STAKEHOLDER NETWORKS: IMPROVING SEASONAL CLIMATE FORECASTS

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Abstract. In order for a scientific innovation to reach a wide audience it needs to travel through diverse networks and be understandable to a variety of people. This paper focuses on networks of stakeholders involved in the diffusion of seasonal climate forecasts. It is argued that understanding stakeholder networks is key to determining the opportunities and barriers to the flow of forecast information, which could enable more focused forecast dissemination. Lesotho is used as a case study where Stakeholder Thematic Networks (STNs) are used as a novel method for investigating forecast dissemination. STNs enable qualitative information to be analysed through semi-quantitative mapping of relationships that enable the networks and scales of linkages to be visualised. This illustrates the types of nodes and channels of seasonal forecast information flow and so enables existing or emerging patterns of dissemination to be uncovered. Sub-networks that exist for purposes other than climate information dissemination are identified as salient sub-networks for focusing development of future forecast dissemination. These existing sub-networks enable stakeholder needs to be addressed and decrease the need for new networks to be established. By using these sub-networks, information relating to climate variability can be mainstreamed into existing development pathways. This is critical to recognise if innovations relating to climate information are to be used to improve climate change adaptation.

1. Introduction

For a scientific innovation to be useful to a wide audience it needs to be communicated through diverse networks and be understandable to a variety of people. Although the nature of the innovation needs to be appreciated, the social aspects of the network through which innovation travels need to be considered in order to improve dissemination [1] and application. This paper focuses on the dissemination and use of seasonal climate forecasts; seasonal forecasts being a probabilistic prediction of the climate for the season.

Research on the applications of seasonal forecasts has shown that there are many constraints to using forecasts in developing countries but the focus has been mainly on constraints to uptake associated with end-users (Mjelde et al., 1997; Eakin, 1999; Klopper, 1999; Bohn, 2000; Mukhala et al., 2000; Vogel, 2000; Archer, 2003; Ziervogel and Calder, 2003). There is a gap in the literature when it comes to illustrating actual cases that examine the role of the national, sub-national

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and local players in the network of forecast dissemination and how disseminators constrain or encourage the uptake of the forecast. Stakeholder networks are therefore advocated as a novel method of determining the effectiveness of forecast dissemination, identifying the barriers to using forecasts and therefore, determining the contribution that forecasts can make in improved adaptation to climate variability and potentially climatic change. The aim of this paper is to unravel the stakeholder networks that transform seasonal forecast information into action.

An analysis of stakeholders[2] and the efficiency of the networks within which they operate is a useful way to examine the effectiveness of seasonal forecast dissemination (Valente, 1995). Effective dissemination occurs when stakeholders pass on forecast information and it is used or added to before being passed on again. In order for networks to be classified and for dissemination to be judged as effective or not, stakeholders need to be characterised, relationships between them defined and a description of how the environment controls their interaction included. This can be achieved by accomplishing four tasks; first, examining users' perceptions of forecast dissemination; second, establishing the users' role as both user and disseminator; third, the interaction of users uncovers the existing networks and fourth, existing networks are contextualised within their wider decision environment.

The paper first provides an overview of seasonal climate forecasts. Stakeholder networks and their components of nodes and channels are then outlined as a means for identifying the flows and blockages of information dissemination. Lesotho is used as a case study, where forecasts have been issued for five years, yet as in much of southern Africa, use is not widespread (O'Brien et al., 2000). The methodology of Stakeholder Thematic Networks (STNs) is introduced. Interviews and workshops are used to characterise stakeholders and the networks within which they are situated. The results are analysed through semi-quantitative mapping of relationships that enable the networks and scales of linkages to be visualised. STNs can be extended into multi-agent systems, which are essential when complexity increases as the number of actors, levels and emergence increases. In this case study, Lesotho Meteorological Services' (LMS) and other stakeholders' perceptions of forecast dissemination highlight the problems associated with dissemination from the users' perspective. STN analysis is divided into stakeholder and network categorisation, the first of which is needed to build the second. The implications of the existing networks are discussed with respect to the role they play in determining the opportunities and limitations of present seasonal forecast dissemination and for focusing how future dissemination might be improved with the ultimate goal of using effective forecasts to provide a means for adapting to climate variability.

2. Seasonal Forecast Dissemination Networks

Seasonal climate forecasts have been promoted as a measure to ameliorate the impact of climate variability in southern Africa (Blench, 1999; O'Brien et al., 2000).

They have been used to predict rainfall in southern Africa for more than a decade (Mason et al., 1996; Mason, 1997) but can still be considered as an innovation as they are not widely used (Mukhala et al., 2000; O'Brien et al., 2000). The forecasts are based on the premise that the probability of certain climatic conditions prevailing can be determined by observing the boundary conditions, such as the sea surface temperature, that evolve more slowly than atmospheric changes (Palmer and Anderson, 1994). The probabilistic nature of the forecast requires that the forecast product is well understood. This is critical in order to prevent the forecast being misinterpreted as a deterministic forecast that will loose credibility if the observed rainfall is not the same as the forecast. If the probabilistic nature and other constraints are appreciated, forecasts can contribute to decreasing the negative effect of climatic extremes by early warning and allow for optimum use of climate variability through appropriate preparation (Washington and Downing, 1999; Patt and Gwata, 2002).

In order for the constraints to be appreciated, the forecast skill needs to be understood. Although the forecast is a prediction over a large area, many fail to understand that it does not mean that the whole area can expect the same amount of rainfall. A prediction of 'normal' rainfall is different for each location depending on what the mean annual rainfall total is. The level of skill or spatial accuracy will therefore be different depending on the scale of activity undertaken. So, although there might be high regional skill according to meteorologists, users operating at the local scale, such as a farm, might find the skill to be inadequate. At the same time, it is important to note that human decision-making does not occur at a fixed scale. A farmer may want to use the seasonal forecast for decisions at a number of scales; in order to manage farm decisions; to plan water resource management depending on how much rain is expected in the catchment or to use the expected national maize supply forecast to decide on the investment in inputs. This illustrates that although users may operate primarily at one scale, their decision-making may depend on information from a variety of scales and so varying levels of forecast skill might be acceptable. Despite the scale of action and decision-making, it is paramount to accompany improved dissemination with improved explanations of forecast characteristics and limitations.

Seasonal forecast applications research has focused on the forecast product (in terms of its accuracy and limitations) (Mason et al., 1996; Mason, 1997; Ward, 1998; Hyden and Sekoli, 2000) and forecast utility (how and why it is or is not used if and when it reaches end-users) (Roncoli et al., 2000; Vogel, 2000; Phillips, 2001; Ziervogel, 2001; Patt and Gwata, 2002). In order to reach potential end-users it is necessary that there is 'effective and equitable distribution' (Pfaff, 1999, p. 645), which requires good communication. This aspect of seasonal forecast applications research has not received enough attention. One of the most comprehensive accounts of stakeholder networks and how their geography has manipulated forecast dissemination is provided by the case study of the Peruvian fishing industry, that showed how artisanal fisherman that did not have access to the forecast suffered more than the commercial fishing fleets that were able to access and use the forecast (Agrawala and Broad, 2002; Broad et al., 2002). This was in part determined by the status of the stakeholders who disseminated the information and in part by access to resources. More research is needed to establish methodologies that capture these network and institutional constraints.

