SEASONAL CLIMATE FORECASTS – POTENTIAL AGRICULTURAL-RISK MANAGEMENT TOOLS?

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Abstract. The importance of anchoring seasonal climate forecasts to user needs is examined in this paper. Although it is generally accepted that seasonal climate forecasts have potential value, many constraints preclude the optimal use of these forecasts, including the way forecasts are produced, interpreted and applied in a variety of decision-making processes. In South Africa, a variety of agricultural users exists, ranging from the small-scale farmer to larger commercial farming entities. Useful seasonal are those produced and disseminated with the end user in mind. A retroactive test period during the 1990s, evaluates the perceived impact of incorporating seasonal rainfall forecasts into decisions made by commercial crop farmers in the central parts of South Africa. Although a small sample of commercial farmers was interviewed, the results show some benefits to commercial agriculture if seasonal climate forecast information is continuously and effectively applied over the long-term.

1. Introduction

Much has been said about the impact of adverse weather events or longer-scale climate change scenarios on humans and the environment (e.g. IPCC, 2001). One of the ways to adapt and mitigate the vagaries of climate is through the application of seasonal climate forecasts. A number of studies have recently tried to determine the value of forecasts in a variety of settings (e.g.: Hulme et al., 1992; Hammer et al., 1995; Mjelde et al., 1997; Hansen, 2002) for a number of users. Weather and climate forecasts, for some, usually have convenience value and changes in weather usually only mean adjustments in daily activities. For others, particularly farmers, seasonal climate forecasts may have more profound impacts.

The Intergovernmental Panel on Climate Change (IPCC), for example, reported on the direct consequences of global climate change on crop yield, and thus food security (IPCC Report, 2001) in several areas of the world, including parts of Africa. In Africa, for example, grain yields are projected to decrease for many climate-change scenarios. Owing to low regional adaptive capacity, vulnerability may increase. There has been a renewed focus on climate impacts, vulnerability and adaptation in current climate impacts, response and vulnerability assessments (e.g. IPCC WG II, Fourth Assessment process).

Seasonal climate forecasts are a potential tool that can assist individuals and organizations in coping and adapting to variable climate conditions. Allied to

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discussions of adaptive capacity, building adaptive capacity and improving adaptation, is the role of communicating climate information (for example seasonal forecasts) to a variety of users and of finding effective ways of communicating information that may be useful in managing climate risks (Moser and Dilling, 2004).

Seasonal forecasts are an estimation of probabilities of key variables in future seasons. These variables could be a dynamical model's own rainfall and temperature forecasts, or large-scale patterns that can be either dynamically or statistically downscaled to temperature and rainfall over a specific area. Either way, in addition to the skilful description of seasonal climate probabilities that are focused on small geographical regions, seasonal forecasts must, in order to be of value, quantify the probability of each possible outcome throughout the full range of possibilities, from extremely wet to extremely dry seasons.

Forecast information can only have value, moreover, if the user can use the information, together with a range of other tools and methods to enhance decision-making and improve overall risk management. Forecasts, however, are not issued in a 'neutral landscape'. Many non-weather factors, such as market tendencies, available capital, agricultural policies, among others, may preclude the uptake of forecasts (see for example Eakin, 2000; Vogel, 2000; Roncoli et al., 2001; Lemos et al., 2002; Archer, 2003; Ziervogel and Calder, 2003). Furthermore, some users are in a better position than others to capitalize on the information provided through seasonal climate forecasts. Rural women who are smallholder farmers, for example, are often precluded from gaining easy access to agricultural information including seasonal climate forecasts (e.g. Archer, 2003).

The value of seasonal forecasts to a particular enterprise, in the decision-making process, is the expected increase in economic benefits arising from the use of these forecasts. For various potential users of longer-term forecasts, social, environmental and economic influences also govern the sensitivity and vulnerability to climate events and this will determine the type of information needed to respond. The South African Weather Service (SAWS), for example, strives to improve seasonal forecasting in South Africa by developing and improving the modelling capabilities (Landman and Mason, 1999; Landman and Tennant, 2000; Landman et al., 2001; Landman and Goddard, 2002) and dissemination channels (Klopper, 1999). These efforts reflect growing international and regional concern on the use and dissemination of seasonal climate forecasts (e.g. Pfaff et al., 1999; Eakin, 2000; Finan and Nelson, 2001; Roncoli et al., 2001; Lemos et al., 2002; O'Brien and Vogel, 2003; Ziervogel and Calder, 2003).

