Climatic Change (2007) 83:287–300
DOI 10.1007/s10584-006-9192-5

Sustaining agricultural production and food security in Southern Africa: an improved role for climate prediction?

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Received: 12 May 2004 / Accepted: 6 September 2006 / Published online: 15 March 2007

Abstract Livelihoods and household food security in the Southern African region can be extremely vulnerable to the negative effects of climate stress as shown by the 2002–2004 'complex emergency.' Climate prediction may prove a valuable resource in mitigating these effects. If climate prediction is applied successfully, it may be able to help guide responses in populations at risk to reduce vulnerability to climate stress. The study presented here seeks to understand what would constitute an improved role for climate prediction in contributing to sustaining agricultural production and food security in Southern Africa. Investigation undertaken during the 2002/2003 rainy season under regional conditions of elevated disaster risk shows, however, that a number of weaknesses and gaps persistently characterize climate information systems in the Southern African region, and constrain such systems' ability to benefit key sectors, particularly agriculture. The stakeholder identification of such gaps forms the basis for distilling concrete recommendations to improve process and organizational efficiency. Such recommendations, while developmental, should better enable institutions and stakeholders involved in climate prediction to fulfill their potential in supporting development of successful adaptation strategies in populations and sectors at risk.

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1 Introduction

The Southern African region faces well-documented challenges in maintaining and improving food security in the face of multiple stresses. Climate stress in particular can compromise the ability of the region's agricultural sector to sustain production. Such a situation is particularly concerning in the light of projected increasing climate stress under future climate change due to, for example, increased frequency of extreme precipitation events (IPCC 2001). Specifically, the Intergovernmental Panel on Climate Change (IPCC) states that: "Warmer temperatures will lead to a more vigorous hydrological cycle: this translates into prospects for more severe droughts and/or floods in some places...several models indicate an increase in precipitation intensity, suggesting a possibility for more extreme rainfall events." (IPCC 2001, p. 4). The project 'Mitigating the Effects of Hydroclimatic Extremes in Southern Africa,' funded by the US Agency for International Development (USAID), focused on problems of climate information dissemination and interpretation in the region as a strategy to contribute to mitigating current (and future) climate risk. Essentially, the project attempted to answer the question "What would constitute an improved role for climate prediction in contributing to sustaining agricultural production and food security in Southern Africa?." This paper discusses project findings related to application of climate information in the agricultural sector, using a targeted multi-stakeholder analysis to identify gaps and to draw out recommendations.

Key gaps seen as a priority included the lack of information on intraseasonal distribution, insufficient translation in terms of language and terminology and a range of challenges around stakeholder and institutional capacity. Recommendations are made in the areas of forecast improvement (e.g. greater focus on forecasting intraseasonal distribution) and increased national and non-traditional investment in outreach and applications, amongst others.

It should be emphasized that while production is an important component of food security for the majority of the population in Southern Africa, it is not solely important. As stated below, we acknowledge that low agricultural production is merely one factor in food insecurity; and is usually coupled to, for example, problems around distribution. Food insecurity is clearly a function of both food availability and restricted access to food (Devereux and Maxwell 2001). We focus on one component of the food insecurity challenge-on applying climate information to help stabilize agricultural production and to contribute to early warning and early action in response to climate hazard events in the region.

2 Background

The 2002/2003 season in Southern Africa was typical of what some authors have described as 'complex emergencies' in the region. Such emergencies, also referred to as situations of 'adverse synergies' (Kasperson et al. 2006) comprise a mix of potential external stressors including climate, HIV/AIDS, civil insecurity and conflict, macroeconomic stressors (e.g. through domestic and regional food markets), leading to humanitarian agency intervention (Mano et al. 2003; Vogel and Smith 2002; Holloway 2003; Clay et al. 2003). In many ways, the situation in the 2002/2003 season in Southern Africa qualified as a complex emergency according to the above criteria.

For example, Devereux (2002) intensively examines the early 2002 food crisis in Malawi, showing competing causal explanations. The so-called 'technical' view attributed the crisis to substandard rainfall, insufficient information and import bottlenecks; while the 'political' view variously attributes blame to key political actors such as the IMF, traders and government officials (Devereux 2002, p. iii), In fact, Devereux shows, the early 2002 food crisis in Malawi can be regarded as a classic situation of multiple stressors. All factors described above come to bear to greater or lesser extents-environmental factors such as agricultural drought and flooding were compounded by ‘vulnerability factors’ such as lack of investment in smallholder agriculture, maize distribution gaps, weak social networks and the numerous direct and indirect effects of HIV/AIDS (Devereux 2002).