Innovation diffusion or technology transfer is a useful way to frame the problem of seasonal forecast dissemination. Agrawala and Broad (2002) suggest different models of technology transfer as a tool for situating the state of seasonal forecast dissemination and adoption. On the one end, the 'Appropriability model' says that the utility of the product should sell itself and on the other end, the 'Contextual adaptation model' says that product adoption will depend on its 'fit' with existing cultural and mental models along with the demonstration of the product utility. The history of seasonal forecasts has seen a shift, within the scientific community, from perceiving the intrinsic value of the forecast as reflected in the Appropriability model, to emphasising the need for communicating with end-users to ensure a 'fit' (Orlove and Tosteson, 1999), as reflected in the Contextual adaptation model. One way to assess what stage of technology transfer persists is to look at the networks of information flow.

Social network analysis has been shown as an informative way to explore innovation diffusion (Valente, 1995). Social networks are appropriate for assessing relational data (Mitchell, 1969; Scott, 1991) and innovation diffusion relies on relations between actors (Rogers, 1995). Historically it has been shown that adoption is usually slow to start because the use of an innovation entails risk and uncertainty (Mahajan and Peterson, 1985; Valente, 1995). Adopters therefore turn to peers to gain more information about potential adoption decisions and so it matters whom they are in contact with in their social network. The location of the actors in the network will therefore determine what information they are exposed to and so what role they will assume within the network.

Networks can be conceptualised as having nodes and channels. In this paper, organisations and individuals are the nodes and the communication of the forecast forms the channels. The channels, or information conduits, depend on existing institutions. Institutions can be viewed as structures of power and relationships between stakeholders, resources and knowledge as well as the socialised ways of viewing the world (Jordan and O'Riordan, 1995). These institutions enable or constrain decisions and action and determine whether information flow is possible or not (Jordan and O'Riordan, 1995; Bakker, 1999).

The components of the seasonal forecast dissemination network are presented in Figure 1. The network starts with the producers of the forecast, who may compile their own original forecast or combine existing model data, to attain a forecast product. The forecast product is then disseminated. The disseminators can either pass on the forecast as it is or they can add value by changing the forecast to suit user needs. Once the forecast is received, users need to decide whether or not it is suitable to use and if so, what response options to pursue. Repeated

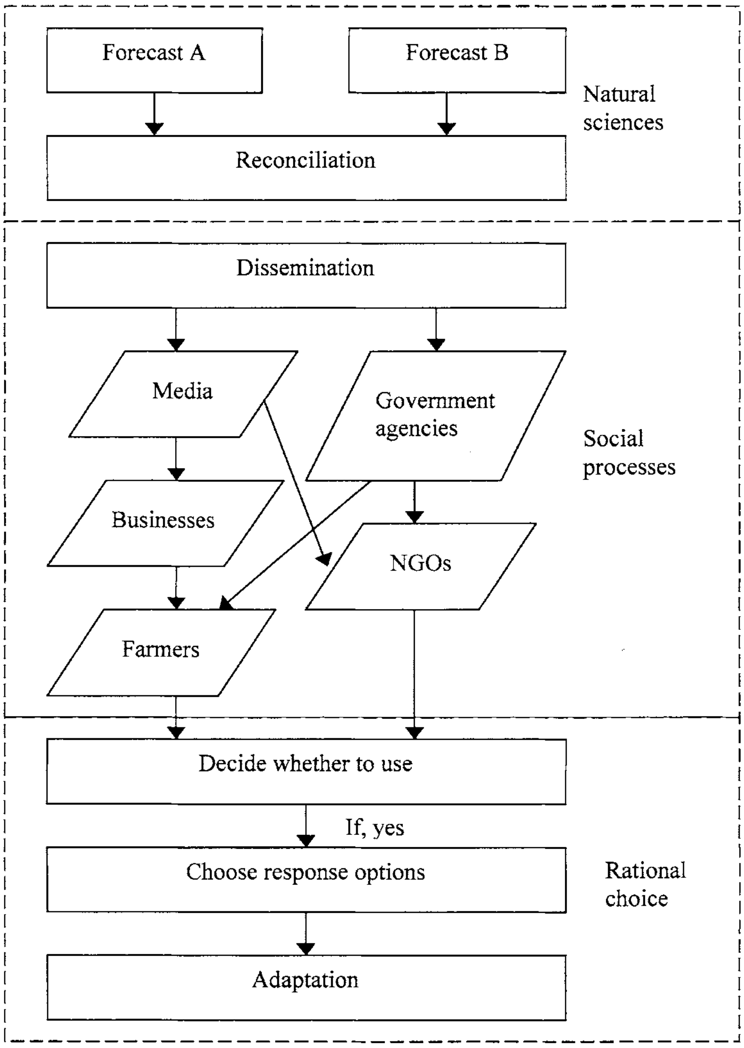

Figure 1. Potential seasonal forecast dissemination pathways (adapted from Washington and Downing, 1999).

receipt and use of the forecast will prompt users to formulate strategies of how to use the information. The learning process can contribute to increased adaptive capacity. Figure 1 represents a simplified version of one pathway of information dissemination. In reality, dissemination is more complex and so the dynamics of interacting pathways of information flows need to be explored. For example, all receivers of the forecast become potential users and disseminators. For example, if the Maize Board receives a forecast of below normal rainfall, they can pass it on as it is, or they might suggest the use of short-maturing maize varieties. Similarly, a farmer could receive the forecast from the Maize Board, use it in planning what seeds to buy, and then pass it on to other farmers at the Farmer's day. That farmer would be both a disseminator and an end-user.[3] Even if stakeholders do not use or disseminate it further, the reality is that they could have. Therefore a method is needed to capture complex information flows and their consequences.

2.1. THE SEASONAL FORECAST IN LESOTHO

Lesotho is a small mountainous country in southern Africa, which is entirely surrounded by South Africa. In the late nineteenth century and early twentieth century Basotho[4] were able to feed themselves, as well as export cereal crops (Gay and Hall, 2000). Due to the growing population and the diminishing land base they no longer produce enough food to be self-sufficient and the amount they do produce is declining steadily (GIEWS/FAO, 2000). Despite adverse conditions, of poor, highly eroded soils, extensive overgrazing and a highly variable climate, there is still a large emphasis on the role of agriculture and livestock (Chakela, 1999). This can be attributed to the nature of the society that has and still does try to subsist from the land. Seventy per cent of all households derive all or part of their livelihood from agriculture (Ministry of Natural Resources, 2000). Lesotho does not have many other natural resources. Diamonds were once mined commercially but now there is only small-scale mining where hand tools are used (Chakela, 1999). Water, also known as 'white gold', is the most important natural resource as it is sold and used for the generation of electricity. The Lesotho Highlands Water Project, regarded as one of the largest transfer schemes in the world, has brought considerable economic benefits to Lesotho (Horta, 1995; Waites, 2000).

In southern Africa the rainfall season extends from October to March (Washington and Downing, 1999). Lesotho receives eighty-five per cent of her annual rainfall between October and April (Chakela, 1999). The rainfall during the second half of the season (January–March), which originates in the tropics, is thought to be more predictable than the first half of the season when the rainfall originates in the mid-latitudes (Harrison, 1984; Tyson, 1986). Forecast verification[5] has shown that southern Africa has the potential to have high forecast-skill levels but in some months the skill is not sufficient for the forecast to be released (Mason, 1998). In these instances, a forecast of climatology is issued, that attributes equal probability to receiving above, below or normal rainfall. Lesotho falls into the southeast corner of South Africa's central rainfall region where the skill is better than other parts of the country (Landman et al., 2001) although it is at the convergence of regions, which means it is a variable zone in terms of climatic predictability. It has high inter-annual variability, which makes a skillful forecast valuable although difficult to achieve.

