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Adapting to climate variability: Pumpkins, people and policy

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Abstract

Understanding of how best to support those most vulnerable to climate stress is imperative given expected changes in climate variability. This paper investigates local adaptation strategies to climate variability, focusing on agricultural decision-making in a communal irrigation scheme in Vhembe District, Limpopo Province, South Africa. Research done through interviews, surveys and participatory methods demonstrates that adaptation strategies within a community are socially differentiated and present differing objectives and priorities. These results highlight the need for intervention and policy that support a heterogeneous response to a wide range of stresses. Evidence for climate change is clear and the need for adaptation is urgent. However, adaptation measures have to be sensitively integrated with ongoing development pathways to ensure they are sustainable and relevant to local priorities.

Keywords: Adaptation policy; Climate change; South Africa; Vulnerability; Multiple stresses; Agriculture.

1. Introduction

Climate change projections for southern Africa suggest that variability may increase in the future and that extremes might become more frequent (Tadross *et al*., 2005; Hewitson and Crane, 2006). This type of evidence has resulted in a recent interest in how people and systems respond and adapt to climate variability (Adger, 2003; Adger *et al*., 2005; Berkhout *et al*., 2006; Conway *et al*., 2005; Kahn, 2003; Mortimore and Adams, 2001). Concern has been raised about marginal groups that are dependent on climate-sensitive resources but who do not have the means to adapt fast enough and are thus vulnerable to both current and future climate variability (Adger *et al*., 2001; Downing *et al*., 2005; Ribot *et al*., 1996; Smit and Pilifosova, 2001). Adaptation to climate variability is necessary both to reduce current vulnerability to climatic hazards and stresses as well as to prepare for future climate change. Although development cannot necessarily be made climate-proof, development strategies should acknowledge predicted climate change in order to minimize its impact.

It is of paramount importance that research aimed at supporting adaptation to climate variability among such groups is well-grounded and based on the experience and needs of marginal groups. Not enough attention has been paid to the means which vulnerable people themselves use to respond to stresses (Wisner *et al*., 2004). Additionally, as Pachauri states in the foreword to *Up in Smoke* (Simms *et al*., 2004: 1), "Most notable as a major issue of concern is the nexus between climate change and the widespread prevalence of poverty in the world."

This paper argues that policies for adaptation to climate change must anticipate that climate is only one stress in a complex environment. This presents a challenge when proposing specific suggestions on how to improve capacity to adapt to climate change at either the local or the national level. Stakeholders in various sectors are impacted by climate and employ a variety of approaches that are relevant to their context, enabling them to address challenges and respond to multiple pressures (Adger *et al*., 2005; Anderson, 2003). As climate and climate variability change over time, resource managers, from vulnerable local populations to international policy makers, must be prepared to alter their strategies accordingly.

In order to support adaptation to climate variability, it is necessary to understand the vulnerability of the system or actors of concern. Although vulnerability has numerous definitions (See Bohle *et al*., 1994; Downing *et al*., 2005b; Kelly and Adger, 2000; O'Brien *et al*., 2004; Wisner *et al*., 2004), it is viewed here as the degree to which people or the environment are susceptible to harm. This definition acknowledges both the external exposure to hazards or stress and the internal ability to cope, recover, or adapt to such stresses, which is linked to the sensitivity and resilience of the system (Kasperson *et al*., 2005). The

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sensitivity can be seen as the likelihood of negative impacts occurring based on endogenous characteristics, while the resilience is the ability of the actor or system to absorb or adapt to stress (Adger *et al.*, 2004; Brooks, 2003). Increasing adaptive capacity can therefore increase resilience, by enabling change to have positive or limited impacts (Sharma *et al.*, 2005). Building on the definition of vulnerability above, it is recognized that vulnerability is dynamic and can be constructed simultaneously at a number of scales and for multiple stresses (Downing *et al.*, 2006; Leichenko and O'Brien, 2002; Reid and Vogel, 2006; Ziervogel *et al.*, 2006).

The adaptive capacity determines the nature of adaptation strategies. In the climate change context, effective adaptation strategies are those that reduce present vulnerability at the same time as decreasing vulnerability to future climate change (Huq *et al.*, 2003). In order to reduce misunderstanding, adaptation nomenclature helps to systematize defining the adaptation process (Ionescu *et al.*, 2005). An actor-oriented approach reflects agency and purposeful action in a dynamic way. An 'actor' may possess an adaptation strategy which is a part of a set of actions that an actor can choose from, that leads to a specific response or adaptation action that can be implemented by the actor. Each of these actions includes several attributes, such as information or resources required to enact the action as well as expected outcome and links to other actors. Responses build on existing strategies and sets of strategies that are often complex, differentiated and frequently overlapping.