The extent to which these types of stressors amplify each other’s effects, and operate interactively to increase vulnerability to other external stressors is the subject of substantial investigation and analysis. Actors such as the Famine Early Warning System Network (FEWSNET), the World Food Program and partners within the Southern African Vulnerability Initiative (SAVI), for example, seek to identify and address food security risks in a sustainable manner (Marsland and Oliviera 2003; SAVI 2003).

In this paper, we specifically consider the role of climate information in sustaining agricultural production and improving food security. Climate impacts on agriculture affect food security through the ways in which they propagate through the economy (Sen 1981) as well as affecting household food supply directly. Climate fluctuations, particularly drought, are often associated with reduced agricultural production. Such a relationship may work in tandem with, and be amplified by, other stressors such as those described above.

As stated above, we acknowledge that a focus on agricultural production addresses only one component of food security in Southern Africa.[1] Again, it is clear that “food security in Africa is a product of low agricultural production plus low incomes, not one or the other alone, and is a consequence of policy failure as well as institutional failure.” (Devereux and Maxwell 2001, p. 1). Given agriculture’s social and economic importance, reduction of (climate) risk within the sector would ideally have knock-on effects on the action and interaction of other stressors. Due to the increased attention paid to other aspects of the complex emergency (for example Mano et al. (2003) excellent examination of policy determinants of the 2002 food security crisis), we hope that focused attention to this part of the puzzle will complement attention in other areas (e.g. the role of policy failure and macroeconomic issues such as market operation).

Mano et al. (2003, p. 4) observe in their analysis of the 2002 food emergency that ‘early warning systems worked.’ They note, however, that gaps remain in the ability of the early warning system to provide sufficient information and analysis to guide response planning. For example, in Zambia, governments did not head early warning of impending shortfalls disseminated by the Southern African Development Community Food, Agriculture and Natural Resources Development Unit (SADC-FANR) and thus did not take timely action (Mano et al. 2003). Considering the 2000/2001 and 2001/2002 seasons, Clay et al. (2003) specifically investigate whether climate forecasting could have contributed to mitigating negative effects of the 2002 food security crisis in Malawi. They found that key agents such as FEWSNET, the Ministry of Agriculture and the Department of Disaster Management took little action in response to the climate outlook of the Southern African Climate Outlook Forum (SARCOF) showing above average rainfall across the region (p. 66).

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[1] Such recognition includes clear acknowledgement of assertions such as those of Buchanan-Smith et al. (1994, p. 69) that ‘prediction is not prevention.’ Nearly a decade after this assessment of famine early warning systems was completed it is clear that we have yet to effectively address the response side of the equation in the SADC region. Again, we would propose that efforts to achieve improved food (or livelihoods) security comprise coupled efforts on *both* the information supply and response sides (as well as intermediary stages). In this way, more relevant and usable information envisioned in this document would ideally integrate with efforts to improve response.

The authors also state that 'National economic and food security decisions appear not to have been sufficiently well-informed by an understanding of agro-meteorological relationships' (p. 67). It is important to note that early cessation of the 2001/2002 rainfall season was also significant for diminished agricultural production (SADC-RRSU 2002). This parameter would, however, not show up in the current forecast content provided by SARCOF and the national meteorological services. The notion of forecast content needing to include predicted intraseasonal variability to have greater utility is referred to again later.

The examples of Zambia and Malawi (amongst others) show clearly that critical gaps exist in the ability of climate information to be applied in the agricultural sector. Further analysis of how climate information could better serve the agricultural sector thus seems an essential task. The main challenge here is to balance what users in the agricultural sector require with what scientists can confidently provide. In focusing on concrete recommendations, we hope that a middle ground is evident (some of which is already being gained, albeit in a piecemeal fashion).