This history of climate variability has resulted in the Basotho developing their own ways of predicting and responding to climate variability (Wilken, 1982; Pepin, 1996) as agrarian communities have done around the world for centuries (Bharara and Seeland, 1994; Eakin, 2000). In Lesotho, environmental indicators (based on observations of local conditions) are of more significance than cultural practices and beliefs, with the behaviour of birds and insects being the most common environmental indicators (Ziervogel, 2001). This local forecasting knowledge, for both environmental indicators and cultural practices, seems to be losing prominence in Lesotho. The reason for this might be attributed to two things; it may be due to climatic changes and so less consistency between indicators and outcomes or to changing social environments that do not always place as much emphasis on traditional beliefs as in the past (Roncoli et al., 2000). Nevertheless, using local climate indicators as an analogy for seasonal climate forecasts could be a useful way of introducing forecasts instead of presenting something alien that competes with traditional values (Patt and Gwata, 2002). Research undertaken with villagers in rural Lesotho, showed a significant interest in seeing how the seasonal forecast might be used (Ziervogel, in press).

Lesotho's dependence on water resources, pastoralism and agriculture means that seasonal forecasts are likely to engage the attention of a wide range of stakeholders, as environmental indicators and cultural beliefs about the weather and climate have done in the past. If climatic uncertainty could be decreased it seems reasonable to expect the potential ramifications to be significant both in terms of managing hazardous climate extremes as well as maximising better years. These benefits will only be realised if the information reaches users and if the constraints to using the forecast are well communicated. If the forecast is used without an understanding of its probabilistic nature, stakeholders might become more vulnerable than they were before using it. Similarly, if one group uses the forecast to their advantage and other stakeholders do not receive the forecast, it can result in inequality (Agrawala and Broad, 2002; Broad et al., 2002). These constraints are important to acknowledge, although this paper focuses on the problem of ineffective dissemination in order to establish how more effective dissemination might be achieved.

3. Methods

Interviews and workshops provided stakeholders with a forum for expressing their views about forecast utility and perceived effectiveness of present seasonal forecast dissemination. Climatologists from Lesotho Meteorological Services (LMS) participated in a workshop where their views on forecast development, dissemination and use were documented which allowed for the formal and informal institutions relevant to forecast dissemination networks to be uncovered. Six climatologists from LMS and one representative from Department of Water Affairs attended the workshop. Participatory methods allowed for individual and group feedback.

Actual and potential forecast recipients' perceptions of the forecast were gathered from semi-structured interviews. Twenty interviews with key stakeholders enabled answers to be compared and certain topics to be expanded on. Participants were chosen from the group of people who attended the national workshop that announced the seasonal forecast, as well from organisations that could potentially be interested in the forecast because their work was either directly or indirectly affected by climate. More governmental stakeholders were interviewed because more of them attended the workshop, as LMS is obliged to inform them. Public stakeholders that were interviewed included representatives from government departments such as Land Use Planning department, Groundwater department, Department of Science and Technology, Ministry of Agriculture (MoA) and Disaster Management Authority. Private sector stakeholders included representatives from the flour mills, dairy, input suppliers, commercial farmers and consultants involved in agriculture and water resource management. International stakeholders from Red Cross Lesotho and the regional SADC (Southern African Development Community) water sector and media representatives from both government and private sector were also interviewed.

Information from the district and local level was gathered using semi-structured interviews and participatory research methods. Two workshops were held with district-level personnel from the MoA Field Services division to establish whether the forecast that reached the top level of the Ministry of Agriculture, Field Services division, was passed on to the district level extension agents. The forty participants, including the District Agricultural Officers and extension agents involved in crops, livestock and natural resource management, commented on when and where they had heard of seasonal forecasts, whether they would pass on the information and what type of climate-related information they would benefit from most. Local farmers were interviewed and participated in participatory research to provide a comprehensive overview of their perception of the forecast. The results are not dealt with explicitly in this paper but can be found in other work (Ziervogel, 2001, in press).

These methods enable data on the four tasks outlined in the introduction to be captured. Users' perceptions of forecast dissemination (task 1) and other attribute data gathered in the interviews enable profiles of stakeholders to be built up (Klopper, 1999; Roncoli et al., 2000; Vogel, 2000; Phillips et al., 2001; Ziervogel, 2001; Patt and Gwata, 2002). Each respondent was assessed: in terms of their scale of action (regional, national, district or local); whether they were public or private; how climate information impacted on them, how they use or would use the forecast and their perception of present and future forecast utility. Two elements; scale of action and whether public or private, were chosen to define five levels of stakeholder classification ranging from the national governmental stakeholders to the local users.

Stakeholders as both users and disseminators (task 2) and the interaction of stakeholders and the networks within which they operate (task 3) require relational data. Questions about interaction with other users were asked in the interviews and workshops to establish this. The questions included specific reference to passing on and receiving the forecast as well as passing on and receiving other types of information. Users were asked which other stakeholders they trusted and how often they interacted with them. This data was entered into incidence matrices that enabled networks to be constructed (Scott, 1991). Stakeholder Thematic Networks (STNs) were used to formalise the patterns of stakeholders by grouping them into themes based on stakeholder analysis and relational data (Giansante, 2000). This relational data enabled networks to be established and mapped as sociograms. Circular typology was used by illustrating the stakeholder classification levels in concentric circles with the disseminators of the forecast (LMS) at the centre and local-level users furthest out from the centre. The STNs are used prescriptively, by combining empirical and theoretical evidence, to identify existing networks and sub-networks of users.

The details of the STNs contribute to the fourth task that contextualises existing networks within the wider environment and enables the evaluation of the existing stage of technology transfer, with the option of identifying different stages of technology transfer for different sub-networks.

4. Perceptions of the Problem

Since September 1997, climatologists and users from the SADC countries have gathered to develop a consensus seasonal forecast for the southern African region (O'Brien et al., 2000). The consensus forecast is then taken back to the individual countries that are responsible for adapting and disseminating it (Basher et al., 2000). In Lesotho the final seasonal forecast for October, November, December (OND) and January, February, March (JFM) is presented at a national workshop in Maseru, the capital, in early October. In December, an update of the forecast for JFM is issued as a press statement. One year, the invitations for the workshop were sent out on the Tuesday and Wednesday when the meeting was held that Friday. They were sent to most government departments and there was an announcement in the newspaper that invited all interested parties. There were thirty-two people at the meeting; four small commercial farmers, four media representatives, three from non-governmental organisations, two from education and the rest from government departments. No radio programmes covered the meeting, although a press release (see Box I) was issued to announce the forecast as presented at the meeting. A workshop participant from the national radio station said that she wanted to announce the forecast on the radio after the meeting but never received the forecast she asked LMS to fax.

It was clear from initial research that forecast awareness is not well established in Lesotho. In order to investigate why this is the case, users' perceptions of the effectiveness and efficiency of seasonal forecast dissemination need to be elicited.

Box I

Press release issued on 1st November 2001 by Lesotho Meteorological Services

The Current Climate Situation in the Country
[First section: description of the rainfall from the previous decad (10-day period) and predictions for the next decad].

Meanwhile, last week on 25th October 2001, Lesotho Meteorological Services held a workshop to issue the seasonal rainfall outlook. It is expected that for October, November, December rainfall and temperatures will be normal to above normal.