Potential applications of seasonal forecasts are extensive, with the greatest value attributed in the planning stages of operations. Despite the wide group of potential end users, evidence of the use of seasonal climate information shows that only a relatively small fraction of the total number of individual users usually benefit. Forecasts are often ill-suited for direct application in decision-making due to a lack of experience in using this information by end users, poor and inaccessible presentation and communication of forecasts and several factors (such as access to credit, land and other agricultural inputs particularly in Africa) that further precludes the effective uptake and use of forecasts (O'Brien and Vogel, 2003). There is also a range of cognitive illusions caused by the way forecasts are presented, such as the reference to previous major events that may influence decisions (Changnon et al., 1995; Pulwarty and Redmond, 1997; Nicholls, 1999).

The commercial farmer usually uses weather forecasts in day-to-day planning and execution of farming operations. On a seasonal time-scale, climate information is applied in the long-term planning process (Kininmonth, 1994; Klopper, 1999), for example, influencing decisions on to what to produce, when to plant, fertilizer applications, livestock management and labour requirements. In a farming environment, reliable seasonal forecasts could be very valuable in forward planning, and in investment decisions on farm buildings, field machinery, and crop drying and irrigation equipment. Other important management decisions relate to the amount and timing of applications of input variables such as crop variety, fertilization rate, cultivar type, seeding rate, applied nitrogen rate and planting date (O'Brien and Vogel, 2003). Decision-support systems include expected pasture growth, animal live-weight gains and optimal stocking rates, grain production, optimal fertiliser applications and projected yields, frost prevention measures, and pest and disease management (Sonka et al., 1987). The methods by which agriculturalists cope with climate variability can be classified according to whether these strategies affect production or consumption activities (Anaman et al., 1994; Stern and Easterling, 1999). Actions can also be classified in terms of the timing thereof, i.e. actions taken in anticipation of a particular climate event or activities that take place after the event occurred. To have economic value, climate information has to be understood and used to support a decision-making process.

In this paper, we examine the end-to-end process of seasonal climate forecasts in South Africa. The use of forecasts is examined, and the potential value of forecasts to a sample of large-scale, commercial crop farmers in South Africa is assessed. The perceptions and value of the forecasts, current constrains to forecast use and steps and processes required for the production, use and uptake of forecasts as risk-management tools, is assessed. A retroactive test period during the 1990s is used to evaluate the perceived impact of incorporating seasonal rainfall forecasts into decisions used by commercial crop farmers in the central parts of South Africa.

On a national scale, the agricultural sector is the largest single group of users of weather and climate forecast information (GCOS-9, 1994; O'Loughlin, 1998, Klopper, 1999; Klopper and Bartman, 2003). This sector has undergone various changes including those linked to macro-economic changes and impacts coupled to climate stresses (e.g. Vink and Kirsten, 2003). Only some 14% of the 100.6 million hectares of agricultural land receives enough rainfall for arable farming. An estimated 1.35 million hectares of the arable land available is irrigated and yields at least a third of total agricultural output (e.g. Vink and Kirsten, 2003;

Directorate Agricultural Statistics, 2002). More than 95% of the marketed output is produced by approximately 60 000 commercial farmers who occupy about 87% of the total agricultural land. Smallholders and emerging farmers occupy land in former homeland areas (an estimated 13% of agricultural land) (e.g. Vink and Kirsten, 2003).

One of the most important factors limiting agricultural production in the country is the availability of water. Almost 50% of South Africa's water is used for agricultural purposes (National Department of Agriculture, 1997). Rainfall is highly seasonal (Keen and Tyson, 1973; Tyson, 1986) and distributed unevenly across the country, with humid, subtropical conditions occurring in the east and dry, desert-like conditions occurring in the west (Figure 1). Rainfall also varies temporally, with more than 80% of the annual rainfall of southern Africa occurring between October and March (Taljaard, 1986; Tyson, 1986). The exceptions are the south-western Cape, where more than 80% of the annual rainfall usually occurs during winter, the southern coastal regions and the adjacent interior where rainfall occurs throughout the year (Tyson and Preston-Whyte, 2000).

A number of causes of rainfall variability have been identified (Tyson and Preston-Whyte, 2000). On a seasonal timescale, the El Niño/Southern Oscillation