Urgent or political needs tend to be addressed first and the short-term urgency of climate change is not always apparent. Developing countries are often lacking the necessary institutions or people to deal effectively with climate-related priorities (Adger *et al.*, 2005; Clover, 2003; Ziervogel and Downing, 2004). Yet social capital and efficient institutional networks are key to developing adaptive capacity in response to climate change and other stressors at all levels (Adger, 2003; Brooks *et al.*, 2005; Pelling and High, 2005; Tompkins *et al.*, 2002). Additionally, climate change adaptation has tended to focus on individual and sector-specific aspects rather than exploring the broader institutional arrangements that could be renegotiated to decrease vulnerability (Thomalla *et al.*, 2006). Cross-scalar solutions need to be sought (Adger *et al.*, 2005). Climate change adaptation rhetoric needs to be more closely linked to political ecology, sustainable development and development policy initiatives in order to seek win–win solutions at multiple scales (ADB *et al.*, 2003; Munasinghe and Swart, 2005; Simms *et al.*, 2004).

Climate-related interventions therefore need to be integrated into development planning and support poverty-reducing and development initiatives that are ongoing and have institutional support (Burton *et al.*, 2002; ADB *et al.*, 2003). This can help support the goals of addressing issues of equity and distribution of benefits in climate adaptation policy (Adger *et al.*, 2006; Paavola and Adger, 2006; Thomas and Twyman, 2005).

The emerging field of adaptation policy supports the need for involvement of targeted beneficiaries and an understanding of local vulnerability to build our understanding of adaptation to climate change (Huq *et al.*, 2003; Lim *et al.*, 2005). Some least developed countries (LDCs) have started to explore national priorities for adaptation and have developed national adaptation plans of action (NAPAs) (Huq *et al.*, 2003). However, the need still exists to do further work on understanding the existing dynamics of adaptation before projects are initiated. This understanding should provide the basis for developing an adaptation policy to climate variability that aims to reduce vulnerability and human insecurity (Sharma *et al.*, 2005). Case study evidence is therefore critical in helping to illustrate local dynamics and underlying vulnerabilities that need to be acknowledged before pursuing adaptation support.

2. Case study: Mangondi Village, Limpopo Province, South Africa

Mangondi Village is situated within Vhembe District, Limpopo Province, in the north-east region of South Africa. Parts of Vhembe District formed the Venda homeland, established under apartheid, where black households were relocated to restricted areas. Limpopo Province is known for its livestock farming in the northern, drier parts, timber plantations in the southern areas, the Kruger National Park game reserve in the east, and for its fruit industry in the central zone, where Vhembe District is located. Large-scale commercial fruit farms produce mangoes, bananas, macadamia nuts and avocados.

Mangondi is a village of 400 households and around 2,000 people. Among Vhembe villages, it is not particularly vulnerable. It has good access to the nearest town, Thohoyandou (14 km away), it is near to a river that provides a constant source of water, and it receives enough annual precipitation for rainfed agriculture and livestock production, which most households engage in to some extent. Employment, both formal (in nearby and distant towns) and informal, provides income for many households, as do social grants (pensions, child, foster care and disability grants). Of the 51 people interviewed, 20 households had a member engaged in formal employment within the province and 7 had members working in Gauteng. Twenty-six of the 51 respondents indicated that someone in their household was receiving a state grant.

Many previously disadvantaged farmers in the area are engaging in commercial agricultural operations, supported by increased access to resources such as irrigation, though often through donor or government sponsored projects. Although there has been an increase in productivity among many of these farmers, they still face many constraints. A key constraint is the high climate variability, with numerous droughts and floods having occurred in past decades (such as floods in 2000, drought in 2002/2003). Other common stressors, such as restricted land availability, political instability, market fluctuations, globalization, and HIV/AIDS, place additional strains upon agricultural production.

Mangondi has an annual rainfall of 847 mm that falls predominantly in the summer. Climate observations show that the onset of the rainy season (usually around September) is starting later than it used to. In addition to this, climate change predictions suggest increased late summer rainfall (around March) and an increase in average temperature (Tadross, 2006). The high climate variability in Limpopo determines the types of crop grown. As indicated by one of the farmers, “During drought, carrot, beetroot, cabbage and spinach do well. Chinese (lettuce) can’t survive high temperatures but spinach can”. According to local farmers, when rainfall is average, maize grows well if the land is in good condition, although the yield (around 1 ton/ha in a good year) is considered low by international standards. Maize is grown primarily for home consumption, while other vegetables are grown both for consumption and sale.

A communal irrigated farming project was initiated in Mangondi in 1993 by the Department of Welfare. As the project developed, additional government departments got involved in helping with the water supply infrastructure and in 1996 the Jewish National Fund of South Africa and ABSA bank provided additional financial support. The project aimed to support women in the production of vegetables to combat malnutrition among children (Archer, 2003). Land for the project was identified and prepared in 1994/5, and in 1996 it was first cultivated by a group of 59 women and 5 men. The garden is easy to access as it is located within walking distance from the village. In the first year of the project, only subsistence crops were planted. In later years, vegetables for sale from the garden or at the local market have been planted.