The current climate situation will have positive effects on moisture availability, which is favourable for agriculture and water resources. It is also expected as per the outlook that these conditions will be sustained throughout the agricultural season. However, expected hailstorms will have negative effects on agriculture.

Issued by Head of Lesotho Meteorological Services.

4.1. THE FORECAST FROM LESOTHO METEOROLOGICAL SERVICES' VIEWPOINT

The LMS climatologists mentioned over twenty stakeholders whom they thought used the forecast. These included many government organisations involved with food distribution and planning, disaster planning, water management, agriculture and tourism, as well non-governmental stakeholders such as media representatives, students, planning bodies and farmers. They thought the information was used for planning, advising others, general awareness and management strategies and that other stakeholders, such as constructors, industry, electricity department, police department, telecommunications and education could receive and benefit from the forecast in future.

The climatologists identified a number of constraints that they viewed as hindering present forecast awareness and uptake. These included:

- Poor understanding of the forecast.
  The forecast is issued in English not Sesotho and uses technical language (as seen in Box I) that expects a common understanding of words such as normal.
- Inappropriate product.
  The timing of forecast delivery, its variable skill and its course spatial resolution result in the forecast being a product that is not suited to all users.
- Poor dissemination.
  Potential users do not know about seasonal forecasts, where they can be obtained or how they might be used.

The climatologists suggested that in order to improve forecast dissemination, LMS needed to concentrate on three areas: the internal workings of LMS; the interaction between LMS and stakeholders and the role of stakeholders in disseminating the information and feeding back to LMS. Three suggestions were provided as to how these areas could be improved:

1. LMS could improve the forecast product. Increasing the number of meteorological stations and training observers to take more accurate measurements could improve the quality of data fed into the forecast models. The timing of forecast delivery could be improved by disseminating the forecast as early as possible but more staff would be needed.
2. Communication between LMS and the public could be improved. Increasing public awareness of the services that LMS offer could be achieved by the distribution of pamphlets, advertisements on the radio or workshops for users (where the technical language and potential uses are unpacked). Traditional methods, such as *pitsos* (community meetings) that are presently used in the villages to inform the community about a wide variety of issues, could also be used. Stakeholders' contribution to forecast dissemination needs to be explored further. LMS cannot reach all potential end-users given their current resources, so in order to reach greater numbers of end-users, stakeholders' roles needs to be strengthened and feedback mechanisms made available so that future dissemination could be more effectively targeted.

4.2. THE FORECAST FROM THE STAKEHOLDERS VIEWPOINT

The stakeholders that are presently in contact with LMS and have heard of, or used, the forecast span a range of sectors from food security to agriculture to water management. The type of climate information that stakeholders desire is noted in Table I. The information that would be most useful varied considerably between stakeholders. The role that stakeholders see themselves playing also varied. It is clear that some want to pass on information, while others want to use it themselves.

In the surveys, all except one of the twenty respondents said that they would like to receive the seasonal forecast. Only two respondents said that they did not want to hear the forecast if it only predicted the actual climate for three out of every four years. The preferred method of receiving the forecast was in bulletin form (stated ten times), as it provides something to refer back to. Email and fax were listed as being the second and third most preferred way of receiving the forecast and the national workshop and personal visits to LMS were also cited. The month that people most wanted to hear the seasonal forecast varied immensely. The preferred months to receive the forecast were July and August, both mentioned five times, followed by September and then the desire to hear it every quarter.

Although there is demand for the forecast, explanations of how the forecast is used at present are more revealing. There were not many concrete examples of this and so investigation on past behaviour related to the climate was explored. Stake-

Table I
Examples of the type and use of desired climate information

Sector	Information desired	Reason
Land-use planning	Rainfall distribution Temperature during critical periods	Planning woodlots and cropping guidelines Frost limits many activities
Food distribution	The local climate	Plan movements because we contract private transport
Agriculture	Seasonal forecast	Pass on to farmers so they can make appropriate decisions
Disaster planning	None	Already get everything we need
Water management	Predicted rainfall	Pass on to stakeholders
Commercial farmer	The rainfall prediction and what happened	Assess the effects and what should be done next time

holders were asked what they would do if below normal rainfall was predicted. They were also asked what they would have done differently if they had had a forecast of the previous year's climate, when it had been a dry winter but good rain came late in November. A selection of responses is presented in Table II. This illustrates that there is the potential to integrate forecast information into management plans and implementation strategies, as stakeholders already have options for how to respond. Although people have argued that in developing countries there are often not the resources to pursue the desired response (Hulme et al., 1992; Vogel, 2000), the table indicates that there are many strategies that can be undertaken with few resources. Organisations often have access to credit and aid that allows precautionary measures to be put in place, which individuals often can not do.

The climatologists' and stakeholders' perceptions provide an important introduction to the problem of forecast dissemination. Stakeholders want to hear the seasonal forecast but they are not satisfied with the timing and form. Dissemination between users is limited which contributes to poor awareness and utility. It is primarily the stakeholders who attended the workshop that know about the forecast. In order to establish whether LMSs' suggestions for dissemination are viable the existing networks need to be better understood. This is done using stakeholder characterisation that is used to build up network characterisation to illustrate how stakeholders are connected within existing communication networks. This provides an analytical lens for focussing future forecast dissemination and adaptation strategies.

Table II
Adaptation strategies for previous year and drought years

Actions undertaken if below normal rainfall is forecast	Actions that would have been implemented if the previous year's climate were known in advance
Warn government of expected bad harvest; Follow up information at clinics as disease often increases	Would have advised those in flood plains of high waters and depths
Calculate how much food will be needed	Would have ensured a better stock of food aid
Advise farmers to grow fodder and different crop varieties, such as sorghum	Would have prepared land earlier
Get milk powder stocks in early before price rises	Would not have secured contracts
Have meeting with other bodies to strategize and form a task force	Would have advised farmers of appropriate pastoral strategies, such as later shearing of sheep and different grazing patterns
Advocate wise use of water	Would have used more water earlier if we had known that the dame would fill up again

5. Analysis

5.1. STAKEHOLDER ANALYSIS

The characteristics of stakeholders determine how forecast information is received, used and further disseminated. This section characterises stakeholders according to different levels depending on their status (private, public or parastatal) and their scale (as a function of their operations within the national system). Stakeholders' use and demand for climate-related information is then discussed. Their attendance at the national workshop, and so whether they received the seasonal forecast, is also documented.

