Adoption of improved maize cultivars for climate vulnerability reduction in Malawi

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Abstract

The projected negative impacts of climate change threaten to endanger smallholder rain-fed maize production and therefore food security across Sub-Saharan Africa. It is widely advocated that the provision of improved, climate-tolerant maize seeds will overcome this problem by enabling agricultural adaptation to changing weather conditions. However, attempts to launch new agricultural technologies in Africa have rarely successfully transformed prospects for the most vulnerable, and historical uptake of improved maize has remained low in some countries, including Malawi, despite a strong political legacy of modern input promotion.

This thesis investigates how social dimensions (such as asset ownership, cultural preferences and perceptions of climate risk) affect the potential for cultivar adoption to enable equitable adaptation to climate change amongst smallholder maize farmers in Malawi. National strategies for the diffusion of maize cultivars are explored and analysed with reference to agricultural innovation theory. Adoption outcomes are then assessed using household data from two case study areas selected on the basis of their contrasting climate vulnerability characteristics and productive potentials for maize. Lastly, perceptions of climate change amongst research participants are explored and considered in relation to a statistical analysis of historical rainfall and temperature data within the two research areas, Kasungu and Ngabu.

The empirical findings reveal that whilst Malawi's maize seed industry is modernising, changes do not necessarily benefit smallholders, and access to cultivars and information about them remains unequal. State agricultural policies lack regional contextual specificity and have contributed to heightened vulnerability in Ngabu (the less productive case study area). Stakeholders' perceptions and attitudes about current and future climate change reveal incongruities and misconceptions. Widespread beliefs that seasons are shortening are driving preferences for short season hybrid cultivars, which increasingly flood the seed market, but statistical analysis of historical seasonal rainfall data reveals no clear seasonal trend in this direction. New diffusion strategies, increasing policy sensitivity for dealing with climate vulnerability in marginal areas, and better understanding and communication about climate variability and change will all be required if cultivar adoption is to enable successful and equitable adaptation for Malawian smallholders. These goals could be better supported if vulnerability reduction, rather than corporate growth, was made central to the development of Malawi's agricultural innovation system. Practical methods by which this change might be achieved are discussed.

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List of acronyms and abbreviations

AIS	Agricultural Innovation System
AISP	Agricultural Input Subsidy Programme
DADO	District Agricultural Development Office
DoI	Diffusion of Innovations
DTMA	Drought Tolerant Maize for Africa
EPA	Extension Planning Area
FAO	Food and Agriculture Organisation of the United Nations
MNVAC	Malawi National Vulnerability Assessment Committee
NARS	National Agricultural Research System
OPV	Open Pollinated Variety
SSA	Sub-Saharan Africa
T&V	Training and Visit
WEMA	Water Efficient Maize for Africa

Glossary

adoption	*The act of taking up an action, approach, method or technology. Within this thesis the term 'adoption' mainly refers to the uptake of new or different maize cultivars by smallholder farmers*
cultivar	*A plant variety produced by selective breeding and not usually found within natural populations, a cultivated variety*
dent maize	*Varieties of maize with soft, starchy kernels*
dimba	*A Chichewa term for a garden or plot of land that is irrigated by a natural water supply such as a stream or river*
disadoption	*The subsequent abandonment of an innovation that was adopted previously*
flint maize	*Varieties of maize with hard-coated kernels*
ganyu	*A Chichewa term for informal agricultural labour or piecework*
germplasm	*Genetic material, usually contained within seeds*
growing degree day	*A unit measuring heat accumulation and determining the rate of growth of a plant*
heterosis	*The tendency of hybrid cultivars to display superior growth or other desirable characteristics*
hybrid	*A plant bred from parents with different, uniform genotypes, often in order to achieve a strongly heterozygous hybrid genotype conferring desirable traits*

inbreeding depression	*Breeding between genetically similar individuals leading to an accumulation of negative traits and a reduction in vigour*
innovation	*An idea, object or technique that is perceived as new by potential adopters*
local maize	*Land races of maize which have developed over many generations of seed-saving by farmers*
maladaptation	*An adaptation which leads to greater vulnerability in the long term or elsewhere in a system*
munda	*Chichewa term for agricultural land which has no source of natural irrigation other than rainfall*
ndiwo	*Chichewa term for relish, meaning any type of food which accompanies nsima*
nsima	*Stiff maize porridge consumed across Malawi as the main national staple*
open-pollinated variety	*A variety where field pollination is not controlled but plants share a similar genetic pool and therefore inherited traits remain fairly consistent between generations*
phenotype	*The physical expression of a genotype*
short-season	*A cultivar or variety that matures quickly*
transgenic	*An organism containing genes from another organism that have been introduced via genetic engineering*
ufa	*Chichewa term for refined flour*
z-score	*A standardized score in statistics determined by the number of standard deviations a value falls away from the mean*

Chapter 1 - Introduction

1.1 Food security and development in Sub-Saharan Africa

Food security has been described as a "precondition for sustained human development" (United Nations Development Programme, 2012, p. 9). The inference of this is that food insecurity leads to sustained under-development, and levels of poverty, hunger and malnutrition in many parts of Sub-Saharan Africa (SSA) suggest that this is the case (United Nations Development Programme, 2012). In addition to markers of under-development including low life expectancy at birth and high child mortality, populations in SSA continue to suffer severe food crises and countries within the region are regularly forced to rely on food aid (Cromwell and Kyegombe, 2005, United Nations Development Programme, 2012). Poor access to food is not limited to these crises, but is a chronic problem with thirty percent of the sub-continent's population classed as undernourished in 2010 (FAO, 2010). This population is currently approaching 1 billion, and high fertility rates are projected to double it by 2050 (Zuberi and Thomas, 2012). Meanwhile, seasonal and extreme temperatures and the intensity of droughts experienced by countries within the region are projected to increase as climate change progresses (Cairns et al., 2013). The problems the continent faces in feeding its inhabitants therefore look poised grow.

Food insecurity in the region is a product of a complex range of factors that include "misguided policies, weak institutions, and failing markets" leading to powerlessness and vulnerability at the household level (United Nations Development Programme, 2012, p. 47). Although food insecurity results from much more than inadequate production levels, and importantly concerns access and entitlements (Sen, 1981), SSA's food security challenges are compounded by the fact that the region is currently a net importer of cereals overall, with the vast majority of countries experiencing cereal production deficits in recent years (United Nations Development Programme, 2012). Population growth is outstripping growth in food productivity by 1% (Edmonds et al., 2009) and stagnant agricultural growth rates over the past forty years suggest that problems with food insecurity are likely to increase as population growth continues (Jama and Pizarro, 2008).

Despite its weak productivity, agriculture accounts for the main economic activity of 60% of SSA's population (United Nations Development Programme, 2012). Smallholder farming dominates, with 80% of farms consisting of landholdings of less than two hectares (Livingston et al., 2011). Rain-fed production is also the norm, providing 90% of the population's food and accounting for the livelihoods of 74% of SSA's poorest people (Besada and Sewankambo, 2009). Declining nutrient contents of soils, low access to and use of inputs such as improved seeds and inorganic fertilizer, and high levels of inter and intra-annual rainfall variability (including drought and flood hazards) all characterise farming within the region's mainly semi-arid and sub-tropical environments, and have been highlighted as direct production constraints (Hudson and Jones, 2002, Hansen, 2005, Funk et al., 2008). The development and diffusion of agricultural technologies which seek to abate and overcome these constraints has been a key focus for development efforts for several decades. Such efforts include the promotion of improved cultivars for key staple crops such as maize which potentially provide higher yields whilst effectively withstanding biotic and abiotic stresses. The current global political focus on climate change is heightening efforts to breed and diffuse increasingly resilient cultivars.

1.1.1 Maize

Amongst the crops that are produced and consumed in SSA, maize is one of the most important (Shiferaw et al., 2011). It accounted for 27 % of the land area devoted to cereals and 34% of cereal production overall in 2005-8 and covered around 25,000,000 hectares in 2010 (Smale et al., 2011). In contrast to other parts of the world where most maize is destined to become livestock feed, in SSA the vast majority of what is produced is consumed by humans (McCann, 2005). As a dietary component it is the largest single source of calories and has accounted for between a fifth and a quarter of starchy staple consumption since 1980 in Africa as a whole (Smale et al., 2011). Maize has become particularly important as a dietary staple in Southern and Eastern Africa, where its dominance in cropping systems has increased over time (Byerlee and Eicher, 1997, McCann, 2005).

Despite its importance, maize is not native to Africa. It was domesticated in Mexico and varieties were probably first brought to Africa after 1500 as part of the process of global trade expansion that followed Columbus' arrival in the New World (McCann, 2005). Initially occupying a small place within a very diverse cropping system, maize grew to prominence because of its capacity to yield more per unit of land and labour than traditional crops in most of Africa's growing conditions (Smale and Jayne, 2003). However, having had very little time to adapt to this new production environment, it is more susceptible to drought and less suitable for marginal semi-arid areas than Africa's native sorghum (Bedell et al., 2005). Nonetheless, it is into such areas that most maize cultivation expansion has occurred in recent years, thereby heightening the climate sensitivity of maize production within the region, and increasing the perceived need for a transformation of maize agriculture via the modernisation of the germplasm upon which farmers rely (Byerlee and Eicher, 1997).

1.1.2 Climate change impacts on maize production

Since nearly all maize production in SSA is rain-fed, and because maize production relies heavily on water availability, the predicted impacts of climate change across Eastern and Southern Africa are a cause for great concern (Cooper and Cappiello, 2012). Along with soil nutrient depletion, drought has been named as the most important stress facing maize production in most of SSA (Banziger and Diallo, 2001). Current climate trends for Southern Africa indicate that a decadal warming trend of between 0.1-0.3°C is underway (Boko et al., 2007). There is no clear desiccation trend, but rainfall variability increased towards the end of the twentieth century (Richard et al., 2001).

Predictions based on the assumption of a continuance of medium to high greenhouse gas emissions suggest that by the end of the present century temperatures across SSA will have increased by 3 to 4 degrees Celsius, and possibly by as much as 7 degrees in Southern Africa within the dry season (Boko et al., 2007). Higher temperatures not only lead to water stress by increasing rates of evapotranspiration, they also directly constrain yields of many important food crops above certain thresholds (Challinor et al., 2005, Chen et al., 2012). Since the determinants of precipitation across Africa are highly complex, it is difficult to model future rainfall with certainty (Boko et al., 2007). However, it appears likely much of Southern Africa will see small increases in total seasonal rainfall towards the end of the century but with significant changes to its seasonal distribution, consisting of increases in intra-seasonal dry spells, rainfall intensity and extreme events (Hudson and Jones, 2002, Wang, 2005). The conversion of land cover for farming expansion is likely to exacerbate these climate impacts (Boko et al., 2007).

Maize is particularly vulnerable to heat stress and to insufficient or excess water at certain stages in its growth cycle (Tadross et al., 2009, Cooper and Cappiello, 2012, Chen et al., 2012). If water is withheld during pollination, kernel formation can be severely inhibited, and where soil becomes too moist mature plants are prone to lodge (or fall over), which also fosters poor cob development (Sleper and Poehlman, 2006). In addition, too much rain at the end of the season can lead to storage problems, since most maize varieties last longer when dry at harvest. Therefore, the predicted changes to rainfall in Southern and Eastern Africa are likely to pose serious problems for maize production in this highly maize-dependent region.

Predictions have suggested that with little mitigation of carbon emissions, climate change by 2080 will have resulted in cereal yield reductions in Africa of 30% (Parry et al., 2005). Furthermore, outlooks suggest yields of maize will suffer proportionally greater losses than the other top regional staples (Tadross et al., 2009, Schlenker and Lobell, 2010).

The economic implications of greater rain-related yield losses on agriculturally-dependent Africa will contribute to less purchasing power for buying in food from elsewhere (Boko et al., 2007). Climate change therefore compounds the food insecurity problems already being faced in Africa and poses a major threat to development and poverty reduction in the near and longer term (Thornton et al., 2010).

1.1.3 Enhancing productivity under climate change

Solutions to these pressing problems are being sought based on agricultural change. The Green Revolution has been described as, "one of the greatest technological success stories of the second half of the twentieth century" (Toenniessen et al., 2008, p. 234). It famously provides evidence of how improved seeds and fertilizers can transform crop yields and livelihoods across vast areas (Evenson and Gollin, 2003), and it has been seen as a desirable blueprint in as far as expectations of agricultural productivity enhancements within Africa are concerned (Denning et al., 2009). But launching Africa's green revolution has not been straightforward, and to date attempts are considered to have failed or at best only succeeded temporarily because agricultural technology uptake has remained spatially isolated and has rarely been sustained over time (Mosley, 2002, Jama and Pizarro, 2008, Toenniessen et al., 2008).

A number of empirical examples show that where access to improved seed and inorganic fertilizers is facilitated, considerable yield gains can be achieved in African environments (Jama and Pizarro, 2008, Denning et al., 2009). It has also been shown in several East African contexts that historical increases in crop yields have been tied to increases in real wages and decreases in the market price of food (Mosley, 2002). It is with these success stories in mind, and in recognition of Africa's burgeoning food security issues, that attempts to launch a green revolution for Africa are being renewed (Annan, 2008, Yuksel, 2008, Sachs, 2008, Toenniessen et al., 2008, Sanchez et al., 2009, Denning et al., 2009). In 2006, AGRA (the 'Alliance for a green revolution in Africa') was launched with initial funding of 150 million dollars from the Rockefeller Foundation and the Bill and Melinda Gates Foundation (Semal, 2008). The initiative has been embraced by the United Nations, with ex-UN President, Kofi Annan, as chairman (Holtz-Giminez et al., 2006, Yuksel, 2008). The program pursues a theory of change which it labels, “market-led technology adoption”, and whilst admitting that “Asia’s Green Revolution had a somewhat similar theory of change” (Toenniessen et al., 2008, p. 236), Africa’s unique production constraints are emphasized. Instead of the fertilizer-response problems that were overcome in Asia through the breeding of shorter stature rice varieties, the problems faced in Africa are identified as stemming from low soil nutrients and high environmental stress related crop losses (Toenniessen et al., 2008). To address these problems AGRA seeks to increase yields and yield stability by enhancing nutrient supplies, increasing soil-water conservation, providing farmers with more resilient cultivars, and improving the functioning of input markets. AGRA seeks to achieve “nothing less than a complete transformation of the agricultural sector” (Alliance for a Green Revolution in Africa, 2013).

The threat which climate change poses to agricultural production within Africa is not clearly addressed within articles promoting the work of AGRA, beyond the observed need to provide more resilient crop varieties (Yuksel, 2008, Toenniessen et al., 2008). However, analysts have argued that a technological transformation of African agriculture is precisely what is needed to overcome climate change as well as hunger (Brown and Funk, 2008). Those adopting this stance dismiss ‘climatic determinism’ and suggest that by transforming “these agricultural systems through improved seed, fertilizer, land use and governance, food security may be attained by all” (Brown and Funk, 2008, p. 581).

The improved seeds upon which such an agricultural transformation will most likely rely are being developed by programmes such as CIMMYT’s Drought Tolerant Maize for Africa initiative (DTMA) (which launched the same year as AGRA with support from the Bill and Melinda Gates Foundation, the Harold Buffet Foundation, USAID and the UK Department for International Development), and Water Efficient Maize for Africa (WEMA); a public- private partnership also funded by the Bill and Melinda Gates and Howard Buffet Foundations. Both programmes have been formed specifically to address the issue of susceptibility to drought through breeding better maize cultivars for use in Africa (Hemming, 2008, Cooper and Cappiello, 2012). Their geographical focus partly overlaps, and the main apparent distinction between the two programmes is WEMA’s readiness to embrace transgenic biotechnology and its involvement with corporate agricultural giant Monsanto (Hemming, 2008). These programmes exhibit high confidence in the potential of agrotechnology to transform productivity and reduce climate vulnerability, however a thorough analysis of the potential for such technologies to reduce social inequality of vulnerability to climate change is lacking.

1.1.4 Critiques of technological revolutions

The idea that modernising Africa's agriculture will solve many of her problems is not new. The literature abounds with stories of agricultural development programs that have failed to successfully transfer technologies to African environments (Richards, 1985, Eicher et al., 2006, Babu et al., 2007, Grant, 2009, Temudo, 2011, Cunguara and Hanlon, 2012, Whitfield, 2012). On the basis of these failures, the assumption that it is even possible to replicate Asia's green revolution in Africa is regarded by some as spurious (Scoones et al., 2005). Moreover, research has shown that in addition to damaging the environment and reducing biodiversity (Shiva, 1991, Holtz-Giminez et al., 2006), the Asian Green Revolution exacerbated wealth inequalities. All this gives rise to doubts about the paradigm's usefulness for vulnerability reduction (Falcon, 1970, Evenson and Gollin, 2003). Despite interventions, African agriculture is considered to have stagnated and many now profess little faith in so-called "technical fixes" (Scoones et al., 2005, p. 2) and "the modernist project that has come to dominate food and agricultural policy" (Thompson and Scoones, 2009, p. 386).

Understanding why attempts to boost yields in Africa have met with limited success is essential for current efforts to address present food insecurity and the likely future impacts of climate change. But the explanations for past failures are nearly as diverse as the contexts in which these failures have occurred. Projects have sought to launch inappropriate technologies that are poorly suited to local needs and conditions (Richards, 2010). They have underestimated the extent to which poverty and production risks determine input usage decisions amongst poor smallholders (Briggs, 2005) and failed to adequately grasp the heterogeneity which characterizes farming systems in Africa (Hansen, 2005, Horlings and Marsden, 2011). They have prioritized scientific 'expert' knowledge whilst ignoring the contextual insights of local knowledge (Belshaw, 1979). The variety of barriers faced makes it difficult for those wishing to launch Africa's Green Revolution to fix on the single best pathway to take to ensure widespread adoption. A top-down aspiration to 'scale up' technological success may be of limited utility within the contextual diversity of African smallholder agriculture. Consequently some analysts are highly suspicious that AGRA's attempts to launch Africa's green revolution will fail to alleviate poverty and hunger (Holtz-Giminez et al., 2006).

Past failures to ignite revolutions within African agriculture can often be attributed to an inability on the part of technicians to engage properly with the social dimensions of the social-ecological systems into which new technologies are issued. Paul Richards (2010) argues that this problem might rest on too simple an interpretation of the term technology as tool, when a more useful definition is technique, or “knowing how to do something” (Richards, 2010, p. 3). He calls for much closer “observation of interactions between user and artefact”, terming this type of study ‘technography’. Such an approach, he affirms, can assist in narrowing and eventually closing the gaps between agrarian engineers and users of agrarian engineering in ways that can genuinely improve food security from the grassroots (ibid.). But preferences for the simplicity of a technological fix remain evident in the oft-heard claim that the knowledge to improve maize yields (via improved inputs usage) in African settings already exists (Millenium Development Goals Centre, 2004, Denning et al., 2009).

The dangers of pursuing simplistic solutions in seeking to remedy the problems posed by climate change have also been highlighted by scholars of governance within social-ecological systems (Ostrom et al., 2007). Some of those involved in AGRA have been at pains to emphasize that the campaign for Africa’s Green Revolution must not be launched with silver bullets (Yuksel, 2008). Yet the project’s scant mention of long-term climate change and its failure to openly address whether increasing reliance on inorganic fertilizer might constitute a maladaptation by increasing greenhouse gas emissions (Branca et al., 2011) suggest that complexity is being under-addressed. Similarly, it has been observed that DTMA fails to address the problem that temperature rather than drought is likely to be a stronger determinant of African maize yields under climate change, with every one degree Celsius increase in temperature projected to reduce maize yields by 20% in three quarters of SSA’s maize-growing areas (Burke et al., 2009, Lobell et al., 2011, Cooper and Cappiello, 2012). Some have questioned whether concentrating on maize cultivation is an optimal solution for climate change adaptation in some parts of Sub-Saharan Africa. In Southern Africa, for example, maize yields are likely to be so negatively affected that it might be preferable to encourage farmers to switch to a less impacted crop such as sorghum (Lobell et al., 2008). Yet those favouring technological change deem it too complicated to engender cultural changes to food habits in the region (Brown and Funk, 2008). It is unclear why implementing technological agricultural change should be perceived as comparatively simpler, especially given the fact that both types of change occurred rapidly within the recent past, when maize succeeded sorghum, millet and rice to become the region’s top staple (McCann, 2001).

The question of how to “stop striving for simple answers to complex problems” is addressed by Ostrom (2007, p. 15182), who counsels for first understanding how the nested attributes of resource systems variously affect the incentives of actors in the pursuit of sustainable outcomes. Large numbers of variables determine actors’ decisions within social-ecological systems and as such causes “are always multiple”(Holling, 1993, p. 554). Since it seems unlikely that a single cause will be found to explain the stagnation of agricultural production in Africa, gaining insights into the complex range of factors which currently inhibit or facilitate cultivar adoption outcomes for African smallholders is an essential step towards enabling accessible adoption of more climatically resilient maize cultivars in the future. In order to identify and understand how variables influence differentially sustainable adoption decisions, it is necessary to carry out research from multiple perspectives within regional seed systems and arrive at an integrated viewpoint which highlights contextual complexity (Almekinders et al., 1994); the present study shapes itself around this assumption.

The idea that improved cultivars will enable adaptation to climate change for African farmers appears widely within the climate impacts modelling literature and is also set out as a key adaptation response within several East African national adaptation policy documents (Jones and Thornton, 2003, Malawi Environmental Affairs Department, 2006, United Republic of Tanzania, 2007, Brown and Funk, 2008, Thornton et al., 2009). Indeed, drought tolerant maize varieties are likely to be one important element amongst a range of strategies that will be necessary to build security and adaptive resilience within SSA's food systems. However, the existence of improved cultivars will not reduce climate vulnerability amongst farmers unless they are actually used on farms (Langyintuo et al., 2010). It has been observed that assumptions about farmers' real practices are often oversimplified by those attempting to determine the future impacts of climate change (Kandlikar and Risbey, 2000). Yet, the heterogeneity of impacts and responses at a household level should be a key concern for those wishing to reduce vulnerability (Thornton et al., 2009). The research in this thesis responds to calls to enhance understandings of the social and human aspects of adaptation at the local scale; the scale at which vulnerability is itself experienced (Challinor, 2008, Wilby et al., 2009, Ayers, 2010).

If improved maize cultivars are to effectively reduce vulnerability to climate change amongst African smallholders, the factors which affect their adoption as an adaptation to climate change must be scrutinized. Building on this need, this project seeks to contribute to a multi-tiered technography of maize cultivar adoption for adaptation, by undertaking in-depth, cross-disciplinary research involving stakeholders at multiple entry points within a national maize seed system in SSA. This thesis locates adoption decisions within the context of climate change adaptation in order to ask how new cultivars will help reduce vulnerability to climate change, and specifically whose vulnerability will be reduced. These goals will be achieved by investigating the barriers and drivers that presently influence adoption decisions amongst smallholder farmers whilst addressing stakeholder perspectives about current and future changes to the regional climate.

1.2 Malawi

Malawi was chosen as the location in which to undertake the research for this project for a number of reasons. Since independence there has been a series of strong political drives to enhance the uptake of modern maize cultivars and inorganic fertilizer amongst smallholders, with the current Agricultural Inputs Subsidy Programme (which aims to deliver a targeted inputs subsidy to 1.6 million farmers) drawing both high praise and criticism from national and international sources (Chinsinga, 2006, Dorward and Chirwa, 2011, Javdani, 2012). In terms of the importance of maize within national consumption habits, Malawi is at the top of the charts for East Africa. Maize makes up a higher proportion of the national diet than in any other comparable African country, providing 65% of the daily calories consumed by the average Malawian (Smale, 1993, Takane, 2008), and livelihoods are considered to depend on this crop more than any other (Katengeza et al., 2012). This extremely high reliance on maize has been highlighted as a factor increasing vulnerability to climate-related production shocks (Cromwell and Kyegombe, 2005).

Maize is also hugely important in production terms. Ninety-seven percent of farming households grow maize, and it occupies over half of all the smallholder land that is cultivated within the country (Smale, 1993, Denning et al., 2009, Chirwa, 2010). Whilst Malawi is at the extreme end of the scale in terms of maize consumption and cultivation within East Africa, the smallholder context, the predominance of maize consumption and cultivation, and the impacts of its return to agricultural subsidies post structural adjustment in the 1990s make it a case study with broad relevance and interest for surrounding nations.

Malawi also exhibits most of the same symptoms of underdevelopment as many other countries in SSA and has been described as “a country in perpetual crisis” (Frankenburger et al., 2003). Life expectancy has moderately increased over the past decade, but remains low at 53 years (in 2011) (Africa Statistical Coordination Committee, 2012). In global comparative terms Malawi is extremely poor and displays high levels of wealth inequality (Cromwell and Kyegombe, 2005). Food purchases account for on average 65% of household expenditure and 73.9% of the population live on less than $1.25 a day (United Nations Development Programme, 2012). Diseases associated with poverty such as diarrhoea and malaria are a considerable health burden (Devereux et al., 2006) as is HIV prevalence, estimated to infect one in ten of the population aged between 15 and 49 (UNAIDS, 2011). Access to healthcare is also low, with less than one doctor per 50,000 people (United Nations Development Programme, 2012). The total fertility rate has fallen somewhat over the past decade, but remains high, at 5.7, and infant mortality is estimated at 88.5 per thousand (Africa Statistical Coordination Committee, 2012). Literacy and access to education is low, with Malawians spending an average of just over four years in education (United Nations Development Programme, 2012). Malawi was ranked 160th in the 2009 United Nations Human Development Index (United Nations Development Programme, 2009), is heavily in debt, and is heavily reliant on international aid (House of Commons Committee of Public Accounts, 2010).

As elsewhere in SSA, smallholder farming is of great importance to livelihoods in Malawi. Agriculture is the main economic activity of 85% of the predominantly rural population and accounts for 35% of Malawi's GDP (Chirwa, 2010). Agriculture mainly consists of smallholder rain-fed production, which in turn leaves the country's food system and economy as a whole highly vulnerable to climatic variation (Cromwell and Kyegombe, 2005). A reflection of this, (and also of Malawi's history of mercurial agricultural policies) is that maize yields have fluctuated widely, particularly in recent years (Harrigan, 2003) (see Figure 1.1). Household maize shortfalls are commonplace and regional and national food crises have occurred throughout Malawi's history (Mandala, 2005). Significantly, in 2001-2, relatively mild climatic disturbances led to a serious food crisis which resulted in several hundred deaths from starvation (Devereux, 2002, Menon, 2007).