Of the farmers surveyed, 45 out of the 51 have fields surrounding the village where they grow rainfed crops, such as maize and sorghum. An annually elected committee now runs the project, with limited donor involvement. Each person has their own plot (20 m × 30 m) where they can choose which crops to grow, although the group has contracts that oblige it to provide certain produce to the local school and the hospital for example. Some farmers have more than one plot which enables greater flexibility in choice of what to plant. Community garden sales through contracts are established before the season begins and then individuals are responsible for contributing produce at certain times. Individual sales depend on home consumption needs. People decide on what else they want to plant by addressing the communal commitments first, then the home commitments and lastly private sales. The market for private sales might be local in terms of the village and surrounding villages or at district level, which requires transport to take crops to the market.

Over the years, the success of the project has fluctuated in terms of production levels and degree of participation. In some years, farmers have had a functional irrigation scheme, money for inputs and have made a profit. In other years, the pump for irrigation has failed, people have planted less, or not at all and harvest and sales have been poor. Irrigation, which can be viewed as an adaptive strategy, can buffer climate variability. However, in Mangondi, irrigation has also increased vulnerability because it is unreliable: agricultural decisions have to be significantly altered and resources are wasted when planning for one circumstance but experiencing another.

This case study illustrates the range of stresses that communities are adapting to and thus why policy options must consider the complex nature of vulnerability, rather than a single stress such as climate, when developing strategies for intervention.

3. Field research — from pumpkins to people

Mangondi communal garden was chosen as the focus for research because there is high climate variability and the farmers’ understanding and use of seasonal forecasts in this area is acceptable. In addition, expanding smallholder production is reflective of other farmers in southern Africa attempting to increase production for market. Climate variability impacts both the irrigated agriculture in the communal garden as well as the rainfed field crops that many farmers are involved in. The case study considers how climate variability is factored into agricultural decision-making, specifically in the communal garden. Previous research assessed the use of seasonal forecast information as an adaptation strategy to climate change (Archer, 2003). This paper includes forecast uptake as an adaptation strategy and compares it to other factors that affect agriculture-related decisions, to evaluate the importance farmers place on climate information. It is surmised that in order to support adaptation to climate change, the range of strategies, including market information, input supply, and extension advice, among others needs to be understood. The research and analysis enables a range of response and adaptation actions to be explored.

The research presented in this paper builds on data from surveys that were undertaken two years apart. All the farmers involved in the communal garden were surveyed in 2001 and 2003, numbering 49 and 51, respectively. These data formed the basis for the selection of nine farmers for individual interviews and the experimental computer-based interview method, which requires the use of knowledge elicitation tools (KnETs) (Bharwani, 2006). The selection aimed to get a distribution of profiles in terms of the gender of the head of household, age and wealth groups (poor, average and better-off farmers) that had been established using the survey data on income and household assets.

Table 1. Farmers' perceptions of the impacts of the Mangondi Community Garden project

Positive aspects	Negative aspects
Drip irrigation is good as it reaches the root zone.	Irrigation machine isn't reliable and causes water stress.
Able to produce products to sell and so have been able to send children to school.	Drip irrigation pipes got burnt when someone was clearing and it affected four fields.
Improvement of health in the community as able to grow own vegetables.	The reservoir is too small to supply the whole project.
Garden has helped to eliminate poverty in the community and in surrounding villages by providing employment.	Belief that the soil has some disease — they were told there was a shortage of lime on the whole field.
Have money so can buy other food.	The entrance gate is not secure and does not stop theft.
Don't have to go far to buy vegetables and so don't need transport, which saves money and time.	Measuring gauge on reservoir is broken so do not know how long water will last for irrigation and how long the reservoir takes to fill up.
Tourists come to the garden to buy vegetables because they see the sign.	Would like more land to farm, so could clear the surrounding land.
Have vegetables at home.	Road to pump machine is not well constructed.
	Fence is not very high so livestock climb over it.
	Pipes disintegrate in the heat.
	Problem of bathroom (only two long-drops at present).

KnETs is an interactive activity that represents various environmental, socio-economic and climate scenarios in order to identify the specific variables required for the farmers' process of decision-making about adaptation to proceed. This 'constrained information processing' task requires participants to select actions they would undertake in response to given scenarios. The set of actions they can choose from is based on previous fieldwork. This process was used to identify drivers and possible heuristics or decision-making rules, particularly as responses to seasonal forecast information (Bharwani *et al.*, 2005). This is essentially a method that allows one to 'tune in' to tacit knowledge which is difficult to access by other means. It also provides robustness to the collection of qualitative data, by providing processes of verification and validation of knowledge as it is collected (Bharwani, 2006).

Participatory approaches — including focus groups, timelines, ranking, matrices and mapping — were used with groups of farmers. Some exercises were undertaken with single-sex groups and others with mixed groups. These exercises enabled group perspectives to be captured around the impact of climate variability and climate information, environmental and socio-economic stress and response to these stresses. The scenarios and actions presented in the knowledge elicitation activity were based on the outputs from the participatory exercises.