Five levels, determined by stakeholders' scale of action and whether public or private, are used for the initial classification of stakeholders. Level 1 is where the forecast originates, which in Lesotho is the LMS. Level 1 is embedded in the regional context to include forecast input from SARCOF (Southern African Regional Climate Outlook Forum) and international forecast organisations. The second level represents governmental stakeholders that operate at the national level. These differ from the third level, which are non-governmental national stakeholders. The fourth level in the network represents district level stakeholders (both public and private) whose influence covers a smaller area than national-level stakeholders. The fifth

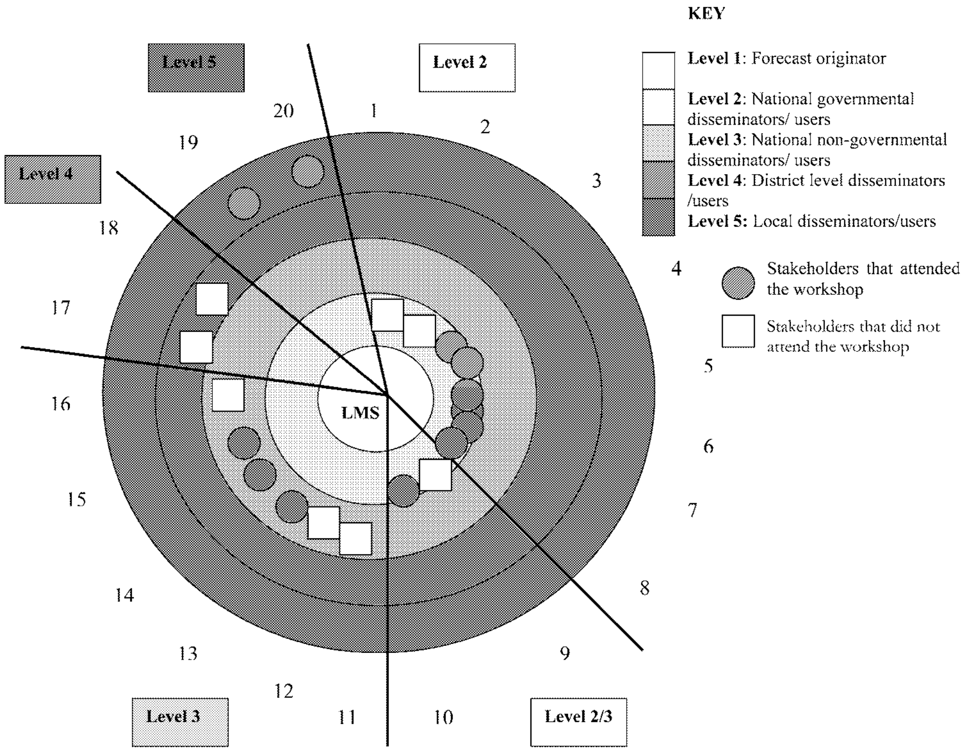

Figure 2. Mapping of stakeholder levels and attendance at the national forecast dissemination workshop.

and final level in the network are the local users/disseminators that have the smallest geographic influence. They are likely to be 'furthest away' from the central national location from which the forecast originates, both geographically and in terms of the time information will take to reach them. Table III provides details on whether users are public, private or parastatal, whether they said that they use the forecast or not and which sector they are in. This data has been converted to a simple graphical sociogram in Figure 2. This enables a visualization of the range of stakeholders, the levels in which they are situated and which of these stakeholders attended the forecast workshop.

Level 1 is the forecast originator. In Lesotho this is the responsibility of LMS who are based in the Ministry of Natural Resources (Ministry of Natural Resources, 2000). They have produced forecasts since 1997 and independently since 1998[6] but not many people have heard of seasonal rainfall forecasts. Those that have heard predictions of how much rain there might be in the rainy season have heard the information from the workshop, on the radio or from occasional bulletins such as the ones the Disaster Management Authority (DMA) issues. LMS produces an agro-meteorological bulletin every ten days in the rainy season. It includes the

Table III
Stakholder profiles and network levels

No.	Interviewees	Status	Scale	Level	Workshop	Use
	Lesotho Meteorological Services (LMS)	P	N	1	Y	–
1	Agricultural Crops (MoA)	P	N	2	N	S
2	Agricultural Field Services (MoA)	P	N	2	N	S
3	Agricultural Planning (MoA)	P	N	2	Y	Y
4	Department of Science and Technology	P	N	2	Y	Y
5	Disaster Management Authority (DMA), Early Warning Unit	P	N	2	Y	Y
6	Food and Nutrition Coordinating Office (FNCO)	P	N	2	Y	S
7	Groundwater, Department of Water	P	N	2	Y	Y
8	Land use planning department	P	N	2	Y	S
9	Lesotho Highlands Development Authority	Pa	N	2/3	N	S
10	SADC water sector	Pa	R	2/3	Y	S
11	Food and Agriculture Organisation (FAO)	Pr	N	3	N	N
12	Red Cross Lesotho	Pr	N	3	N	N
13	Joy Radio	Pr	N	3	Y	N
14	Lesotho News Agency (LENA)	Pa	N	3	Y	S
15	Lesotho Dairy Products	Pr	N	3	Y	Y
16	Lesotho Flour Mills	Pr	N	3	N	N
17	Extension agents	P	D	4	N	N
18	Pannar seeds, Mohales Hoek	Pr	D	4	N	N
19	Maqalika agricultural consultancy	Pr	L	5	Y	Y
20	Commercial farmers	Pr	L	5	Y	Y

Status: Public (P)/private (Pr)/parastatal (Pa).
Scale: Local (L)/district (D)/national (N)/regional (R).
Level: Forecast originator (1)/ National governmental disseminators or users (2)/National non-governmental disseminators or users (3)/District level disseminators (4)/Individual end-users (5).
Workshop: Attended (Y)/Did not attend (N).
Use (in 2000): Sometimes use (S)/Do use (Y)/Do not use (N).

forecast and the past climate history but unfortunately it does not get disseminated due to lack of personnel and resources.

Level 2 are the national governmental disseminators/users. The Early Warning Unit, which is part of DMA, has the most interaction with LMS as they have staff working in LMS. They are a national branch of the Zimbabwe-based Regional Early Warning Unit (REWU) and so linked to the regional stakeholders. DMA is responsible for producing Quarterly Bulletins and monthly updates of the current status of food supplies, agriculture and climate as well as potential disasters. The climatic data (including seasonal forecast information) comes from LMS and is reported on in the bulletins that are disseminated to over a hundred stakeholders from different sectors.

The Ministry of Agriculture (MoA) is the most dominant stakeholder in the agriculture sector. Since Lesotho's independence in 1966 it has been one of the biggest line ministries, employing over 3,500 people and consisting of eight divisions plus an agricultural college (Chakela, 1999). At present the forecast reaches top-level management who attend the workshop but they do not seem to pass it on to others in their divisions. The divisions could have different roles when it comes to forecast dissemination and use. Divisions such as field services, research, crops and livestock could be directly involved in disseminating the forecast (particularly the field services division that has district level offices) and providing advice on how best to use the forecast in the different sectors.

Water-related stakeholders have an interest in the forecast because it allows them to manage their resources. A representative from the Groundwater Department, who attended the workshop, said that they were interested in the forecast for planning purposes because it would enable them to assess how much water would be available from boreholes over the season. They are positioned at Level 2 but seem to have little interaction with other stakeholders who are interested in climate information. Lesotho Highlands Development Authority (LHDA) is responsible for managing the Lesotho Highlands Water Project, which is one of the largest inter-basin transfers world-wide. LHDA straddles Levels 2 and 3 as they are a semi-parastatal. They value the forecast for planning purposes so that they 'can deliver a schedule' of how much water to release and when. SADC water sector also straddles Levels 2 and 3. They are involved in regional and national planning. They felt the forecast was important to them because of the coordinating role they play within Lesotho and SADC but the first time they heard the forecast was at the 2000 Workshop. They saw themselves being able to play a role in disseminating the forecast to other stakeholders such as water suppliers.

Level 3 are the non-governmental disseminators/users that include media, development organisations and industry. Although it is the media's role to disseminate information, they said they found it hard to understand what the forecast meant and subsequently had not always announced it on the radio although they had read out press releases from LMS. The director of LMS has spoken on the radio and mentioned the forecast a few times a year but no programmes deal with it explicitly.