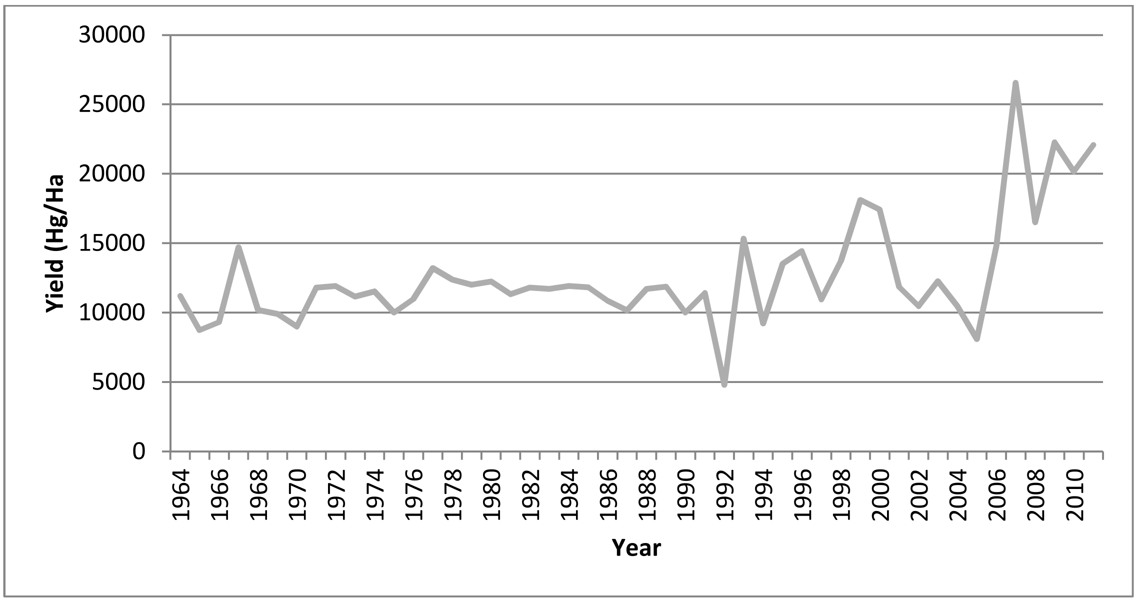


Figure 1.1: Maize yields in Malawi from Independence to 2011 (Source FAOSTAT)

Meanwhile, historical attempts at modernising maize production through the use of improved seed and inorganic fertilizer have resulted in isolated pockets of uptake that have fizzled out rather than endured (Smale, 1993, Denning et al., 2009, Mosley, 2002). Given this context, maize cultivar adoption has formed the object of several studies based in Malawi (Levy, 2005b, Cromwell and Zambezi, 1993). However, unlike studies that have been undertaken in Nigeria and Kenya, no studies in Malawi have explicitly posited adaptation to climate change and the outlook for the adoption of better adapted cultivars as a central feature (Brooks et al., 2009, Tambo and Abdoulaye, 2012).

Maize production in Malawi stands to be impacted negatively by climate change. Without the adoption of improved cultivars and other changes to agricultural practice, maize yields are predicted to be reduced on average throughout Malawi from 1541 Kg/ha to 1366 Kg/ha by 2055 (with considerable variability in how this deficit is realised at a regional and household level, leading to much greater vulnerability for some) (Jones and Thornton, 2003). Malawi presents a good location for studies concerning climate change because it is topographically diverse and composed of areas that manifest a range of different exposures to drought and flooding, and exhibit different maize production potentials (MNVAC, 2003). Unlike some other East African countries, Malawi has one rainy season (receiving between 725 and 2500 mm of rainfall annually) and therefore only one shot annually at producing the majority of its food (Makoka, 2008).

But Malawi is also a unique case in some respects that make it particularly interesting for a study of this sort. Malawi is small, land-locked and has over thirteen million inhabitants, making it highly populated in relation to other countries within the region (Makoka, 2008) (see Figure 1.2). This means that land holdings are limited in size and decreasing over time, a factor closely linked to rural poverty (Harrigan, 2008), and one which necessitates the intensification rather than expansion of agriculture if future food requirements are to be met (Boserup, 1965). As already indicated, since independence from colonial rule was achieved in 1964, and particularly over the last decade, the country has implemented a number of schemes to subsidize smallholder maize production. These programmes made global headlines in 2008 with the news that they had succeeded in transforming Malawi from a food insecure country to a food secure one (Bloomfield, 2008, Mutharika, 2009), and Malawi’s subsidy scheme has been recommended as a case of interest to Malawi’s African neighbours (Denning et al., 2009). Nonetheless, Malawi’s subsidy programmes are not without criticism, not least because they have become so politicised (Harrigan, 2008, Chinsinga, 2011).

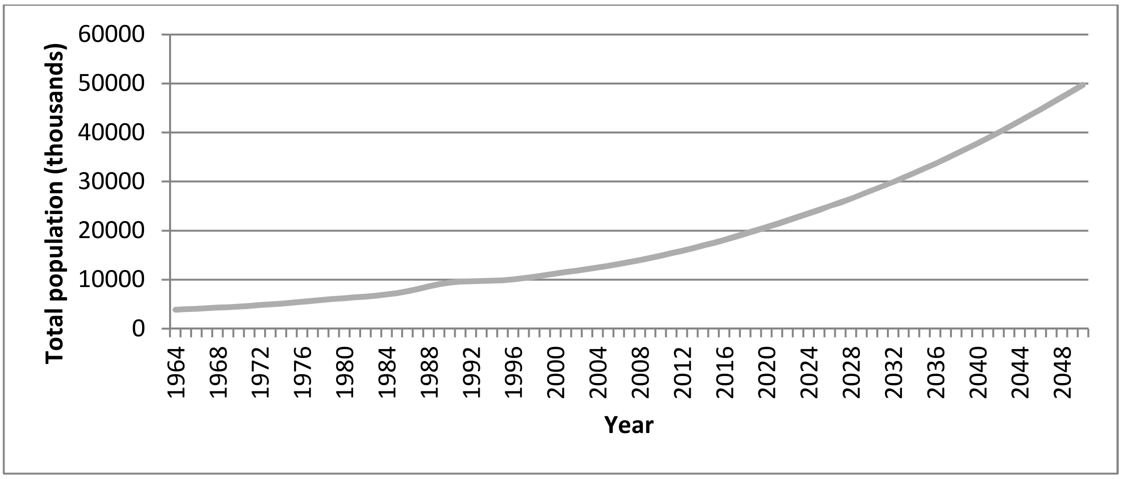


Figure 1.2: Malawi's population growth projected to 2050 (Source: FAOSTAT)

Finally, Malawi was selected for reasons of logistical practicalities. The country's compactness and comparatively good road system enhanced the accessibility of field sites located within different districts. Malawi also differs from many of its neighbours in SSA since to date it has been free from serious political unrest in the post-independence era, and is a relatively safe place to travel, and having been a British colony, one of Malawi's two official languages is English, which meant that fieldwork interviews with urban participants could be conducted without the need for a translator.

1.3 Aim and Objectives

The aim and objectives of the research are:

Aim: To understand how social dimensions (asset and land ownership, cultural preferences and perceptions of climate risk) affect the potential for cultivar adoption to enable equitable adaptation to climate change amongst Malawian smallholder farmers.

Objectives:

1. Describe the diffusion of modern maize cultivars to smallholders in Malawi
2. Identify adoption outcomes in the two research areas
3. Identify barriers to and drivers of adoption decisions within smallholder households
4. Explore the implications of findings for 1, 2 and 3 for climate change adaptation and vulnerability reduction amongst smallholder households in Malawi
5. Identify policy recommendations to facilitate equitable distribution of adaptation benefits from improved maize uptake and production.

1.4 Thesis structure

The thesis is divided into seven chapters which present the research that was undertaken in terms of its purpose, methods and results. The current chapter provides a broad introduction to the research by presenting the issues which drive the project's aim. It has also outlined why Malawi was chosen as the location for fieldwork. Chapter two presents a literature review of the historical and contemporary role of maize within Malawi's production and consumption systems and presents theories relevant to agricultural technological change and climate change, outlining how these theories contributed to decisions regarding the choice of methods and analysis employed. Chapter three presents the research design and methods that were used to direct fieldwork, indicating their basis within the literature and highlighting their selection with regard to the project's aim and objectives. Chapters four, five and six present the results of the research. Chapter four presents an overview of the ways that maize cultivars are currently diffused to smallholders in Malawi and reflects on these with reference to theories of agricultural innovation. This enables an assessment of the likelihood that the former will lead to equitable adoption outcomes and an evaluation of the utility of the latter for directing diffusion strategies which enable vulnerability reduction amongst smallholders. Chapter five presents the production and vulnerability characteristics of the two research areas and explores how the modes of diffusion presented in Chapter 4 translate into patterns of cultivar use amongst smallholder households within the two research areas. Associations between household wealth and the adoption of modern cultivars are scrutinized and the complex contextual factors which drive adoption decisions are revealed. The benefits of the Agricultural Inputs Subsidy Programme and the modernisation of Malawi's seed industry for socio-economically vulnerable households are assessed. Chapter six explores the drivers of cultivar adoption in each research area and considers their implications for adaptation to current climate variability and future climate change. Chapter seven presents the implications of the research findings for vulnerability to climate change amongst smallholder households in Malawi and presents and discusses policy recommendations and avenues for further research.

Chapter 2 - Maize and agricultural change in Malawi

This chapter will develop an outline of the context for maize cultivar adoption in Malawi in theoretical, cultural, political and historical terms. In doing so the past and current roles of maize at both the household and national level will be explored and academic frameworks for approaching innovation and climate change adaptation will be used as a guide for developing the study's research approach including methods and analysis.

Sections 2.2 and 2.3 are intended to elucidate the historical context which has determined the contemporary role of maize in Malawian diets and farming practices. As will be seen, smallholder maize production has developed under the auspices of state support through subsidies and pricing interventions. However, the features of this support have constantly shifted, reducing Malawian national food security and the resilience of the smallholder production system. Attempts to modernize maize cultivation habits have often been frustrated due to a range of factors including a weak and indecisive national maize-breeding program, the marketing of unsuitable cultivars, and smallholder financial constraints (Smale and Jayne, 2010).

Section 2.4 builds a theoretical foundation for the exploratory analysis of contemporary maize cultivar adoption as an adaptation strategy. Approaches to understanding the spread of agricultural innovations are introduced and critiqued, and literature concerning climate change adaptation is explored with a view to gaining insights into adaptation decisions and the constitution of vulnerability to climatic hazards broadly relevant to smallholder maize production in East Africa.

This background sets the stage for the investigation of maize cultivar diffusion within the national seed system undertaken in Chapter 4, helps to explain the adoption patterns that were encountered within the research study sites described in Chapter 5 and provides a framing for analysing the drivers of adaptation decisions that are examined in Chapter 6.

2.1 Maize in Malawi: The past and the present

2.1.1 Malawi's staple food crop

It would be difficult to overstate the importance of maize as a food crop in Malawi. Despite the fact that maize only started to replace sorghum as a staple food in Malawi a little over a century ago (Smale and Rusike, 1998), the crop now occupies such significance that when Malawians talk of 'food', they are usually referring to maize (Smale, 1993). It has (in line with the primacy of food security as a national concern), become a highly political crop (Chinsinga, 2011), and it is passionately preferred by the vast majority of Malawians as their staple food (Smale, 1993, Levy, 2005b). For most, eating maize is "seen as essential to having a good life", and self-sufficiency in maize is a widely and highly held value (Levy, 2005b, p.119).

In Malawi, maize is predominantly a subsistence crop, with less than 20% of what is produced ending up as marketed surplus (Chirwa, 2010). The majority of the crop is harvested when dry, or allowed to dry in the sun post-harvest. It is then processed by women in several stages involving de-husking, winnowing, soaking and pounding with a pestle and mortar to produce flour (although mechanical maize mills are now widely employed, which saves on female labour) (Kydd, 1989). Traditional hand-processing produces several different grades of flour, incorporating more or less bran. The most highly prized is pure white flour known as *ufa* which is considered men's food and the most suitable kind to offer to guests (Kydd, 1989). Maize is used to produce several types of Malawian food (and also drink), but the most important is *nsima*, (a stiff porridge) which is eaten up to three times a day and accompanied by *ndiwo* (which means relish and refers to meat, fish, legumes or vegetables) (Mandala, 2005). *Nsima* can also be made entirely or partially from other grains and/or starchy tubers, including sorghum, millet and cassava. Maize *nsima*, however, is strongly preferred for reasons of flavour and digestibility (Kydd, 1989). The culinary uses and processing techniques that Malawians apply to maize influence national preferences for particular types of maize cultivar (in particular, those with flint texture which last well in storage and pound well by hand).

Although self-sufficiency is an important aim at both the national and household level within Malawi, producing enough maize to last until the next season's crop is harvested is usually only achieved by a minority of smallholder households (Smale and Rusike, 1998). The majority rely on the market for purchasing their maize throughout several months of the year. A variety of cash-earning activities are engaged in, but most dominant by far is *ganyu*, meaning piecework or informal agricultural labour (Bryceson, 2006). The market for maize functions poorly and prices fluctuate considerably throughout the year (Smale, 1995). They are highest during the hungry season from January to March (the final months preceding the harvest), a time when many households depend on the market for maize and, through lack of income earning opportunities and scarcity of *ganyu*, engage in coping strategies which erode their asset base (Devereux et al., 2006). Wealthy, large-scale farmers who grow maize for the market and have the means to store what they have produced are known to refrain from selling until prices start to rise in the hungry season (Devereux et al., 2003).

Price fluctuations for marketed maize become particularly acute during national food crises. Crises within living memory occurred in 1949-50 (The Great Famine), 1987, 1992 (as a result of the Southern African drought), 2002 and 2005 (Vaughan, 1987, Devereux, 2002, Menon, 2007, Harrigan, 2008). The 2002 food crisis is considered to have incurred very high costs in terms of human lives lost, damage to livelihoods and the breakdown of social bonds, despite resulting from a far less severe climate trigger than earlier crises (Devereux, 2002). This has been taken as evidence of increasing smallholder vulnerability following structural adjustment, although the seriousness of the famine was also due to institutional failings such as the mismanagement of the strategic grain reserve and the delayed provision of food aid (Devereux et al., 2003, Harrigan, 2008). The sporadic to regular reliance on purchased maize that characterises most Malawian smallholder households means that they are vulnerable to both climatic and market vagaries and are likely to require carefully planned institutional support as well as more resilient production strategies if the risks which climate change poses to their livelihoods are to be effectively addressed (Stringer et al., 2010).

Malawi differs from neighbouring countries in that it lacks a strong commercial maize sector (Smale and Rusike, 1998). This means that preferences for types of maize in Malawi are strongly determined by consumption, culinary and storage characteristics which complement household processing and eating habits. Malawian smallholders overwhelmingly prefer to grow and eat white, flint maize, which, due to the hardness of the grain, has preferable processing, cooking and storage characteristics (Smale and Rusike, 1998, JAICAF, 2008). Maize landraces that are common in Malawi (known as local maize varieties) usually possess these characteristics, which translate into excellent pest resistance in the field and in storage, a clean separation of bran from the endosperm during hand-pounding and, despite relatively low yields, a high flour to grain ratio (Kydd, 1989). Preferences for white flint maize are common in Eastern and Southern Africa, but rare on a global scale, where the majority of maize breeding efforts have gone into the production of high-yielding dent, yellow cultivars. Initially only these improved yellow dent cultivars were marketed in Malawi which could partly account for slow adoption rates (Smale and Rusike, 1998).

In addition to choosing maize varieties on the basis of grain density, Malawian farmers also choose between hybrid, improved open-pollinated varieties (OPVs) and local cultivars, which each offer a variety of different yield potentials, biotic stress tolerances and days to maturity. Malawi's local maize cultivars are open-pollinated and seed is saved from each generation to plant the next season's crop. Since maize is cross-pollinated by wind-carried pollen from other maize plants in the local area, local maize varieties can manifest a high degree of phenotypic and genetic variability within and between generations (Magorokosho, 2006). Seed-saving can lead to inbreeding depression which can contribute to poor performance (Borlaug, 1983). Local maize cultivars tend to be late-maturing, but have been noted to display unusually high temperature tolerance, an uncommon yet under-recognised trait which could be useful to breeders (JAICAF, 2008).

Hybrid maize is produced when two genetically different plants are crossed to produce an F1 generation of plants which are all genetically identical and exhibit heterosis (hybrid vigour) (Smale and Jayne, 2003). Yields from modern hybrid cultivars are usually much higher than those from OPVs (Magorokosho, 2006). Hybrids, however, are comparatively expensive to buy, and seed-saving is advised against since subsequent generations will exhibit highly variable performance and yield declines.

Finally, improved OPVs represent a middle ground between local and hybrid cultivars. Being open-pollinated, farmers can save seed for the next year's planting from up to three crops in a row before inbreeding depression becomes a problem. They are cheaper to produce and purchase, but, unlike local maize, they have been bred under controlled conditions in order to stabilize characteristics and enhance yields, earliness and stress tolerance.

2.1.2 Post-colonial agricultural modernization

Throughout the nineteenth century settled agriculture in Central Africa was severely weakened by slave-raiding, the violence of Zulu expansion, and drought (Frankenburger et al., 2003). The British colonial government of Nyasaland in turn continued to undermine the agricultural base by dismantling traditional systems of land management, establishing systems of forced labour and heavy taxation, and strongly promoting the growth of estates whilst blocking smallholder access to land and markets (Bryceson, 2006). The British ceded power to the newly formed nation of Malawi in 1964 (see Figure 2.2 for a timeline of key historical events post-independence). It is surprising given this fractured background that Hastings

Kamuzu Banda's policies should have successfully engendered rapid economic growth for the first fifteen years of his rule (1964-1979). Nonetheless, an average 3% GDP growth per annum was achieved through what has been termed "state monopoly capitalism", which was supported by a "relentless centralisation of power", and undergirded by Banda's autocratic and intimidating persona (Harrigan, 2003, Cammack and Kelsall, 2011, p. 89). Banda focussed strongly on agriculture and pursued a populist strategy by prioritizing national food security (Harrigan, 2008). He introduced universal fertilizer and small-scale credit subsidies and controlled maize prices through the parastatal maize marketing board, ADMARC (Allcock and Kainja, 2011). He formed Press Holdings, which took over many ex-colonial estates, and dominated tobacco production as well as processing and retailing interests, in addition to running the Malawi Congress party newspaper (Cammack and Kelsall, 2011). His government strongly promoted the expansion of estate agriculture which largely accounted for the economic growth that occurred (Harrigan, 2003). However, this growth masked the increasing impoverishment of smallholders who, unlike the estate sector, were banned from cultivating Burley tobacco, tea and sugar (Harrigan, 2003). Smallholders were thus forced to choose between labour migration to South Africa, *ganyu* or estate work to earn an income (Frankenburger et al., 2003). Those returning from migrant labour in South Africa were significantly better off than others who had remained behind which contributed to a process of rising wealth inequalities amongst smallholders that continues today (Frankenburger et al., 2003).

Due to a combination of internal and external factors, including war in Mozambique which blocked trading access to the coast, drought, rising oil prices and the market distortions of his policies, Banda's economic successes could not be sustained into the latter years of his rule, which came to be characterised by "a culture of detentions and human rights abuses" (Frankenburger et al., 2003, Cammack and Kelsall, 2011, p.90). In 1981 Banda accepted several loans as part of a structural adjustment programme involving the World Bank, the IMF and a number of other donors (Harrigan, 2003). The programme specified better market prices for smallholder products and commenced market liberalization which included the removal of maize seed and fertilizer subsidies (although government reticence to relinquish control meant that subsidy removal for fertilizer was not actually completed until 1995) (Frankenburger et al., 2003, Harrigan, 2008). Whilst smallholders initially saw some benefits including the opening up of tobacco production and club access to credit through the Smallholder Credit Association (Frankenburger et al., 2003), their wages fell whilst the cost of inputs soared (Harrigan, 2003). As structural adjustment proceeded, national food security weakened, with Malawi starting to import large quantities of maize by the end of the 1980s (see Figure 2.1).

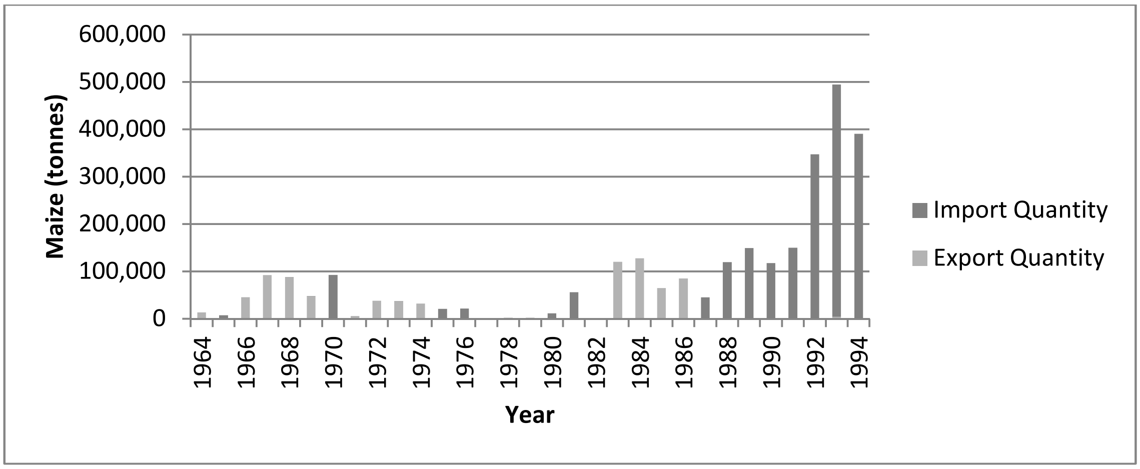


Figure 2.1: Maize imports and exports during Kamuzu Banda's rule (source: FAOSTAT)

From 1991 to 1993 the Southern African drought reduced maize yields in Malawi by over 50% and shortly after this the Smallholder Credit Association collapsed due to the high number of loans being defaulted (Frankenburger et al., 2003, Harrigan, 2008). The government responded with food aid and distributed free maize seed (actually maize grain purchased from local markets) under the Drought Relief Seed Distribution Project (Tripp and Rohrbach, 2001). In subsequent years the free distribution of seed continued with the Drought Recovery Inputs Programme in 1994-5 (distributing hybrid seed), the Supplementary Inputs Programme in 1995-6 (hybrid seed and fertilizer in high potential areas), and the Starter Pack Scheme in 1998 (Tripp and Rohrbach, 2001). These distributions, following on from Banda's subsidies and price-fixing regimes, stimulated increases in maize acreage (Harrigan, 2008), accompanied by a narrowing of crop diversity, increases in continuous maize mono-cropping and decreases in traditional fallowing and rotations, all of which increased the sensitivity of the production system to climate hazards (Devereux et al., 2003).

Meanwhile, the country transitioned to a multi-party system of governance in 1994 with Bakili Muluzi taking the Presidency. Muluzi's rule (from 1994-2004) is viewed as a time when corruption spiralled out control and structural adjustment continued to weaken the resilience of smallholder livelihoods (Frankenburger et al., 2003). The devaluation of the kwacha by 62% in 1998 contributed further by making basic commodities even less attainable for poor households (Frankenburger et al., 2003). The final straw for Muluzi's reign was his initial denial of the 2002 food crisis. He lost the 2004 elections to his successor Bingu wa Mutharika (Devereux, 2002, Cammack and Kelsall, 2011).

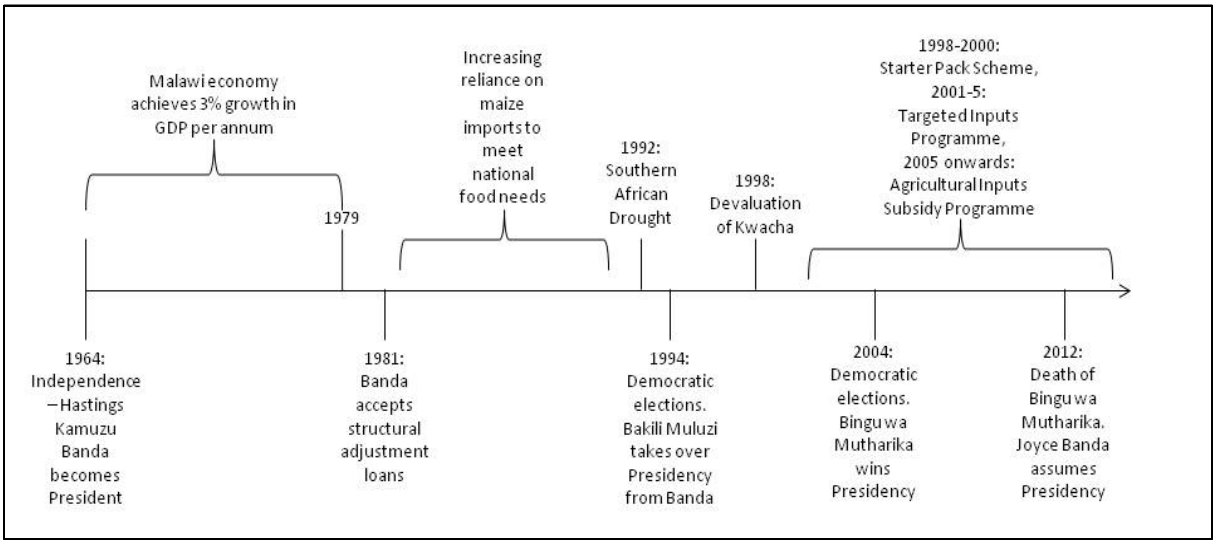


Figure 2.2: Key events in Malawi's political history

Mutharika concentrated his attentions on an anti-corruption drive, prioritized economic growth and promoted his government on the back of the populist issue of national food security by embracing and expanding the central notion of the Starter Pack Programme (the provision of farm inputs to boost national level maize productivity). Such was the agricultural focus of his presidency that input subsidies became central to Malawian politics and some analysts have claimed that “votes were harvested from a poverty-oriented agricultural strategy” (Cammack and Kelsall, 2011, p. 93, Chinsinga, 2011). Whilst Malawi’s economic performance improved during Mutharika’s first term (2004-9), it deteriorated rapidly during his second (2009-2012). His sudden death from a heart attack in 2012 took place following a period when chronic national foreign currency and fuel shortages were crippling the country and leading to rising political unrest (including a protest-turned-riot that resulted in a number of deaths at the hands of the police) (Cammack and Kelsall, 2011, Dionne and Dulani, 2013). His alienated Vice President Joyce Banda took over the Presidency and followed IMF advice to devalue the kwacha, whilst continuing to pursue the wide-reaching provision of agricultural subsidies from which it has now become difficult for any political party to extricate themselves (Scott and Banda, 2013). She has voiced commitments to modernise Malawian agriculture in a bid to reduce current levels of malnutrition and attain food security for the future (Lamble, 2013).