The combination of quantitative approaches (survey data, KnETs output data and some of the participatory tool data) and qualitative approaches (focus groups, individual interviews and other participatory techniques) helped to provide a more holistic picture of the environmental and socio-economic stresses and of individual actions and decision-making processes. The analysis of field data presented in the paper focuses on the nine individuals who were interviewed and participated in KnETs. The other methods provided additional information that is brought in to the analysis. The need for qualitative evidence was considered essential: in-depth research with a select few individuals allowed us to explore livelihood and agricultural dynamics and decision-making which can then inform further investigation on a larger scale. Although Mangondi has some unique characteristics, such as the nature of the irrigation supply, many aspects of this scheme are common to other villages in South and southern Africa, such as market access, climate variability, irrigation, and input and extension constraints.

The perceptions of the community garden members, as gathered from a focus group, about the positive and negative aspects of the project helped to contextualize how farmers had experienced the undertaking (Table 1). These responses include short- and long-term benefits and positive and negative aspects. The first column (positive aspects) indicates that the garden has affected livelihoods for the better by providing employment, improving food security and supporting other livelihood strategies such as sending children to school and shortening the time spent travelling to the market. The second column (negative aspects) shows that technical problems with the irrigation system have hampered the success of the project.

Knowledge of seasonal climate forecast information is widespread in Mangondi. Only 2 out of 51 farmers had not received the forecast, as established in the survey (Washington *et al.*, 2005). The forecasts have been disseminated through the radio and awareness is high, possibly because the person who presents them originates from Vhembe. These forecasts give probabilistic distributions of the percentage chance of rainfall falling into specified categories of below normal, normal and above normal. At present the main seasonal climate forecast for South Africa is developed and disseminated by the South African Weather Service (SAWS), a semi-private organization, but other forecasts exist (see Johnston *et al.*, 2005). Forecast information can be applied in numerous ways (Goddard *et al.*, 2001; Murphy *et al.*, 2001; Stern and Easterling, 1999; Washington and Downing, 1999). In southern Africa, the forecast has been used to support agricultural management (Bezuidenhout, 2001; Klopper, 1999; Patt *et al.*, 2005), although there have been challenges with assimilation

Table 2. Planting responses to hypothetical cases of a selection of irrigation supply and forecast information scenarios for September–October–November (beginning of summer season)

Forecast information	Status of irrigation	Respondent A	Respondent B
		Farmer: Female household head Age: 49 years Household: 6 members Wealth: Better-off *Children are extension officers*	Farmer: Son to household head Age: 27 years Household: 6 members Wealth: Average
No Forecast	Reliable	Butternut, Beetroot, Carrots, Onions, Spinach, Maize	Butternut, Beetroot
	Unreliable	Plant nothing	Butternut *Wait for rain in October*
Above Normal Forecast	Reliable	75% Drought resistant maize, 25% Spinach	Drought resistant maize *Other crops get damaged*
	Unreliable	75% Drought resistant maize, 25% Spinach	Drought resistant maize *Other crops get damaged*
Normal Forecast	Unreliable	Beetroot, Spinach, Maize, Tomatoes, Onions *Will plant less of everything*	Butternut, Beetroot, Maize
Below Normal Forecast	Reliable	Beetroot, Spinach, Maize, Tomatoes, Onions *Plant all plots*	Not asked
	Unreliable	Plant nothing	Not asked

(Vogel, 2000; Ziervogel *et al.*, 2005), including relevance placed on the forecast information, and trust and difficulties dealing with probabilities in the forecast (Patt and Gwata, 2002; Nicholls, 1999).

Response to seasonal forecast information is one type of adaptation to seasonal variation, since the awareness and the capacity to use this information on an annual time scale enables users to adapt. The survey documented a number of options that people said they would consider in response to different forecasts. For example, in a scenario where farmers receive a below normal rainfall forecast, 20 out of the 51 farmers in the 2003 survey said they would not change their agricultural activities in response to the information. The activities that some farmers said they might undertake included planting less land, planting earlier and stopping preparation altogether. Some said they would not farm at all when they heard a forecast of below normal rainfall whereas some saw seasonal forecast information as assurance to support what they were already doing in terms of adaptation response.

In the individual interviews, changing the crop types and varying the amount planted was the most common response to above normal, normal and below normal forecasts, with some suggesting a change in timing of planting. These responses are fairly typical and have been found in other similar studies (Ziervogel, 2004; Ziervogel and Calder, 2003; Mpandeli, 2006).