Industry users are more interested in the forecast for personal use than disseminating it to other users. The manager of Lesotho Dairy Products thought that the forecast would be very helpful for planning milk supplies and demand. They have found the supply of milk to be correlated with the amount of rainfall and demand to be correlated with temperature and rainfall. They saw the forecast as a chance to gain a competitive advantage in planning their operations. Lesotho Flour Mills on the other hand, where not as interested in the forecast for Lesotho. They are heavily dependent on the maize situation in South Africa, as Lesotho is not self-sufficient in maize and so they import large quantities of maize and prepare it in Lesotho (Chakela, 1999). They said the forecast might be useful in decreasing uncertainty when securing forwards. They did emphasise that if they failed to deliver they would loose out which is why they are sceptical. The forecast for South Africa was of more interest to them.

Level 4 are the district level users/disseminators. Lesotho is divided into ten districts. At the district level, the MoA plays a major role as each district has offices where the District Agricultural Officer (DAO) and a number of extension agents are based. Field-based staff were not aware of seasonal climate forecasts as a product that was developed and issued by LMS. Some said that they had heard something about whether there would be a lot or a little rain on the radio but they did not know where they could get further information from.

Non-governmental organisations (NGOs) play an important role at the district level as that is the level that projects are implemented at and where a lot of aid money is concentrated (Ferguson, 1997). Most of these NGOs seem unaware of the forecast. Research done with the CARE Lesotho staff gave a mixed signal as to what they felt their role could be in disseminating the forecast (see Ziervogel, in press). Some felt that they could be informed about the forecast and pass it on to farmers with whom they work. Others emphasised the focus on experiential learning and non-dependency and felt that farmers should hear the forecast from other sources and then ask advice from the CARE staff, which they would be willing to provide if they could. NGOs often have better resources than government institutions to implement communication systems, which means that they could be targeted as key disseminators of the forecast that could be more effective and equitable.

Input suppliers could play an important role in passing on information, particularly to farmers. When farmers are choosing which inputs to purchase they are in direct contact with input suppliers and so could receive advice on appropriate seeds for dry conditions for example. Pannar seeds and other district level input suppliers have no apparent knowledge of the forecast. A national level government input supplier distribution point is run by the MoA and sells subsidised fertilizer and seed as part of a Japanese aid project. One of their employees had attended the October workshop, but said that he did not pass on forecast information to farmers as he felt that although the forecast information was interesting, he was not going to change the advice he gave on what seeds to use based on the forecast but would stick to making suggestions according to the geographic area and soil type of the fields as he had done in the past. This shows how sceptical of change people are when faced with new information.

Level 5 are the local users/disseminators. They access and use the forecast in their personal capacity. They include subsistence and commercial farmers, the manager of a dam or the head of a rural clinic. A handful of small commercial farmers[7] have used the forecast in previous years. Most of them are based near Maseru and have attended the national workshop or contacted LMS directly for updates. But few subsistence-level farmers have received the forecast. They are an important group to consider when targeting forecast information, as they are highly susceptible to climatic variation (Scoones, 1997). Farmers could use the forecast for planning activities such as crop rotation, timing and amount of inputs, water resource management or market analysis for example. Although there may be other constraints before the forecast can be factored in to decision-making, it is often these stakeholders that need additional information to offset risk as much as possible. At the same time, their vulnerability means that they should not be subject to the incompetencies that might accompany pilot dissemination methods. To include subsistence farmers in forecast dissemination networks requires an understanding of the existing networks.

5.2. NETWORK ANALYSIS

Stakeholder characteristics from the previous section are used to describe the nodes and establish the relationships that exist between stakeholders. The type of node is critical when trying to understand how existing networks operate and how future networks might be best developed. An illustration of the linkages, graphically represented using sociograms which map stakeholder interactions and the type of interaction, helps to highlight the interconnectedness or disconnect between stakeholders in the forecast dissemination network. This graphical representation promotes the recognition of patterns that might be missed in qualitative analysis.

Network nodes can be characterized into typologies. Two types of nodes facilitate further dissemination and two types terminate dissemination. Further dissemination can either entail changing the information before passing it on so that it becomes value-added (node i) or passing on the forecast as it is with or without using it (node ii). For example, value-added information could be passed on which might suggest how water managers could manage their dams according to the forecast or the forecast could be passed on in the same form as when the disseminators received it and the managers could decide for themselves how they want to use the information. If the forecast is received but not disseminated it terminates. It might or might not be used (node iii and node iv respectively) before it terminates. For example, stakeholders might use it but have no incentive to disseminate it further

Table IV
Stakeholder node typology

Node i – Added value (effective node ii – Pass on as is (disseminate) dissemination)	
Lesotho Highlands Development Authority	Disaster Management Authority
Maqalika consultancy (agriculture)	Food and Nutrition Coordinating Office (FNCO)
Commercial farmers	SADC water sector
	Lesotho News Agency (LENA)
Node iii – Use and do not pass on (terminate)	**Node iv – Interrupted (terminate)**
Agricultural Planning (MoA)	Agricultural Crops (MoA)
Department of Science and Technology	Agricultural Field Services (MoA)
Groundwater, Department of Water	Land use planning department
Lesotho Dairy Products	Joy Radio
Node v – Do not receive	
Food and Agriculture Organisation (FAO)	
Lesotho Flour Mills	
Extension agents	
Pannar seeds	

and so it would terminate. Or, they might not use the forecast they receive because it is inaccessible and inappropriate or merely because they are not interested in it. The last type of node (node v) is when the forecast is not received at all. The node typology and associated stakeholders are shown in Table IV.

The way the forecast is disseminated determines what channel of information transfer prevails. At present, dissemination in Lesotho occurs via the national workshop, bulletin, word-of-mouth and the radio. The existing channels are mainly one-way transfers of information, which makes effective communication difficult (Rogers and Kincaid, 1981). It is only the national workshop and word-of-mouth that allow for two-way communication and for recipients to ask questions. If dissemination networks are to improve it is necessary that more feedback opportunities exist in order for users and disseminators to query the information received and to comment on how the existing systems could be improved.

Stakeholders have different perceptions on how they might use the forecast and this will have an impact on whether they will disseminate the information or not. The public sector and governmental stakeholders emphasised the planning aspects of forecast use and often viewed the forecast as general information that might encourage an existing decision rather than prompting new ones. Private stakeholders on the other hand are more interested in using the forecast for management and operational decisions and personal use. They are also more engaged with the market than the governmental stakeholders, who tend to be more engaged in policy. Bureaucracy seems to hinder governmental stakeholders more than others, which can lead to a retarded process of competitiveness. District-level stakeholders, such as the District Agricultural Officers and the CARE staff, are more interested in their role as disseminators as opposed to users of the information. Local stakeholders are interested in the forecast for planning and operational decisions but will only use the information if it is not too risky and they have the resources to do so.

These stakeholder and network characteristics have been combined to produce a sociogram of the existing forecast dissemination network in Lesotho (see Figure 3). This builds on the earlier simple sociogram (Figure 2) that illustrated the individual stakeholder characteristics. Figure 3 includes the earlier characteristics of the stakeholder levels but now incorporates interaction between stakeholders by including the type of node of forecast dissemination and the channel of information transfer between stakeholders. If the forecast is passed on, examples of the recipients are included. The sub-networks of existing stakeholder networks are overlain on top of the seasonal forecast dissemination networks. This is explained further below.

