- Herd management should be aimed at maximising animal condition during the growing season as it affects the degree at which animals lose/gain weight and condition during the dry periods.
- Decide in advance when to switch the animals to different levels of feeding.
- Sell mature livestock as soon as they reach marketable condition.
- Treat the rangeland as a valuable asset.
- Build fodder reserves in years of good rainfall.
- Always practice rotational grazing.
- Retain nucleus of best cows aged 4 to 6 years.
- Diseases- Local veterinary services.
- Always consider relevant vaccinations and control outbreak of diseases.

E. Grazing (very important)

- Subdivide your grazing area into camps of homogeneous units (in terms of species composition, slope, aspect, rainfall, temperature, soil and other factors) to minimise area selective grazing as well as to provide for the application of animal management and veld management practises such as resting and burning.
- Determine the carrying capacity of different plant associations.
- Calculate the stocking rate of each, and then decide the best ratios of large and small animals, and of grazers or browsers.
- Provide periodic full growing-season rests (in certain grazing areas) to allow veld vigour recovery in order to maintain veld productivity at a high level as well as to maintain the vigour of the preferred species.
- Do not overstock at any time to avoid overgrazing.
- Eradicate invader plants.
- Periodically reassess the grazing and feed available for the next few months, and start planning in advance.
- Spread water points evenly.

- Provide suitable licks to make coarse, dry range grasses more palatable.

F. Veld fires (very important)

The provinces and farmers are advised to ensure that the firebreaks are in place especially in the winter rainfall areas. An owner of the land who is obliged to prepare and maintain a firebreak must ensure that, with due regard to the weather, climate, terrain and vegetation of the area, the following is taken care of in terms of installing the firebreaks
(Chapter 4 of National Veld and Forest Fire Act No. 101 of 1998):

- It has to be wide enough and long enough to have a reasonable chance of preventing a veld fire from spreading to or from neighbouring land.
- It does not cause soil erosion and
- It is reasonably free of inflammable material capable of carrying a veld fire across it.
- Firebreaks may be temporary or permanent.
- Firebreaks should consist of fire-resistant vegetation, inflammable materials, bare ground or a combination of these.
- Firebreaks must be located to minimize risk to the resources being protected.
- Erosion control measures must be installed at the fire break.

Firebreaks can be made through the following methods:

- Mineral earth fire break:
    - Through ploughing, grading, other earth movement.
    - Erosion very possible.
- Use of herbicides
- Use animals to overgraze specifically to minimise fuel.
- Strategic placement of burned areas
    - Not to be done on days with fire hazard (windy/dry/hot).
- Plant fire resistant plants

- Plant species selected for vegetated firebreaks must be non-invasive and capable of retarding the spread of fire.

What to do when conditions favorable for veldfires are forecast:

- Prohibitions of fires in the open air during periods of high fire hazard, and the establishment of fire control committees.
- To control fires, an alarm system, fire fighting teams, and beaters must be organized in advance and plans prepared.

What to do during veldfires:

- Livestock should be moved out of grazing land to safe land.
- Water is generally not available in sufficient quantities or at adequate pressure

for the control of major fires; however, sand or other loose mineral soil material can be an effective method of control.

G. Floods (Very important)

Various methods are used to minimise the impacts of floods and among others consider the following:

Proper drainage system – Shallow drains due to silts must be cleaned constantly. Clean drains ensure proper water irrigation.

- Relocate/Move animals and movable assets to a safe place when heavy falls are forecasted.
- Farmers are encouraged not to practice farming activities along the flood plains.
- Be extra cautious for pest and diseases after rain has fallen, as high moisture content may trigger these.

- Assume that floodwater contains sewage and might be harmful for human and livestock consumption.
- Before leading livestock across a river, check whether the water level is rising. This is especially necessary if it is already raining, but remembers that there could be a storm further upstream and floodwaters could be on the way.

H. Heat stress – bad for productivity (Very important)

Livestock

- Signs of heat stress: Bunching in shade, high respiratory rates open mouth breathing
- Risk factors: Health problems, confinement, weight, dark hide
- What to do:
  - Offer shade
  - Offer water – keep good quality water in front of animals
  - Sprinklers
  - Wet with sprinklers/fire hose etc.
  - Water ground
  - Avoid overworking animals

Crops

- Cover or mulch to conserve soil moisture.
- Irrigate early morning or during afternoon.
- Increase water intake by: roughening surface, minimise evaporation (covering surface – organic material.

Flooding decreased during February and it is anticipated that the rainfall will decline further into autumn. In spite of these expected conditions measures for isolated heavy falls i.e. proper drainage systems, relocation of livestock and movable assets to a safe place should be maintained. Precautionary measures should also include those for severe storms accompanied by strong damaging winds and hail. Contingency plans for outbreaks of pests and diseases associated with wet conditions should be maintained. Warnings have been issued frequently for conditions conducive for veldfires over the winter rainfall areas. These conditions will continue until significant rainfalls. With this in mind, contingency measures in line with the National Veld and Forest Fire Act No. 101 of 1998 should be in place and maintained. Water should continually be conserved in accordance with the Conservation of Agricultural Resources Act (No. 43 of 1983) although excessive rainfall has fallen over some of the summer rainfall areas.

The users are urged to continuously monitor, evaluate, report and attend to current Disaster Risk issues. It is mandatory for farming communities to always implement disaster risk measures and maintain good farming practices.

The climate advisory should be disseminated widely. Users are advised to be on the look-out and act on the extreme daily warnings as well as the advisory update next month. Information sharing groups are encouraged especially among farming communities for sustainable development.

The Disaster Management Act (Act No. 57 of 2002) urges Provinces, individuals and farmers, to assess and prevent or reduce the risk of disasters using early warning information.

The current advisory can be accessed from the following websites: www.daff.gov.za and www.agis.agric.za.

For more information contact: -

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