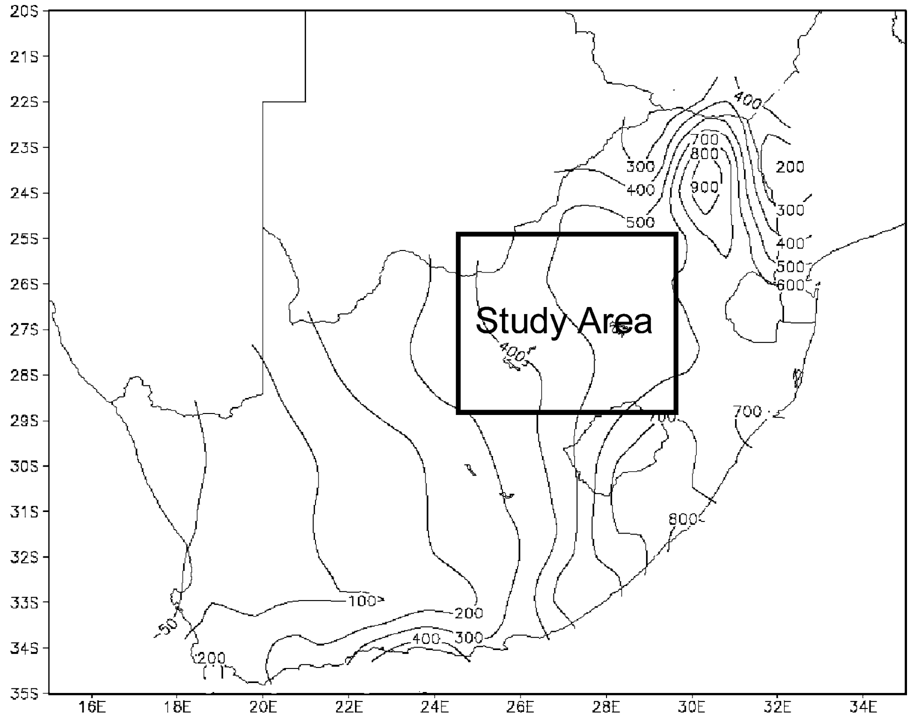

Figure 1. Total rainfall distribution (mm) over South Africa during the main rainfall months (October to March). Study area also indicated.

(ENSO) phenomenon (Zhang et al., 1997; Philander, 1990; 1999) contributes to about 30% of the rainfall variability in South Africa. The country tends to experience dry conditions during El Niño events, and normal to wet conditions during La Niña events (Lindesay, 1988; Van Heerden et al., 1988; Schulze, 1989; Main and Hewitson, 1995; Kruger, 1999). Even if the occurrence of an El Niño or La Niña event could be predicted with absolute certainty, it remains uncertain what the exact rainfall and temperature profiles of specific sites would be. The reasons for this uncertainty are that El Niño and La Niña events are not the only influence on southern Africa's seasonal climate variability (Landman and Mason, 1999; Mulenga et al., 2003; Reason and Mulenga, 1999; Reason, 2001; 2002; Rouault et al., 2003). Moreover, previous El Niño events cannot be used as a consistent future guide to likely outcomes as recent events have produced different features and outcomes (e.g. normal rainfall as opposed to drought, notably the 1997/98 event) to the 'historical norm' of such events (Landman et al., 2001).

Several questions remain then, including – how useful are seasonal climate forecasts, and how can their potential value be increased? There are no easy or direct answers. First it should be acknowledged that a vast variety of different users exist, each with their own needs and requirements (e.g. Niewoudt and Groenewald, 2003). Furthermore, many potential users of seasonal forecasts are currently unaware of the existence of these products. The forecasts are also usually difficult to interpret and therefore their potential as a risk-management tool is not being realised.

2. Evaluating the Uptake of Seasonal Forecasts by Commercial Farmers in SA

The scientific capability to measure and model the effects of seasonal climate forecasts is in its infancy, although the challenges of valuing climate forecasts are numerous (Stern and Easterling, 1999). The value of forecasts, however, cannot be measured directly. Measures of the additional value of forecasts can be derived based on assumptions for estimating what the outcomes might have been in real-life situations. Furthermore, the modelling task is complicated by the probabilistic nature of seasonal forecasts. Lack of quality data is also a major obstacle in valuing climate forecasts, and the benefits of climate forecasts take many forms (Pfaff et al., 1999). Many decisions involving the use of meteorological information consist of sequences of decisions that need to be made over time. The action to be taken at any point, and the real and perceived value of information used in choosing this action, might depend on previous and possible future actions and events. Notwithstanding these difficulties in assessing seasonal climate forecast value, attempts to establish their use and their improved value, is essential if those involved in the climate change enterprise are serious about improved adaptation to climate risk.

The value of climate forecasts depends partly on the relevance of the information to users' decision-making environments and the accessibility of the information to users. Various methods evaluate forecasts, including *ex ante* (change that has yet to occur) and *ex post* (change that has already occurred) assessments (e.g. Thomton, 2005). The case-study method (e.g. Yin, 1992), as a tool for evaluating situations in real-life contexts, has been employed here to test the hypothesis that seasonal forecasts are useful and have value when applied by commercial farmers, albeit their perceived usefulness and value. In an attempt to understand and assess the perceived value of forecasts, individual commercial farmers were presented with retroactive seasonal forecasts (i.e. forecasts made as if in an operational environment) produced for the summer rainfall seasons of South Africa during the period 1991/92 to 1999/2000.