It is evident that although all the stakeholders are mapped on to one network they do not all interact with the same stakeholders in the network and some channels are stronger between some users than others. For this reason, the next logical step is to distinguish which stakeholders interact with each other, not only with regards to disseminating the forecast but also for other purposes. These interactions are not explicitly included in Figure 3, as it would make the figure too complicated. Rather, they have been abstracted by incorporating users that interact in sub-networks into polygrams. Because these sub-networks exist for other reasons the links between these stakeholders already exist. For example, agricultural extension networks span from governmental national stakeholders to district level stakeholders to local stakeholder such as farmers. This existing network is not presently used for forecast dissemination even though it is one of the few networks that spans the different levels. The sub-networks that have been hypothesised include the government-policy sub-network, the agricultural-extension sub-network, the media sub-network, the market sub-network and the commercial farmers sub-network. It is possible that stakeholders can be part of more than one subset. For example, a commercial farmer might receive information from the extension agents and so be part of that network as well as being in the sub-network with other commercial farmers and with the market. The media stakeholders might receive the forecast from LMS or from the government-policy sub-network via the DMA bulletin for example. If they were a potential key disseminator, a special effort would be required to ensure that they did receive the forecast. In theory, the governmental departments are closely linked, which should make communication between them straightforward. The non-governmental stakeholders, on the other hand, do not have official communication pathways with the government stakeholders in place and so might need to assume a more proactive role of initiating contact with the

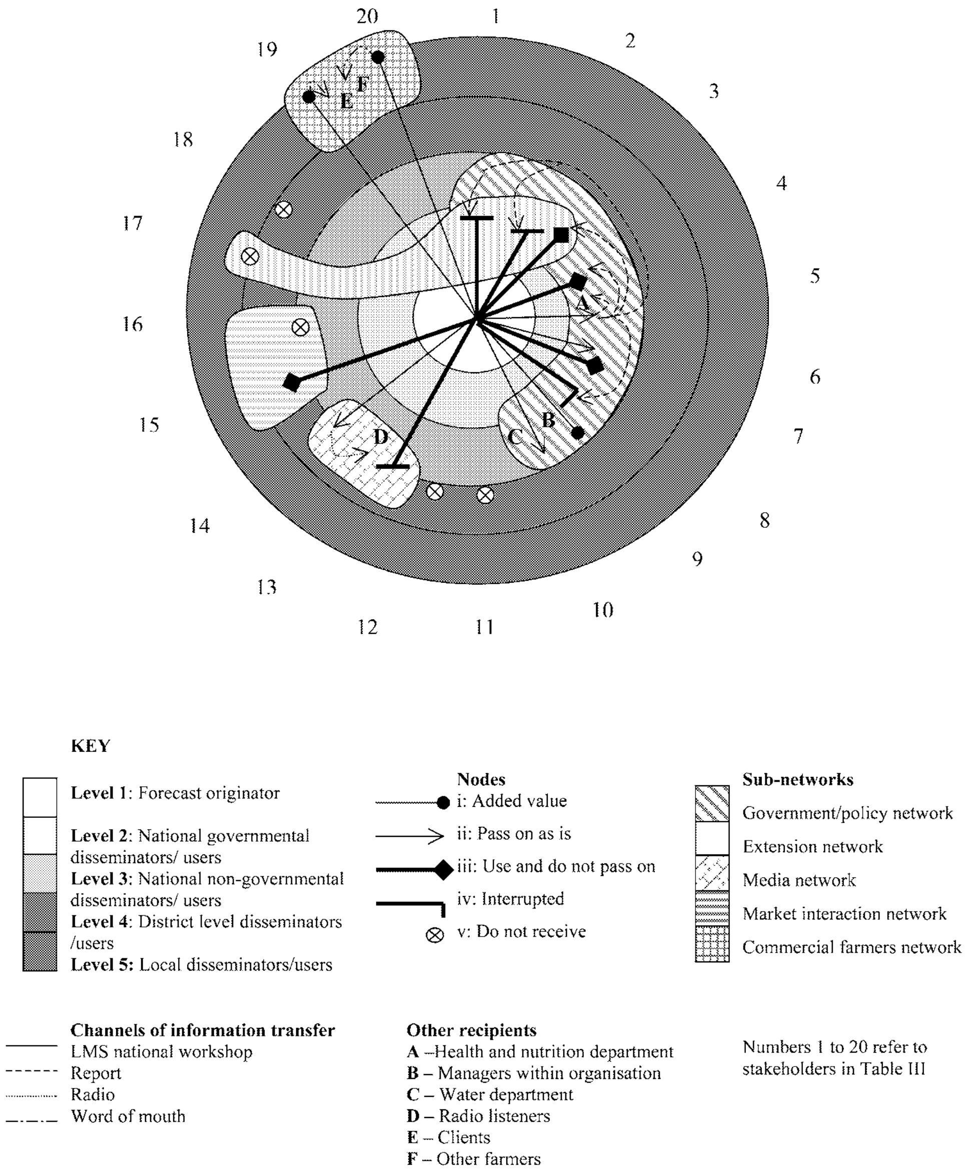

Figure 3. Stakeholders and sub-networks in Lesotho's forecast dissemination.

national originator and maintaining communication if they wish to receive the forecast. Horizontal linkages, between stakeholders that operate at the same scale, for example two development NGOs and hierarchical linkages between stakeholder operating at different scales but interacting because of a common interest, such as agriculture, could be a starting point for targeting existing networks.

The existence of sub-networks emerges as having a more important role than one national forecast dissemination network. Although some stakeholders might be involved in more than one sub-network, others might not be. If the channel between disseminators and recipients breaks down, it is important to know which sub-networks include which stakeholders and so whether or not they are likely to receive the information from another source. Once there is effective dissemination within sub-networks the logical progression would be to focus on stakeholders who are in more than one sub-network. These stakeholders could be key nodes in linking the sub-networks as they potentially speak both languages.

Social network analysis asserts that where people are placed in the social network determines what information they are exposed to (Rogers, 1995). This is relevant in the case of forecast adoption, as those stakeholders that could potentially use the forecast but are not exposed to it or to demonstrations of its applicability, are less likely to adopt it. Figure 3 illustrates that there are a number of users at the district and local scale that do not receive the forecast, although the interviews indicated that they were interested in receiving them. This is important to consider for issues of equity. If there are sub-networks that could benefit from the forecast but are not likely to have adequate exposure to adopt it spontaneously, efforts would need to target those groups to illustrate forecast use. Those sub-network stakeholders could then make the decision as to whether or not they will use the forecast.

Individuals often wait until the most influential members adopt the innovation (Rogers, 1995). In Lesotho there do not seem to be many stakeholders who have adopted the forecast, benefited and whose experience is widely known. Village-based fieldwork suggests that farmers want to hear the forecast and have strong preferences for how they want to receive it. Many indicated that they would prefer to hear forecasts for above normal rainfall rather than for below normal rainfall, which is not necessarily expected (Ziervogel, in press). One commercial farmer has applied the forecast successfully and he has told a number of other farmers who have subsequently adopted it but the critical threshold has not been reached (Valente, 1996). The nature of the forecast product, such as its limited skill at the local scale or its probabilistic nature, might mean that a critical threshold will never be reached and so adoption will not be widespread. What matters is that effective and efficient dissemination is a goal so that stakeholders, including those on the outskirts of the physical and information networks who are often already worse-off, can receive the forecast and choose whether or not to use it rather than decide indirectly by never receiving it.