Information about the type of crops grown, conditions which support or constrain crop choice and the inputs and climate conditions needed were captured using the KnETs methodology (Bharwani, 2006). For each scenario, farmers indicated the type and amount of crops they would plant if irrigation was reliable or unreliable, for both winter and summer seasons and how this would change if they received a forecast of below-normal, normal and above-normal rainfall for the summer season. The details of crop choice in relation to forecast and irrigation availability are highlighted by two individual's responses, shown in Table 2. Then the domain of market demand for crops was added to see if there would be a difference in strategy if market demand alone were to change. One of the differences that stood out was that farmers with access to transport could plant crops without too much concern as to whether buyers would visit their fields, as they could transport the crops to the market if necessary. Farmers without access to transport rely on buyers visiting the garden and so need to ensure that vegetables are sold and therefore do not rot in the garden.

Table 2 shows that both respondents plant for market, as most vegetables are sellable and maize is generally for home consumption. With the advantage of a reliable irrigation system, Respondent A would plant cash crops to increase her income. She even tries to grow cash crops in a year with a forecast of normal when irrigation is unreliable. However, in general, better-off farmers appear to avoid the risk of planting when they receive a forecast of below normal. It should be noted that this response is based on future scenarios and not necessarily what they have actually done. Better-off entrepreneurial farmers tend to block plant their whole plot with a single market crop, thereby producing a good income in a good year or potentially significant losses in a bad year. Thus, if forecast information is not favourable, they tend to avoid pursuing their usual strategy of block planting. However, if the forecast is above normal rainfall, Respondent A is less likely to plant market crops as demand will be lower due to increased household production.

Respondent B is more cautious and only plants butternut as a cash crop in the summer, as there is a guaranteed demand for this crop at Christmas time. This guaranteed market buffers some risk so poorer farmers plant butternut even when irrigation is unreliable. However, while respondent B is more cautious than respondent A, in general, poorer farmers employ more strategies to negate the effects of an unfavourable forecast. That is, with a below normal forecast they do not give up on market crops, but either wait for the rain before planting, or plant half their seed initially and wait for the rain to plant the rest. There are many examples of similar, often traditional, strategies that are employed by poorer farmers who have a highly variable crop mix compared to better-off farmers who do not employ such risk-reducing mechanisms and often pursue a mono-cropping strategy, with little variability.

4. Evaluating adaptation

Responses to the scenarios, additional interviews, and participatory tools provided a range of existing and possible adaptation actions that farmers might undertake. Each action was assessed in terms of the aim and nature of the strategy as illustrated in Table 3. Five categories were used for evaluating each action:

1) Information used:
   - The type of information that promotes the adoption of the strategy;
2) Reduction of impact of increased average temperature and decreased rainfall:
   - Can the action be considered as directly or indirectly adapting to a climate stressor?
3) Risk minimization:
   - Such as staggering planting dates so that if early crops fail there is a chance that crops planted later may succeed;
4) Increase in yield or profit:
   - Actions that aim to improve the physical environment and increase yield, such as mulching for improving water retention;
   - Actions that increase the chance of profit by focusing on marketable goods or increasing market availability after harvesting;
5) Resource intensity:
   - Does it require extra money to implement?
   - Does it require extra resources, such as labour or inputs?

It is important to note that the risk of pursuing an action will increase if the market demand declines unexpectedly or if the strategy relies on irrigation that fails.

The information that supports the actions (in the ‘information used column’) is significant as only one type of action is supported by climate information alone and two others might be supported by climate information. Four types of action are supported by information about market demand. The role of extension advice is also prominent. According to the farmers, there is not adequate extension support in this area, since the officers do not come as

Table 3. The type of actions that farmers in Mangondi Community Garden currently employ

Action	Information used	Adaptation to increased temperature	Adaptation to decreased rainfall	Risk minimizing (in terms of yield)	Increase yield or profit	Money/ resources required
Staggering of crop planting dates	**Climate information**		✓	✓		
Mixing cultivars (e.g., those with broader leaves, lower perishability, etc.)	**Market demand**	?	?	✓		
Replacing seeds that do not germinate	Observation			✓	✓	✓ locally available
Mulching (placing organic matter over soil)	Extension advice, **possibly climate info**	✓	✓	✓	✓	✓ locally available
Using KAN (inorganic fertilizer)	Extension advice			✓	✓	✓ money
Intercropping with nitrogen-fixing crops	Extension advice	?	?		✓	
Hiring transport to take crops to market	**Market demand**				✓	✓ money
Growing market crops (rather than for home consumption)	**Market demand**				✓	
Plant more if below normal forecast to target high market demand	Market demand and **climate info**		✓		✓	
Growing vegetables not widely available	**Market demand**				✓	
Selling non-agricultural products	**Market demand**	?	?	✓		✓

Note: Locally available means that resources to implement strategy are available in the village and do not require money to obtain.
? signifies could help to adapt to change in climate depending on specific situation. E.g., The successful adaptation of mixing cultivars would depend on the seed availability of different cultivars, how suited they are to increased temperature and decreased rainfall and what the market demand is like for the different cultivars.
Extension advice — advice given on agricultural techniques by extension officers who visit the garden or when farmers talk to extension officers outside of the garden.