2.1.3 The Agricultural Inputs Subsidy Programme

The newest incarnation of government support for maize cultivation in Malawi is the Agricultural Inputs Subsidy Programme (AISP, sometimes referred to as the Farm Inputs Subsidy Programme, ongoing from 2006). This programme is the successor to the Starter Pack programme (1998-2000) and the Targeted Inputs Programme (2001-2005) (Chinsinga, 2011), and has evolved in response to food crises and donor concerns. In 2011, when fieldwork for this thesis was carried out, the AISP targeted subsidy coupons for maize seed, legume seed and fertilizer at a total of 1.6 million farm households (Government of Malawi, 2011). The current programme is described as more ambitious and costly than any other within Malawi's history of subsidy provision (Buffie and Atolia, 2009). It has also gained the most international recognition for boosting the country's productivity (Denning et al., 2009).

International acclaim for Malawi's agricultural subsidies was particularly garnered from 2006 onwards. Against the backdrop of the 2002 food crisis where at least several hundred people starved to death (Devereux, 2002), the programme appeared to transform the country from one that was reliant on food aid to one which could export maize to surrounding countries. Additional kudos was given by media commentators (Bloomfield, 2008) since subsidies were pursued as a political strategy despite strong warnings from donors who remained adamant that policies which entailed market distortions should be avoided (Harrigan, 2003, Javdani, 2012). The subsidy aims to increase food security by enhancing maize productivity and concomitantly reducing the market price of maize whilst also freeing up land for other crops. The programme's underlying tenets have been fervidly affirmed by individuals committed to the quest for a green revolution in Africa (Denning et al., 2009), and analysts believe it has "contributed to increased food availability, higher real wages, wider economic growth and poverty reduction" (Dorward and Chirwa, 2011, p. 232). However, there have also been criticisms. Some commentators have speculated about the political role of the subsidy and its longer term sustainability in both economic and environmental terms (Chinsinga, 2011, Mhango and Dick, 2011). Others have noted its failure to address inequalities and localised maize shortfalls (Javdani, 2012), and the cost of the programme's singular emphasis on maize production as a missed opportunity to enhance resilience by diversifying crop production has also been highlighted (Brooks, 2013).

As discussed, agricultural subsidies are nothing new in Malawi. Hastings Banda's policies for agricultural modernisation (1964-1994) included universal fertilizer subsidies, subsidized smallholder credit schemes and government control over maize prices, as well as free distributions of maize seed and fertilizer as emergency drought response measures (Harrigan, 2008, Dorward and Chirwa, 2011). However, the economic collapse and market liberalisation that came at the end of Banda's rule when Bakili Muluzi took over (1994-2004) made inputs unaffordable once more for smallholders, and many subsequently disadopted the use of hybrid maize and fertilizer (Levy, 2005a). A return to subsides to remedy this disadoption was therefore perhaps inevitable.

In response to plunging maize production the Starter Pack Programme (1998-2000) provided subsidized maize seed and fertiliser to 2.8 million Malawians (Buffie and Atolia, 2009). Although Starter Pack had been geared towards universal inputs provision as a way of 'kick-starting' higher yielding maize production for smallholders, the scope of the programme was soon scaled back in response to donor pressure to become the Targeted Input Programme (TIP) in 2001-5. Following this (and a second food crisis in 2005) the AISP took over. Peaks in maize production in Malawi tend to reflect historical incidences of subsidy provision, which perhaps casts doubt on the sustainability of the effects of the current programme if or when the subsidy is scaled back again (Harrigan, 2008).

The original Starter Pack design was based upon extensive research that had determined "Best Bet" technologies for each of the country's agricultural zones, such as area-specific fertiliser doses, appropriate legume seeds, and hybrid maize seed (Blackie and Mann, 2005). When the programme became the TIP the beneficiary target range narrowed to exclude less vulnerable households, and the underlying ethic morphed into a concern with the provision of social safety nets. OPV rather than hybrid maize was provided as it was considered more suitable for poorer households that would be likely to rely on saved seed in the future. The logistical difficulties entailed in producing area specific packs were acknowledged early on, and blanket recommendations for fertilizer provision and application were soon introduced (Potter, 2005). Original concerns to operate with contextual sensitivity were thus eroded in the interests of managerial expediency. When the AISP began, target numbers were increased once more, and in 2007 hybrid cultivars were re-introduced to the packs (Chinsinga, 2011). Perhaps as a result of the inclusion of hybrids in 2006 and 2007, which were years of notably good rainfall, the production levels of 2005 were respectively doubled and tripled (Denning et al., 2009). However, the heights of the 2007 maize yields have not been achieved again, and the high cost of fertilisers on the international market and high local costs for maize have undermined the programme's contribution to food security in recent years (Dorward and Chirwa, 2011).

A cursory nod to diversification and soil health is included in the current programme via the distribution of legume seed vouchers (along with sporadic support for cotton, tea or coffee production through inclusion of specific pesticide or fertiliser vouchers) (Dorward and Chirwa, 2011). However, overwhelmingly the emphasis of the subsidy programme is on boosting maize production for national food security (Chinsinga, 2011), and it is unlikely that President Joyce Banda will abandon this stance any time soon. But regardless of the international fanfare, and despite the programme's intentions to target the most vulnerable households (Dorward and Chirwa, 2011), there are indications that the programme itself does not adequately address issues of social vulnerability or vulnerability to climate change (Chinsinga, 2011, Dorward and Chirwa, 2011, Mhango and Dick, 2011, Brooks, 2013). Commentators have decried the over-dependence on maize that characterises Malawi and many neighbouring countries, whilst highlighting the importance of crop diversification and emphasizing the role that neglected, yet climate tolerant crops could play in assisting adaptation to future climate change (Brooks et al., 2009). Questions therefore remain about the current subsidy scheme's impacts in terms of equity, sustainability and vulnerability to climate change which the results chapters that follow will seek to address.

2.1.4 A history of Maize Research in Malawi

2.1.4.1 Breeding

Public maize breeding in Malawi has an inconsistent history characterized by low levels of state financial support (Smale and Rusike, 1998). Maize has remained a smallholder crop here, and unlike in adjacent Zambia and Zimbabwe, where large settler populations with political influence ensured the development of public breeding programs capable of producing improved cultivars to meet their needs, smallholder trait preferences have only started to function as a concern for breeders in recent decades (Smale, 1995). Nonetheless there were isolated periods where breeding policies did reflect smallholder farmers' concerns (Smale and highly prized??. The national agricultural research station at Chitedze was set up in 1950 in response to The Great Famine of 1949 and resultant concerns about the vulnerability of the maize cultivars in use at the time (Smale and Rusike, 1998). Whilst breeding cultivars to meet the preference for flint maize amongst smallholders was complicated by a scarcity of suitable germplasm (most available hybrid breeding material was dent in texture), early breeding at Chitedze had resulted in the release of one semi-flint hybrid and three semi-flint synthetics (bred for specific agroecological zones) by the mid-sixties (Smale, 1993, Denning et al., 2009). Following independence there was a dearth of breeding activity, and germplasm and seed testing declined. As a result, the quality of seed that reached farmers was poor, with many starting to complain of poor germination rates for some modern cultivars (Smale and Rusike, 1998). The hybrid breeding programme at Chitedze was closed in 1967 for ten years and during the 1970s national breeding efforts instead focussed on producing OPVs (Smale and Rusike, 1998). The focus then shifted back to hybrid production in 1977 which resulted in the production of locally-bred dent hybrids MH12 to MH16 from 1978-1984 (MH stands for Malawi Hybrid) (Smale, 1993). These hybrids also failed to meet local preferences for flint grain texture, (which had remained a breeding concern in the production of OPVs) but eventually efforts to produce hybrids with traits that reflected smallholder preferences resulted in the release of MH17 and MH18 in 1990 (Smale, 1993). Debates over the suitability of hybrids versus OPVs for smallholder production continue today (Chinsinga, 2011).

Up to the end of Hastings Banda's rule there was no private seed industry in Malawi due to the seed-market dominance of state-controlled ADMARC (Smale and Rusike, 1998) and no private seed breeding efforts were undertaken in country. This changed a little in the early 1990s when policy measures began to open up the private seed market and companies such as Pannar began to test materials nationally (Smale and Rusike, 1998). The growth of the private industry has continued, with increasing numbers of seed companies beginning operations nationally, including Pannar, Seed Co and Pioneer. Fifty percent of the seed market is now controlled by Monsanto (Chinsinga, 2011). Smaller private seed companies also operate but on a much smaller scale and with no breeding efforts of their own (they mainly bulk up and distribute public good cultivars from CIMMYT and Chitedze) (Chinsinga, 2011). Today, the liberalisation of the market and the growth of corporate seed companies within Malawi, many of whom only trial (rather than breed) materials in-country, is considered to have resulted in continued neglect of the public breeding system, to the detriment of varietal market choice for smallholders (Chinsinga, 2011). The public system is once more underfunded (since little government finance remains after the subsidy programme costs have been covered), and suffers from the loss of trained professionals to better opportunities elsewhere internationally (Chinsinga, 2011).

2.1.4.2 Adoption research

Adoption levels of improved maize in Malawi remained low for many years even though the first maize hybrids were released within the country over fifty years ago (in 1961), and despite huge promotion efforts by the extension service (Holden and Lunduka, 2012, Katengeza et al., 2012). Improved cultivar uptake has grown in line with the impacts of the AISP, but still stood at only 43% nationally in 2009 (Seed Traders' Association of Malawi, 2011) compared to 75% in Kenya and 97% in Zimbabwe (Smale et al., 2011). It is impossible to say whether Malawi's current adoption levels would be sustained if the AISP were scaled back, although based on levels of past disadoption, it seems unlikely (Levy, 2005a). Studies evaluating disadoption within Malawi have found that for more than fifty percent of households a shortage of finances explains reversion back to local maize (Langyintuo, 2005).

Some studies have been concerned with the question of intensity of adoption (Katengeza et al., 2012). It has been noted that many households continue to grow a combination of modern and local maize cultivars, which leads to the suggestion that only partial adoption has been achieved. There are difficulties with gaining precise information about adoption levels within Malawi because of household discontinuities in seed use. Smale and Phiri (1998) found that very few households they surveyed were able to grow F1 (first generation) hybrid maize from one season to the next. However, many households did recycle saved seeds from original F1 hybrids for several seasons even though this is against extension service advice (Smale and Phiri, 1998). Due to apparent farmer preferences for saving seed on-farm, there are queries over whether smallholders really prefer OPV or hybrid maize. Claims have been made that smallholders have preferentially exchanged subsidy coupons for hybrid rather than OPV cultivars (Denning et al., 2009), but it has also been suggested that the market dominance of hybrids is squeezing the marketing of OPVs to the detriment of smallholder choice (Chinsinga, 2011).

On the basis that the use of improved cultivars could increase yields and therefore household food security, many analysts have sought to explain why Malawi's adoption levels have tended to remain low, often via analyses which identify differences between adopting and non-adopting households (Langyintuo, 2005, Simtowe, 2006). Such analyses have found that adopters often have more land and are more likely to have access to credit (Smale, 1993). In other words, wealth is a major determining factor for farm households deciding whether to grow improved maize. However, poverty is only one explanation put forward. Low uptake is also explained by the fact that the released cultivars have not met smallholder trait preferences, the seed market has operated inefficiently, farmers have not been well informed about what is available, and shifts in state financial support for subsidies have created market disincentives (Cromwell et al., 1993, Smale, 1993, Smale and Phiri, 1998, Harrigan, 2003, Simtowe, 2006, Simtowe et al., 2009, Lunduka et al., 2012). More recently, authors have explained Malawi's adoption plateau by suggesting that farmers opt for diversity and seek to meet preferences for a range of traits which are not embodied in a single cultivar (Lunduka et al., 2012).

An aim of Malawi's inputs subsidy schemes has been to overcome the financial and experiential barriers which might stand in the way of improved maize use for some smallholder households. Following five years of subsidy provision for around fifty percent of farm households (Dorward and Chirwa, 2011), this thesis will seek to assess whether barriers to cultivar adoption have been overcome effectively, and to understand farmers' preferences for maize cultivar use in the future.

The chapter so far has described the importance of maize as a food crop in Malawi and has outlined the country's history of political support for maize production, from subsidized inputs provision to national breeding efforts, thereby providing the reader with insight into the political and social contexts which surround the scenarios of contemporary smallholder maize adoption to be explored in the results chapters. Literature that has sought to explain why modern maize cultivar adoption has remained limited has also been summarized. The remainder of the chapter now explores concepts of agricultural innovation adoption and climate change adaptation from a theoretical perspective.

2.2 Theoretical approaches to agricultural innovation diffusion, adoption and adaptation to climate change

2.2.1 Diffusion of Innovations (DoI)

The spread and uptake of new crop varieties constitutes innovation diffusion and adoption, a process which has been studied widely by researchers interested in the social dimensions of technological change within many different sectors. Perhaps the most significant text in this field is Everett Rogers' "Diffusion of Innovations" (Rogers, 2003). In this work, Rogers draws together diffusion studies from a broad range of disciplines in order "to describe a general diffusion model" (ibid, pp. 39).

Despite the breadth of material to which Rogers refers in his book, the main inspiration behind the approach comes from Ryan and Gross (1943), who investigated the uptake of hybrid maize by farmers in Iowa (Valente and Rogers, 1995). In their analysis Ryan and Gross retrospectively date farmers' adoptions of hybrid maize, producing a quantitative measurement of adoption over time. In line with their findings, Rogers characterizes the cumulative frequency of adoption with an 'S-shaped curve', as shown in Figure 2.3 (Rogers, 2003, pp. 272), and describes how other researchers have gone on to establish that this characterization is appropriate in most, if not all, adoption scenarios. Rogers' DoI framework might therefore be expected to describe and explain adoption patterns for maize cultivars amongst smallholders in Malawi.

Rogers' pre-occupation with the speed with which innovations diffuse and are adopted reflects the concerns of those who wish to launch new technologies, and is the foundation upon which the DoI framework is built (Rogers, 2003). It leads to an interest in establishing what kinds of characteristics (of potential adopters, of the innovation itself, and of the social system in which both are operating) enhance or restrict the pace at which diffusion-adoption occurs.

In his treatment of the characteristics of potential adopters, Rogers categorizes individuals according to where they fall on the 'S-shaped curve' (2003, pp. 279). As depicted in Figure 2.3 individuals are classified (according to their degree of 'innovativeness') either as innovators (the quickest 2.5% of the population to adopt), early adopters, early majority, late majority or laggards (the slowest 16% to adopt). Rogers (2003 pp. 288) generalizes that "the social characteristics of earlier adopters mark them as more educated, of higher social status, and the like. They are wealthier and have large-sized units". In other words, it is those individuals with a greater degree of social power and mobility who are likely to experiment with new innovations and thus benefit first from the successes.

Once the diffusion of an innovation gets underway (the period between early adoption and early majority in Figure 2.3), it becomes largely self-propelling with little need for external intervention. Rogers refers to this period within the diffusion process as "Take-Off" (ibid, pp 11). The notion that only a certain number of individuals need to adopt an innovation before the diffusion process becomes self-sustaining promotes certain strategies for those wishing to stimulate innovation diffusion. Efforts are likely to be concentrated at the start of the diffusion process, and attentions may be focussed upon the individuals who are perceived to be more likely to adopt easily. This approach is evident in Boz and Akbay's (2005) advice to concentrate extension services on wealthier farmers and in Reij and Waters-Beyer's (2001) aim to identify and spread information about farmer innovators in Africa.

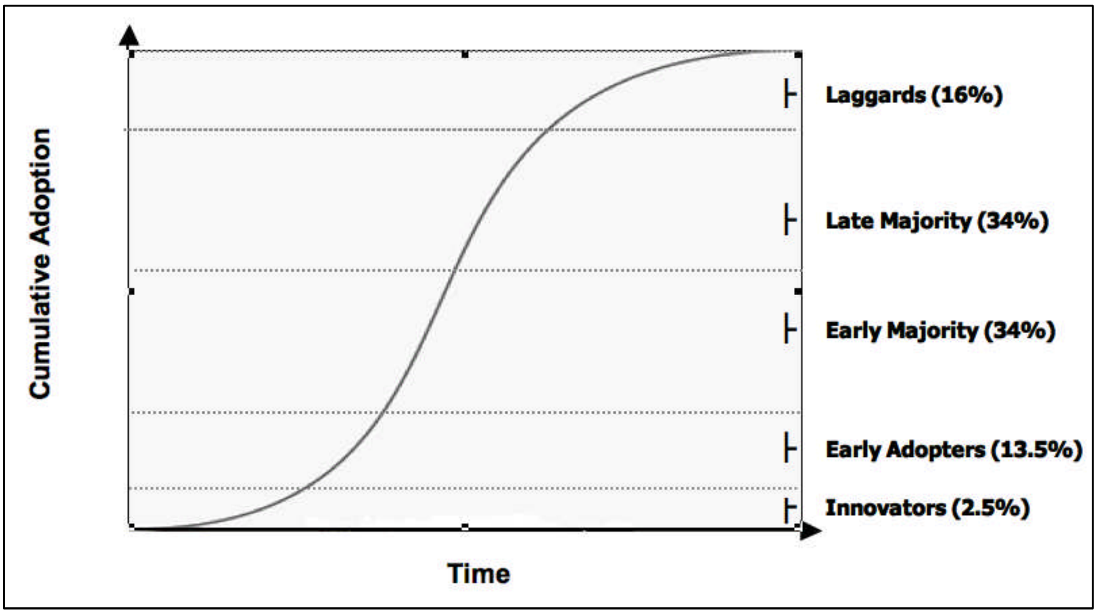


Figure 2.3: Cumulative adoption over time and adopter categories

Rogers also emphasizes knowledge and communication within adoption decisions. He stresses the importance of experimentation and first-hand experience, and envisions individual adopters as actors governed by cultural norms whose positions within social hierarchies affect their perceptions and preferences (Rogers, 2003). Innovations which are perceived to have a clear advantage over what already exists, which are not too radically different from the norm, and which are already in use by social peers, are likely to be adopted at the fastest rate. His analysis therefore provides insights into the successes and failures of different innovations and can be used as a guide for producing innovations whose designs are better shaped to suit local contextual needs, or for enhancing awareness and advertising campaigns through 'audience segmentation' (ibid, pp. 299).

Figure 2.4 depicts Rogers' conceptualisation of the 'Innovation-Decision Process' (through which individuals, with the potential to adopt an innovation, pass). The larger central arrows may be understood as representative of the mental state of a potential adopter, and the arrows feeding into this central process can be seen as forces acting upon the decision-making individual. Rogers emphasizes the effects of intermediary actors on individuals considering whether or not to adopt. He highlights the roles of "opinion leaders" (individuals of high social standing within the social system) and "change agents" (individuals from outside the social system who deliver information about the innovation) in affecting the decision outcomes of potential adopters (Rogers, 2003 pp. 26).

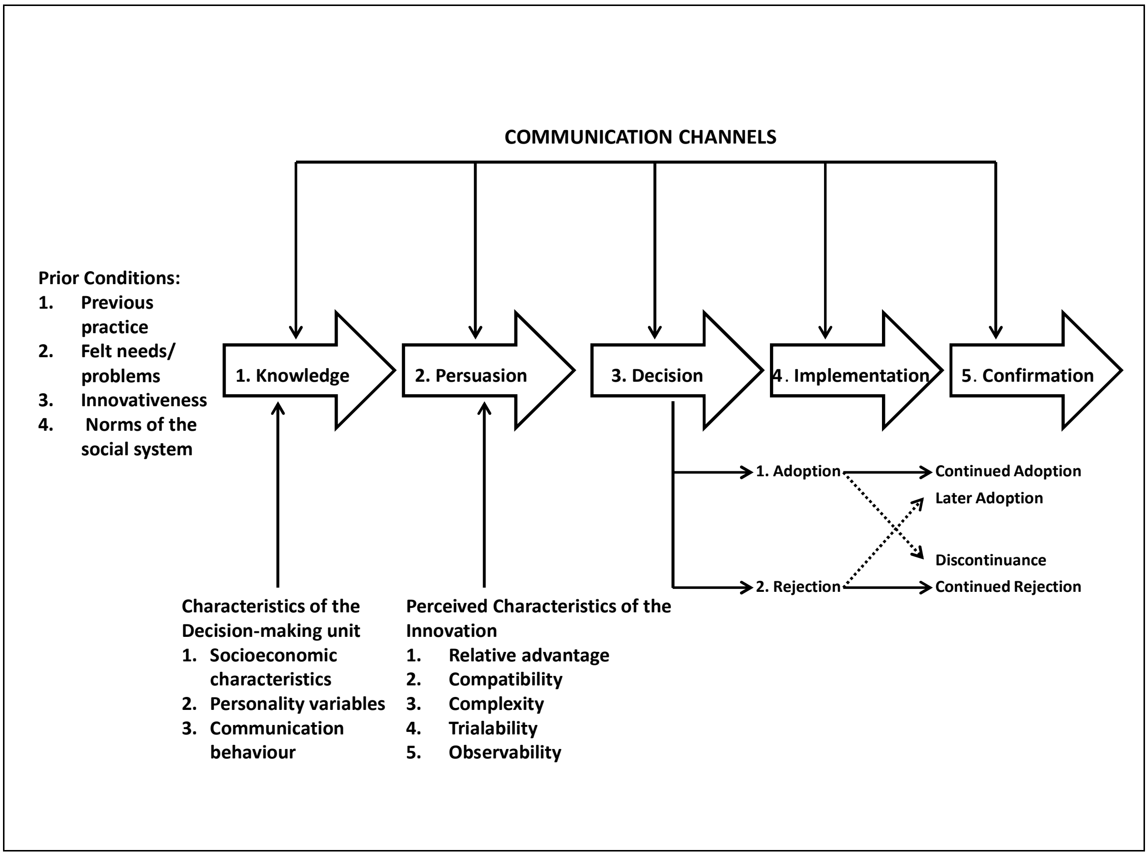


Figure 2.4: The Innovation-Decision Process from Rogers, 2003 (pp. 170)

2.2.1.1 Diffusion of Innovations within African agriculture

The findings of diffusion research which Rogers (2003) summarises are reflected within historical agricultural extension approaches that have been used in Africa and worldwide (Röling and Pretty, 1997). Most agricultural extension has been, and continues to be, concerned with technology transfer. Funding from the World Bank encouraged the development of extension services throughout Africa in the 1970s and 1980s with a major focus on the "Training and Visit" (T&V) approach (Howell, 1988). T&V functioned through "regular visits by extension workers to designated contact farmers and contact groups, carefully selected to achieve a 'spread effect' to farmers who are not in direct contact with extension", and relied upon information travelling in one direction down a chain of personnel from research scientists, who train subject matter specialists, to extension workers on the ground, whose task it is to "gradually disseminate technological packages to farmers, focusing on a few simple messages each visit" (Bindlish and Evenson, 1997, p. 184). The parallels with DoI concepts are clear; the T&V process relies on linear technology transfer, the use of change agents and opinion leaders, and predominantly relies on diffusion from influential individuals to more remote farmers as a mechanism for spreading change.

Fashions in agricultural extension theory have since moved on. More recently the innovation concept has been adopted by those wishing to highlight the value of creative agricultural experimentation by African farmers. Such authors refer to innovative African farmers as "farmer innovators" and seek to find ways to diffuse their grass-roots innovations, acknowledging the contextual suitability of many home-grown techniques and combating the conceptualisation that all innovations originate in research centres (Reij and Waters-Beyer, 2001, p. 51). Meanwhile, the T&V approach has been declared a failure (Eicher, 2007). However, the degree to which practices have changed on the ground in the Malawian context will be of interest to this research.

2.2.1.2 Criticisms of DoI

The Diffusion of Innovations framework has influenced many analyses of adoption within developing country agricultural settings (c.f. Napier, 1991, Boz and Akbay, 2005, Hogset and Barrett, 2007, Matuschke and Qaim, 2009, Mugwe et al., 2009, Bouyer et al., 2011). However, the approach is not without criticism. The most relevant for this study is that the framework is underwritten by a pro-innovation (or pro-modernisation) bias which means that it fails to deal with important concerns for developing country agriculture such as the socio-economic and environmental impacts of innovation adoption (German et al., 2006). In this vein Bordenave (1976, pp. 145) argues that the DoI framework, as a product of a particular socio-economic reality, is guided by an ideological stance which does not apply universally.

The framework's pro-innovation bias is connected to its conceptualisation of potential adopters as passive recipients of innovations positioned along a linear diffusion trajectory, who are designated as increasingly less innovative as the innovation travels further away in space and time from the centre of its creation. On the basis of this conceptualisation, Rogers' framework has been termed a straight transfer approach where, "the promoters are seen as the ones with superior knowledge and the rural poor as those who do not know what is good for them" (Agarwal, 1983 pp. 360). Rogers' use of the term 'laggards' lays the blame for failure to adopt with potential adopters themselves. However, some writers have suggested that it should be the innovation design qualities (rather than the characteristics of adopters) which deserve scrutiny when farmers fail to adopt (Sumberg, 2005).