The dominant technology transfer models can be identified from the network analysis. The ‘Appropriability model’ that claims that the utility of the product should sell itself is not a suitable model for assessing seasonal forecast adoption in Lesotho. The ‘Contextual adaptation model’ is more appropriate as it asserts that the nature of the innovation has to be compatible with user characteristics (Rayner and Malone, 1998). This was evident in the sense that stakeholders who saw no way of applying forecasts did not think that it was useful but those who had options on how to use the forecast were more interested. If examples existed as to how the forecast had been successfully used by other stakeholders it is more likely that adoption would increase.

6. Conclusion

Forecasts have the potential to alleviate some of the impact of climate variability. Without engaging the existing network of users it is unlikely that forecasts will reach users in an effective and efficient manner. The case of stakeholders involved in forecast dissemination and use in Lesotho gives prominence to different stakeholder needs and perceptions and the varying roles that stakeholders play in the existing network. Private and public stakeholders want to use the forecast but the mechanisms are not in place for them to receive it efficiently and advice is not available on how to use it effectively. The networks that are in place may also be inappropriate. As suggested earlier, farmers had a preference for above normal forecasts, yet early warning systems are more focused towards disaster management and drought warnings, and so these networks might not address user needs sufficiently. The institutional arrangements in Lesotho make it easier for national governmental disseminators/users to receive the forecast than non-governmental stakeholders or local users. At first glance it might appear that if more resources were spent on the development of seasonal climate forecasts, awareness would improve but if the networks are not understood dissemination could be inefficient and inappropriate. In order to avoid this, an ongoing communication process between forecast provider, disseminators and users is required. If smallholder farmers are a particular concern it will not help to focus on general dissemination strategies but rather on targeting the needs and the networks within which the smallholder farmers are already situated.

The 'Contextual adaptation model' seems to be the appropriate model of technology transfer for Lesotho as users want the information to fit with their demands. Although LMS has recognised the importance of communicating with users, their communication is not efficient. They suppose the forecast will 'sell itself' which means they are assuming the 'Appropriability model' (Agrawala and Broad, 2002). This misperception is likely to be matched with unsuitable and unsuccessful forecast development approaches. Different sub-networks might also be at different stages of the technology adoption continuum and so have different needs and cultural models. This will require dissemination to be tailored to user groups so that the forecast is best understood.

Stakeholder network analysis, supported by Figure 3, illustrates the clear existence of (1), a lack of effective dissemination between a diverse range of stakeholders that are interested and affected by climate variability and (2), the occurrence of sub-networks that exist for other purposes but could be used to disseminate forecast information. These results have policy relevant conclusions. The key users of this information would be LMS that could use the results of the network analysis to focus their development strategies. LMS recognise that stakeholders' role in facilitating dissemination needs to be strengthened but they do not have means for targeting specific stakeholders. The network analysis suggests that if one sub-network was targeted, more effective dissemination could be expected within that group. Policy could therefore support the improvement of dissemination with key stakeholders and sub-networks. For example, LMS could start by increasing efforts to target the agricultural sub-network, with whom communication channels already exist. At the same time, the stakeholder network showed a distribution of nodes and sub-networks between levels. The relevance of this is that effective dissemination will only filter from the national bodies to local users (Level 1 down to Level 5, as seen in Figure 2) if national and district levels are overtly involved (even if there is a focus on one sub-network). At the same time the importance of communication should be stressed: communication codes need to be shared in order for networks to be efficient (Rogers, 1995; Castells, 1996). Given this, the use of communication channels that offer feedback opportunities, such as workshops, should be prioritised if the resources exist.

Seasonal forecasts are a relatively new form of information so it is not surprising that there is lack of awareness about the seasonal forecast and that adoption is not widespread (Blench, 1999; Murphy et al., 2001), although the suggestions made above could contribute to improving awareness and adoption. Although the stakeholder network analysis has provided insight into how the network of users of seasonal forecasts could be improved, it has limitations. Although it focuses on the type of dissemination of the forecast and on interaction between various stakeholders, it has a limited ability to pick up some of the institutional and cultural factors that may constrain improved dissemination. Further research is needed to consider why information is not better disseminated (including details on gender, power and resources) and how information conduits between and within each subset can become more effective. It might help to evaluate cases of other types of information or products where dissemination between subsets of the network has been effective. More comprehensive inventories of stakeholder profiles would provide more complete analysis of sub-networks and so foster the development of dissemination strategy links between sub-networks, which could contribute to national and regional networks.

More insight could be gained into prospective dissemination networks' success by using social simulations and multi-agent systems. Formal testing would allow for networks to be modelled, which could capture how efficient information dissemination compares to inefficient information dissemination. These social simulations would enable different stakeholders to act according to different rules. If STNs are essential to processes of adaptation to climate impacts and risks, then there is a need to incorporate actors and their relationships in formal models of climate impacts. Pursuing a formal method has advantages in exploring alternative futures, increasing the number of actors, linking risks and responses and communicating opportunities to the diversity of potential users (Downing et al., 2000).

Lesotho is not alone in facing hindrances towards the efficiency of her information networks. It is a problem that has been recognised for most developing countries, particularly in southern Africa. Sivakumar et al. (2000) state that the strengthening of agrometeorological networks is necessary to promote sustainable agriculture worldwide. One of the key conclusions in Gibberd et al.'s (1996) 'Drought Risk Management in Southern Africa' is the need for institutional development and appropriate investment of meteorological institutions. Stakeholder thematic networks provide a tool for understanding the nodes and channels and weaknesses of information flow that compose the network of forecast dissemination. This provides a spring board for targeting future forecast dissemination, which is imperative if this information is to be of use, particularly to marginal groups. This tool could be used more extensively in future for determining the extent to which existing networks can be used and determining how networks need to adapt to address stakeholder profiles. This is particularly important in the sciences where different levels of disseminators and users might not speak the same language.

The experience with developing seasonal climate forecasts is relevant to adaptation policies for climate change. The United Nation Framework Convention on Climate Change (UNFCCC) is promoting National Adaptation Programmes of Action (NAPAs) for Least Developed Countries (LDCs). The agreed NAPA guidelines prioritise measures that reduce current climate vulnerability. The effective use of seasonal forecasts is one way in which vulnerability to future climatic variability might be reduced. More fundamentally, understanding processes of disseminating and using seasonal forecasts provides insight into institutional processes and opportunities that might augment adaptive capacity. From the Lesotho example we would argue that enhancing existing resource management networks, so that they can incorporate the management of climate variability and mainstream climate risk management, is more effective than building parallel networks devoted solely to climate change.

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Notes

1. Dissemination is the directed communication of ideas or products that involve a degree of uncertainty. We refer to dissemination as a type of diffusion (Rogers, 1995).
2. The term stakeholder is used to refer to the individuals and individuals representing organisations who are users or potential users of forecasts and so actors in the forecast system.
3. Although end-user is common terminology, we use user instead of end-user from here on, as all users could be end-users if they didn't pass the forecast on, and similarly all people who receive and use the forecast could pass it on further and so would not be end-users.
4. Basotho is the name given to the people who live in Lesotho. They speak Sesotho.
5. Forecast verification is usually defined as the degree of correspondence between forecasts and observations (Murphy, 1997).
6. In 1997 LMS issued the forecast as presented at the SARCOF meeting, but since then they have adjusted the forecast using their own data and methods.
7. There are very few large-scale commercial farmers in Lesotho due to the poor environment and the competition from South Africa.

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