It should also be noted that estimates (and perceptions) of seasonal climate forecast skill have dropped consistently since the technique of seasonal climate forecasting was first introduced region-wide in 1997. A series of El Nino Southern Oscillation (ENSO) events associated with region-wide climate anomalies in the 1980s and early 1990s created widespread expectations that the 1997/1998 season would be accompanied by a major regional drought (Dilley 2000). Initial suggestions that not just rainfall but even climate-related impacts could be forecast in the region based on ENSO (see Cane et al. 1994) have been tempered by more recent assessments of regional forecast skill. The International Research Institute for Climate Prediction (IRI) has evaluated the skill of its seasonal-scale temperature and precipitation forecasts for the region using Ranked Probability Skill Scores (RPSS), a very conservative measure of forecast skill (Goddard et al. 2003). RPSS values ranged from 10 to 60% for the region overall for temperature and 0–30% for precipitation (an RPSS of 10% for the IRI's and SARCOF's 3-category forecast system is approximately equivalent to a correlation coefficient of 0.50). While these skill levels can be improved slightly through statistical correction of general circulation model output (Landman and Goddard 2002), and skill levels may well be sufficient for certain applications, limited skill in the region dictates that special emphasis be placed on identifying the particular kinds of climate-related problems that can benefit from the skill that is available and that climate information be tailored specifically for supporting decisions in the identified problem areas.

It is important to note that forecast benefits cannot be assumed, as shown by a range of case studies in the field of forecast applications. The field has grown substantially in the last 5 years, and is a significant contribution to the discussion around increasing forecast utility. For example, Ziervogel and Downing (2004) characterize stakeholder networks and the extent to which they do and don't produce flows and blockages in information dissemination. The authors observe that in Lesotho (the case study), forecasts have been issued for (at the time) 5 years, yet the use is not widespread. Lemos et al. 2002, in their case study in Ceará, northeast Brazil, show that social and political factors can profoundly limit forecast utility for application. Forecast utility has been further compromised in this area through factors such as inappropriate forecast content, format and dissemination strategies.

Patt and Gwata (2002) propose six groups of constraints limiting forecast utility in their case study in Zimbabwe. Such constraints include scale (where forecasts have insufficient local specificity), choice issues (for example, whether the forecast actually contains appropriate information to alter strategies), and issues around institutional factors (where intra- and inter-institutional inertia delays forecast dissemination). Pfaff et al. (1999) describe equity issues around forecast access, where certain groups of potential users in the Peruvian fishing industry were excluded from forecast receipt.

Finally, in West Africa, Roncoli et al. (2001) investigate obstacles and incentives to forecast use in Burkina Faso through their Climate Forecasting for Agricultural Resources (CFAR) project. Farmers in this area use their own forecasting methods (Roncoli et al. 2001). Farmers were then also experimentally exposed to external forecast information (Roncoli et al. 2001), and some success in forecast applications was noted (Kirshen et al. 2003). Authors describe, however, a range of challenges to realizing forecast benefits very similar to those described later in this paper. For example, institutional challenges abound – the Burkina Faso Meteorological Service needs more training and field experience. There are a number of scientific challenges – for example, there is a clear need for in-country research to improve forecast skill. Farmer resources are a challenge where farmers require a particular resource to help them adapt. Finally, there are significant challenges in forecast dissemination around language, terminology, and translation of forecasts into management options (Kirshen et al. 2003).

3 Materials and methods

The SADC Regional Remote Sensing Unit (RRSU) convened an annual early season Agrometeorological Workshop from the 11th to the 15th November 2002 in Harare. The workshop was entitled “Application of climate information to sustain agricultural production and food security in the SADC region” and was attended by Agronomy, Agrometeorological and National Meteorological and Hydrological Service (NMHS) representatives active in the National Early Warning Units (NEWU’s) of Southern African Development Community (SADC) member states. As part of the workshop, stakeholders present were interviewed and requested to prepare detailed responses regarding their assessment as to the extent to which the climate information system currently served the agricultural sector in their countries. Twelve countries responded: Angola, Botswana, Lesotho, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia and Zimbabwe.

Specifically, NEWU participants were asked to answer four overarching questions:

1. What are the specific forecast needs for agricultural decision-making, given the specific characteristics of your agricultural sector?
2. To what extent are such forecast needs currently being accommodated in your country’s forecast system?
3. What are the specific gaps in your forecast system (as it serves the agricultural sector)?
4. Can you identify three strategies to close these gaps?

Participants prepared in-depth responses to the questions; frequently going beyond the brief laid out (for example, most country representatives developed substantially more than three strategies in response to question 4).

Selected further targeted interviews were undertaken with the representatives, providing a basis for analyzing gaps in the way the climate information system serves agriculture as well as NEWU-identified priority strategies for improvements in the system to support improved agricultural production and food security.