The examples Rogers cites (which include mobile phones, weed killer, photovoltaic cells, hybrid corn, modern maths, antibiotics and hypodermic needles) tend to focus on innovations that have been shaped by modern preferences for development. As such it is questionable whether his statements about the characteristics of earlier adopters (being wealthier and more educated) are universally correct, or whether they apply only to adoption scenarios for modern innovations. Whilst some developing country studies, for example Tura's (2010) (which examines the adoption of improved maize in Ethiopia) and Boz and Akbay's (2005) (examining the uptake of maize as a new commercial crop in Turkey), do support Rogers' statements about the characteristics of earlier adopters, there are others which show that the influence of adopter characteristics on adoption varies considerably. Mwaseba et al. (2006), in their research comparing the adoption of techniques for rice production in Tanzania, find that most variables influencing adoption are not the same between the study areas they looked at, and Walters et al. (1999), find no clear patterns of response to the promotion of soil conservation and tree planting between proximate villages in the Philippines. Moreover, other research has found that where the innovation being considered is less modern in nature, the characteristics of earlier adopters do not align so well with Rogers' assumptions about innovativeness. Grisley (1993) finds that, contrary to Rogers' (2003) indications, less educated farmers are more likely to adopt a new variety of bean which can be saved on-farm. Similarly, Hogset (2007) finds households with smaller farms and lower educational-attainment levels are more likely to adopt the practice of pit-manuring. In both cases, the authors suggest that their findings about adopter characteristics are due to the fact that the innovation they are investigating is more traditional in nature.

As discussed, it is recognised that Rogers' theory has largely underpinned the development of extension services worldwide, particularly the Training and Visit (T&V) approach (Röling and Pretty, 1997). On the back of this, there is a risk that Rogers' statements about adopter characteristics (whether they can be decreed as universal or not) might result in biased extension service delivery in favour of wealthier and more educated individuals. Such a bias has been noted by those reviewing extension delivery across Africa (Roberts, 1989), and has been reported separately for various East African countries, including Ethiopia, Mozambique and Malawi (Asfaw et al., 2011, Cunguara and Moder, 2011, Chipande, 1987). It has also been suggested that this bias could result in the reification of Rogers' original assumptions about early adopters and innovators having higher socio-economic status (Röling et al., 1976).

An additional consideration is that innovation diffusion has been found to reinforce the socio-economic superiority of more 'innovative' individuals by widening wealth inequalities between early and later adopters (Röling et al., 2004, Havens and Flinn, 1975, Feder et al., 1985). Therefore, a potential effect of diffusion strategies which are built upon Rogers' framework would be that, short of reducing the vulnerability of potential adopters, those who are in an inferior socio-economic position at the outset actually wind up in a comparatively worse one at the end.

All these observations led Niels Röling to observe in a paper written nearly forty years ago that, "diffusion generalisations adequately draw conclusions about current practice, but this may be very different from offering recommendations for optimal practice" (Röling et al., 1976, p. 157). This project builds on Röling's standpoint by seeking to assess the extent to which current cultivar diffusion strategies in Malawi reflect the "Diffusion of Innovations" style of approach, and the extent to which these strategies lead to inequitable adoption. Where the interest is in ensuring vulnerability reduction within farm households (Yuksel, 2008, Toenniessen et al., 2008), using the "Diffusion of Innovations" framework as a guide for stimulating the uptake of new maize cultivars amongst smallholders may entail a failure to achieve this goal (Tambo and Abdoulaye, 2012).

2.2.2 Agricultural Innovation Systems (AIS)

It has been suggested that the various criticisms of the DoI approach discussed above are highly relevant to "current practice within the agricultural sector throughout much of the developing world" (German et al., 2006). ToT and the T&V approach which it inspired have been labelled as failures in terms of their capacity to diffuse modern cultivars to rain-fed areas of Asia and Africa (Byerlee and Eicher, 1997). More generally, this style of approach has been criticised for failing to recognise the value which is added to innovations by farmers, extension workers and other actors (Engel and van den Bor, 1995).

As a response to these paradigmatic and practical problems, agricultural research scientists working in the 1970s began to look for alternatives (Moris, 1991). The dominant agricultural development frameworks to which scientists and funders turned for guidance have subsequently shifted from the linear ToT approach (embodied by the NARS or National Agricultural Research Stations of the 1970s), to approaches which place greater emphasis on knowledge-sharing (the Agricultural Knowledge and Information Systems or AKIS approach), and towards more systems-oriented viewpoints which are embodied in the Agricultural Innovation Systems (AIS) approach that is in favour with funders today (The World Bank, 2006).

Many of the difficulties inherent in the DoI style of approach boil down to the fact that it favours a central source of innovation model. An alternative approach, and one which has been claimed to describe empirical realities more accurately, is to use a model that incorporates multiple sources of innovation (Biggs, 1990).

The 'National Innovation Systems' concept originally arose within evolutionary economics as a means to explain Japan's unprecedented development into an economic superpower in the early latter half of the twentieth century (Freeman, 1995). The concept was then introduced to the analysis of developing country agriculture, predominantly as a way of critiquing the NARS approach (Spielman and Birner, 2008).

An innovation system can be defined as "a network of organizations, enterprises and individuals focussed on bringing new products, new processes and new forms of organization into economic use, together with the institutions and policies that affect their behaviour and performance" (The World Bank, 2006, pp. vi). Based on this definition, an AIS approach does not theoretically oppose or negate the validity of the DoI framework. The diffusion framework can be seen as taking place in and being subsumed by an agricultural innovation system; and the DoI approach may be critiqued according to AIS principles.

Since AIS theory perceives multi-directional networking to drive innovation, the linear and uni-directional diffusion process within DoI could be viewed as restricting innovative potential. The two approaches also promote different analytical pathways. Diffusion theory may be used in analysis at a range of scales, but in many ways lends itself most effectively to analysis of individual adopters and their immediate social surroundings. AIS analysis is geared to understanding systems and networks, and can be applied more successfully at a larger scale. Whereas a DoI approach would attribute innovation-diffusion failure to the properties of a narrow range of actors, or possibly the innovation itself, an AIS approach would seek explanation in the operation of institutions governing interactions between a much broader range of actors. These differences inevitably translate into considerably different kinds of policy recommendations for agricultural development and the delivery of extension (Agwu et al., 2008).

The AIS approach is starting to make headway amongst those researching and funding agricultural development and technology policy (Klerkx et al., 2010, Hall et al., 2001) and has notably formed the focus of several World Bank publications (The World Bank, 2006, Spielman and Birner, 2008, The World Bank, 2012). The extent to which AIS has gained favour amongst such powerful organisations has led some analysts to describe the approach as a 'pipeline to donor funding' (Eicher, 2007).

However, clarity and consensus on an AIS framework remains well behind that achieved by Rogers (2003) in his work on innovation diffusion. Authors have commented that no blueprint for innovation yet exists (The World Bank, 2012) and that applications of AIS remain nascent (Spielman et al., 2009). Some have suggested that the approach may suffer from operational difficulties (Eicher, 2007).

Attempts have been made to develop ways of measuring and comparing national agricultural innovation systems, yet these attempts remain disparate. An early gesture is Biggs' (1990, p. 1494) suggestion that a key indicator of a multiple innovation-source approach can be found in the extent to which funds are allocated towards strengthening, "the research capability of poorer groups in rural areas of developing countries". Hall et al. (2001, p. 4) somewhat vaguely describe "three broad principles for examining the relative performance of innovation systems". They suggest that comparative performance can be determined by the extent to which those working in research and economic production interact iteratively; by the extent to which spontaneous formations of novel relationships to address new tasks occur; and by the nature of the overall "institutional set-up" at a national level (ibid.). By contrast, Spielman and Birner (2008) and Spielman et. al (2009) are far more precise in their attempts to develop an indicator-driven approach. They detail the three domains essential to an innovation system: the knowledge and education domain, the business and enterprise domain, and the bridging institutions which effectively link the two (see Figure 2.5). Relative to these respective domains, they then select indicators from secondary economic data measuring national agricultural performance, and complement these with further, more qualitative, indicators amassed via expert interviews (the latter indicator group aims to capture the more systems-oriented features generally overlooked by the economic data). Hekkert et al. (2007) take a different approach, inspired by the need to measure process rather than outcome, detailing seven different types of function which should be assessed in innovation systems analyses. These are: entrepreneurial activities, knowledge development, knowledge diffusion through networks, search guidance (referring to "those activities which can positively affect the visibility and clarity of specific wants amongst technology users"), market formation (which involves the creation of a "protected space for new technologies"), resource mobilization (sufficient financial and human capital), and the creation of legitimacy for the innovation (2007, p. 421-425). The lack of accord between these different attempts to regulate AIS analysis reveals that despite the popularity of the AIS approach within funding circles, its implementation within research and as a policy directive is still hazy and open to interpretation.

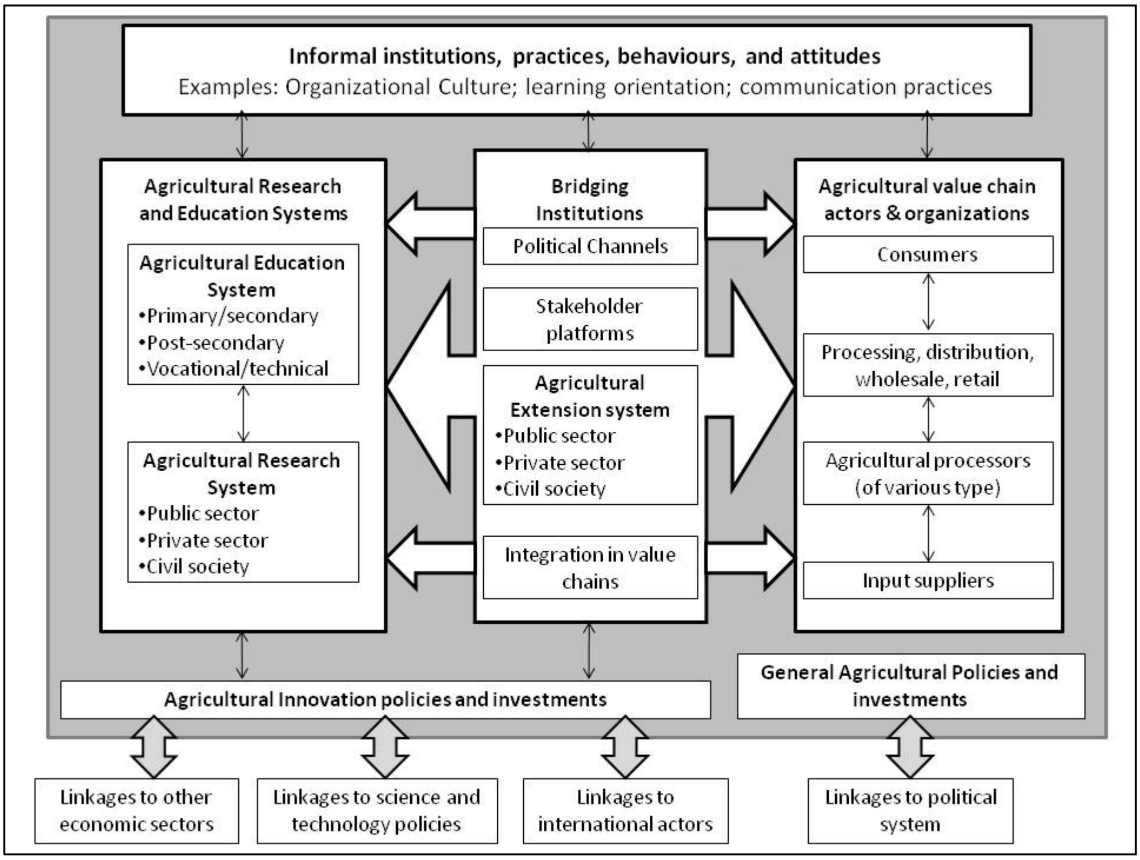


Figure 2.5: Conceptual diagram of an AIS from Spielman and Birner, 2008 (p. 6)

It is evident that despite the early emphasis placed upon participation in research activities from poorer players within the agricultural system (Biggs, 1990), AIS approaches have in general not taken up this concern and have instead been preoccupied with interactions between the business and research domains. This stance is exemplified by the fact that within Spielman and Birner's (2008) conceptual framework (shown in Figure 2.5), farmers and agricultural producers are excluded entirely, with the qualification given by the authors that they are "implicit throughout the system" (Spielman and Birner, 2008, p. 7). The decision to represent the system without explicitly including agricultural producers means that their heterogeneous needs and preferences remain invisible and questions about whether they are effectively served by the operation of the system may not be asked. More generally, by presenting a system overview, the AIS approach fails to deal with the subjective perspectives of different actors within the system. This reduces awareness of the varied political goals of systems actors and of the degree of power they have to realise them. Klerkx et al. (2012) refer to 'hard systems' and 'soft systems' with regard to their discussion of the evolution of agricultural systems approaches, wherein 'hard systems' thinking is based on the assumption that "systems exist independently from the observer, and can be analysed, understood and 'engineered' towards an unambiguous goal" (p. 463), whilst 'soft systems' thinking emphasizes that systems are likely to be understood differently by different actors. Where AIS approaches lean towards hard systems thinking and present networks in a static fashion, there is a danger that the conflicting goals and interests of different actors remain undisclosed, and that the political decisions determining the construction of AIS conceptual frameworks themselves remain uninterrogated (Klerkx et al., 2012).

A range of different perspectives continue to exist on the interpretation and operationalisation of the AIS concept (Klerkx et al., 2012). Since there is no clear consensus on how best to apply AIS within analysis, this thesis will use the overarching features of the concept as a guide for analysing Malawi's maize seed system. These features will be used to direct expert interviews and to identify elements of the seed system to target for data collection. Specifically, drawing on the AIS principles commonly emphasized within the literature, the thesis will seek to evaluate the extent to which smallholders are able to participate in and influence research, look for evidence of learning and iterative interaction between all system actors, focus on the degree of entrepreneurial activities within the seed system, and assess the flexibility of policies and institutions which determine and influence system operations and maize farming activities amongst smallholders. The thesis will also pay attention to how 'bridging institutions' (see Figure 2.5) operate within Malawi's AIS for maize cultivars, because they are key for effectively channelling information between domains.

An AIS approach does not automatically prioritize questions about the vulnerability of system actors. The derivation of AIS as a concept from evolutionary economics has meant that the role of markets has tended to be prioritized and evaluating poverty reduction has rarely been a key concern within studies (Spielman and Birner, 2008). Where poverty reduction is a key concern (in the World Bank papers, for example), analyses usually seek to measure it at a national level, and are therefore unlikely to gain insight into equity dimensions. Since the driving forces that stimulate the innovation system are identified as "markets, urbanization and globalization" (The World Bank, 2012, p. 2), the danger arises that those actors most able to exert their influence within such processes take centre-stage, whilst those on the margins (such as smallholder farmers) are neglected. In line with this, criticisms have been levelled at AIS studies for failing to focus on the micro-scale (Hekkert et al., 2007), and for potentially over-looking the "activities of innovating actors" by concentrating on high levels of aggregation over long timescales (Klerkx et al., 2010, p. 391).

These criticisms suggest that whilst applying the tenets of AIS theory to the analysis of the maize cultivar diffusion system in Malawi will reveal the system's potential to effectively serve the needs of smallholder households, it will not enable an explanation of intra-household differences in cultivar adoption and vulnerability to climate change. As discussed, whilst the DoI approach does provide the analytical tools for an investigation at this level, its failure to deal effectively with equity relative to the impacts of innovation adoption remains a problem. Recent scholarship on climate change adaptation deals explicitly with the issue of vulnerability and we will now turn to this work in order to develop the research strategy further.

2.2.3 Adaptation to Climate Change

As discussed in Chapter 1, the adoption of cultivars with improved stress tolerance is regarded as an important strategy for enabling adaptation to climate change within agriculture in Malawi and Sub-Saharan Africa more broadly (Malawi Environmental Affairs Department, 2006). However, the question of how adaptation of this type will occur and specifically who will undertake such adaptations needs to be addressed in order to identify the probable outcomes for climate change vulnerability. This section will introduce academic approaches to understanding adaptation, vulnerability and adaptive capacity and review work on barriers to adaptation to provide a background for better understanding the potential for adoption of improved maize cultivars to enable climate change adaptation and vulnerability reduction within Malawi and beyond.

Successful adaptation to climate change is often understood as a reduction in vulnerability or an increase in resilience; two qualities which have become key concepts within the climate change adaptation arena (Adger, 2006, Folke, 2006, Smit and Wandel, 2006, Adger et al., 2007b, Nelson et al., 2007, Villanueva, 2011). Vulnerability is often defined as the combined product of sensitivity, exposure and adaptive capacity (Adger et al., 2007a), and resilience can be thought of as "the capacity to sustain a shock and continue to function" (Anderies et al., 2013, p. 7), and is generally assigned to systems which are diverse, flexible, and capable of learning and change (Folke et al., 2002). Arguments have thus been made that modern conventional agriculture, which relies on a narrow genetic and landscape base and highly specialised production and marketing channels, lacks resilience and is vulnerable to hazards such as climate change (Fraser et al., 2005). The dominance of maize within Malawian diets and the promotion of improved germplasm in Malawi's production systems should be considered with regard to this perspective on resilience.

Both vulnerability and resilience are abstract concepts which are scale-dependent. This means that there is little agreement on which indicators should be used to measure them, and that different indicators are likely to be suitable for measurements taken at different scales of concern (Luers, 2005, Eakin and Bojorquez-Tapia, 2008, Jones et al., 2010, Villanueva, 2011). Recognition of the importance of gaining understandings of vulnerability outcomes at multiple scales is reflected in the concept of maladaptation, wherein an adaptation at one scale results in increased vulnerability or undermines resilience at another scale (Barnett and O'Neill, 2010). Scale here can be spatial or temporal. The importance of timescales within adaptation planning has been highlighted by several authors who have sought to categorize adaptations according to whether they are designed to reduce vulnerability to current climate variability, or to respond to the future impacts of climate change (McGray et al., 2007, Cooper and Coe, 2011, Vermeulen et al., 2013). Rickards and Howden (2012) define adaptations as 'incremental', 'systems' or 'transformational' according to the degree of climate change which they seek to address, and categorise varietal change and the use of 'climate-change ready crops' as either incremental or systems adaptations (p. 243). They point to the possibility that "incremental adaptation alone may act as a blockage for necessary change by increasing investment in the existing system or locale and narrowing down alternatives for change" (ibid, p. 242). Concepts of maladaptation and this type of 'lock-in' or path dependency are important ones to consider relative to heavy state emphasis on the promotion of maize agriculture and improved cultivars within Malawi and surrounding nations. The necessity of undertaking transformational adaptation to farming systems in the future is becoming increasingly likely, yet change at this level will not be achieved autonomously (Anwar et al., 2013). This means that strategic political oversight for progressively phasing appropriate agricultural adaptations is likely to be essential, and Malawi's policies on cultivar change as an adaptation strategy, and the standpoints adopted by state level actors, require scrutiny in this regard.

The issue of scale also signals that assessments of climate change vulnerability may have different outcomes depending on the scale of the unit of analysis. For example, patches of vulnerability may exist nested within larger areas which are broadly considered not to be vulnerable (Osbahr et al., 2008). Whilst differences in levels of exposure and sensitivity may decline as the geographical scale of focus narrows, levels of adaptive capacity may still differ widely between households. Adaptive capacity is often viewed in terms of wealth despite evidence of high adaptability amongst some resource poor communities living within highly exposed environments (such as pastoralists in the Sahel) (Adger and Vincent, 2005). However, efforts to measure adaptive capacity in terms of the five assets of the sustainable livelihoods framework have been criticised in terms of failing to elicit important information about the enabling environment which strongly determines local capacity to adapt (Jones et al., 2010). The question of how wealth affects adaptive capacity (and in particular the capacity to adapt by adopting improved cultivars) will be a key concern for the analysis of field data undertaken within the results chapters of this thesis.

Writers seeking to better understand the nuances of adaptive capacity have recently highlighted the importance of perceptions and cultural values as determinants of (or potential barriers to) adaptation decisions. Moser and Ekstrom (2010) discuss the role of signal detection as a significant first step in the process towards adaptation. The degree to which African farmers' perceptions accurately reflect changes in production factors such as rainfall has been dealt with by several writers who have mostly found that farmers do claim to perceive changing trends despite the fact that natural variability within rainfall is currently too high for any significant trends be detected statistically (Simelton et al., 2013, Rao et al., 2011, Osbahr et al., 2011). The degree to which Malawian farmers are able to recognise and therefore select cultivars for appropriately exploiting current rainfall conditions is a question which this project will seek to answer.

Other writers have highlighted the role of culture as a determinant of how climate change is defined, and how individuals perceive their own adaptive capacity and ability to understand and adapt to future changes (Dessai et al., 2004, Grothmann and Patt, 2005, Kuruppu and Liverman, 2011). Following this lead, this project will seek to evaluate the role of local understandings of and beliefs about climate change as well as cultural values as factors influencing adaptation outcomes with regard to the adoption of new cultivars.

2.3 Summary

This review of the literature has sought to elucidate the social history of maize consumption and production practices in Malawi and the political efforts that have been undertaken to modernise them. We have seen that problems of food insecurity in Malawi have endured throughout the country's history, sometimes erupting as food crises at a national scale. State emphasis on the use of agricultural inputs has boosted production, particularly in recent years, but it is not clear whether these gains are sustainable, or how much they succeed in reducing vulnerability to climate change. Theories on agricultural innovation and adaptation to climate change have also been presented and discussed. The thesis will use these theories as a guide for selecting methods and analysing empirical data. Ultimately the empirical findings of the thesis will be used to critique the utility of the referenced theories for directing strategies that can enhance equitable adaptation to climate change via the mechanism of cultivar adoption.

Chapter 3 - Methods and methodology

As presented in section 1.3, this thesis aims to understand how social dimensions (such as asset and land wealth, cultural preferences and perceptions of climate risk) affect the potential for cultivar adoption to enable equitable adaptation to climate change amongst Malawian smallholder farmers. In order to fulfil this aim the thesis pursues the following objectives:

- To describe the diffusion of modern maize cultivars to smallholders in Malawi
- To identify the adoption outcomes of these diffusion strategies amongst smallholder households
- To determine the associated drivers and barriers of adoption decisions, and,
- To assess the implications of these three elements for climate change adaptation and vulnerability reduction for smallholder households in Malawi
- To yield insights for policy recommendations that can facilitate more equitable access to the benefits of modern, climate-resilient maize cultivars

Thus far we have explored literature that broadly explains the social, historical and political factors surrounding contemporary maize cultivar use in Malawi, and considered theories which can explain processes of adoption and its potential function as a climate change adaptation strategy.

The current chapter presents the methods that were chosen to undertake the thesis' objectives, with reference to their methodological basis and practical application in the field.

3.1 Research Design

3.1.1 Constructionism, pragmatism and mixed methods

The importance this project attaches to the influence of social factors on adaptation and vulnerability outcomes stems from a constructionist epistemology which emphasizes 'reality' as a human construct, such that "all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world, and developed and transmitted within an essentially social construct" (Crotty, 1998, p. 42). This perspective does not imply that there is no reality outside of human consciousness, but does imply that there can be "no meaning without a mind" (ibid, p. 11). Identifying knowledge of reality as social representation signifies that known realities can be multiple. It points to the need to choose between representations, and reveals the political nature of this selection process. With this in mind, this study does not automatically accept claims about optimal cultivar use and agricultural practice. Instead it seeks to explore why there may be multiple different answers to questions about what is optimal, and to highlight the benefits of considering the range of possible responses within processes for determining whether and how climate change adaptations should be undertaken.

By highlighting the socially determined nature of all knowledge of 'meaningful reality' (Crotty, 1998, p. 63) attention is drawn to the operation of narrative. Research itself is a process that develops narrative representations of reality (Ragin, 1994), and the author's perspectives have naturally shaped the representations in this thesis. To explore the realities associated with cultivar adoption for climate change adaptation in the Malawian context, this thesis engages with the roles played by narratives and perceptions as determinants of cultivar production, diffusion, adoption and linked adaptation outcomes.

As constructionism is understood here, research methods options are not limited, and a pragmatic theoretical perspective is adopted. Pragmatism particularly lends itself to a mixed methods approach wherein the researcher is free to devise combinations of different methods strategies according to their appropriateness for the question at hand, rather than on the basis of strict allegiance to an underlying philosophical perspective (Creswell, 2009). Mixed methods are able to draw on both quantitative and qualitative approaches and combine these to best effect for developing an understanding of the question being asked and enhancing the strength and breadth of the findings produced (Creswell, 2009). Typically, qualitative approaches are associated with constructionist and interpretivist stances, whilst quantitative approaches are associated with positivist stances, with these associations leading to what has been referred to as a 'paradigm war' between the two categories of research method (Bryman, 2008). It is questionable whether these paradigmatic associations are in fact natural or necessary (Crotty, 1998), and a pragmatic approach ignores them in the interests of serving the research question (Bryman, 2008). Employing quantitative and qualitative methods enables the researcher to ask both "how many" and "how" type questions (Silverman, 2010). Here, it has enabled the production of a proportionally representative overview of cultivar use within the research areas and a 'scientific' estimation of changes to rainfall, as well as enabling an exploration of the social mechanisms and perspectives that influence farmers' options and decisions about cultivar adoption and adaptation. The research can thus explore both the processes and outcomes which cultivar use patterns shape and are shaped by (Creswell, 2009).

3.1.2 A theoretical frame for methods selection

The mixed methods approach followed here reflects Creswell's description of 'transformative mixed methods' (2009, p. 15); the research strategy has been assembled via a theoretical lens and seeks to make an assessment of the value of the theoretical approaches it references as guiding strategies for climate change vulnerability reduction. Building upon these theoretical approaches, and seeking to evaluate their usefulness in empirical terms, the research strategy incorporates methods which reflect the epistemological stance of each theory, thereby grounding its critique within the methodological narrative of each approach.

The innovation diffusion research tradition summarized by Rogers (2003) has been described as objectivist and positivist (Beltran, 1976). This perception arises from the evident modernisation or 'adoption bias' displayed in most diffusion research; from the theory's reductionist approach and search for a universal 'diffusion curve'; and from the degree to which it essentializes the concept of "innovativeness" as a human trait, dividing potential adopters into categories as "innovators" or "laggards" (Rogers, 2003, p. 273), diminishing individual agency, and emphasising socioeconomic determinism. Rogers observed that the distribution of adoption over time is usually normal or bell-shaped and he created adopter category divisions according to divisions based on standard deviations away from the mean (referencing probability values as employed in statistical significance testing). This gives scientific credence to the placement of adopter categories. However, the value-laden nature of these divisions is evidenced by the importance allocated to the "innovator" category (the top 2.5% who adopt over two standard deviations earlier than mean adoption time). No such importance is attached to the bottom 2.5%; the division is not even made.