Farmers were identified using the SAWS seasonal-forecast mailing list. Farmers were selected from just one forecast region, namely the north-eastern interior of South Africa (24.9 to 28.9°S; 24.7 to 29.3°E) (Figure 1). This specific region includes the main maize production areas of South Africa. Each individual had to be involved in commercial farming activities for some time because the questionnaire covers the period from 1991 to 2000. The mid-summer rainfall season (December, January, February, DJF) was an important period in the respondent's agricultural year since the questionnaire tests the use of seasonal forecasts during this season.

The interview questionnaire consisted of five sections:

(i) The first section identified the agricultural profile of the respondent. The respondents provided background information on their specific farming situation including, farm location, length of farm operations – how long the farmer has been involved in farming activities, the size of the farm, etc.

Each of the seven respondents satisfied the basic criteria described earlier. Four of the respondents are members of study-groups in the region and thus were not only reflecting on their personal experience but were drawing on years of collective farming experience in their study group.

(ii) Farm decision-making procedures included descriptions decision-making processes at the beginning of the rainfall season. Specific emphasis is placed on the different factors that influence the decisions, and their corresponding importance.

To deliver a relevant service, it is important to know the critical times for farming activities (for example planting). These are usually also the times when farmers make the most important economic decisions. The critical time for decisions of farmers that cultivate summer crops are during the months just before the rainy season (in this case August, September). At this stage a farmer needs to decide what to plant, when to plant and how much. Different factors could influence the decisions made by farmers at the beginning of the rainy season. The factors influencing decisions as well as those factors that could limit the execution of these decisions are listed in Table I. All respondents indicated that the 'expected' seasonal rainfall forecast is an important factor. In addition, the onset and the timing of the

TABLE I
Factors that influences the decisions taken by commercial crop farmers

Respondent	Factors influencing decisions	Factors limiting execution
1	Seasonal rainfall forecast Market prices (SAFFEX) Available capital	Available capital Availability of land to rent Availability of workers Status of machinery (are they new, old, need to be replaced, serviced etc.)
2	Seasonal rainfall forecast Financial position Forage needs	Onset of rainy season
3	Seasonal rainfall forecast Market prices Water quota	Market prices
4	Seasonal rainfall forecast Start of rainy season Area prepared during winter Market prices and tendencies	Available soil moisture
5	Market prices Financial position Seasonal rainfall forecast Quality and cost of labour	Risk of drought Status of machinery Fuel prices Available capital
6	Seasonal rainfall forecast Market prices	Financial position
7	Seasonal rainfall forecast Available moisture Market prices	Labour risk

rainy season are critical for farming operations. Other important factors include market prices, tendencies and the farmer's own financial position. Factors that hamper the execution of decisions include labour issues such as the availability and cost of labour. In general, the cost of maintaining and upgrading machinery also compounded farmers' decisions during certain seasons.

Perceptions of climate variability are also key factors in framing possible forecast use. Respondents, for example, defined "normal rainfall" and a "drought" in particular ways. From the responses listed in Table II, it is clear that 'perceived' drought conditions are different for the cases given. Of interest for producers of forecasts was the general perception that 'less than normal rainfall' did not necessarily imply drought. This result is informative, because users usually equate less than normal rainfall as a dry spell. Timing of rainfall also emerges as being very important. Farmers were very clear about their temporal recollection of drought frequency. On average, droughts are experienced one out of five years, with flood conditions an infrequent occurrence. Of relevance to this research, is that it would

TABLE II

Respondent's perspective of normal rainfall, drought and frequency of drought and flood conditions experienced

Respondent	Normal annual rainfall (mm)	Definition of drought	Frequency of drought disasters	Frequency of floods
1	600–650	Little rain during January/February with annual total less than 500 mm	1 in 10 years	1 in 10 years
2	550–600	Little rain during January/February with bad timing during rest of the season	1 in 4 years	seldom (land is well contoured)
3	600	Low rainfall during two consecutive seasons that will result in low dam levels and possible water restrictions	1 in 10 years	never (high altitude)
4	450	Little rain during January/February with high temperatures	2 in 10 years	no
5	550	Bad distribution throughout season	2 in 10 years	no
6	500	40 dry days in mid summer with high temperatures	2 in 10 years	no
7	750	Little rain during January/February	1 in 10 years	no (well contoured)

seem that farmers are aware of national and local efforts to mitigate floods, but seem to be unaware of similar measures to manage and mitigate drought impacts. Rather drought mitigation is viewed as being taken in an isolated *ad hoc* manner that is response-driven and reactive.

(iii) To establish whether more information would have been of benefit, the respondents described their real 'experienced situation' during each season of the 1990s. Here farmers indicated when and why they made a decision and the positive or negative impact such decisions had on their farming enterprise.