4 Key findings: weaknesses and recommendations

NEWU representatives identified 12 key areas of weakness in their climate information systems, with much commonality (Fig. 1). Categories were inductively derived from open-ended responses. Specific findings are discussed further in the following section, distilled into two major overarching recommendations with more specific proposed actions addressing one or more of the identified weaknesses.

Southern African countries' climate information systems currently comprise the regional Southern Africa Climate Outlook itself, plus, in most cases, additional (or supplementary) predictive information produced and/or supplied by their national meteorological/ hydrological services (NMHS). The Outlook is a regional seasonal weather prediction and application process adopted by the 14 SADC countries, distributed by the SADC Drought Monitoring Centre (SADC-DMC) in Harare, supported by the Belgian government, the World Meteorological Organization and SADC (SADC-DMC 2004).

The consensus outlook is produced at the Southern African Regional Climate Outlook Forum (SARCOF) prior to the start of the rainy season, usually at the beginning of September. It is preceded by a capacity building training workshop for NMHS representatives, where national forecasts are created. These forecasts are then brought together and presented at SARCOF itself, and a 'consensus' seasonal outlook for the region is generated. A mid-season correction meeting is held to adjust the seasonal outlook, usually in late December. NMHS's also hold workshops at country level, although there is not a consistent format or calendar for such meetings. Several countries also produce value added or supplementary predictive information at the country level, and either integrate

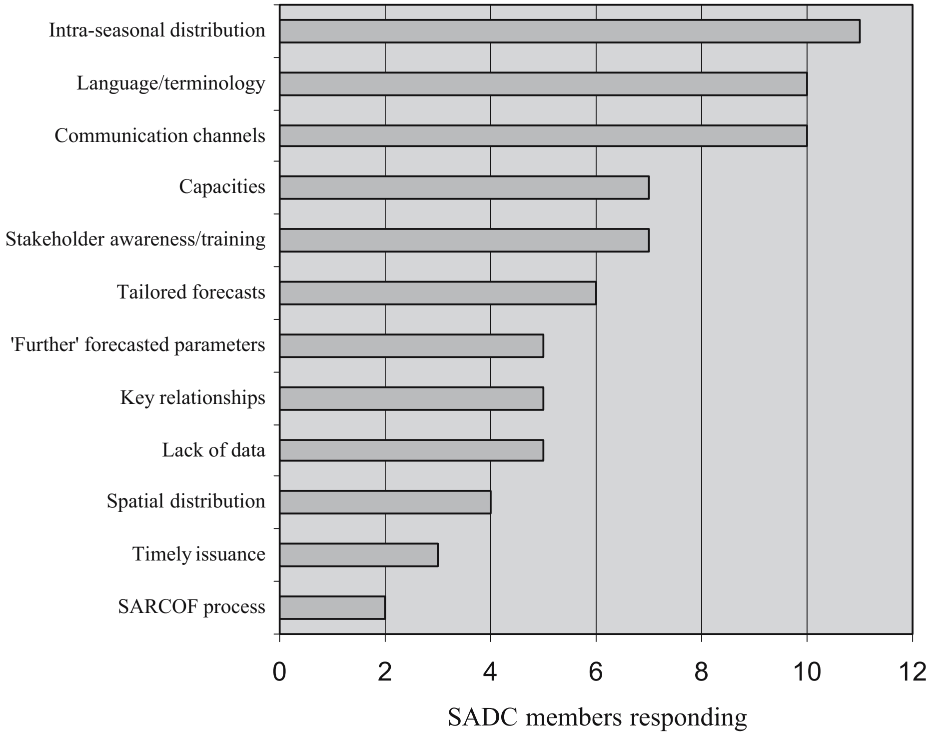

Fig. 1 Identified priority weaknesses/gaps in the climate information system

with the regional SARCOF prediction for their country, or make both available. The SARCOF process places particular emphasis on the need for country level users to contact NMHS's for more specific or value-added information.

4.1 Stakeholder identified priority weaknesses in the climate information system

4.1.1 Intraseasonal distribution

NEWU representatives asked that measures of intra-seasonal rainfall distribution or 'seasonal quality' be predicted. Other studies of forecast applications and informational needs have shown this to be a climatic parameter of extreme criticality to a number of decision-makers in the agricultural sector (e.g., Usman et al. 2005).