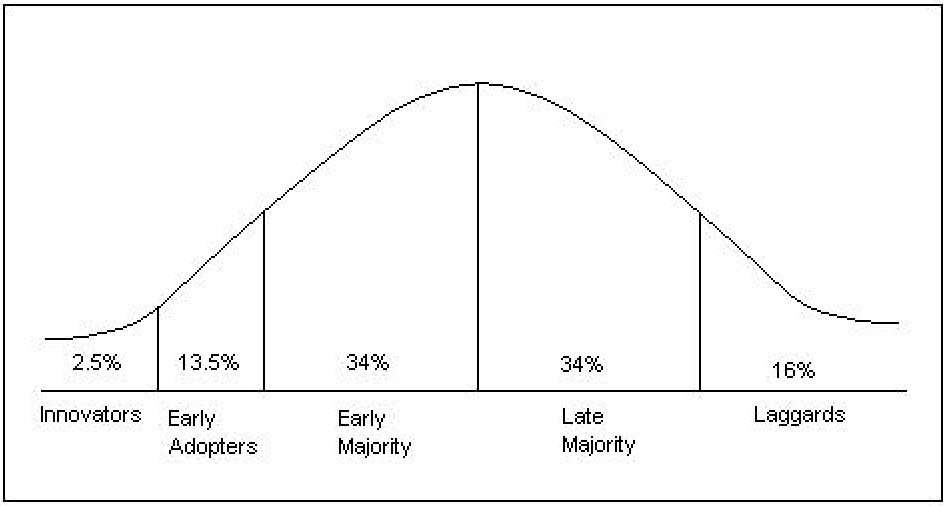


Figure 3.1: Adopter categories in the normal distribution from Rogers, 2003 (p. 281)

Most research in the DoI field has employed the systematic use of questionnaire surveys and statistical analysis (Beltran, 1976). In order to assess the degree to which the "Diffusion of Innovations" framework is able to describe and explain the adoption patterns encountered within the research areas, questionnaire survey methods and statistical analysis were also included as part of the research strategy pursued here.

As discussed in Chapter 2, the AIS approach is less well established in methodological and theoretical terms. Nonetheless, the worldview it presents clearly differs from that adhered to by the "Diffusion of Innovations" framework. Agency is emphasized in terms of actors' potential to change the structures in which they operate and achieve improved market outcomes, and analysts often seek to understand the complexity of communication networks within the system, rather than to simplify them. In this regard, the AIS epistemology could be considered as constructionist, and research approaches often seek to engage with the perspectives of key stakeholders within the system (Ortiz et al., 2013). In order to incorporate an AIS approach within this project, research methods were selected to facilitate engagement with the perspectives of actors occupying different positions within Malawi's maize seed system. Key stakeholders were identified from within the organisations and groups that make up the system, and in-depth interviews were used to obtain insights into the viewpoints and attitudes of different actors. The research particularly sought to understand the perspectives of smallholder farmers with regard to how well they considered their needs to be served by the current operations of the seed system.

The research also bases itself around academic approaches to understanding adaptation. Studies of climate change adaptation vary in their epistemological standpoints, with impacts studies presenting a more positivist stance and often relying on technical expertise in the natural sciences, and studies of adaptive capacity often stemming from approaches within the social sciences and in particular development studies and the sustainable livelihoods framework (Jones et al., 2010, Vermeulen et al., 2013). The need to locate climate change studies at the boundary of climate and society interactions has led to broad agreement that studies of adaptation, like other studies concerning the sustainability of social-ecological systems, need to combine research approaches from multiple disciplinary backgrounds (Ostrom, 2007, Thompson and Scoones, 2009, Reed et al., 2013). Such studies combine the use of stakeholder and scientific knowledge to better determine sustainable outcomes (Reed et al., 2007) and collect data from multiple points within systems in order to try to gain understanding of cross-scale interactions and influences (Osbahr et al., 2008). This study employs these approaches by engaging with multiple scales within Malawi's seed system, from the national to the household level, and by undertaking an analysis of historical meteorological data (rainfall and temperature) which can be compared with stakeholder perceptions of changing weather conditions.

3.1.3 A comparative case study approach

Whilst this project aims to produce a detailed picture of the activities and attitudes of stakeholders, it also aims to make an assessment of vulnerability to climate change and, in recognition of the nuances of vulnerability at different scales, seeks to do this at both the household and the regional level. Household level quantitative data were collected in order to identify patterns of association between socio-economic characteristics and cultivar adoption. Quantitative household data was then aggregated with qualitative village and research area data to enable contrasts to be drawn between the two research areas in terms of the nature of vulnerability to climate change in each place and the degree of institutional support allocated for combating it. Where research evaluates patterns of similarities and differences across a moderate number of cases, it can be described as taking a comparative, case study approach (Ragin, 1994). Yin (2003) suggests that case studies are the preferred research approach when how or why questions are being posed and when the investigator has little control over the situation being investigated. Here, the decision to include more than one research area reduces that degree of information that can be obtained in each case, but enhances the explanatory power of the analysis. Malawi is geographically diverse, and different degrees of vulnerability to current climate variability are characteristic of different parts of the country (see Figure 3.3). Yet the government has focussed predominantly on a single over-riding approach to food security, which strongly emphasizes maize production (Chinsinga, 2006). The two research areas were chosen to compare the outcomes of this strategy. One of the areas is considered highly productive for maize farming (Smale, 1993), whilst the other is considered far more marginal (Mandala, 2005). Figure 3.2 depicts a schema of the research design, illustrating the sources from which data was sought; organisations at different levels within the national system and the two case study research areas, which each subsume the individual villages where fieldwork was undertaken and the meteorological stations from which climate data was obtained.

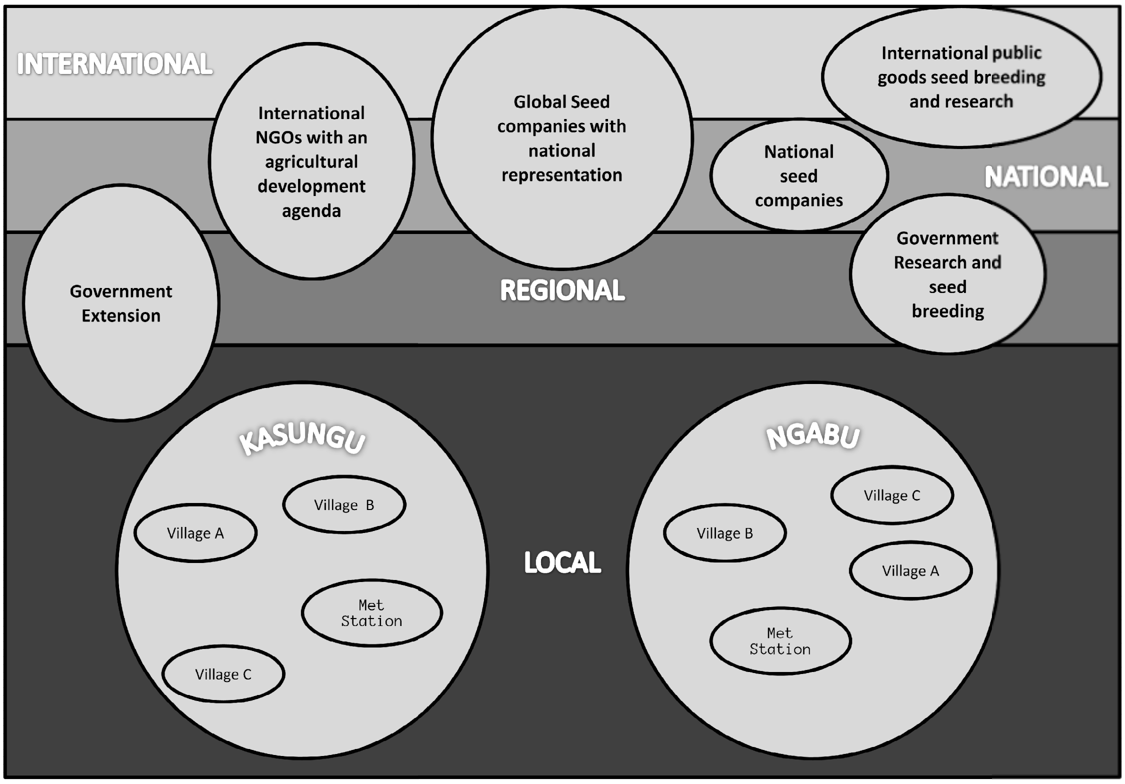


Figure 3.2: Conceptual schema of the research design

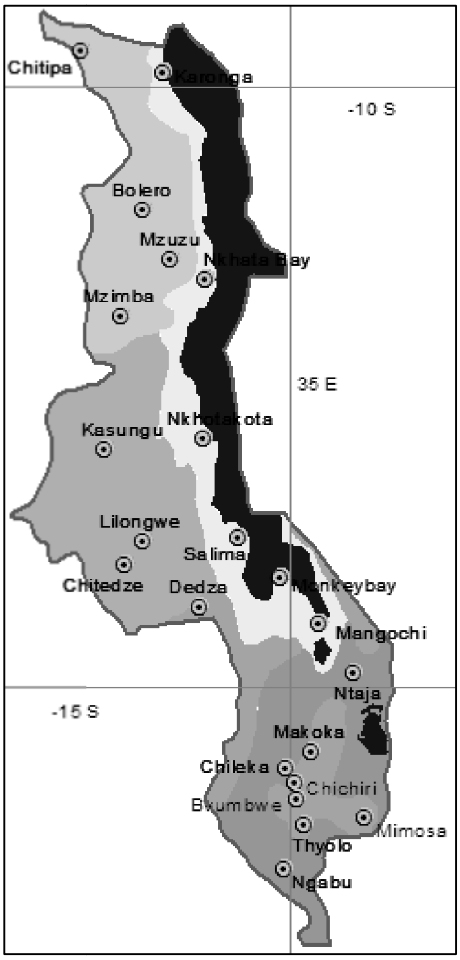
3.2 Data Collection

3.2.1 Selection of case study areas

The criteria for selection of the two research areas was that they should have differential productive potential for maize, display different degrees of susceptibility to the types of climate hazard likely to be associated with climate change, and rely primarily on maize as a dietary staple. A profile of livelihood zones mapped by Malawi's National Vulnerability Assessment Committee (2003) was used in order to narrow down the selection of research areas (see Figure 3.3). The Lower Shire Valley is considered vulnerable to climate hazards and is correspondingly food insecure, experiencing a high incidence of drought and flooding, and frequently requiring food aid (Phiri and Saka, 2008). The Kasungu Lilongwe Plain was selected as the second research area. This is an area where a maize surplus is often produced. The area is nonetheless vulnerable to drought, having suffered severe losses from drought in the 2002 famine, and again in 2005 (Devereux et al., 2006, Kamkwamba and Mealer, 2009).

Livelihood Zone	Description
Central Karonga	Good maize/cassava base for food & cash, even for poor. Much ganyu done by migrant labour. Livestock comparatively important.
Western Rumphi/Mzimba	People highly maize-dependent but do not produce surplus. Tobacco sales crucial for poor as well as others. Drought hazard.
Mzimba Self-Sufficient	High maize yields and cassava assure zonal food security, with tobacco as main cash crop. But poor still depend on ganyu.
Nkhata Bay Cassava Zone	High rainfall but very poor soils mean unique cassava dominance but food deficit. Poor rely heavily on migrating for ganyu.
Kasungu Lilongwe Plain	Surplus maize is second only to tobacco as cash crop. But land pressure makes poor highly ganyu-dependent. Drought hazard.
Southern Lakeshore	Fishing dominates the economy, in ganyu for poor as well as fish sales for others. But cropping is important. (mz, sw pot.)
Shire Highlands	Country's densest population, but largely self-sufficient in grain. For cash, rich sell crops, poor and middle do ganyu and trade.
Middle Shire Valley	Relatively dry area with modest grain crops; winter crops and fishing along Shire River. Poor sell cash crops and look for ganyu.
Phalombe Plain/Lake Chilwa	Weak production zone for the staple maize, with cash from rice/ tobacco/fish. Poor & middle do farm/estate ganyu. Poor road /market network and proneness to dry spells.
Thyolo Mulanje Tea Estates	Very small landholdings mean middle and many rich, as well as the poor, work on tea estates and elsewhere for main living.
Lower Shire Valley	Hot dry lowlands. Maize dominates for cash as well as food. Seasonal employment on sugar estate. Drought and flood hazards.

Figure 3.3: Malawi Baseline Livelihood Profiles (MNVAC, 2003)



3.4: Meteorological station locations in Malawi

A second selection criterion was that rainfall and temperature records could be obtained from a meteorological station local to the research villages, enabling a comparison with local perceptions of climatic conditions. The geographical distribution of meteorological stations in Malawi is shown in figure 3.4. In the Lower Shire Valley, the area around the meteorological station maintained by Ngabu research station was the only option. Within the Kasungu/Lilongwe Plains, the area around Kasungu airport meteorological station was selected, (rather than either of the areas surrounding the stations at Lilongwe and Chitedze), as it was desirable to avoid the livelihood and maize cultivar selection influences that could result from close proximity to Lilongwe, Malawi's capital city, or to Chitedze, (the National Agricultural Research Station where most cereals development trials are undertaken).

Kasungu

The town of Kasungu is located in the district of Kasungu in the central region of Malawi, about 127 km North of Lilongwe (Government of Malawi, 2007). Being located in the Lilongwe plains, the district is mainly flat with an altitude of around 1,342m above sea level and soils that are predominantly pure sand or sandy clay loam (Government of Malawi, 2007). Temperatures range from 12 °C to 30°C throughout the year, with the hottest months occurring before the start of the rainy season (Government of Malawi, 2007), which lasts from December to March. Rains in the area are generally considered to be good (Government of Malawi, 2007), and an average of 805 mm has been reported to fall annually (with a coefficient of variation of 23%) (Jones and Thornton, 1997).

Agriculture is the mainstay of the local economy, accounting for the employment of 66% of the district population aged 15 years and over (Chibwana et al., 2012). The district contains 3,804 villages and farm households number 292,680 (Government of Malawi, 2007, Government of Malawi, 2011). Tobacco is an important cash crop in the area (Prowse, 2009) as well as groundnuts, cassava and sweet potato, but maize dominates by planted area, accounting for the use of 41.1% of district farmland in 2007 (Government of Malawi, 2007). Smallholder farms account for half of all arable land within the district, with just over half of all farm families farming under one hectare (Government of Malawi, 2007).

Ngabu

Ngabu town is in Chikwawa district, in the southern part of Malawi known as the Shire Valley, which is considered one of the poorest areas in the country (Chidanti-Malunga, 2011). Whilst Chikwawa district houses 125,552 farm families (Government of Malawi, 2011), production is not reliable, and areas such as Ngabu regularly receive food aid (Madziakapita, 2008). The area contains the Shire river, the only outlet of Lake Malawi, which floods the lower parts of the valley recurrently contributing to alluvial soils with good production potential but also often destroying crops (Mandala, 2005). The area is home to several sugar estates which use irrigation from the river, and local cash cropping of cotton has been promoted by both colonial and state governments (Mandala, 2005). Ngabu is situated roughly 100 km to the south of Blantyre, Malawi's commercial capital (Briggs and Bartlett, 2008). Soils in the Ngabu area are described as clay loam, and the area is divided into uplands and lowlands (the latter of which enable *dimba* production) (Chidanti-Malunga, 2011) with an average altitude of 100m above sea level. Ngabu experiences very high temperatures throughout the year, ranging between 16.7°C and 36.2°C, with the annual peak prior to the start of the rains in November or December (Wang et al., 2009). Average annual rainfall was reported at 924 mm by Wang et al. (2009), but inter-annual variability is high with the area suffering from both droughts and floods (Phiri and Saka, 2008). As well as cash-cropping cotton, farmers in the area produce maize, sorghum, millet, legumes, sweet potatoes and other vegetables (Mandala, 2005)

3.2.2 Selection of research villages

Villages were selected by the criterion of being situated within 15 km of a rainfall station. The proximity of the rainfall stations to large trading centres in each area meant that a potential bias was introduced; namely the likelihood that village households would have greater access to modern cultivars than farmers living further away from the beaten track. To try to control for this, research villages were selected for inclusion on the basis of differential levels of access to the nearest trading centre. However, it is likely that the levels of recorded cultivar use are not representative of areas situated further away from trading centres. At the outset of the research process, the District Agricultural Development Office (DADO) in Kasungu, and Ngabu Agricultural Research station were visited, and the purpose of the research was explained to key staff members there, whose assistance was sought in identifying appropriate local villages to invite to participate in the research.

In Kasungu, two days were spent visiting each of the nine villages that staff at the DADO recommended. At each village we met with the Chief and explained the purpose of the research to him or her, asking whether they would, in principle, be willing to allow research to be carried out in the village. A site checklist was used to compile information about the villages, including number of households, local climate hazards, and proximity to the rainfall station and nearest tarmac road. Completed site checklists were obtained from all the villages except one (where a funeral was taking place), and this information was then used to select the three most suitable villages. Villages which contained too few households or far too many were excluded (in the interests of simplifying the sampling procedure for carrying out the survey) and three villages, all within a 10 km radius of the rainfall station, and located at different proximities to the town, were selected.

In Ngabu, in accordance with advice received from research station staff, site checklists were not completed. Instead three suitable villages were selected directly based on research staff suggestions, after the variables of interest for the research had been carefully explained. In Ngabu all the villages were within a 15 km radius of the nearest rainfall station, and were located at differing proximities to the town. The headmen of the six selected villages were subsequently visited again and the research was explained in more detail, the data collection activities and goals were outlined and expectations regarding the timing of the research, potential disruption to the village, and what participation would involve were established. In accordance with University of Leeds AREA Faculty Ethics Committee recommendations, each Chief was presented with an information sheet written in both Chichewa and English (see appendix i). It was emphasized that participation was entirely optional, and villages or households were free to discontinue participation at any time.

3.2.3 Selection, sampling and snow-balling

To gain insights across the national and local contexts, participants for the research were sought at different levels within the system. At the national level, interviews were requested with seed company representatives from both major and minor brands. The intention was that the sampling strategy should result in full coverage of all brands marketed in each of the research areas. However it was only possible to achieve interviews with three of the four major international brands that were available in the research areas. National level companies tend to concentrate on the multiplication of public goods varieties, rather than cultivars for which they are the sole licensee, and it was not always possible to determine which company was responsible for the public goods cultivars found in each area. Although four interviews were sought from amongst this group, only two requests were accepted. Interviews were also sought and undertaken with a representative from CIMMYT, a national government maize breeder and representatives from national NGOs and NGO representatives in the two research areas. For these interviews a snowballing approach was undertaken whereby initial contacts were asked to identify further contacts that might be willing to participate in the research. Finally interviews were sought with extension and research managers in each research area, local extension officers and maize growers within the research villages. The selection of village level interview participants is described in section 3.4.2.

3.3 Ethics, positionality and challenges

Much has been written about the "long and anguished history" of social research as a tool of colonising governments, particularly within the disciplines of anthropology and sociology (Denzin and Lincoln, 2005, p. 2, de Leeuw et al., 2012). Whilst most contemporary researchers take pains to reduce the extractive nature of their projects and seek to ensure that benefits will ultimately accrue to participant populations, the power imbalance that characterizes research concerning vulnerability and poverty is largely insurmountable (de Leeuw et al., 2012). Fieldwork for this thesis was no exception to this. My identity as a white, female, European researcher shaped the nature of the interactions I had with many research participants, and I was perceived to be in a position of extreme relative wealth and power by the village level participants I interviewed. My whiteness and perceived wealth more obviously influenced the reactions of smallholders and seemed to outweigh the importance of my gender in this regard. For the most part, my status as an outsider ensured that I was received as a guest and participant behaviour was likely influenced by a politeness bias. To a degree my nationality, as a British citizen, also had an impact, due to the negative recollections which many older participants held about Malawi's history as a British colony prior to independence. Responses were occasionally hostile, and at one of the research villages, (village C in Kasungu) this reached a level where it was no longer possible, in consideration of social disruption and personal safety, to continue research activities. Questionnaire data had already been collected at this village, but has been excluded from the analysis within the thesis.

Another factor influencing the reception given by villagers was the identity of fieldwork assistants. Six assistants were used during the two fieldwork sessions, five of whom were female and predominantly urban and college-educated. The presence of the assistants clearly influenced the social atmosphere during questionnaire fielding and focus groups, with the less educated assistants tending to put more effort into engaging with participants and making them feel comfortable. Whilst the college-educated assistants were able to comment critically on the research approach that was being undertaken, they tended to take less interest in interacting with village level participants and to be less respectful. For this reason, as fieldwork progressed I opted to use assistants with less specialist research skills, but with better interpersonal skills in the rural setting. Overall, the male assistant engaged most fruitfully with research participants and was most inclined to observe traditional conventions of politeness in his interactions with participants. It is hard to say whether this was because of his gender, upbringing or personality, but it was invaluable to the research process to have an assistant who was able to put participants at ease and create a pleasant atmosphere around the research proceedings.

In the case of regional and national level interviewees from within the seed system, there was less of a power imbalance and my gender potentially played more of a role in influencing the interactions I had with others (however, without being able to experience the same situation in different shoes it is difficult to be sure of this). All interviewees in the higher echelons of the seed system were male. Female interviewees were only encountered within the extension service. The seed company employees gave their time generously and although they mainly seemed concerned to present the official line, a rapport developed during the conversation and the answers given, especially towards the end, came over as honest and direct. It is possible that interviewees tried harder to be helpful because I am female and might be perceived as a less challenging or threatening than a male interviewer.

During fieldwork in the villages, issues around access to assets arose. Participants asked if I could contribute financial support to pay for school fees or hospital visits. When medical emergencies occurred I offered assistance where possible, however beyond this financial help was not offered because of the social disruption that could be caused by an unfair distribution of benefits resulting from participation in the research. In line with this principle, because it was not possible to sample every household within each research village, compensation was not offered to questionnaire respondents. When households were invited to participate in the research they were informed in detail about the purpose of the research, told that their participation was entirely voluntary and they were free to refuse, and informed that no direct financial benefits to their households would result from participation.

There was a high level of interest and concern about the nature of the research activities, particularly in Kasungu. The fact that names were collected with questionnaires (to enable purposive sampling for focus groups and of seasonal records participants), aroused concern because extension workers had collected names in the past prior to distributing fertilizer coupons. The severe negative impacts of the 2002 food crisis in the area meant that issues around subsidized farm inputs access were highly politicised and those who were not included as questionnaire respondents (due to the nature of the sampling strategy) were anxious that their names were not being recorded. Time was duly taken to also explain to these households that no survey households would directly benefit from participation in the research. A related consideration was that, because participants perceived me as a potential source of wealth, there was a risk that my presence at interviews would lead them misrepresent their level of household poverty. In order to assess whether this was contributing to a bias in the questionnaire data collected, surveys that were collected in my presence were marked and analysed to assess whether there were any consistent differences from surveys undertaken in my absence. No significant differences were found to be present.

Language was also a challenge during fieldwork in the two research areas. My inability to converse in Chichewa necessitated the use of interpreters. Several different research assistants were used as questionnaire enumerators and again it was possible to statistically analyse whether any biases in the information collected had developed in association with enumeration by particular individuals. Again, no biases were evident from these checks.

Before participating in the research, participants were asked to provide informed consent to signal that they understood and were happy with what being involved in the research would entail. Since literacy was not universal, verbal rather than written consent was sought from village-level participants.

An application for ethical review was submitted to and granted by the University of Leeds Ethics Committee prior to the commencement of fieldwork in 2010, AREA 09-137. Additionally, the research proposal was also submitted to the National Research Council of Malawi, and granted permission to go ahead.

3.4 Primary Data

Fieldwork was undertaken in two stages. Three and a half months were spent in Malawi from September to December 2010, with the addition of a further two and a half months from June to August in 2011. The fieldwork was arranged in this manner in order to avoid the rainy season because it was considered that participation in research activities would present less disruption for most smallholder households during the dry season when agricultural labour demands are lower (Booth, 1984). The fieldwork was split into two phases in order to enable the collection of participant seasonal observations from the 2010-2011 production season which could then be compared with rainfall records. This arrangement also allowed for data analysis and strategic research planning in the interim between field seasons. Details of the research activities undertaken are provided in Table 3.1.

3.4.1 Surveys

The decision to employ the use of a questionnaire survey in the 2010 research was driven by a desire to produce a structured dataset which could provide an accurate overall picture of socioeconomic wealth, maize-use, farming and livelihood activities within each research area and allow for the identification of socio-economic patterns in cultivar use. The survey also yielded the foundations for an informed sampling technique for assembling qualitative data. A survey-based approach is sometimes considered restrictive and unimaginative, however, it aids in overcoming the criticism of subjectivity which can be levelled against purely qualitative methods (de Vaus, 2002). In order to be as unrestrictive as possible, many of the questions in the first survey were open-ended, and coding categories were determined during data entry on the basis of the range of responses received.

A scoping visit to Malawi was undertaken early in 2010 during which time potential research villages were visited and a basic questionnaire was tried out. When fieldwork commenced in autumn that year time was short following site selection and for that reason a formal pilot survey was not carried out.

Data collection for the 2010 survey was carried out within three villages in each research area. In order avoid restricting the possibilities for statistical analysis of results, the aim was to collect at least thirty surveys from each village (Field, 2009). To ensure representative samples were achieved, where villages were composed of in the region of thirty households, enumerators aimed to obtain a questionnaire from every single household. Where villages were too large for sampling every household to be feasible within the time available, enumerators systematically visited every second or third household they came to. The survey was translated into Chichewa to ensure consistency of question phrasing by different enumerators. The English version of the survey is included in appendix ii.

The second questionnaire, which was fielded in July 2011, collected more specific data on households' historical cultivar use, and ranked preferences with regard to cultivars. This questionnaire was fielded in villages A and B in Kasungu (village C was excluded from the research and analysis by this point), and all three villages in Ngabu. Although the second questionnaire was not planned for as part of the original research strategy, it was introduced on the basis that the first questionnaire had not succeeded in eliciting full histories of cultivar use, an oversight which was recognised during analysis between the two field seasons. The 2011 survey is included in appendix iii.