Table 4. Individual profiles and how they fit the distribution of actions employed

Interview number	1	6	8	2	9	3	5	4	7
Household characteristics									
Age	46	68	65	72	47	27	54	35	49
Sex (household status)	W	F (HH)	M	W	F (HH)	M (son)	W	W	F (HH)
Wealth (P, A, B)	P	P	P	A	A	A	A	B	B
Adaptation actions									
Staggering	✓		✓						
Mixing cultivars				✓		?			
Replacing seeds that don't germinate				✓					
Mulching									✓
*Using KAN**		✓	✓!			✓	✓	?	
Intercropping with nitrogen-fixing crops	✓								
Hiring/have transport						✓		✓	✓
Growing market crops (rather than for home consumption)		✓	✓		✓	✓	✓	✓	✓
Plant during Below Normal to target high market demand		✓	✓		✓	?	✓	✓	✓
Growing vegetables not widely available							✓		
Selling products	✓	✓			✓		✓		
Seek external advice	1	3	3	2	5		3		4

Notes: ! Uses KAN (inorganic fertilizer) if cash available to buy.
Sex: F — female, M — male, HH — household head, W — Wife
Wealth: P — poor; A — average; B — better-off.
Advice:
1. None.
2. Others in the garden.
3. Others in the garden and extension officers.
4. Children, who are extension officers.
5. Agricultural Research Centre staff and Department of Health.

Note: Italicized actions can be implemented in response to climate information.

regularly as needed and they are often unable to provide farmers with the information they require. Some of these actions might help to reduce the negative impact of increased temperature and decreased precipitation, but it is the combination of information that enables the negative impact of climate variability to be minimized and adaptation strategies to succeed.

Table 4 illustrates the types of action undertaken by farmers as gathered from the nine in-depth interviews. The distribution of livelihood profiles and associated actions employed suggests that different actions are undertaken by farmers of varying profiles. The responses of the interviewees supported by survey data and participatory activities suggest an initial set of adaptation options and the type of person who employs them. For example, it appears that poorer households are more likely to stagger their planting. This is a risk-coping strategy that suggests that these households would rather increase their chances of having some yield than investing everything in planting when the first rains come and risk losing it all if the rains do not continue. Similarly, hiring transport is restricted to average and better-off farmers. This strategy is effective in dealing with variable market demand. These individuals are able to take a bulk-load of produce to markets further afield where there may be higher demand and thus they are also able to secure higher prices away from the community garden. Female farmers appear to prioritise crops for home consumption more than men, yet they are aware of market demand so they plant both marketable and home consumption products. Although climate information is often not used directly, it is seen as an additional source of information that contributes to their knowledge about the 'risky' environment in which they operate.

5. Discussion — from people to policy

In terms of vulnerability, the case study evidence suggests that poorer farmers are more directly dependent on climatic conditions, as they have less opportunity to access other resources that reduce its impact — such as, fertilizer, transport and other business opportunities. On the other hand, poorer farmers have reduced their vulnerability and have increased their resilience to climate variability by diversifying their strategies and the crops they plant. For example, some poorer farmers plant nitrogen-fixing crops together with other crops, while better-off farmers are more likely to buy inorganic fertilizer when they can afford to.

In Mangondi, better-off farmers appear vulnerable to the direct impact of climate variability on their crops, as they tend to plant a single crop, which can render no returns at all in unfavourable climate conditions. However, in good years, they may be able to increase their income base and thus their resilience. They also tend to have better access to financial resources which indirectly buffer the shock of negative climate impacts or other production stresses.

Adaptive capacity and the adaptation actions pursued depend on a range of factors from resources, to information, to social capital to personal choice, as much of the literature has suggested (Adger, 2003; Yohe and Tol, 2002; Smit and Pilifosova, 2001).

It is clear that the use of seasonal forecast information feeds into the adaptation strategies of farmers with a range of resources. Many farmers are using the forecast and many apply safety mechanisms to account for its probabilistic nature. What emerged in this study is that if farmers are planting for subsistence they are eager to hear the forecast for above normal rainfall where they can try to maximize environmental conditions, whereas if they are planting for market and have access to irrigation, they are keen to receive and use a below normal forecast as this can help them to make market-related decisions. The market-related decisions depend on climate variability, as when rainfall is below normal, it generally means that household production in the area is less than usual and so there is higher market demand for crops and vegetables, and therefore higher crop prices.

Better-off farmers tend to focus on market priorities rather than responding to predicted climate *per se*. That is, although poorer farmers also pursue market-driven actions, better-off farmers can afford to do this more frequently since they have the resources to buy food for subsistence and have a greater likelihood of making an income selling marketable crops due to their access to transport.

Thus, although wealth determines the type of response action employed, it does not mean that better-off farmers are better adapted to current climate variability. On the contrary, actions that respond to climate variability, such as staggering as a method of reducing risk and planting nitrogen-fixing crops, are low-cost management strategies employed widely by poorer farmers. This shows that not all responses require money to implement. Many actions use local resources or require a change in the way existing resources are used.