4.1.2 Language/terminology

Challenges of language and terminology were specifically highlighted by 10 of the responding country teams. For example, very few NMHSs translate their forecasts beyond English and perhaps one major additional language. This is a substantial hurdle in forecast outreach – it may also marginalize particular communities and areas of a country. Terminology in forecast content is consistently a challenge – for example, the terms 'probability' and 'average' are often insufficiently described and inadequately understood.

4.1.3 Communication

Representatives from 10 out of 11 countries responding highlighted communication as a key weakness in the ability of the climate information system to serve the agricultural sector. This is a weakness that has been well documented in the forecast applications literature (e.g. IRI 2000, 2001), yet remains of critical importance. The Zambia country team, for example, identified key weaknesses in dissemination of climate information to outlying farming areas (a reliance on ZNBC TV and radio for dissemination, restrictions on ex-Lusaka phone calls).

4.1.4 Capacity of key institutions

NMHS and Agrometeorological capacity (e.g. skills, equipment) was cited as a priority concern by more than half the country respondents. Teams from Malawi, Mauritius, Namibia, South Africa, Zimbabwe, Swaziland and Zambia all described weak NMHS capacity in detail. One key area noted as a weakness, for example, is the lack of programming skills amongst NMHS staff throughout SADC.

4.1.5 Stakeholder awareness/training

A range of country teams also consider user/stakeholder training and awareness a critical weakness. A large number of strategies to improve user and stakeholder awareness of climate information and its potential applications were suggested by the representatives, including extensionist training and conscientization of farmers. It should be noted that a number of countries are initiating these types of awareness and training activities (albeit not always consistently).

4.1.6 Tailored forecasts

Workshop participants called for more emphasis on tailoring climate forecasts to specific agricultural sectors and/or commodities. We acknowledge that the increasingly used term ‘tailored forecasts’ may have differing meanings for different readers. In this case, tailored forecasts are considered as the full range of instances where additional parameters or information may be added to the basic conventionally provided climatic forecast to provide greater, more specific utility to a particular user. Such products may range from simply adding temperature to a rainfall prediction (in response to demand); to identification of real management options as a result of above-normal, near-normal or below-normal basic precipitation forecasts.

4.1.7 ‘Further’ forecasted parameters

Country teams also requested ‘further’ parameters to be forecast, such as relative humidity and temperature. For example, Swaziland representatives requested help in developing their ability to monitor soil moisture pre-season and during the curing season, and requested technical support in forecasting temperature. Several other countries requested tailored forecasts showing the probability of temperature exceeding a certain threshold critical to a particular commodity (such as livestock).

4.1.8 Key relationships

Countries also found that weaknesses in relationships between key partners in climate information systems and NMHSs have critical implications for system effectiveness. Of particular concern to many countries is the weakness of links between NMHSs and the extension service or other agricultural expert intermediaries. Such a phenomenon is by no means limited to the area of climate prediction and seems a common feature of government departments, parastatals and other institutions. It is a substantial handicap.

4.1.9 Lack of data

Five countries identified lack of data (with specific attention paid to observational networks) as a major concern. Teams from Angola, Botswana, Namibia, Swaziland and Zambia all described problems with their (in some cases declining) numbers of reporting meteorological stations as a top priority.[2]

4.1.10 Spatial distribution

Lack of specificity in the spatial distribution of forecasted seasonal rainfall is of particular concern to several countries. The difficulty of forecasts of being too general (spatially and other) to really be of use to the agricultural sector echoes findings of other assessments of the role of climate information in the emergency – for example, Clay et al. (2003) observe (also for Malawi) that “...seasonal forecasts are highly generalized....”.

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[2] Such concerns are reflected in findings of reports a range of climate scientists, including that of Mason and Goddard (2003), which show a dramatic reduction in reporting met stations in the SADC region in the 1990s.

Multiple Output Statistics (MOS) based on regional dynamical models with finer resolution than that provided by GCMs may address this point in the future (Landman and Goddard 2002). Both dynamical and empirical downscaling systems address the problem of simulating sub-GCM grid features, but evidence that such additional characteristics or features are skillfully predicted is still lacking (Landman personal communication). The potential for such methods certainly exists, and is being actively pursued in Southern Africa.

4.1.11 Timely issuance

Several country teams (Lesotho, Mozambique and Swaziland) found that timely issuance remains a key weakness in climate information systems. The Mozambique team, for example, observed that at present the forecast is provided too late for planting decisions in parts of southern Mozambique.