Table 3.1: Primary data collected during fieldwork in 2010 and 2011

Fieldwork Session	Description	Location	Respondents/ Participants
September-December 2010	**Village data**		
	Primary Questionnaire	Village A, Kasungu	40
	"	Village B, Kasungu	45
	"	Village C, Kasungu	45
	"	Village A, Ngabu	50
	"	Village B, Ngabu	61
	"	Village C, Ngabu	51
	Focus Group: Local Agricultural History	Villages A and B, Kasungu and Ngabu	4 Groups (Max participants: 10)
	Focus Group: Maize production and Rainfall vulnerability	Villages A and B, Kasungu and Ngabu	4 Groups (Max participants: 10)
	Focus Group: Agricultural Trends	Villages A and B, Kasungu and Ngabu	4 Groups (Max participants: 10)
	Focus Group: Maize production problem-ranking	Village A, Kasungu (separate male and female groups) Village B, Kasungu (3 x groups, local maize cultivators, modern maize cultivators, mixed cultivators)	5 Groups (Max participants: 10)
	Focus group discussion on climate impacts, livelihoods and	Ngabu Village A and B (2 groups in each village, one that had ceased to cultivate	4 Groups (Max participants: 10)

	adaptation	maize, the other that continued to cultivate maize	
	Short household interviews	Village A, Kasungu	9
June – August 2011	Secondary Questionnaire	Village A, Ngabu	24
	"	Village B, Ngabu	28
	"	Village C, Ngabu	31
	"	Village A, Kasungu	50
	"	Village B, Kasungu	57
	Interviews with seasonal records participants	Village A, Ngabu	4
	"	Village B, Ngabu	3
	"	Village C, Ngabu	5
	"	Village A, Kasungu	3
	"	Village B, Kasungu	4
	Short interviews with target low-wealth rank households	Ngabu	12
	"	Kasungu	11
	Seed Network Stakeholder Data		
	Interview - extension staff 'subject matter specialist'	Ngabu	1
	"	Kasungu	1
	Interview - government research officer	National (head of cereals research)	1
	"	Ngabu	1
	"	Kasungu	0 (No dedicated research station in Kasungu)
	Interview - non-governmental research body staff	International	1
	Interview - NGO staff	National	2
		District – Chikwawa	1
		District – Kasungu	1
	Interview - seed company manager	Lilongwe	5
	Interview - seed associations	Lilongwe	1
	Interview - commercial maize farmers	Lilongwe and Kasungu	2
	Short questionnaire - seed outlets	Ngabu	5
	"	Kasungu	9

A third survey was carried out to collect information from seed outlets in each trading centre about what maize cultivars were stocked, and how popular different cultivars were. The aim was to obtain information from all the seed outlets in each trading centre, although ultimately total coverage was not achieved since there were two outlets in Kasungu where no staff members were available to participate. A list of the seed stock that was reported for sale in both research areas is included in appendix vi.

3.4.2 Participants' Seasonal Records

A number of questionnaire respondents from each research village were invited to participate in an additional research activity which involved keeping a record of observed weather conditions for the 2010-2011 season, including information about farming decisions regarding maize, such as which varieties were grown by the household, in what quantities, when they were planted, when plants flowered, when maize cobs were harvested, and in what quantity. During the second fieldwork session from June to August 2011, these participants were visited again by the researcher and interviewed to obtain a detailed history of their maize cultivar use and the reasons behind it, and to find out about their perceptions of current weather conditions.

Due to the nature of the seasonal records task, it was only possible to ask literate questionnaire respondents to participate. Whilst efforts were made to involve equal numbers of male and female respondents from all wealth ranks, it was not always possible to find willing participants from the small pool of literate farmers in the bottom wealth rank. This meant that the diary participant sample was skewed towards the wealthier participants. In order to try to counter-balance this bias, short interviews were sought from households with lower asset wealth to avoid the risk that a misrepresentative picture of household practices was built up through over-reliance on the diary participant sample.

3.4.3 Interviews

Semi-structured interviews were carried out with seed company professionals, seed breeders, NGO staff, government extension workers, and members of smallholder households. Interviews were geared towards gleaning factual information as well as understanding the participants' opinions and beliefs about topics such as climate change and the suitability of different maize cultivars and cultivation strategies, and more broadly, their perspectives on agricultural modernisation and adaptation. A topic guide with key questions was referred to, but additional topics arising through the course of discussion were also explored according to the degree of interest the interviewee appeared to accord to them. Where value statements were made by participants, the semi-structured nature of the interview format enabled attitudes to be explored further. An example topic guide can be found in appendix iv.

3.4.4 Focus Groups Discussions

Towards the end of the fieldwork session in 2010 focus groups were facilitated at four of the villages that had been included in the questionnaires. Initially, participatory exercises were used in the facilitation, but at some of the later focus groups a simple discussion format was adhered to. The specific topics which the focus groups aimed to investigate are listed in Table 3.1, but overall they helped to develop a rich contextual understanding of the maize production context in each area, and to explore specific themes of interest that had arisen in the course of the questionnaire survey. Focus groups can be used to "generate rich, complex, nuanced and even contradictory accounts of how people ascribe meaning to and interpret their lived experience, with an eye toward how these accounts might be used to affect social policy and social change" (Kamberelis and Dimitriadis, 2005, p. 546). In order to optimize the potential benefits for attendees, and insights that could arise, focus group participants were purposively selected along lines of gender or cultivation strategies with an eye to minimize social discomfort for attendees, to create opportunities for group discussion which could be fruitful for participants as well as meeting the needs of the research question, and to enable potentially 'contradictory accounts' to surface. In some cases, focus group topics were repeated two or three times with different attendees to explore how perceptions differed between groups. For example, groups which cultivated maize and had ceased to cultivate maize were both convened in two of the research villages in Ngabu, in order to better understand why a large minority of farmers were choosing to abandon maize cultivation in their farming practice. The participatory research tools employed resulted in the production of timelines detailing local agricultural histories (which were produced through discussion and card-sorting), agricultural trend diagrams and problem-rankings for maize production (see Figure 3.5 and Figure 3.6 for examples of a ranking exercise and agricultural history timeline) (Chambers, 1992, Henman and Chambers, 2001, Kumar, 2002, IIED, 2009).

Figure 3.5: Problem ranking for maize cultivation, Kasungu

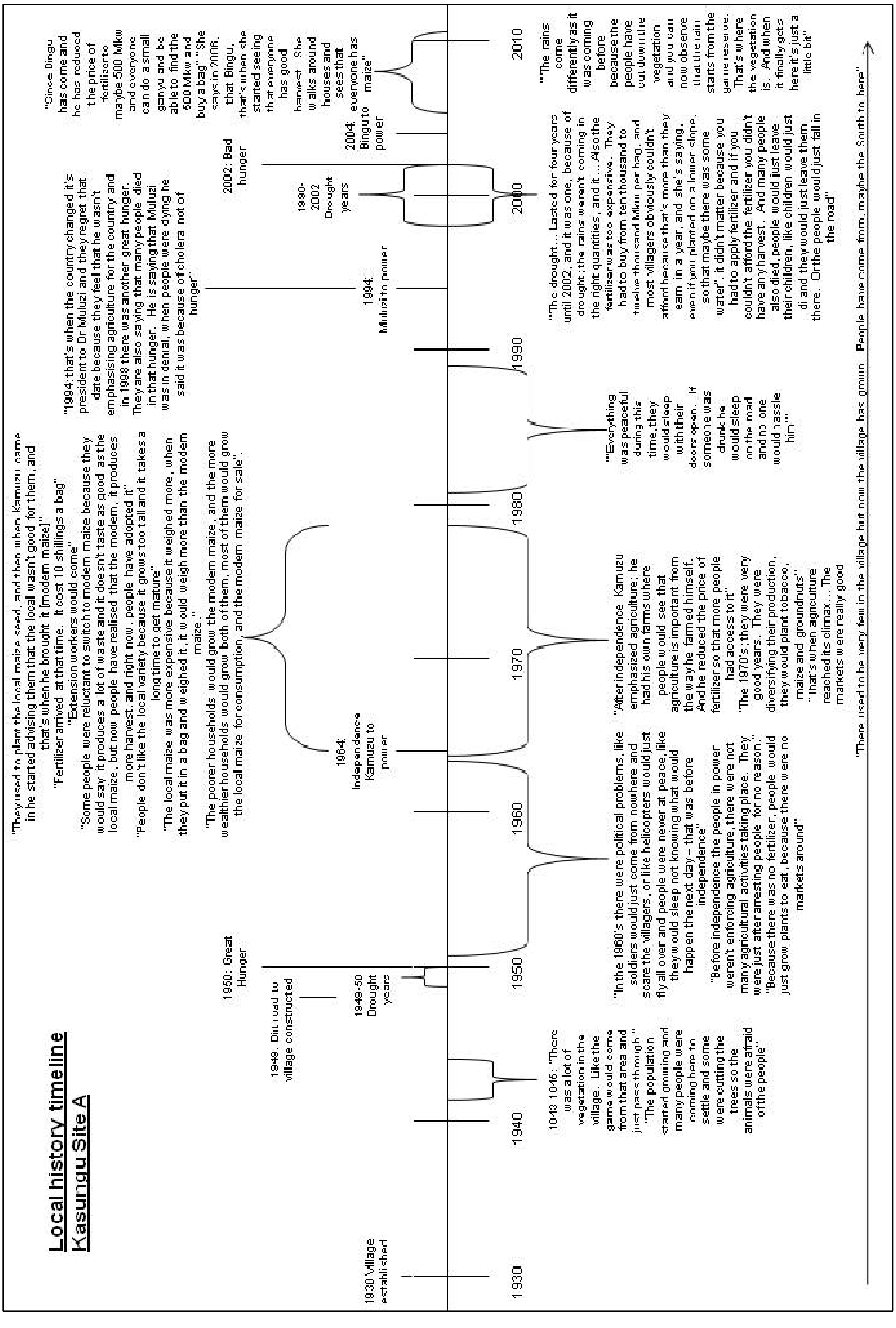


Figure 3.6: Local historical and agricultural timeline, Kasungu

3.4.5 Aquacrop simulations

Crop model software, Aquacrop v.4.0, which is freely available from the Food and Agriculture Organisation of the United Nations, was used to simulate maize yields based on climate files created from the temperature and rainfall data records from each of the meteorological research stations in the research areas. Aquacrop is described as a 'water-driven' model, where crop growth and production is determined by initial calculations of evapotranspiration. The program, which balances "simplicity, accuracy and robustness" (Steduto et al., 2009, p.426) is intended to be accessible to non-specialists with agricultural interests, such as extension officers. Although Aquacrop has been noted to underestimate the negative impacts of severe water shortage on maize production in some test simulations (Heng et al., 2009) it is considered "a valuable tool for estimating crop productivity under rain-fed conditions" (p. 488). A general crop file for maize is included with the software provided, which has been demonstrated to accurately simulate grain yield in non-water stress and mild stress conditions in varied environments (Heng et al., 2009). Simulations were created using this generalised maize crop, with some minor adjustments to parameters for field conditions to better approximate general smallholder production conditions in Malawi (e.g. planting density and average rooting depth). The generalized maize file was used to produce two new cultivars, one short season and one longer season. This was done by proportionally reducing or increasing the growing degree days required for plants to complete major developmental phases (see Table 3.2). Yield simulations for each cultivar were produced and compared.

Table 3.2: Growing degree days for simulated cultivars

Growing degree days to...	Standard Aquacrop maize file	Long season maize cultivar	Short season maize cultivar
Emergence	80	98	60
Maximum canopy cover	705	720	684
Maximum rooting depth	1409	1728	1116
Start of canopy senescence	1400	1715	1008
Maturity	1700	2267	1332
Flowering	880	1078	636
Length of build to harvest index	750	1140	636
Duration of flowering	180	220	132

3.5 Secondary data

3.5.1 Rainfall and Temperature Data

Daily rainfall and temperature data for the two local rainfall stations were kindly provided by Malawi Meteorological Services head office in Blantyre. The datasets had already been processed and checked for errors, so that little further processing was required. For Kasungu, daily rainfall data was obtained from 1961 to 30th April 2011, and for Ngabu the dataset started in 1960, and continued to the same point in 2011. For the purposes of statistical analysis, the data were processed as seasons rather than as years. Given that the useful growing season for maize in Malawi lasts from November to April, information about the rainfall for the 2010-2011 season was included in what was obtained, allowing comparison with the seasonal observations recorded by participants. The temperature datasets were not as long as those for rainfall. For Kasungu temperature records from January 1st 1983 to December 31st 2005 were provided. For Ngabu, the records obtained were from January 1st 1971 to December 31st 2005.

3.6 Data Analysis

3.6.1 Statistical analysis

Simple statistical techniques were used to analyze both the data assimilated via the questionnaire surveys and the meteorological data. Initially the data were explored using descriptive techniques and then co-variation and statistical differences were assessed using tests such as Pearson's chi-square, ANOVA and correlation.

Rainfall data was explored with regard to the incidence of dry spells, heavy rainfall, annual total rainfall and the timing and duration of seasons. Decadal means and overall trends in these rainfall features and in simulated yields were explored using Spearman's Rank Correlation Coefficient (Gauthier, 2001), which has been found to be effective in detecting monotonic trends time and space, and is not sensitive to the population distribution, which was significantly non-normal for much of the data.

3.6.2 Socio-economic ranking

There are a number of different possibilities for deriving proxy measures of wealth and approaching socio-economic analysis within subsistence agriculture contexts where household monetary income is likely to be poorly indicative of actual household wealth. Wealth can be defined differently according to cultural perspectives of value. Methods with high local contextual sensitivity, such as participatory wealth ranking (Grandin, 1988), are often preferred because they achieve insights that other methods may miss out on (Scoones, 1995). However, whilst the initial plan was to use this approach, it was ultimately found to be likely to be too time-consuming for use in the six villages (some of which were composed of over a hundred households which were not all well known by Chiefs). According to time constraints, a survey based indicator approach was used instead.

The wealth-ranking method that was followed is described in Cordova (2008) and Filmer and Pritchett (2001). It has been described as "pragmatic", "straightforward" and the results are considered to be "reassuringly consistent with other approaches" (Filmer and Pritchett, 2001, p. 115). Unlike some approaches, which simply add together all the assets owned by households as if their value was equivalent (Cordova, 2008), this method effectively solves the problem of how to weight different assets in order to reflect their value within the local context, based on a measure derived from the frequency (or alternatively, scarcity) of each asset within the dataset. Asset ownership must be represented by a dichotomous variable, where 1 indicates ownership and 0 indicates no ownership. Assets that are included for selection should be logically assessed to ensure that scarcity and the local value of the asset are actually correlated. Assets which are locally rare but not of high value in local terms should not be included, since the method employed will wrongly assign a high score to such assets. Asset values are then calculated by finding the standardized score or z-score for each asset:

$$z = (x - \mu)/\sigma$$

Here, $x = 1$, μ = the mean value for ownership of that asset, and σ = the standard deviation for that ownership of that asset. Values were calculated for all the assets to be included in the analysis, and then these were added together, creating a wealth score for each case included in the survey. Since land could not be treated as a dichotomous variable (as ownership was nearly universal and land sizes were strongly indicative of wealth), a different approach was used to incorporate it into the final wealth score. Land sizes were initially ranked into five groups, and then these different groupings were each assigned a dichotomous ownership variable from which a value based on the frequency of ownership within that ranking could be attained (following the z-score method above). Cases in each research area were then split into three groups according to whether they fell in the top or bottom thirty percent, or middle forty percent of the range of wealth scores. These three groupings were designated as the top, middle and bottom wealth ranks.

A downside to this method is that, since assets will have different frequencies in different areas, its accuracy may be compromised across different contexts. As the analysis was concerned to rank households according to their relative wealth in local terms, separate indexes for the two research areas were calculated, rather than a single index for the total combined dataset. The variables included in the wealth ranking analysis for both datasets (2010 and 2011) were ownership of: 'smallstock' (chickens, pigeons and ducks), 'midstock' (pigs and goats), and 'largestock' (cattle), *dimba* land, mobile phones, bicycles, radios and corrugated iron roofing. Additionally, households were scored on whether or not they employed outside assistance with farming (*ganyu*). For the 2010 questionnaire, data on two additional items had been collected: ownership of a plough and ownership of a treadle pump, so these variables were also incorporated into the analysis for this dataset. However, they were excluded from the 2011 questionnaire since ownership was so uncommon and the single household which owned a treadle pump remained in the top wealth rank whether or not this asset was included in the analysis. For details of the values assigned to the different assets in each area in 2010 see appendix v.

3.6.3 Climate vulnerability indicator

The climate vulnerability indicator was produced by scoring selected variables as one or zero according to whether they represented a source of vulnerability to climate impacts for dichotomous variables, and according to whether they were above or below the mean for continuous variables. The variables selected included the number of crops and income sources households relied upon, whether households had a source of income from outside of the village, whether their primary income source was rainfall dependent, and the degree of variability they experienced between good and bad years in the number of months their harvested stocks of maize lasted. These variables were chosen as they were each considered to approximate the qualities of sensitivity, exposure or adaptive capacity within the household, which are the three components often considered to constitute vulnerability (Adger, 2006). The variables produced were then added together and inverted to produce a score representing the household's degree of vulnerability to negative climate impacts, with higher scores representing lower vulnerability to negative climate impacts. The indicator measures used were specific to each research area so that household vulnerability within each area, rather than across areas, could be compared. This meant that some values were coded differently according to location (see Table 3.3).

Table 3.3: Variables for climate vulnerability indicator

Variable for inclusion in vulnerability indicator	Kasungu or Ngabu	Recode variable to 0 or 1	
		0 (more vulnerable)	1 (less vulnerable)
Household labour	Both	1	>=2
Land to labour ratio	Both	1	>=2
Good to bad year variation in maize harvest	Kasungu	>2	<=2
	Ngabu	>4	<=4
Poor harvests due to drought over 20 years	Kasungu	>1	<=1
	Ngabu	>3	<=3
Number of crops grown (additional to maize	Kasungu	<2	>=2
	Ngabu	<3	>=3
Number of income sources	Both	<=1	>=2
Income source from outside the village	Both	0	>=1
Number of alternative food sources relied upon	Both	<=1	>=2
Respondent is literate?	Both	No	Yes
Drought tolerant crop grown?	Both	No	Yes
Undertook adaptation	Both	No	Yes
Primary income from a rain dependent activity?	Both	Yes	No
Perception that farming is becoming more difficult?	Both	Yes	No

3.6.4 Qualitative analysis

Transcripts from focus groups and interviews were analyzed thematically according to the objectives of the study. This involved careful reading, systematic coding and interpretation of information in a process that can be referred to as 'directed content analysis' (Berg and Lune, 2014, p. 338). Qualitative data analysis software, NVivo 9 was used to organise transcript materials and to develop and organise coding for themes (Gibbs, 2002).

3.7 Summary

The methods assembled for undertaking this research create an integrative, mixed methods approach that enables insights into the broad range of factors influencing contemporary cultivar adoption amongst Malawian smallholders and the value of its role as an adaptation strategy. The thesis now moves onto present the research results in chapters 4, 5 and 6.

Chapter 4 - Maize Cultivar Diffusion in Malawi

4.1 Introduction

Seed systems play an important role in determining the resilience of agricultural livelihoods to stressors such as drought, flooding and food insecurity, yet they remain under-researched (McGuire and Sperling, 2013). Whilst political agendas increasingly recognise the importance of seed systems for African development, technical and market aspects have tended to dominate policy (Scoones and Thompson, 2011), and informal systems have received far less attention (Almekinders et al., 1994). However, the role of informal systems, particularly in mediating seed access during times of crisis, suggests that their operations are equally if not more important than formal systems for supporting resilience (McGuire and Sperling, 2013).

A major study of Malawi's seed system was undertaken in the early 1990s (Cromwell and Zambezi, 1993). At this time national seed provision was entirely managed by ADMARC and all seeds came from a single seed company, the National Seed Company of Malawi (NSCM). Use of improved seeds was low, yet most farmers were seed-secure because they relied predominantly on home-saved seed stock. National provision of improved seeds was characterised by a lack of choice, quantity shortfalls and poor timing (Cromwell and Zambezi, 1993). However, since Cromwell and Zambezi carried out their study, Malawi's seed sector has been transformed.

The formal parts of Malawi's seed system are now determined by a combination of government and multi-national and national seed business activities, with some additional involvement from NGOs. Some farmers still also save their own seed from one harvest to the next, and/or exchange seed amongst themselves, making up the informal parts of the seed system (Almekinders et al., 1994). ADMARC, which controlled all access to modern maize during Hastings Banda's rule (1964-1994), is now in decline, and liberalization of the seed market (as a condition of structural adjustment) has led to the rising importance of powerful multi-national agricultural companies such as Monsanto and Pioneer (Chinsinga, 2011), with new ranges of modern cultivars and in particular, hybrids, having been promoted strongly in recent times (Denning et al., 2009, Lunduka et al., 2012). The failure of marketed cultivars to meet smallholder trait preferences has been considered a factor contributing to historically slow adoption rates for improved maize in Malawi (Smale and Rusike, 1998), so the way in which these new cultivars are being received by smallholders is a question of interest.

This chapter describes how maize cultivars are diffused to smallholders in Malawi and discusses the implications of these diffusion strategies for equitable access and uptake. As such, it fulfils the first objective of the thesis, "to describe the diffusion of modern maize cultivars to smallholders in Malawi". Comparisons are drawn between the empirical situation encountered and the theoretical approaches to innovation ("Diffusion of Innovations" and "Agricultural Innovation Systems") which were discussed in Chapters 2 and 3 (Rogers, 2003, The World Bank, 2012).

4.2 Chapter Objectives

Specifically, this chapter undertakes the following objectives:

1. To empirically describe maize cultivar diffusion in Malawi
2. To discuss implications of Malawi's diffusion systems for equality of access to maize cultivars, with reference to academic theories, the "Diffusion of Innovations" (DOI) and "Agricultural Innovation Systems" (AIS)

4.3 Methods

The literature review, discussion with key informants and subsequent snowballing enabled the identification of actors to target for data collection within Malawi's maize seed system. Semi-structured interviews were carried out with a range of stakeholders from government, NGOs, seed companies and study villages. Interviews were conducted with a view to understanding the full range of diffusion activities that each type of stakeholder engaged with, and to collect rich qualitative material that would yield insights into the motivations and attitudes of different actors. By engaging with stakeholders at multiple points within the diffusion network, an overview of the system was obtained. The collection and analysis of qualitative material enabled actors' perspectives of the system to be explored. The descriptions of seed diffusion activities that were provided by interviewees were considered in relation to the DoI and AIS frameworks, and the narratives in which these descriptions were couched gave insight into perspectives on the efficacy and efficiency of the diffusion strategies being pursued. The main data sources upon which this chapter relies are laid out below in Table 4.1.

Table 4.1: Sources of primary data on the topic of maize diffusion

Data source	Number	Data description
Seed company representatives	5	Interviews were carried out with seed company managers to find out information about the company's operations, including their aims, marketing strategies and breeding priorities.
Seed breeders and researchers	4	Interviews were carried out with a national government maize seed breeder, two regional government research officers and regional manager from an international breeding organization to find out about public goods breeding activities, strategies and priorities.
Government extension staff	4	Semi-structured interviews with extension staff were undertaken to find out about extension activities relevant to cultivar selection.
In depth interviews with village-level participants	19	In each research area a number of smallholder farmers were invited to participate in the research as key informants and seasonal records-keepers. One aspect of the involvement of each was an in-depth interview to explore their personal history of cultivar use.
Short targeted additional interviews	23	Since most participants for records-keeping were selected on the basis of being literate, it was questionable whether their experiences could be held to be representative of non-literate farmers in the area. These additional interviews were carried out with households from lower wealth ranks to try to overcome this potential bias.
NGO staff	3	NGO staff were interviewed to find out about the kinds of activities their organizations were running with a bearing on smallholder maize cultivar selection.
Research area seed outlets	14	Seed outlets in each of the research areas were asked about what they stocked and the popularity of different brands.

4.4 Results

Results relating to the formal parts of Malawi's seed diffusion system are presented first. As discussed, the formal system is mainly made up of government and corporate seed business activities, and results concerning each will be presented in turn. A separate section will then discuss the role of the AISP, combining information relating to both state and corporate organisations, and the last section will explore informal farmer to farmer diffusion.

4.4.1 Government Channels

Besides its influence through the AISP, the Government of Malawi influences the diffusion of modern maize seed to smallholders through extension work and via the national research and breeding programme. The operations of these two routes of influence are now both explored using information gained from semi-structured interviews with professionals working within each service.

4.4.1.1 Government extension activities

Both colonial and post-colonial historical agricultural extension policies in Malawi have been noted as mainly promoting a focus on modernized maize production through the dissemination of “a technological package of hybrid maize seeds and chemical inputs” geared towards mono-cropping (Moseley, 2000, p. 14, Snapp, 2004). This section looks at whether this is still the case, how extension activities aim to affect the diffusion of new maize varieties, and the impacts that these activities actually have. Extension workers in Ngabu and Kasungu were interviewed to find out about the range of activities (especially maize-related) that their services were involved in delivering, and smallholders were interviewed about their experiences of the services they received.

The extension service mainly engaged with smallholders around issues of maize cultivar use by running demonstration plots and making village or household visits to offer advice.

There was a consensus amongst the extension workers and smallholders interviewed that change was best achieved through providing opportunities for first hand observation of the advantages of using modern inputs, and hence demonstration plots tended to be viewed as more effective than household visits:

> *“Yes because farmers they learn by seeing, rather than just telling them ‘do this...do this...do this’. But when they see, they learn more... After seeing, they adopt“*
>
> *Extension worker, Kasungu*

Demonstration plots offered opportunities for farmers to compare the growth, earliness and yields of different varieties under local climatic conditions. By doing so, they enhance farmers’ awareness of (and capacity to select from) the range of maize varieties available to them and thereby augment the ‘trialability’ and ‘observability’ of the cultivars; attributes that are seen as essential to the ‘persuasion’ phase of the innovation-decision process within DoI theory (2003 pp. 170).

Several participants gave positive reports of demonstration plots. However, it was notable that only some were aware of their existence, and because plots are confined to certain locations, many smallholders failed to encounter them. Plots are often positioned alongside major roads into trading centres and are only encountered by town-going smallholders. Additionally, capacity to differentiate between displayed cultivars depends on literacy, since written labels are used to demarcate rows. These factors might contribute to Rogers' (2003) maxim that early adopters will be more cosmopolitan in character.