Poor households are more inclined to trust the forecast, since they know how to implement risk reduction mechanisms if the forecast and actual rainfall differ. In contrast, average and better-off households are more likely to suffer losses by trusting the forecast, because they tend not to employ as many safeguards. This in turn means that their trust in the forecast decreases even more because they suffer more losses (Bharwani *et al.*, 2005). Trust in the forecast and matching forecast information with decisions at the correct scale is critical to assimilation, as reported in other studies (Patt and Gwata, 2002).

The social and political dimensions around adaptation are critical to understanding the nature of actions being adopted. Social networks seemed to be responsible for widespread awareness of the forecast in Mangondi, as the forecast radio broadcast was presented by a local, as explained earlier, and that engendered trust. Another example highlights differential adaptation action assimilation and the role of social networks. One of the better-off farmers used mulching to reduce soil water evaporation, which is a sensible adaptation activity, particularly if hot temperatures and limited precipitation are expected. Although she was a better-off farmer, wealth had little to do with her adopting this response. Her son, an extension officer, had explained mulching to her and so she collected organic material from around the fields and laid it around her plants. She had explained this technique to others but none had adopted it. Her trust in her son, and the family network, was what prompted that particular adaptation strategy. It is clear that there may be other technologies appropriate for adapting to climate variability, yet if the Mangondi farmers are not in an effective extension system, they have a limited number of ways of learning about appropriate technologies.

Farmers might also limit investment in agriculture and invest some of their time and resources in alternative activities, such as baking, crafts and services, in order to supplement their farming income and ensure that they are able to buy food if their harvest fails (Ellis, 2000). Some farmers stop farming when they have made a loss, whether due to poor market prices or failed harvests. At first, these actions might not be seen as adapting to climate variability, but the combination of actions allows farmers to develop an adaptive strategy that can make them more resilient to increased climate variability. It is these nuances of 'adaptive strategy sets' that need to be understood, since such subtleties may be overlooked if direct response to climate variability is the focus.

A focus on changing the constraints created by the local environment can be an alternative form of adaptation, rather than changing habits, or engaging in negative adaptation such as abandoning planting (Sharp and Smith, 2003). Developing social capital is a key example (Pelling and High, 2005), and Sharp and Smith (2003) highlight the importance of establishing relationships with non-farmers and strengthening the rural–urban interface. This can help to build trust and increase opportunities. Relationships that exist and are strong between groups can be used as key conduits for supporting the dissemination of new types of information (Ziervogel and Downing, 2004). It was clear in Mangondi, that farmers with transport were able to use their wider geographic and social networks when necessary and adapt to market demand which potentially decreased the impact of other stressors.

Tompkins and Adger (2004) argue that collective community-based management can enhance adaptive capacity by strengthening networks that support coping strategies during extreme events and by providing support to the basic resources and ecological systems. Collective action can be seen as coordination of efforts among individuals to achieve a common goal which is different to the outcome that would have been obtained if individual self-interest was followed (Ostrom, 1990). These activities might not be explicitly aimed at improving adaptive capacity for coping with climate change, but the nature of community-based systems might support this. In Mangondi, community processes already include planning what to plant for bulk sale, by blocking whole rows of plots for planting to support these bulk sales (for school or hospital contracts, for example), irrigation scheduling and maintenance, and the approach to selling. That is, there are communal vegetable sales and individual sales, which may increase resilience to future market variability thereby improving adaptation to climate change.

Netting (1993) argues that dense populations practicing intensive agriculture produce, organize and consume in household groups. In such populations, access to productive resources is somewhat unequal at any one time, but over the long term, the farming group as a whole remains class undifferentiated. Adaptation to stressors may therefore be occurring at a communal scale, despite some individuals appearing to be maladapted to certain stresses. If as a group they are adapting to a range of stresses, they may be able to support each other when necessary. Similarly, there may be interventions at the village or district scale that might help these farmers adapt better to climate variability.

Drawing on this case study, there are a number of areas where policy support for adaptation to climate change could be pursued. It is clear that directly targeting agricultural activities could be beneficial. For example, providing training to increase the understanding of the seasonal climate forecast would increase the usefulness of the forecast by allowing farmers to plant for and explore alternative responses to the information. This would succeed if implemented by intermediaries (whether media, extension officers or input suppliers) who interact with local farmers. Another area in which policy could support agricultural activities would be through strengthening district extension services.

The case study also highlighted indirect ways of supporting adaptation to climate change. Improved access to markets could increase the sales of poorer farmers. A policy that supports the improvement of this access does not necessarily have to target the agricultural department, but could target local trade centres instead. This illustrates the need for developmental approaches that bridge sectors.

If water resources are depleted and temperatures rise, the small-scale irrigation project presented in this paper might not remain viable. Understanding the role of social support, the levels of unemployment and alternative livelihood opportunities of the farmers will then be essential to be able to support adaptation to climate change. Exploring support for a range of scales is therefore important. It is also clear that support at one level cannot necessarily be scaled up but may need a different type of intervention at a different scale.