4.1.12 SARCOF process

Two countries found that the SARCOF regional forecast consensus process itself had key weaknesses compromising their ability to develop human resources in the region that would apply climate information effectively to the agricultural sector. For example, Botswana representatives observed that each year a different staff member attended SARCOF – something that neither the Botswana nor the Namibia team (who reiterated this concern) considered an effective capacity building strategy. Further, both teams identified weak dissemination of function and capacity down to the national (NEWU) level from SARCOF as a key concern.[3]

4.2 Key recommendations to address identified weaknesses

A focus on identified weaknesses (many of which are already well documented and well known) would be insufficient. Identified weaknesses are thus distilled into concrete recommendations intended to address one or more of the weaknesses. Figure 2 illustrates. Weaknesses are listed in order, with most frequently identified weaknesses at right. Two broad recommendations, addressing in turn forecast improvement itself, and, secondly, increased national and non-traditional investment in outreach and applications, are shown at left. Concrete actions around such recommendations, each shown by arrows to address one or more of the identified weaknesses, appear in the middle.

It is essential to note that in the case of many of these recommended actions, work is already under way. Gaps remain, however, and the stakeholder identified weaknesses shown in this paper ensure that closing these gaps is not merely a research task. As stated earlier, the tradeoff here is between what stakeholders require, and what can be robustly provided. The recommendations, we propose, show a middle ground – much of which, despite existing work, is yet to be attained in the SADC region.

4.2.1 Forecast improvement

Given that many weaknesses refer to different aspects of forecasts themselves, three key sets of actions around forecast improvement can be identified. Firstly, models used in forecasting

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[3] Dissemination of SARCOF functions and capacity down to the national level is considered a key priority for SARCOF, hence this finding is concerning. This topic is being further explored in current investigations.

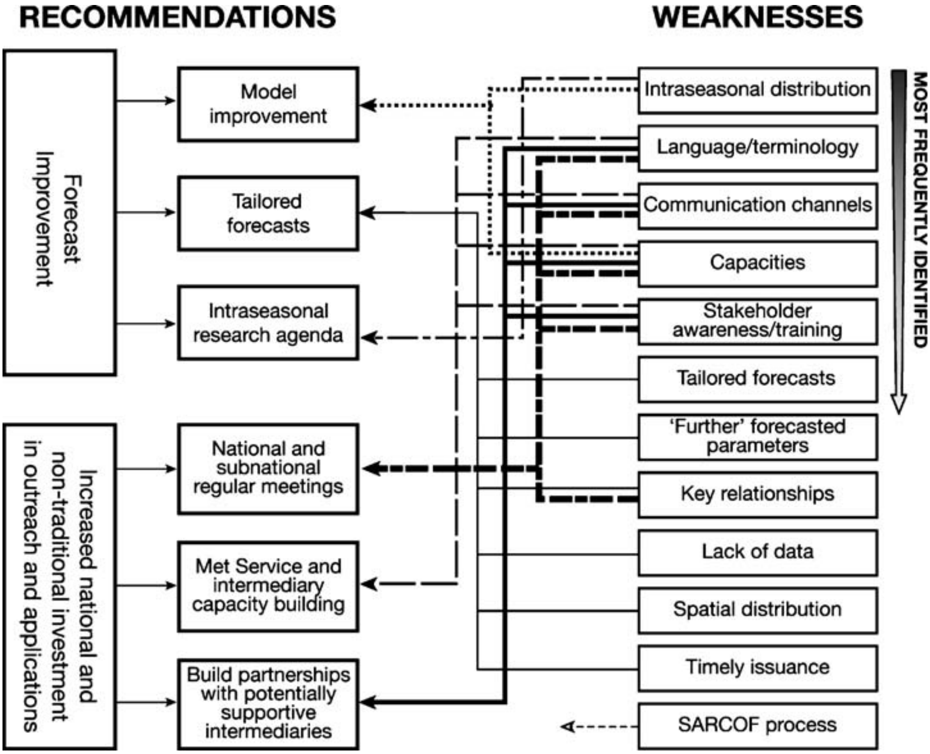

Fig. 2 Recommendations designed to address identified weaknesses

can (and are being) improved in a number of ways. Ongoing model improvement to provide forecasts in a more timely manner while increasing the skill is required.