One participant explained his experience as follows:

> *"First of all, I saw this variety in a demonstration field and I thought it was good, so I was keen to grow it... Every year, the extension workers plant fields along the M1 road. After each field they put a post, saying which variety is being grown there. So as you are coming along this road, it's automatic, you see the maize varieties that are being grown by the extension workers."*
>
> *Seasonal diary participant, Male, 70 years old, Village A, Kasungu*

In addition to roadside demonstrations (which are often sponsored by seed companies so may not include the full range of locally available cultivars), plots are also set up around Extension Planning Area (EPA) offices and within local farmers' fields. Where plots are laid in the surrounds of EPA offices, farmers may visit of their own accord, but they are also invited on dedicated field days.

Respondents underlined the importance of farmer-managed demonstration plots since these better enable comparisons with local techniques and inputs-usage and are more accessible. Villagers themselves may select local farmers to run demonstrations, indicating some devolvement of management power, however, decisions about which cultivars to trial are still made by the extension service. Because demonstration plots tend to use inorganic fertilizer applications at the recommended level, some farmers perceived the results achieved on plots to be unattainable on their own farms. The existence of a disconnect between local resource levels and extension recommendations across Africa was noted by Snapp (2004). In this study, for example, when one farmer was asked why she had not arranged her fields as they were arranged in the demonstration plots she had visited, she responded:

> *"Because I knew I could never afford to do it that way"*
>
> *21 year old female, Village B, Kasungu,*

The extension service aims for field days to be attended by a few individuals from each of the areas under the service's management who can then spread information verbally to other villagers, thereby widening demonstration impacts. This aim reflects a key DoI assumption; that communication between socially similar individuals precedes technology adoption (Rogers 2003):

> *"We have twenty nine sections and our target is ten real farmers from each section, that is to say 290. But our people from around here, it's more difficult for the people to travel from far away, so people from round here, perhaps more come. After they have seen the fields the ten people are the people that go and tell the whole village, like that they should do this, do this, do this..."*
>
> *Extension manager, Ngabu*

Yet, despite the good intentions behind demonstrations and field days, it was evident that extension service capacity to mount them at optimal scales within the districts visited was limited. As such, the extension manager in Ngabu quoted above also admitted:

> *"Most of the time when we want to do demonstration fields we don't call all the villages from the further away divisions, we just call ten people from the closest division, so they come here and see what we are doing here in the demo fields"*
>
> *Extension manager, Ngabu*

Similarly, in Kasungu it was reported that plots demonstrating a range of cultivars for the purposes of comparison were rare. The extension service mounts demonstrations relating to a broad range of agricultural activities, and resources are such that only one type of demonstration is mounted in each area:

> *"It's not in each and every village, we can't afford... we cannot afford the inputs. Yes, maybe at a group village level we can have one demonstration. And it's not only one type of demonstration, like maybe targeting maize and the like. We spread the varieties, like the legume part of it, we throw it in a certain village. Like Conservation Agriculture, we throw it in another corner, and this one, the maize variety, in a certain village. So it's like that, they are all scattered."*
>
> *Extension manager, Kasungu*

Some demonstrations did not accurately reflect what was available to smallholders in the local area at the time of the research. In Kasungu, it was reported that a fifth of the cultivars demonstrated were not available from local outlets that year. This was perhaps because decisions about what to include were not made locally, but were made centrally at the National Agricultural Research Station at Chitedze. Centralized decision-making was blamed for the failure of a recent trial in Ngabu; cultivars were sent late in the season and their planting coincided with a dry spell. Subsequently, the trial was not opened to visitors.

The fact that demonstration plots currently reach only a limited number of smallholders is reflected in the figures from the 2011 questionnaire survey wherein only 31.8% of respondents had ever heard of a demonstration plot taking place in the local area, and only 19.6% had ever visited one (N=107)[1]. One research participant also indicated that plot attendees did not necessarily communicate information to other smallholders:

> *"There are some who went to the demo, but I didn't ask them about it, and they didn't tell the villagers about what they were seeing there."*
>
> *Seasonal Record Keeper, Male household head, 35 years old, Village A, Kasungu*

Where respondents had failed to visit demonstrations despite hearing they were happening they blamed distance, lack of time, lack of interest and poor health. One participant lamented the fact that plots were so few, since he considered them to be the most effective way for farmers to gain information about maize cultivars.

> *"Demonstration fields are the best. There should be more... For example, there is only one demonstration plot for twenty villages. This creates a lot of confusion, because people cannot access the demonstration fields. Instead it should be that for every two villages, you have a demonstration plot."*
>
> *Male household head, aged 40, Village B, Kasungu*

These findings illustrate that whilst demonstration plots are viewed as an effective way to communicate varietal information to smallholders, they are constrained by funding shortages, and their effectiveness for poorer smallholders is limited since the production approaches being exhibited can be viewed as too costly to imitate.

[1] This data only refers to Kasungu, where the question was fielded. An earlier version of the questionnaire that was used in Ngabu did not incorporate the question on demonstration plots

The second way in which extension workers sought to influence smallholder cultivation habits was by offering verbal advice. Historically, descriptions suggest the Malawian extension service has "focused primarily on the staple field crop in Malawi, corn" (Snapp, 2004, pp 8). In contrast to this, interviews revealed the service now promotes a range of crops and emphasizes crop diversification. However, maize has undeniably remained central, even in Ngabu where maize production is widely acknowledged as risky. The extension manager for the area explained:

> *"At first we were encouraging people to concentrate on growing maize, but with climate change, with the way our weather is, it is difficult to tell a farmer that they should do this, so we have tried our best to tell people to be cultivating maize where they have some wet areas, compared to the high lands, were the soil does not keep a lot of water. Although these days, we still encourage them to grow maize, we are not emphasising it as much as in the past, because most of them, when they were growing maize, they would find that their whole land, the whole area, would get scorched with the sun, and hence the people were frustrated, and were saying, 'if we had planted cotton, if we had planted this other type of crop, we could have maybe harvested, but look, you have told me to plant maize and the whole field is getting scorched'. So the people of late have been getting discouraged."*
>
> *Extension worker, Ngabu*

Despite emphasising maize production to smallholders, extension workers were trained not to give specific cultivar recommendations since this was perceived to provide an unfair advantage to certain seed companies:

> *"It's very difficult to tell them that you should go for this one. But what we tell them is that according to this area there are this, this, this varieties, so they can choose. So we tell them about the advantages and disadvantages of each and every variety. If it's long-maturing, like this one, SC719, we tell them it's long maturing and requires a lot of fertiliser and even more rainfall. So we tell them this one has this advantage, but it also has disadvantages. So it's for the farmer to choose, because if we choose for them it's like we are promoting that seed company. We are discouraged to do that."*
>
> *Extension Manager, Kasungu*

The desire not to influence smallholders' cultivar choice indicates a move away from paternalistic technology transfer towards a system that emphasizes choice and learning, but the quoted comment suggests the driver of this approach is a desire to enhance the liberalisation of the seed market. Whilst a competitive market amongst seed providers should result in enhanced input selection choice for smallholders, village participants experienced difficulties remembering the names and characteristics of available cultivars:

> *"Yes, there are a lot of maize varieties, but because there are so many different varieties these days I get confused about the names. I did stay with local for a long time. I can't remember any other names"*
>
> *Male Household Head, 70 years old, Village A, Kasungu*

Such comments suggest the reticence of extension staff to provide direct recommendations better reflects seed industry interests than those of smallholders.

Whilst extension workers did not give direct recommendations about what to grow, those interviewed consistently recommended modern varieties over local maize. However there was disagreement on whether it was preferable to promote OPV or hybrid maize. In Kasungu some smallholders reported that extension workers had recommended OPVs to them, but local extension workers indicated that they advised the use of hybrids. Meanwhile, extension managers in both research areas indicated that both types should be promoted:

> *"The message really should be that they should go for hybrids and OPVs"*
>
> *Extension Manager, Kasungu*

Whatever the nature of the communicated extension messages, a large number of the smallholder participants were either not aware of seed-saving recommendations for OPVs and hybrids, or were not aware of which maize cultivars belonged in which category.

> *"I have never heard any variety that can be recycled. The extension workers told us that we shouldn't recycle maize varieties. That's all I know"*
>
> *Male household head, 40 years old, Village B, Kasungu*

Overall, shortcomings were evident in the communication of extension advice to smallholders both on the basis that extension advice appeared inconsistent over time and because extension workers were discouraged from making area-specific recommendations.

Comments about the extension service revealed a strongly hierarchical system of organisation to dominate. Decisions were described as being predominantly made by staff within the National Agricultural Research Station at Chitedze. These decisions were then channelled through extension staff via local research stations and EPAs to smallholders at the end of the chain. Village level research participants complained of few opportunities for information to flow the other way. One village headman commented:

> *"For me, I think there are some problems. As a chief, I don't have a proper way of sending messages to the people in authority. This is my main worry. People, they have a lot of things to say to the authorities, but we don't have any channels through which we can communicate."*
>
> *Village headman, Kasungu*

Extension workers made comments which indicated that they conceptualised their work to deliver agricultural change as a one-sided learning process on the part of the smallholders, rather than a process of mutual education with information flowing in both directions:

> *"It's still a challenge for us, yes, for them to get what we are telling them. For the farmers to catch up on technologies and the like or rather to understand what we are telling them, what we are demonstrating to them, you know. Don't forget this part of illiteracy..."*
>
> *Extension manager, Kasungu*

And:

> *"Some people they are not able to understand what they've been told. Even those farmers... not all farmers come and attend our meetings. Some are reluctant so we just leave it."*
>
> *Extension worker A, Kasungu*

Other comments also revealed an underlying view of traditional smallholder farming practices as inferior to modern practices:

> *"There is some understanding now of how to produce crops, rather than in the past years. Now people understand, they know when you've got food you are at least happier at your home"*
>
> *Extension worker B, Kasungu*

The hierarchical nature of the extension system was also reflected in comments made by extension workers which suggested they perceived decision-making capacities to rest mainly with their superiors:

Interviewer: And in terms of maize production, does the extension service have any particular plans for trying to adapt maize production to having less rainfall in the future?

Interviewee: Ah no, no. We have no plans... because, at our level, there is nothing we can do.

Extension worker B, Kasungu

And:

"For the subsidy programme, the orders are given from above saying that a certain number of people are required, so we go to the village development committees and we just leave the instructions".

Extension manager, Ngabu

Analysts have pointed to problems of scale and reach in extension services throughout Africa (Aker, 2011). One survey carried out in the districts of Mangochi and Kasungu in Malawi found that only 5% of farmers had received advice from extension staff (Snapp, 2004). Similarly, when respondents of the 2011 survey were asked how they had heard about varieties they wanted to try, only 4% had obtained information from extension workers, with the vast majority having heard through their neighbours or the radio:

Table 4.2: Sources of information about new maize cultivars, 2011 survey (n=126)

Source of information about new maize cultivars	Number	Percentage
Neighbour	68	54.0
Friends	1	0.8
Field trials	3	2.4
Radio	40	31.7
Poster	3	2.4
Extension worker	5	4.0
Agro-dealer	3	2.4
Family member	1	0.8
Flyer	1	0.8

Other	1	0.8

To overcome low staff to client ratios, extension services in Malawi and elsewhere in Africa have followed a training and visit (T&V) approach, wherein certain farmers (opinion leaders) are singled out for contact and encouraged to spread messages to others (Eicher, 2007). The information that smallholders and extension workers relayed during the research about the organisation of demonstration plot visits indicated that this kind of strategy is still being pursued in practical terms.

"Yes, some of the people didn't get to see the fields. Because the government, when they are calling, they call the committees, so the people that are not in the committees are the ones who were not called. They only called for the committee members... Yes, the plan is, after the committee have gone and seen, they come back to the village and tell the people about what they have seen. The reason why they choose only certain people is because they can't call the whole village because the village is too big, it would be a very large gathering, and some people maybe would not be able to see what was in the demonstration fields."

Seasonal record keeper, male household head aged 40, Village B, Kasungu

Both extension and NGO staff made reference to the use of village development committees as well as 'lead' and 'real' farmers as means for communicating extension objectives to smallholders.

"So what we have, is out of those farmers we have what we call, "lead farmers". So it is the lead farmers who conduct the trials."

NGO manager, Lilongwe

And:

"We have our extension staff on the ground and they are responsible for a particular section and in that section they work with the communities, the local leaders and the like, and also the lead farmers and the like".

Extension manager, Kasungu

Whilst the aim of working with opinion leaders is to train up local people who can influence others to adopt, there was evidence that the lack of attention received by those not selected could result in a sense of exclusion:

> *"I'm not happy with what the extension workers are doing here in the village. First they called a meeting at the Chief's house and selected about ten people from amongst the villagers who they called 'real farmers'. Now whenever the extension workers come here they only deal with those people, they don't help the people who are failing to cultivate"*
>
> *Female household head, 50 years, Ngabu*

One NGO worker described a tendency of some poorer households to refuse to become involved with local development projects:

> *"Much as we'd want to target the vulnerable households to learn, we sometimes find there is a problem with their mentality. They think, "I'm not capable of doing this, they should be going to one of those better households somewhere else in the village". One problem for some of the households is that they've checked out of development, they think, "The way I live is the way I live". Those households are difficult. We ultimately have to pick those that have an interest in being involved in what we are doing. We also consider the issue of relations within the community. We need to choose households that are respected and well-integrated with the community. If we choose households that are not well-liked then the possibility of achieving further-reaching change through them will be limited."*
>
> *Regional NGO manager, Shire Valley*

When considered together, these comments raise the query of whether apathy on the part of some smallholders might result from a perception of having been excluded in the past. Such a situation has been described by researchers carrying out fieldwork in Malawi elsewhere (Chipande, 1987).

The findings presented in this section have revealed that the extension service pursues diffusion practices which are reminiscent of a DoI approach. Whilst these activities appeared effective for some of the participant smallholders, they appeared to be failing to reach others. The hierarchical structure of the extension service and a scarcity of funding for extension activities both appear to limit the service's capacity to respond to local needs effectively.

4.4.1.2 Government research and breeding activities

Despite the fact that collaborative approaches to breeding have been widely recognised as a successful means for producing crop varieties which are preferred by farmers (Gyawali et al., 2007), public breeding strategies in Malawi remain predominantly contained within research stations and participation by smallholders is confined to the tail-end of cultivar development. Breeding takes place primarily on-station at Chitedze, and then materials are channelled to regional stations for further local testing before being assessed by smallholders at trials. One problem with this approach is that materials are produced in ideal conditions and may not perform so well on real farms:

> *"If you are doing your research on the station here, you've got everything optimum. You take the same variety to farmers and there is some reduction, because you are now subjecting those particular genetics to the conditions of that farm, so it will not be that ideal, but you might find that they will still get much higher yields"*
>
> *Government breeder, Chitedze*

As well as developing some national hybrids, breeders at Chitedze receive improved, drought-tolerant varieties and germplasm from CIMMYT (The International Maize and Wheat Centre who run DTMA, Drought Tolerant Maize for Africa). CIMMYT have no in-country involvement beyond delivering materials, and leave cultivar diffusion decisions up to the Government of Malawi and corporate seed businesses. This is reminiscent of a 'transfer of technology' approach:

> *"CIMMYT's mandate stops at developing and availing elite materials to national research systems. The national research systems will make sure that the varieties are significantly better than what is already in the farming systems. The seed production, multiplication, and marketing will anyway end up in the hands of the private sector. In the future, the private sector will and shall rule the distribution part of the improved varieties."*
>
> *Associate Scientist, CIMMYT*

Once new cultivars have been developed, regional research staff trial them on actual farms, so they and farmers can assess performance under local conditions. However, researchers rely on extension staff to organise engagement with farmers, meaning that farmers perceived by the extension service as 'lead' or 'real' farmers (as discussed in the last section) are likely to be selected to run trials.

“We go to the extension workers, they choose farmers for us and we work with them directly”

Research station staff member, Ngabu

Whilst trials are located in smallholders’ fields, decisions concerning agronomy and cultivar inclusion are determined by the research station, based on instructions from Chitedze. The trials may therefore lack contextual relevance in terms of local agronomic practices and inputs usage:

“We went into the field, we found the fields and did site selection. Later on we laid out the plots, giving at least three varieties per farmer, planting, fertilizer application - basal and top dressing, everything like that.”

Research station staff member, Ngabu

Failure to involve farmers early on in cultivar development processes may account for the low adoption rates of some previously released cultivars. Farmers’ rejected cultivar MH11 when it was released because its dent texture was unappealing. The market failure of MH11 was described as the main way farmer preferences for flint texture had been discovered. Earlier farmer involvement could have perhaps avoided resources being wasted on the development of an unsuitable cultivar:

“It's in the past that we had problems with MH11. It was very dent, so when it came out, the farmers rejected it outright. It was yielding 12 tonnes, but what we learnt was that no, we cannot be pushing dent any more. Because it was a very good hybrid, very good in terms of response to diseases, and if you looked at the cob, it was a nice cob. But farmers took it and it was producing a lot of chaff. And it just collapsed. Dents will take some time for us to adopt. So having had those kinds of experiences, farmers really tell us what they want. So me as breeder I have to listen to that because if I don't I might raise a variety and it will not go anywhere.”

Government maize breeder, Chitedze

Although direct communication between farmers and breeders is limited, the national research system now engages strongly with corporate actors in the seed market. In particular, STAM (the Seed Traders’ Association of Malawi), acts as a platform or ‘bridging institution’ (Spielman and Birner, 2008), mediating between government and the private sector, producing market research information for the former, and lobbying the government in the interests of the latter:

> *"STAM has been very instrumental in trying to help us a little bit in terms of information. They get organised and we advise them properly... I trained most of the people there myself"*
>
> *Government maize breeder, Chitedze*

The development of STAM indicates increasing opportunities for collaboration amongst some stakeholders within the seed network, but it is private companies who appear to benefit the most. Since CIMMYT and Malawi's national research system do not have the power to bulk up or market cultivars they have produced, they are dependent on private seed companies to do so. Businesses therefore receive saleable materials developed by public goods programmes at little or no cost, and they may even bargain for exclusive rights:

> *"We aim to produce public goods varieties. However, there can be problems in terms of producing hybrids, so sometimes we have to resort to offering exclusive rights over hybrid production to private seed companies operating within the country. As CIMMYT is not allowed to make any profit we merely attempt to recuperate our costs. As such the seed companies do not have to pay us large sums; it is more the case that they provide us with token payment in return for access to germplasm"*
>
> *Associate Scientist, CIMMYT*

4.4.2 Corporate Channels

As already discussed, since the end of Hastings Banda's rule in 1994 Malawi's seed market has been liberalised and now a number of different national, international and global corporate brands operate within the country, bulking up seed and supplying traders (Chinsinga, 2011). When fieldwork was carried out for this project in (2010-2011) nine seed companies were active (Jumbe, 2011). Information about each company is detailed in Table 4.3. The major four companies (Monsanto, Pioneer, Pannar and SeedCo) operate internationally and concentrate on marketing their own hybrid cultivars. A further five national companies multiply and supply public good cultivars (a mixture of OPVs and hybrids developed by national and international research bodies). In excess of 27 varieties of improved maize were commercially available to smallholders in Malawi at the time of the research, with many more in the pipeline due for release. These cultivars were mainly channelled to smallholders through local agricultural outlets, agri-dealers and ADMARC depots. A list detailing available cultivars and data on the range of seeds stocked by local outlets in the two research areas can be found in appendix vi.

4.4.2.1 Corporate diffusion strategies

Seed company managers described relying mainly on radio advertisements and distributing flyers to communicate information about their products:

> *"At present, the only ways we communicate with farmers are just by radio and taking the flyers to farmers, we just distribute them to the farmers, and the field days that we have. Apart from that the farmers themselves go into the shops and find out there."*
>
> *Manager of seed company D, Lilongwe*

In addition, interviewees described often linking up with the extension service to participate in demonstrations:

> *"Because whether you like it or not, Ministry of Agriculture has got a longer hand than any single organisation. So we use their structures, like extension, like research, you know, land husbandry and all those things. We use their infrastructure. We go and work in those areas."*
>
> *Manager of seed company C, Lilongwe*

Evidence that corporate actors were keen to make the most of networking opportunities was also reflected in the formation of the Seed Traders' Association of Malawi (STAM), as discussed in the previous section. One interviewee described how STAM was used as a platform to lobby the government to allow products from all seed companies to be sold as part of the AISP:

> *"When Bingu came to power in 2004 the seed companies approached the new government. It was at this time that the Seed Trader's Association of Malawi was formed... Since it was a new government which had just come to power on the back of an anti-corruption campaign it was possible to convince them that the Starter Pack program needed to operate differently. STAM really basically designed the current subsidy program... The current system allows free choice by the farmers and all the seed companies can sell their maize cultivars through the program. It encourages competition, and encourages the companies to be communicating seed attributes to the farmers"*
>
> *Manager of seed company E, Lilongwe*

Another benefit for seed companies deriving from membership in STAM is the opportunity to gain information about the regional distribution of subsidy coupons, so that seed allocation decisions can be made accordingly.

> *"STAM also communicates information about coupon distribution to the seed companies, so we are able to say, for example, in Kasungu, perhaps that the coupon market will number 5000 (this is obviously in addition to the cash market), so seed companies can choose to distribute their seed accordingly."*
>
> *Manager of seed company E, Lilongwe*

The development of networking activity within Malawi's seed sector aligns closely with an Agricultural Innovations Systems style model however it appears that corporate actors were best placed to profit the most from the greater access to market information and sales opportunities that this networking facilitated.

Table 4.3: Seed companies operating in Malawi in 2011

Company name	Company origin	Marketed Products	Breeding station
Monsanto	North American company with global operations, took over the National Seed Company of Malawi	Hybrids: DKC 80-33, DKC 80-53, DKC 80-73, DKC 90-89, NSCM 41	One centralised breeding station in South Africa, followed by regional trials in Malawi
Pannar	South African company	Hybrids: MH 18, Pan 67, Pan 77, Pan 4-M19, Pan 53, Pan 63, Pan 57	Main breeding station in South Africa, followed by regional trials in Malawi
SeedCo	African company	Hybrids: SC719, SC627, SC513, SC403 OPVs: ZM309, ZM521, ZM523, ZM623	Main breeding station in Zimbabwe, with a second station in Zambia, followed by regional trials
Demeter	Malawian company	OPVs: ZM309, ZM523, ZM621, ZM623, ZM721	No breeding station of its own, markets public goods varieties developed by CIMMYT and the MoA

Pioneer	North American company with operations in eighty countries worldwide	Hybrids: PHB30D79, PHB30G19, P2859W	Kenya and South Africa
Funwe Farm	Malawian company (not for profit)	OPV: ZM621	No breeding station, markets public goods OPVs from CIMMYT and the MoA
Peacock Seeds	Malawian company	Hybrids: MH30 and others from 2012	No breeding station, markets public goods hybrids from Chitedze research station and elsewhere
ASSMAG (Association of Smallholder Seed Multiplication Action Groups)	Malawian association started by a Ministry of Agriculture and donor initiative in 2001	OPVs Through Chitedze Research Station	No breeding station, markets public goods OPVs from CIMMYT and the MoA
Seedtech	Malawian company sponsored by DFID-funded "Seeds of Development Programme"	Hybrids: Public good varieties MH18, MH26 and MH27	No breeding station, markets public goods OPVs from CIMMYT and the MoA

For those companies that engaged in breeding their own cultivars, processes were more reminiscent of a linear central source of innovation model (Biggs, 1990). Production of materials took place at centres elsewhere in Africa and in-country trials only occurred late in the development process. One seed company manager described the long development process that precedes the release of new cultivars. His description indicates that, as with government breeding, there is little involvement from farmers until the end of the process:

"So when we have field days we get information about what the farmers are looking for... Now that information, we feed it through to our development person... This person comes back to Malawi, and he brings the varieties which the breeders have come up with. Before we have taken them to the government for trials he also establishes own trials within the country... Now we take them to the government research stations where they take them for three years and put them in their trials, to check independently, to see whether they are going to perform the same as this guy says they have done... And we also go, they invite us, the government people, through this gentleman, to go and see how the varieties are performing with them. If we are satisfied with them we tell them, "Okay, fine. We are pushing for release with these two varieties"... So we go through the process. There's a committee which looks at the data, compiled over the three years... If they are satisfied then we can release them to the farmers. Then we take them to the farmers through demonstration. This is the first year we hold a proper demonstration. For all up to this time the research that was happening maybe there were just a few farmers where it was done on farm"

Manager, Seed company A, Lilongwe

As was the case for public sector breeding, private sector companies also described finding out about smallholder preferences mainly through past commercial successes and failures, rather than collaboration with farmers at the early development stage:

"Most of its just historical... by the time it gets to the pre-commercial stage we'll have narrowed it down to about ten, and then from those we'll have a field day or something like that to get farmers' opinions."

Manager, Seed company B, Lilongwe

4.4.2.2 Development goals and marketing decisions

Whilst breeding strategies and approaches for engaging directly with farmers differed little from those employed by public breeders and the extension service, the choices made by seed companies about specifically which seeds to market do significantly influence smallholder cultivar access. Company marketing decisions were influenced by ideas about how to compete effectively, but also by aspirations about how to develop Malawian agricultural production.

Corporate seed companies displayed a strong 'modernisation bias' (a criticism that has also been levelled against the Diffusion of Innovations model) (Rogers, 2003), in their preferences for the future development of Malawian agriculture. As such some seed company managers were dismissive of farmers who continue to use local cultivars, using language that indicated they considered the farmers' mindsets as backward:

> *"It is also a cultural thing, because of the illiteracy thing, they are clinging to their old, 'eh I like my local, this is my local variety, these are my local varieties, you know the local type', you know, 'these are our parents' varieties'. It has been like that".*
>
> *Manager of Seed Company A, Lilongwe*

The same manager appeared to regret that numbers of commercial maize producers in Malawi remained low:

> *Interviewer: So would you say your company is also targeting commercial maize producers in Malawi?*
>
> *Interviewee: Oh sure. Unfortunately we don't have... I would say we've got less than 10% of the production done by commercial farmers in this country, for maize, and 90% is done by smallholder farmers.*

Nonetheless, given the importance of smallholder agriculture in the country, companies were keen to sell to smallholders and one manager also expressed a sense of responsibility for the betterment of smallholder farmers.

> *"Our target is the smallholder farmer. That is our major target. It's the person that we are trying to improve really."*
>
> *Manager of seed company C, Lilongwe*

An aspiration that smallholders would become increasingly commercially-orientated was also evident. The AISP stipulation that smallholders pay a top-up in addition to exchanging their coupon for hybrid seed was viewed positively as a way to help cultivate a more commercial mindset:

> *"The idea was... we should assist these farmers to graduate from free things and start contributing and later on he should be able to buy on his own or her own. You see... this farmer; he should not always think that he should be getting these things for free"*
>
> *Manager of seed company A, Lilongwe*

A sense of corporate responsibility for agricultural development was also reflected in discussions about future national food security. The problem of meeting the consumption needs of the growing population was put forwards as an argument justifying the need to concentrate on promoting hybrids rather than lesser-yielding OPVs.