A backdrop of 'real-life' situations, during summer rainfall seasons for the 1990s, included a suite of decisions with respect to seasonal forecasts. Respondents identified a "normal" yield (in tons per hectare). Their results varied from area to area because of the many local influences that affect the potential yield.

According to the normal yield figures, respondents rated the success during each planting season from 1991/92 to 1999/2000 (Figure 2). On the graphs, the Y-axis depicts the success level, with one being an extremely bad season and five an exceptionally good season. During 1991/92 and 1994/95 El Niño seasons most farmers had below-normal yields. It is interesting to note that the 1997/98 El Niño resulted in a normal to slightly above-normal yield. This very strong event was not associated with countrywide drought conditions normally associated with El Niño events (Joubert et al., 1998). A very good rainfall season was the 1999/2000 season (La Niña) with all respondents reporting a normal to above-normal yield.

The role, use and benefits of seasonal climate forecasts for nine test seasons examined. Three of these seasons were associated with El Niño events (1991/92, 1994/95 and 1997/98), three with La Niña events (1995/96, 1998/99 and 1999/2000) and three with neutral conditions (1992/93, 1993/94 and 1996/97). Each map indicated the categorized (three equi-probable categories namely above-normal, near-normal and below-normal) forecast (in this case the category with the highest forecast probability assigned to it) for nine homogeneous rainfall regions and also the probabilistic forecast for the target region. Respondents had to indicate the impacts, either positive or negative, of reacting to the forecasts.

The decision-making logic was also tracked including, for example, how would a decision differ from a wet year to a dry year to a normal year? Respondents applied these decision- strategies to the retroactive seasons 1991/92 to 1999/2000. Respondents then indicated if they would have had a more successful season given the observed scenario. In other words, if the forecast was available, and the farmers reacted on the specific forecast according to their decision strategies during a season, what would have been the outcomes of such decisions?

The seven graphs in Figure 3 depict the potential situation of each respondent with the value indicating a negative situation being the case with the added use of a forecast for the two situations and the third, a better situation using a forecast. It is clear that the respondents think they would have benefited from having seasonal forecast information on a continuous basis. In 33.3% of the individual years, users indicated that they would have had improved success if they had used the information. In less than 5% of the individual years, respondents indicated that they would have been negatively impacted (first value).

The perceived value of seasonal forecasts and improved forecast skill are positive indications of the potential future use and beneficial application of forecasts (e.g. Hammer et al., 1995). Of interest is the finding that the user group made no distinction between rainfall forecasts made during ENSO and non-ENSO years. This is despite the fact that forecast skill during ENSO years is generally higher than during neutral years (e.g. Landman and Goddard, 2002). Users of forecast information, aware of potentially better rainfall predictability during possible El Niño and La Niña seasons, should have a higher perceived value of such forecasts. When evaluating the number of seasons where forecasts are of value (Figure 3) the results do not reflect higher users' confidence during ENSO years. This may be