Continued model improvement to improve spatial resolution is essential. Contributing to all aspects of forecast improvement is the need to support initiatives to entrain co-operating stations. For example, a range of activities are underway in Southern Province, Zambia, led by the Livingstone Meteorological Office, to collect data from 50 volunteer rainfall stations. Such activities may improve many aspects of forecast content and skill; and also help address stated weaknesses around data and capacity. Expensive investment in new meteorological station establishment may not always be the most appropriate action if volunteer stations exist. Research proposals that look at the feasibility of including ‘extra’ parameters in forecast content (e.g. temperature, relative humidity) need to be encouraged and supported. Informal experience shows that there is interest in many SADC NMHSs to engage in this type of investigation, and such interest needs to be encouraged and, if possible, supported.

Secondly, the feasibility of providing ‘tailored’ forecasts needs to be investigated. Such investigation needs to comprise a robust multi-year research investment (not simply a casual workshop). In addition, like the aforementioned recommended support for investigating of the feasibility of predicting ‘extra’ forecast parameters, support should seek to entrain and nurture existing in-country research interest in these areas. A well-managed, SADC-driven small grants programme to solicit country-driven feasibility studies in tailored forecast design relevant to the researcher country has been extensively discussed, and should be established. All projects should include a test of their application in a particular agricultural setting relevant to that particular country.

A last, but possibly most urgently needed set of actions falling within the broad recommendation of forecast improvement is the development of a substantial intraseasonal variability research agenda. Work and discussion on the feasibility of forecasting intraseasonal dynamics is already underway in SADC and in Africa more broadly (Tadross et al. 2005; Usman et al. 2005). A robust research agenda is, however, lacking. One model might also be a SADC-led small grants programme designed to entrain existing NMHS interest in these types of feasibility studies (again, with a substantial capacity building component and real test bed applications). Concrete discussion on which route to follow to develop a substantive research agenda on intraseasonal distribution in forecasting needs to take place as a matter of urgency.

4.2.2 Increased national and non-traditional investment in outreach and applications

In recent years in SADC, it has become increasingly clear that outreach and applications in climate information requires substantial investment. This is not a new finding. What does emerge from the stakeholder identified weaknesses presented in this paper, and from work on climate information utility in specific countries (for example, South Africa and Southern Province, Zambia), is that such investment needs to come not only from external donors, but from national and 'non-traditional' actors themselves.

For example, national and provincial government in Zambia is increasing investment in the Southern Province Meteorological Office. Such increased budget allocation has not taken place in a vacuum. Rather, the commitment of the office to outreach and communication has been helpful in displaying a track record in applications, which has then encouraged increased government support. Increased investment supports such initiatives as regular 10-day bulletins with an agrometeorological report component.

Increased national and provincial government investment in climate information development and application has material implications. It is clear, however, that such investment is also inspiring to NMHSs in a way that shorter-term, less sustainable (and often irregular) external-source donor funding is not. National and provincial investment is a source of pride to NMHSs, and seems to prove more conducive than external funding to the development of country-driven long term research agendas (some of which might also address concrete actions around forecast improvement highlighted in the previous section).

Work in Southern Province, Zambia, further shows that intermediary stakeholders who haven't traditionally been considered in climate information application can be excellent and supportive partners. For example, continued regular meetings with food aid agencies, companies and parastatal agricultural organizations has resulted in such actors developing their role both as users of forecasts (for example, using forecasts to determine the distribution of agricultural inputs) and as forecast intermediaries (for example, Worldvision using its existing agricultural outreach and farmer support programmes to interpret and communicate the forecast, thus substantially expanding NMHS outreach at no extra cost).

Three concrete (and overlapping) sets of actions, represented by headings shown on the lower middle of Fig. 2, should be undertaken in increasing national and non-traditional stakeholder investment in outreach and applications. As in the previous section on forecast improvement, work in these areas is already underway in a number of cases (although certainly not consistently throughout the SADC region).

Firstly, national and subnational meetings around the forecast, its updates and its interpretation should be held regularly. Such meetings should include hitherto 'non-traditional' stakeholders – for example, food aid agencies, government departments not traditionally associated with use of climate information, electricity supply companies and parastatals, and agribusiness. At minimum, meetings should present new or updated climate information, and spend a substantial amount of time interpreting the information for stakeholders (for example, which aspects are relevant during which portion of the season for the Roads Department, and how should they change their strategies in response?).