6. Conclusion

People respond to stresses for different reasons; some to survive and others to succeed. How does one ensure that policies aimed at supporting adaptation to climate variability are relevant firstly to guarantee individuals' and communities' survival and then to help them to succeed? Are policies and support measures making this distinction at present? The recent focus on adaptation to climate change could divert attention from more urgent development needs as it emerges that climate is not necessarily the key driver of change, although it is one important driver among many (Gregory *et al.*, 2005; Reid and Vogel, 2006; Scholes and Biggs, 2004). It is therefore imperative that policies aimed at supporting adaptation to climate change are clear on what type of adaptation is being supported and who within the chosen target group will benefit, recognizing that very few groups will be homogeneous.

This research shows that climate information, such as seasonal forecasts, is used as an adaptive strategy to respond to climate variability. Forecasts are viewed by many of the Mangondi farmers as additional information that changes the context in which decisions are made, even if there is limited change in activities in practice. There is still the need for improved support of forecast information at the national and district level in order to ensure that the probabilistic nature of the forecast is understood and the potential utility of the forecast is maximised at the local level. This has been supported by Patt *et al.* (2005), who show how subsistence farmers in Zimbabwe benefited from forecast information when they understood its probabilistic nature and communication was invested in.

Decreased vulnerability to climate variability can be supported by strategy sets that reduce the negative impacts of a range of stresses including climate, market variability, social and cultural change and environmental change amongst others. Some agricultural techniques reduce the impact of climate variability, such as mulching or using seasonal forecast information. Yet, in Mangondi it was clear that there was a range of actions that were not a direct response to climate variability that enabled farmers to succeed as farmers and become well adapted to their environment. For example, most farmers plant butternuts at Christmas as the market is guaranteed and some farmers find outside markets in order to increase the sale of vegetables, yet this requires transport. Focusing on climate stress alone will therefore not reduce vulnerability.

The vulnerable should be key targets of adaptation support. This research suggests that there will be diversity among a targeted group. Decreasing sensitivity and the likelihood of being exposed to negative climate impacts is as important as developing adaptation strategies to increase resilience and reduce negative impacts of stresses. In Mangondi, farmers that focused on one crop were responding primarily to the market and therefore increasing their sensitivity to market and climate risks, whereas farmers that planted a range of crops could be seen as decreasing their sensitivity to climate stress but also as less resilient to longer-term change if they are unable to build up an asset base. Access to information, perceived risk, adaptive capacity and inclusion in certain social networks are factors that determine differences in adaptation response (Pelling and High, 2005; Grothmann and Patt, 2005). These characteristics differ among individuals that may initially be perceived as a homogeneous group.

Vulnerability is contextual and changes over time. Information gathered in one year cannot necessarily be used to predict future vulnerability or how responses to information will occur over the coming ten years. It is therefore necessary to acknowledge dynamic vulnerability and to develop tools that enable salient processes to be captured and contribute to a broader understanding of vulnerability pathways — for example, an agent-based model has been used to examine some of the responses to forecast as an adaptation to climate variability over time, as shown in Bharwani *et al.* (2005) and Ziervogel *et al.* (2005). The information gathered in this fieldwork highlighted some key responses to stresses, with some being directly relevant to climate information and responding to climate variability while other actions were based on a range of stresses and options for responding. In the Mangondi case, irrigation, market demand and forecast information appeared to be key factors determining the type of agricultural action pursued. In other locations, other factors may determine actions and responses. Adaptation to climate change is therefore going to be best supported through addressing direct climate-related stresses as well as strengthening existing development policies that increase livelihood resilience in the face of multiple stresses. Understanding responses to socio-economic and environmental factors and stressors provides insights that can improve cross-cultural knowledge of vulnerability and adaptation to climate variability. Research that assesses how farmers are currently responding to multiple stresses and what can be done to support adaptation to climate change is therefore urgently needed and critical. Improved methods are needed to unravel the relative importance of climate-related stresses within a highly complex field of dynamic transformations, uncertainties and risk.

Adaptation policy should support strategies that reflect the diverse environment in which people exist. Adaptation strategies should link to the global change environment that could include investigations into how market change, cultural change and the impact of HIV/AIDS affect agricultural adaptation strategies. This research highlights the need to understand the complex nature of adaptation in the balance between climate variability, climate change, social and economic stresses, and poverty and resource endowments. Work on adaptation needs to explore vulnerability to climate change within the context of multiple stresses. In vulnerable communities, support for good governance, equity in social and economic services and resilient livelihoods are essential. National planners should include vulnerability, risk and resilience in development plans such as the poverty reduction strategy papers. International negotiations, from the Millennium Development Goals to multilateral environmental treaties, such as the United Nations Framework Convention on Climate Change, should address adaptation as a process of social learning across scales and stresses.

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