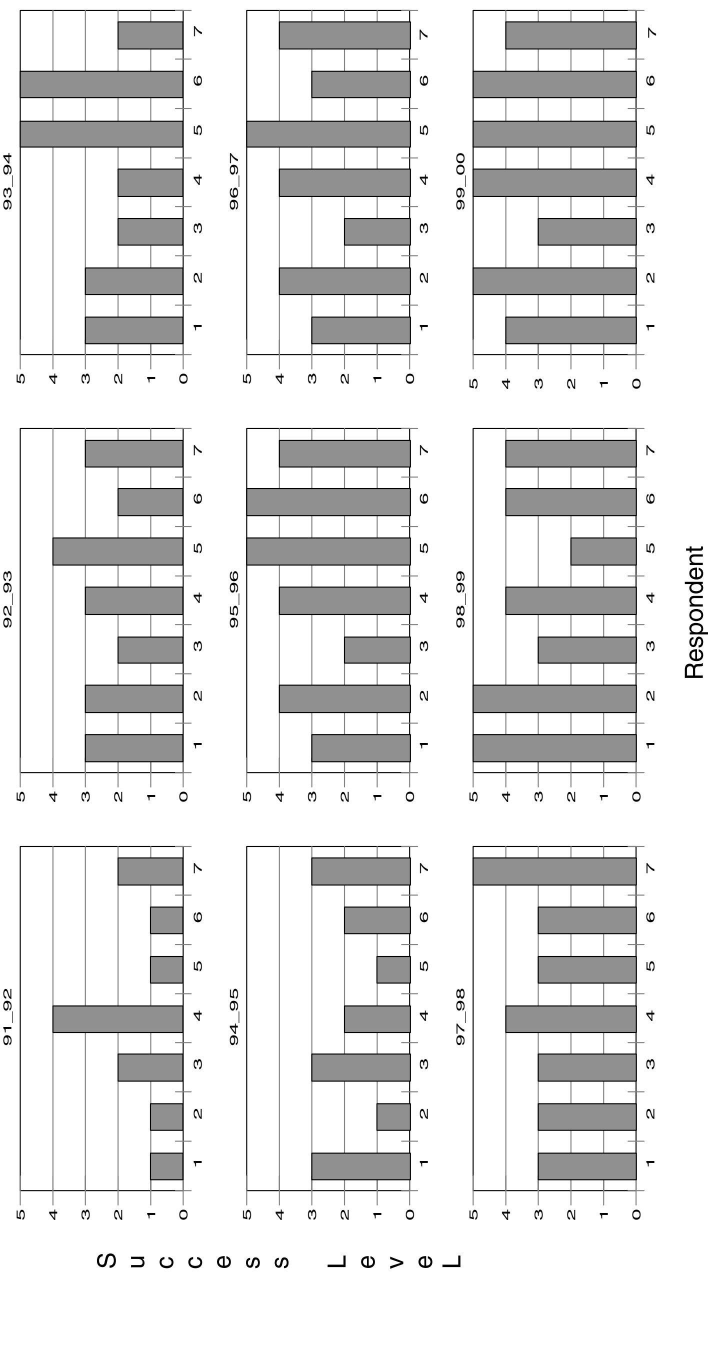

Figure 2. The actual experienced situation during the seasons 1991/92 to 1999/2000. The seven responses are indicated on the *X*-axis and the success level on the *Y*-Axis. 1: Extremely bad; 2: Less than normal; 3: Normal; 4: Better than normal; 5: Very good.

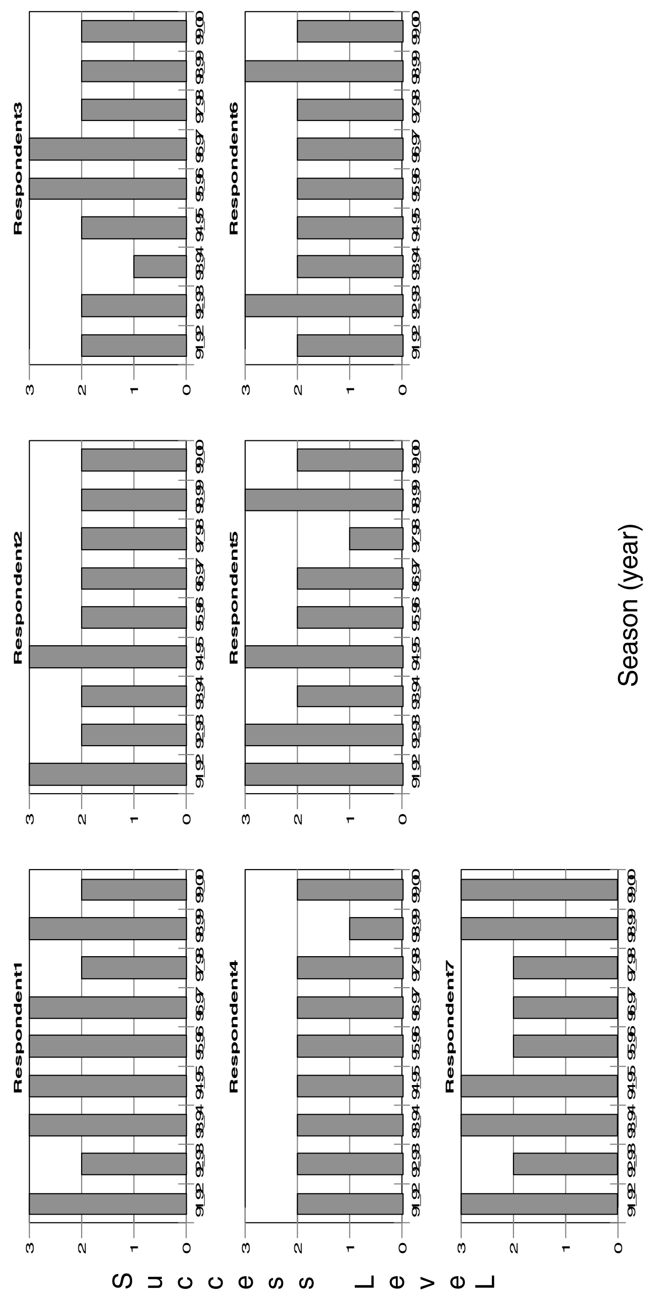

Figure 3. Potential situation of each respondent. The seasons are indicated on the X-axis and the potential success on the Y-axis. 1: Worse; 2: The same; 3: Better.

attributed to the poor 'mainstreaming' and effective communication of the greater potential value and skill of forecasts during ENSO periods, and the 1997/98 ENSO event that was not a 'typical' ENSO for the country.