Regularity here is key. Work in Zambia and in the semi-arid Suid Bokkeveld, South Africa, increasingly shows that regular meetings improve stakeholder confidence in forecast interpretation, strategy building (and adaptation) and even in climate information criticism (an essential step). Such meetings should be supported by national and provincial government, and by the stakeholders themselves. For example, food aid agencies, different government departments and agribusiness companies could take it in turn to host such meetings. Such meetings in themselves *encourage* such investment; again building trust, confidence and a sense of an NMHS track record, if deserved.

Secondly, NMHS and non-traditional stakeholder capacity must be built. The aforementioned regular meeting structure contributes to this process, and as in the regular meeting strategy, capacity building both requires and encourages increased national and non-traditional investment. For example, a series of government departments who have been well trained in how probabilistic forecasts work (and in their limitations, which is also essential), and in how to update and/or adapt their seasonal operations in response to such forecasts (should they choose to do so) will be quicker to encourage provincial and national government to increase budgetary allocation to the NMHS. A food aid agency with similar enhanced capacity will be quicker to offer its outreach infrastructure to the NMHS, in areas where NMHS outreach is poor, for example.

Thirdly, drawing out a recurring theme, concrete actions must be taken in SADC countries and provinces to build partnerships with the aforementioned non-traditional stakeholders. Again, the regular meeting strategy can contribute here; and stakeholder capacity building is an essential component. Again, however, SADC NMHSs also need to think creatively and as a matter of priority about how to entrain and interest non-traditional stakeholders in the climate information system. In each country, the strategy might be different. What should be emphasized is that, like regular meetings and capacity building actions, building such partnerships might require a very small amount of initial investment, but would result in increased support and investment, if correctly managed. As stated earlier, such investment by in-country stakeholders would be more sustainable (and encouraging) than once-off irregular and non-sustainable external donor support.

4.2.3 SARCOF

In closing the section on recommendations, it may be observed in Fig. 2 that while almost all the stakeholder-identified weaknesses are shown (by arrows) to be addressed at least in part by one or more of the recommendations (and following actions) presented above, the weakness around the SARCOF process stands alone. SARCOF, and indeed the notion of Climate Outlook Fora more broadly, has been substantially reviewed and critiqued in earlier studies (Basher et al. 2001). Weaknesses persist, however, and may even be becoming more severe. It is, unfortunately, impossible to produce concrete recommendations for the SARCOF process without acknowledging the wider regional institutional problems within which the process is inextricably nested. Concrete recommendations for SARCOF should probably be held over until the regional institutional architecture is somewhat more robust.

5 A way forward for climate prediction and early warning in SADC?

A number of weaknesses in the ability of the climate information system to serve the agriculture sector have been presented here. The study, as described above, has comprised a very specific and targeted look at a range of issues, led by analysis undertaken with Agrometeorology representatives of country NEWUs and NMHSs. Such weaknesses have been distilled into broad recommendations, with a number of following actions. The key trade off here, to reiterate, is to find a middle ground between what stakeholders require and what scientists can provide with confidence. It should be emphasized that the recommendations are not meant to be exhaustive, and should be seen as developmental.

In closing, our brief here addresses more effective use of climate information to improve resilience of the SADC region agricultural sector to climate stress. Such an emphasis is, as stated earlier, merely one component of the challenge to improve food security in the Southern African region. Such an effort should integrate well with the broader and more comprehensive assessment of recurrent 'complex crises' in the region. The results of this study suggest that there is a demand for climate information from within the agricultural sector as expressed by expert intermediaries, but that further work needs to be done to generate the products and services to meet it. We argue, again, that there is a middle ground to be attained in addressing this gap which may, as mentioned in Section 4.2.1, be well served by a SADC-driven small grants programme, where research themes are stakeholder identified. Achieving this is an essential task for the immediate future.

Acknowledgements This paper was first prepared as 'SADC Working Paper A' for the International Research Institute for Climate Prediction at Columbia University (IRI). Thanks are due to USAID, for providing support for the project through which these investigations were undertaken. Thanks also to the WMO and the IRI for institutional support. We would like to thank Dr Willem Landman at the South African Weather Service for contribution of discussion and material on regional downscaling. A special thank you is due to Dr Jim Hansen at the IRI for comment on an earlier draft. Sincere thanks to two anonymous reviewers for their extensive and valuable comments. Mrs Wendy Job recrafted Fig. 2 for clarity and accessibility, for which the authors are extremely grateful. Lastly, we would like to thank both the SADC Regional Remote Sensing Unit and Drought Monitoring Centre, as well as National Early Warning Unit stakeholders for multi-faceted support and for remaining central to operations described here.

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