(iv) Lastly, responses included personal perceptions about seasonal-forecast information and the potential value, if forecasts are included in their decision-making process.

Every user in the group indicated that they perceived forecasts to be of some use. They regard this information as needed and potentially useful in their planning process. Climate information to supplement the forecasts, as a way of enhancing their value, is essential. Climate-related information that could improve the decision-making process of these farmers included information on winds and soil moisture. Early warnings of strong winds could enable farmers to protect plants from "sand blasting" of smaller plants and destruction of larger plants. Information on the frequency of hail and frost events also emerged as important. Although potential in predicting the intra-seasonal characteristics (e.g. extreme events such as cold snaps, dry spell duration, etc.) has been suggested (Tennant and Hewitson, 2002), predicting the likelihood of these sub-seasonal characteristics is not yet operational in the region. Inputs from end users such as those portrayed here could, however, improve the final products if they are implemented and tested in the region.

Finally, the misinterpretations of forecasts and the low importance given to climate information are additional constraints on the use of seasonal climate predictions. Many traditional beliefs and theories about local weather and climate influence the way the scientific information is perceived and interpreted. To build confidence in forecasts and to reduce and better manage climate risks, scientists should provide user-targeted evaluations of forecasts in a meaningful way to potential users (Hartman, et al., 2002).

3. Discussion

The use of seasonal climate forecasts by commercial farmers in South Africa during the late 1990 summer rainfall seasons was evaluated. The main aim of the study was to examine the perceived value of seasonal forecasts amongst a target, commercial-farmer group. The study involved telephone interviews with a small sample of farmers, with some representing and reflecting on their collective farming experience with other farmers in their immediate area. Certain criteria were prescribed in selecting appropriate respondents.

Several factors should be considered by those who produce seasonal forecasts so as to enhance the overall uptake, use and value of forecasts in the country. Respondents have certain interpretations and perceptions of climate features (Letson et al., 2001). They, for example, generally consider "normal rainfall" to be the 'climatological average' at their respective farms. Their definition of drought and normal rainfall is therefore different from the definition of 'below-normal rainfall' and 'near-normal rainfall' used in the forecasts presented to them. This discrepancy in the understanding of what normal rainfall is should be borne in mind by forecast producers to guard against presentation of information that can be misinterpreted by users. Information can be used naively (or deliberately) and can even be used politically to frame interventions in a region that has experience heightened food insecurity (Vislocky et al., 1995; Nicholls, 1999). Lemos et al. (2002) illustrate how forecasts in Brazil were subject to distortions, misinterpretation and for political manipulation. The effectiveness of forecast information strongly depends on the clear understanding of the context and 'environment' in which forecasts are being applied, and how the information is being produced, presented and distributed (Stern and Easterling, 1999). Inappropriate content (for example, categorical forecasts not well explained or understood) or other external constraints (for example, the inability of users to change decisions) may contribute to confusion by users.

An additional concern that should be considered by forecast producers is that of the timing and temporal perception of when rainfall occurs. The DJF-season was used in the analyses owing to the high rainfall totals normally received over a large part of the maize growing areas during this period. From the data collected from the respondents, the critical period for drought is perceived to be January and February, which corresponds to the period of grain-filling of their crops. This suggests that the more important stages of production are those stages observed during the second half of the rainy season. Early season forecasts for the second half of the rainy season (i.e.: at long lead-times), are therefore potentially more valuable. Modellers may as a result concentrate their modelling efforts on improving forecast skill over the second, as opposed to the first half of the summer rainfall season. Information on when to start to plant, however, is also critical. Medium – (up to 10 days description of weather parameters) and extended-range (beyond 10 days and up to 30 days description of average weather parameters) forecast can be utilized to partially address this need. We therefore suggest that long-range climate forecasts should be accompanied by shorter-range forecast updates since the most significant economic benefits are derived from application of shorter- range forecasts (Lyakov, 1994).

Retroactive probabilistic rainfall forecasts for each individual summer season for the period 1991/92 to 1999/2000 were distributed to the respondents. The respondents then indicated in which years they could have benefited from applying this information. The results demonstrate that users, specifically commercial farmers, should be able to benefit from applying seasonal rainfall forecast information on a continuous basis. The results also show that despite known impacts on crop yields during El Niño seasons and positive crop yields during La Niña years, users did not indicate higher perceived value during ENSO years – years that are generally associated with higher rainfall forecast skill.

From this work, it would seem that users are not always aware of the potential use and value of seasonal forecasts. Forecasts, uncertain as they are, can help with planning if the decision-makers know the reliability and credibility of the product. It is thus the responsibility of the producers to enable potential end-users to derive value from such information. An educational programme, including workshops and information sessions, may reveal the existence and potential use of these products to various end-users. Such workshops, however, can also educate forecast producers about the needs and environments in which users operate. Innovative forecast-design strategies, the institutional arrangements and 'boundary organisations' to improve the value of the product also require further local attention (e.g. Cash, 2001). Thus, the effective use of information requires rigorous research efforts to determine how to frame forecasts within the specific needs of decision-makers.

Although seasonal forecasts are expected to be used more frequently in the future, the cost of taking precautions (based on the forecast) must be weighed against the savings that the precautions would bring if the unwanted climate event occurred. Users of seasonal forecasts could, for example, be more actively engaged in economic evaluation assessments (Richardson, 2000) to get an idea of the potential rewards and penalties accrued in unfavorable weather situations.

Seasonal forecasts are part of a larger, interdisciplinary system requiring collaboration between various different disciplines. Training and research efforts should be improved to maximize the use of these products and should include the insights of various practitioners who may make use of such products. Training of a group of 'intermediaries' or 'brokers' of such information could also be considered, particularly those that have training and expertise in a variety of disciplines e.g. sociology, economics, political studies, history, communication skills, etc.

The agricultural sector in South Africa has undergone marked changes in recent years in policy and farmer-support (e.g. Vink and Kirsten, 2003). Land-reform policy, deregulation of agricultural marketing boards and the reduction in subsidies to farmers over time have meant that several farmers have either had to find alternative agricultural activities. Diversification has included – farming alternative crops (e.g. asparagus from maize); switching into cattle farming from maize farming and considering other ways to manage their agricultural risks (e.g. private companies, futures trading etc) (Schrimer, 2000). Not all these alternative options are open to all farmers and "…there are many farmers who are unable to access such arrangements, and in their opinion, they face a political environment in which the government appears either as unhelpful or as threatening' (Schirmer, 2000, 149). The use and uptake of forecasts therefore needs to be viewed within the broader perspective of what is 'do-able' given the current agricultural environment. Small-scale or smallholder farmers, as with the some commercial farmers, have repeatedly indicated their frustrations in being unable to effectively use a seasonal forecast in their farming decisions because of complex land use arrangements, lack of financial resources nested in the wider agricultural policy environment that ultimately impacts on agricultural production (e.g. Eakin 2000; Vogel, 2000; Archer, 2003; Ziervogel and Calder, 2003).

Many factors including market tendencies, socio-economic and wider political issues, availability of funds, labour, and other resources, are all important inputs to the decision-making process of an end-user. Moreover, in addition to the above, factors such as users' unfamiliarity with the impact of climate affects on their business (Hulme et al., 1992), or incomplete knowledge on the interpretation of forecasts made at different timescales exist (Letson, et al., 2001) further frustrating forecast uptake.

4. Conclusions

Greater interaction between users and producers of forecasts can potentially improve the uptake, use and added value of seasonal climate forecasts. Liaison between users and producers of seasonal forecast products, improved institutional arrangements and the training of a group of 'intermediaries' that move between producers and users of forecasts, are fundamental to improving the value of seasonal forecasts. Several factors emerged in this preliminary interaction with commercial farmers in the country that point to areas requiring further investigation. Firstly, better identification of the key variable(s) to incorporate in the forecast (e.g.: seasonal rainfall totals, mean temperature) has been shown to be important. These must be derived in consultation with users. Secondly, the time period during which the user is most likely to be subjected to variability in rainfall and temperature should be better understood (e.g. this case showed that the second half of the rainfall season was beneficial to commercial crop farmers). The tailoring of forecasts to various end users needs is thus clear.

Despite the range of difficulties, uncertainties and problems surrounding climate change science, this study has shown that there may be some value in carefully crafting a detailed strategy to better produce and disseminate seasonal climate forecasts. Several respondents, many linked to large-scale farming enterprises, regarded aspects of weather and climate to be important factors (Klopper, 1999) in their daily risk management practices. Coupled to this perceived need, the rising concern of possible changes in rainfall associated with longer-term global warming and constraints to adaptation for the southern African region point to the future development of reliable and credible forecasts to the benefit of a variety of end users.

The economic benefits from seasonal forecasting are being maximised through improved understanding, monitoring and predicting the global climate system by research into regional climate impacts, international cooperation, and the development of industrial sector applications and services. Seasonal forecast production and dissemination, including forecast skill, must be promoted. Likewise, perceptions of climate variability and climate change more broadly (e.g. perceived value of climate information, constraints precluding forecast use) are important challenges facing the SAWS and others interested in climate science and related issues. There is apparent support for such efforts. There is a need for similar assessments of the use of climate forecasts in other sectors, for example, water and possibly energy sectors. Finally the effective dissemination and use of the information, as well as increased interactions between users and producers of climate information is critical for enhanced adaptation to periods of climate stress and variability.

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