> *"Looking at Malawi, I think Malawi; where we are heading... I think people should be honest with each other. I think if you are investing into composites, then we will not really achieve this food production, what we are calling valid food production, later on... So, honestly, the future of this country's maize production, people should not start focussing on composites because I tell you, composites, whatever the case, in terms of yield, its lower than hybrid, you know that, so Malawi is being a small country, the population is growing, the land size is the same, some of the land is degrading, what do you do, the small land that you have, you maximise that land and make the best out of it and use the highest-yielding inputs in those particular places"*
>
> *Manager of seed company A, Lilongwe*

Strong preferences for hybrids over OPVs were expressed by all the seed company managers interviewed, except one whose company specialised in OPVs. Negative views of OPVs were generally expressed:

> *"Me, personally I wouldn't want to go for an OPV. It's a local variety really, nothing but a local variety that has been specially selected for an area. Using OPVs is a step backwards; they are not really different from other local varieties. "*
>
> *Manager of seed company E, Lilongwe*

Another suggested the use of OPVs was not in the best interests of smallholder farmers and categorized smallholders into 'good' or 'bad' farmers based on their adoption of hybrid seed:

> *"We used to have some OPVs that we used to sell, but we've decided, like it's just, I mean, hybrids beat OPVs hands down. The only advantage of an OPV is that if you replant it... But we believe that you are setting a farmer back, I mean if he's planting OPVs he's got half the yield potential of a hybrid. Um, and then his sales from his crop from the previous season more than compensate his ability to buy the new season hybrid...*

The good farmers do go for hybrids, and then the poorer farmers and the less competent farmers do go for OPV, because they are obviously just looking at the price, which is a factor a lot of the time. Unfortunately in Malawi, everyone is a farmer, and that's the case in a lot of African countries. Whereas you know like in the U.K. not everyone is a farmer, but here, like I said, the only option to most people is farming. So you got the people that are better farmers that go for hybrids, and then the poorer ones. But everyone who can, goes for the... everyone who properly understands the hybrid, goes for a hybrid."

Manager of Seed Company B, Lilongwe

Although OPVs were not favoured, they were still seen by some as an improvement on local cultivars, and were viewed as a step in a developmental process that would naturally end up with the use of hybrids:

"So we still encourage, if a farmer cannot afford a hybrid, let them go and use a composite. We encourage that, because we know a composite is a stepping stone. If he says, 'I am able now to get two tonnes or three tonnes per hectare, then maybe I should go to the hybrid, if I'm able to get this with this, then what more with that?' Other than still sticking with the so-called local maize."

Manager of seed company A, Lilongwe

Whilst much was said in favour of the yield advantage that hybrids provide, their greater potential profitability than OPVs (since they must be purchased new each season) was left unmentioned by most of the managers. Only the manager of the company selling OPVs made reference to this issue. When asked whether his company made it clear to their customers that they could save harvested seed to plant the following season for three years in a row, he replied that they did not:

"For a company it would be suicidal to tell the farmers not to buy again, because if you tell them just to recycle the same seed, then I will not be here. I would be out of the business"

Manager of Seed Company D, Lilongwe

The strong preference of most of the companies for hybrids was reflected in the range of cultivars that were stocked by outlets in the two research areas. Sixty-six of the sixty-nine stock items that were reported were hybrid (sixty-five of which were hybrids over which seed companies had exclusive breeder's rights). Whilst private companies are able to multiply and market seed of public goods cultivars, they stand to gain more from promoting cultivars over which they have exclusive rights. The fact that so few public goods cultivars were found to be available in the shops was predicted in a comment by a staff member at a major NGO, who explained that companies may choose to under-promote public goods cultivars to avoid the possibility that such cultivars will compete with their own products:

"The seed companies are leaders in terms of adverts and so on, so you may find that public goods are not well known out there... because they want to promote their own varieties, they will make sure that these public goods varieties are not really available, because, otherwise, if they make them readily available, they will compete with their own varieties... So as you go around you may find that in a shop you have very few bags of MH18, but you'll find Pannar, you'll find DK, you'll find Seed Co and so on."

Staff member of national NGO

Companies may also follow their own agendas to determine the market life-span of a cultivar, regardless of whether or not demand for the cultivar remains with farmers:

Right now, with our leading cultivar, although the farmers are liking it, we are now trying to make it flat. We are now trying to promote its replacement, because we know it's going to cover up on whatever else should be still there, but for a farmer, there'll be really still some resistance from some farmers, who'll say,' ah no, for me it's the previous variety'..."

Manager of seed company A, Lilongwe

Such comments revealed that the high degree of competition that now characterises Malawi's seed system does not necessarily create a system where farmers' preferences are always put first. Every seed company interviewed had new cultivars in the pipeline due for release. One manager suggested that the time taken to develop new cultivars was decreasing, indicating that the rate at which new cultivars are introduced to the market may increase in the future:

"At the moment I'd say it takes us probably 12 years from conception to releasing a new hybrid, but now with new methods and breeding technologies that's getting narrowed, so new hybrids will be coming onto the market faster so the turnover will be quicker"

Manager of seed company B, Lilongwe

Whilst the turn-over of marketed cultivars may be high in line with the competitive pressures of the liberalized seed market, the degree to which sufficient information can be effectively channelled to smallholders so that they can make an informed decision about which modern cultivar to choose is questionable. As previously mentioned, smallholders in both areas commonly expressed difficulty remembering the names and traits of cultivars they had grown or wanted to grow:

"There are a lot of varieties, but I have just forgotten their names"

Male Household Head, 35 years old, Top wealth rank, Village A, Kasungu

A few farmers suggested that it did not matter that much which modern cultivar they grew:

"There are a lot of hybrids and they all do well, but I can't remember any specific names"

31 year old female, Bottom wealth rank, Village B, Kasungu

Several respondents also described simply buying the first cultivar that they saw in the shops. Others reported that many smallholders grow whatever is available, whether or not it is well-suited to local conditions:

"A lot of people because they don't prepare properly for the next farming season, they'll just get any seed that is available and plant that, but it's not that a lot of people are using the type of maize variety that is suitable for this type of climate, most people take any type of seed, they don't even know what they are planting, they just take any type of seed. I think it has to do with poverty, a lot of people don't have money to prepare for the planting season"

- Male household head aged 70, top wealth rank, village A, Ngabu

Such comments indicate that some smallholders are not well equipped for engaging with an increasingly sophisticated range of marketed maize seeds. The limited cultivar trait knowledge many smallholders possessed indicates the problems faced by companies seeking to communicate complex information to a widely dispersed population with low literacy. Given these difficulties, it was surprising that companies rarely provided cultivars with names that were easy for smallholders to remember. Instead they often continued to use the field codes that had been given to cultivars at breeding sites. Only Seed Co recognised the difficulty smallholders faced in recognising names, and consequently gave its cultivars animal names in

Chichewa. SC403 was given the name 'monkey' (*kanyani*), SC627 was called 'lion' (*mkango*) and high-yielding SC719 was 'elephant' (*njobvu*).

As previously mentioned, all companies relied on a limited range of advertising strategies, mainly using radio transmission and distributing flyers in rural areas. Several managers acknowledged that there were limitations to the efficacy of spreading information in print. However, some participants pointed out that they considered radio advertisements were not well suited to their particular production contexts:

> *"We do have a radio and we hear the adverts but the soils in this area are totally different"*
>
> *Female, 26 years, middle wealth rank, Village B, Ngabu*

The suitability of cultivars for particular areas was a topic that was discussed by several interviewees. On this issue, a research scientist suggested that because of seed market liberalisation the delivery of cultivars to different areas of the country was not strictly regulated:

> *"You know there is liberalization at this time, so to bar someone to bring exactly what is required for this area, it's not there. We just get anything that is available, but it's still, through the extension workers, and us research people, the farmers have been told what type of variety to look for, but when it's not there, they just go for anything"*
>
> *Research scientist, Ngabu*

When asked about how seed companies ensured that they supplied the correct cultivars to the correct areas, a seed company manager and representative of STAM suggested that ethical guidelines existed, however they were not actually produced in written form:

> *"Seed companies have cultivars that are meant for low, medium and high altitudes. The seeds are distributed to areas in accordance with this. A low altitude seed can be distributed to a high altitude area, because farmers can just delay the start of the planting, however a high altitude seed cannot be distributed to a low altitude area. STAM creates ethical guidelines which the seed companies should adhere to, although the onus of this is upon the seed companies themselves. There are no written guidelines as such"*
>
> *Manager of Seed Company E, Lilongwe*

The observation that low altitude seeds can be distributed anywhere was mirrored by the market dominance of short season cultivars (which are suitable for low altitude areas). It was notable that in both areas, short season cultivars for the two leading brands were available in nearly every outlet, whilst the availability of longer season cultivars was far more limited (see Table 4.4). This was surprising given that Kasungu is a mid-altitude area where it should be possible to get better results with longer season cultivars:

> *"In Ngabu... you cannot give them any of the other varieties, the long-maturing varieties. It would be wrong to give them any other crop... But Kasungu I know, is not Kanyani... Because Kanyani has a potential yield which is much, much lower. It's maybe six tonnes, or something like that, while other later varieties, they are much, much higher"*
>
> *Government maize breeder, Lilongwe*

Table 4.4: Cultivar availability at seed outlets within the two research areas

Cultivar Name	**Duration**	**Number of outlets which stocked cultivar in 2010-11 season**	
		Ngabu (n=5)	Kasungu (n=7)
Kanyani	Ultra-short season hybrid (90-95 days)	5 (100%)	7 (100%)
DK8033	Short season hybrid (110-115 days)	4 (80%)	7 (100%)
Pan 67	Medium season hybrid (120-130 days)	3 (60%)	4 (57%)
DK 8031	Early season hybrid (equivalent to DK 8033)	2 (40%)	1 (14%)
DK 8053	Medium season hybrid (130-135 days)	1 (20%)	4 (57%)
DK 8073	Long season hybrid (140-145 days)	0	5 (71%)
Pan 53	Medium season hybrid (125-135 days)	0	4 (57%)
Mkango	Medium season hybrid (info on days unavailable)	0	3 (42%)
Njobvu	Long season hybrid (info on days unavailable)	0	2 (28%)

All the seed companies indicated that they were concentrating on breeding shorter season cultivars because they considered that seasonal rainfall was changing and they perceived short season cultivars to be drought tolerant:

Interviewee: So our definition of drought, it's really, okay, so let's come up with varieties which should be drought tolerant. What do we mean, we mean the variety which is still going to, in 90 days, if you plant it, it will still give you something.

Interviewer: So a short season variety is a drought tolerant variety?

Interviewee: Yup.

Interviewer: And are you working to create any varieties which can cope with longer dry spells within the middle of the season?

Interviewee: Um, currently I think the approach is just to look at the shorter, early maturing varieties.

This perspective goes against the public sector viewpoint, where short season cultivars are defined as those which 'escape drought'. Actual drought tolerance was defined as ability to cope with reduced water availability during the growing cycle, with ability to cope with water shortages at flowering being considered particularly important.

"You have to know what kind of mechanism you can bring in to make sure that you are able to produce materials which not only escape drought, but can also withstand, because escaping drought is not the same as being drought tolerant, because you plant early and then you can harvest before the rains stop, that is just escape, but sometimes you can have the crop, you plant it, and within the season you have drought, but you see that the plant hasn't really withered, that is what we are talking about. So as you are doing your breeding what you will try to do is to see how you can create this tolerance towards drought.

Me, I worry about the drought which comes during flowering. Because that's the one where the flowers are aborted, they don't pollinate properly and therefore you have lost the crop. Basically you get a hundred percent loss."

Government maize breeder, Lilongwe

4.4.3 The Agricultural Input Subsidy Programme (AISP)

This section examines the operation of the AISP from a diffusion perspective, based on material from interviews with extension workers, seed company managers and coupon recipients. The AISP is examined conversely from an adoption perspective in Chapter 5.

The aims of Malawi's input subsidy programmes are reported differently by different authors, perhaps reflecting the way the scope of the programmes have shifted since the start of the millennium, and highlighting the possibility that programme efficacy may have been limited by a lack of consistency in the delivery of subsidized inputs. The programme's aims are variously described as having been intended to bring about long term agricultural change for smallholders (Blackie and Mann, 2005), to "enable poor smallholder farmers to access fertilizers, improved seeds, herbicides and extension services" (Mutharika, 2009), to improve both national and household food security, to enhance crop diversification and soil fertility (Nyirongo et al., 2003), and latterly, with impetus from donors, to promote greater private sector involvement in inputs supply and distribution, and to promote greater input selection choice for smallholders (Chinsinga, 2006).

4.4.3.1 Pack contents and allocations

Some studies report that since 2006 the subsidy has aimed to allocate coupons to around 50% of farm families within Malawi (Dorward and Chirwa, 2011). However, the two research districts received considerably lower allocations than this in recent years. The allocations for 2010 were reported as 15% and 31% of farm families in Chikwawa (the district where Ngabu is located) and Kasungu respectively (Government of Malawi 2011). The subsidy package that was distributed consisted of two fertiliser coupons and two seed coupons, one for maize and one for a legume. The fertiliser coupons required an additional top-up payment from the farmer of 500 Malawi Kwacha (MK)[2], and could be exchanged for a 50 Kg bag of NPK and a 50 Kg bag of urea. The maize coupon could either be exchanged for a 5 Kg bag of hybrid seed (wherein the farmer was required to add a top-up of MK 100), or a 7.5 Kg bag of open-pollinated maize seed (for which the seed companies, of their own volition, decided not to apply any cash top-up). The legume coupon was intended to be exchanged for a 2 Kg bag of certified seed of either, beans, cow peas, pigeon peas, ground-nuts or soya. It was intended that each beneficiary family should receive and use all four vouchers.

[2] In summer 2011 there were 255 Malawi Kwacha to one British Pound, and 160 Malawi Kwacha to one American Dollar

4.4.3.2 Target beneficiaries

The identification of beneficiaries and voucher distribution was undertaken mutually by District Agricultural Development Officers and community leaders (Government of Malawi, 2011). The targeting of beneficiaries incorporated elements of both a social safety net approach, and of one which was concerned with maximising productivity. It was described by extension staff in each research area as follows:

> *"Yeah, no it's targeted... Those ones are for the poorest, but in addition to that we also go for the physically challenged, the HIV/AIDS affected people, yes, the orphans and the like. It's for the vulnerable and the poorest. But they should have land to cultivate. It should be a farmer."*
>
> *Extension manager, Kasungu, 2011*

> *"The target instructions are that beneficiaries should be poor, disabled, and maybe the elderly, but they should have land to cultivate. It should be people that are sure to cultivate well so that the subsidy can be used to good effect."*
>
> *Extension manager, Ngabu, 2011*

Details of coupon distribution within the two research areas are provided in Chapter 5, section 5.4.3.

4.4.3.3 The Subsidy Programme and the Seed Industry

Comments from seed company officials confirmed the huge significance of the AISP to the operation of seed businesses in Malawi:

> *Interviewee: Eighty percent of our sales are going through the subsidy. Twenty percent are commercial.*
>
> *Interviewer: So would you say that it's been good for your business?*
>
> *Interviewee: Very much so, it's a good market; as long as the subsidy is there it's a good market for us.*
>
> *Manager, Seed company C, Lilongwe*

Seed company executives emphasized the opening up of the subsidy programme as a way to enhance seed choice for farmers, pointing out that originally the program had restricted options by only providing OPVs:

"We said, the key thing is, let's give the farmer a choice. The farmer should be exposed to everything. Let a farmer choose. Don't restrict a farmer. Because the original program, it was restricting a farmer to OPVs. There may have been some farmers who would want to go for hybrid, but there was no free hybrid."

Manager of Seed Company A, Lilongwe

Some authors have suggested that the AISP has revealed high levels of demand for hybrids amongst farmers, based on the fact that nearly three quarters of farmers used their subsidy coupons to obtain hybrid in 2007 (Denning et al., 2009). However, reduced market availability of OPVs that was observed during fieldwork indicates the possibility that farmers had no choice but to use hybrids.

The extent to which the AISP has enhanced competition amongst seed companies cannot be underemphasized. All companies recognise that the subsidy represents a huge additional market which would otherwise not exist and for which they must compete heavily:

"Because we are so many companies you see. There's Monsanto, SeedCo, Pannar, there's DeKalb. There's so many companies. All these so many companies are just putting through to look for these few farmers."

Manager, Seed company D, Lilongwe

Competition to capture AISP sales revenue is high and affects marketing strategies. One seed company manager observed:

"With the subsidy program sometimes it's best to give varieties which are suitable in most all the places"

Manager, Seed Company A, Lilongwe

Such a strategy could reduce seed company losses since it enables stock which has not sold in one area to be diverted to another. A regional government researcher likewise suggested that cultivar production objectives have moved away from a principle of breeding for area-specificity towards producing cultivars with the potential for universal use, and highlighted that this approach particularly serves the interests of seed companies. Therefore, whilst the extent to which the subsidy programme enhances seed choice for smallholders was widely acclaimed by seed companies, in reality cultivar choice in shops may be restricted, not only because of companies' marketing strategies but also because quantifying stock supplies to meet subsidy demands is difficult:

"Based on what your perceived market share is, what you want to do in each area, you'll decide. We think we'll be able to get 500,000 of those from the farmers so then we supply seed to that value, and then farmers will come to each agro-dealer, they'll come and take what they want and then any leftovers at the end of the programme just get sent back to us. So, it's very good for the farmers. On our side it's very inefficient, because basically, in Malawi, the seed market is over-supplied 4 times, because basically everyone sends everything everywhere, because you are not working on an orders basis. You don't know what you can really expect to sell"

Manager, Seed company B

Seed managers also admitted that there was often a 'scramble' in shops for smallholders with coupons to get the variety they wanted:

"Sometimes it's just unfortunate that the product may not be there at that particular time because of supply issues. We may supply, but it can quickly get finished"

Manager of seed company A, Lilongwe

There were also indications that some seed companies responded to subsidy incentives with scrupulously questionable behaviour, for example, by distributing their seed right next to coupon distribution locations:

Interviewee: There were two sheds. There was the shed where we were receiving coupons, and then there was the shed where we were receiving the variety. So after receiving the coupons in one shed, we would then go to another shed.

Interviewer: And so the shed with the variety, was that run by the extension service, or a company?

Interviewee: The extension workers were not involved with that, it was being run by a company.

Interviewer: Do you remember the name of the company?

Interviewee: I can't remember the name. It was unusual that it was organised like this, most of the times we would get the coupons and then go to depots elsewhere.

Interviewer: So did you notice were most people just going in to get the seed there rather than getting the seed from the shops?

Interviewee: All the people were just exchanging there. Why should we waste time going to another place?

Male aged 70, Top wealth rank, Village A, Kasungu

An extension worker commented on the situation as follows:

"It's not... we don't recommend. These other companies were going straight to areas where we were distributing from those office compounds. But it's not recommended because that doesn't give a choice to the farmer. The farmer doesn't have that choice to buy maybe the seed of his or her preference, just because they have just seen maybe a van is selling a specific variety of seeds so they have no choice. So we discourage that one, we prefer that maybe they should have agro- dealers in those areas so that farmers can buy seed of their own choice."

Extension manager, Kasungu

The same issue was also raised by a seed company manager residing in a different district, indicating that the reported scenario may have been widespread:

"Last year there was a bit of a problem. It was agreed that you weren't officially allowed to be anywhere near where the vouchers were distributed, but last year some people were there and some guys could go straight there and sell the seed."

Manager, Seed Company B, Lilongwe

Finally reports were made of occasions where some seed companies had entirely disregarded area-specific recommendations, in order to absorb more sales through the subsidy:

"Because even with the subsidy, it happens where they are taking varieties which they are supposed to sell in other areas, because they just want to sell, we found that."

Government seed breeder, Lilongwe

4.4.4 Informal seed networks and Farmer to Farmer diffusion

4.4.4.1 Historical maize innovation

Many of the crops grown in Malawi are not of African origin, which is an indication that Malawian farmers have not historically been reticent about capitalising on new introductions. Despite stereotypes of smallholders as risk-averse and conservative in their attitudes towards agricultural change (Hansen, 2005), the historical adoption of New World crops shows that

Malawian farmers have sustained the uptake of agricultural innovations in the past. Local histories of maize farming compiled by focus groups at the research sites demonstrate that in the past many smallholders in the area keenly adopted foreign varieties of maize and assimilated them into their farming practices:

> *"In the 1960s Kamuzu opened an estate near this village. The estate was managed by Chinese, and Malawian Young Pioneers were employed there. The Chinese managers bought a type of local maize from China which they called 'Millo 11'. We asked if we could buy some from them because it had bigger grains than the other local varieties around. It became really popular. So then at that time we had three local types; a variety called 'Yoyera', red 'Kenyan Maize', and 'Millo 11'."*
>
> *Local history focus group, village elders, Village A, Ngabu*

Focus group participants also asserted that they continue to seek out and try new varieties whenever possible, in particular because they need to adapt to changing production pressures:

> *"New varieties are available every year, and we do try them. Because of the current situation we are keen to try new things"*
>
> *Maize growers focus group, mixed participants, Village B, Ngabu*

4.4.4.2 Seed-saving and exchange

Portuguese sailors probably first brought maize into Africa in the sixteenth century but local maize cultivars in Malawi originate from Caribbean, Brazilian and more recently North American open-pollinated introductions (McCann, 2005). However maize first found its way into Malawi, it is thanks to over a century of seed-saving by Malawian farmers that it has remained there. The saving and exchange of maize seed at farm-level has not only sustained its availability, but also enabled the development of local cultivars which have been selected to cope with the stresses that characterise the diverse micro-ecologies of the country (Magorokosho, 2006).

Results from the 2010 survey showing the sources from which households obtained their maize seed are illustrated in Table 4.5 below. Households were asked to provide information about all the maize varieties they had grown in the preceding year, hence the row total exceeds the total number of households surveyed. An open-ended question was used to ensure the survey picked up on all categorical sources. This means that some of the reported categories are not exhaustive (for example, where households indicated that they obtained seeds from the subsidy scheme, the actual physical source of their seed could have been a shop in town, the government marketing board ADMARC or elsewhere).

Table 4.5: Sources of maize seed, 2010 survey (n=242, responses=326)

Commercial exchange (72%)				Non-commercial exchange (28 %)				
Subsidy Scheme	Shop in town	ADMARC	Local market	Previous harvest	Village	Relatives	Friends	NGO
15%	46%	8%	3%	11%	9%	5%	1%	3%

It is evident that the majority of seed was accessed through commercial exchange and mostly purchased with cash (see table 4.6 below).

Table 4.6: Payments for maize seed, 2010 survey (n=242, responses=326)

Money	Nothing	Food	Work	Seed
66%	32%	1%	1%	1%

The commercial character of most of the maize seed access within the research areas today contrasts with reports village elders made about the way seeds were accessed in the past. Reports of historical local seed costs revealed that:

"You can't really compare because we didn't buy the local, we would just share it"

Local history focus group, village elders, Village B, Kasungu

Or:

"The local maize wasn't free, but the prices were very low. Everyone would have been able to afford it"

Local history focus group, village elders, Village A, Kasungu

Focus group participants in Ngabu described a similar situation of easy and relatively equitable access to seed.

The current emphasis on purchasing modern cultivars adds to the burden of financial pressures which households face, and it was clear that some households face difficulties meeting these costs:

"One problem is that we lack seeds, because we have the desired seeds in our minds, but because we lack enough income to buy the seeds in order to plant we end up just planting any type of thing"

Maize problem-ranking focus group, local maize growers, Village B, Kasungu

Although many households do now pay for modern maize seed, various routes exist for sidestepping the cost issue. In addition to saving their own seed from one harvest to the next, households often receive seeds from their relatives. When households are in need, they may beg for seed from households that have sufficient stocks to give some away:

"I was growing a mix of local or MH18, or whatever I could get from other people"

Personal history of seed use, Female aged 30, Lower wealth rank, Village A, Kasungu

And:

"Mostly I don't know what variety I'm going to grow, I just go to the households of those who have dimbas and do some ganyu in return for a bucket of maize"

Female household head, bottom wealth rank, Village B, Ngabu

One participant suggested that this is the method by which most poor households obtain their maize seed, increasing the likelihood that they will wind up relying on recycled seed from hybrids:

"Poorer households get seed from the harvests of wealthier households. They will usually either pay money or do some piecework"

Female household head, upper wealth rank, Village C, Ngabu

Respondents also reported buying farm-saved seed that was for sale in local markets.

Research elsewhere supports the idea that the true measure of the success of a new cultivar is automatic farmer to farmer diffusion with minimal stimulation from external forces (Grisley and Shamambo, 1993). This viewpoint was echoed by stakeholders from within the seed network:

"When something is good it sells itself. I've seen that myself. People come and steal it, and start using it in their fields."

Interview with government seed breeder, national research station

One village participant reported taking maize seed from the agricultural company he worked for. He confirmed that he did not know the name of the seed he had stolen. Other participants reported having requested seeds from friends within the village based on the appearance of the variety:

> *"It seems as if it is an OPV, because I was given it by Mr XXXX, and he always used to use the best varieties in his fields so I went to his house and asked, and he gave me some of the variety so that I could plant it in my field. To me, it seems just the same as an OPV"*
>
> *Personal history of seed use, Male aged 30, middle wealth rank, Village B, Kasungu*

The flow of seeds through informal networks and the maintenance of farm-saved varieties are thus important routes for some households to access seeds. However, given that the origins of seed obtained in this way are often unknown or unclear farmers using such seed are unlikely to know what traits will be exhibited. Survey results and qualitative comments suggest that a large proportion of this seed is recycled from hybrid. Whilst saving seed from local cultivars is a long-standing tradition, official recommendations are that seeds from OPVs should only be saved for three years, and seed-saving from hybrids is advised against entirely. Despite this, in the 2011 survey, over half of the surveyed households confirmed that they had saved seed from hybrid cultivars. More surprisingly, the majority of these respondents stated that they were aware of a problem with saving hybrid seed, which many of them named as quality deterioration. The results are shown below in Figure 4.1 and Figure 4.2.

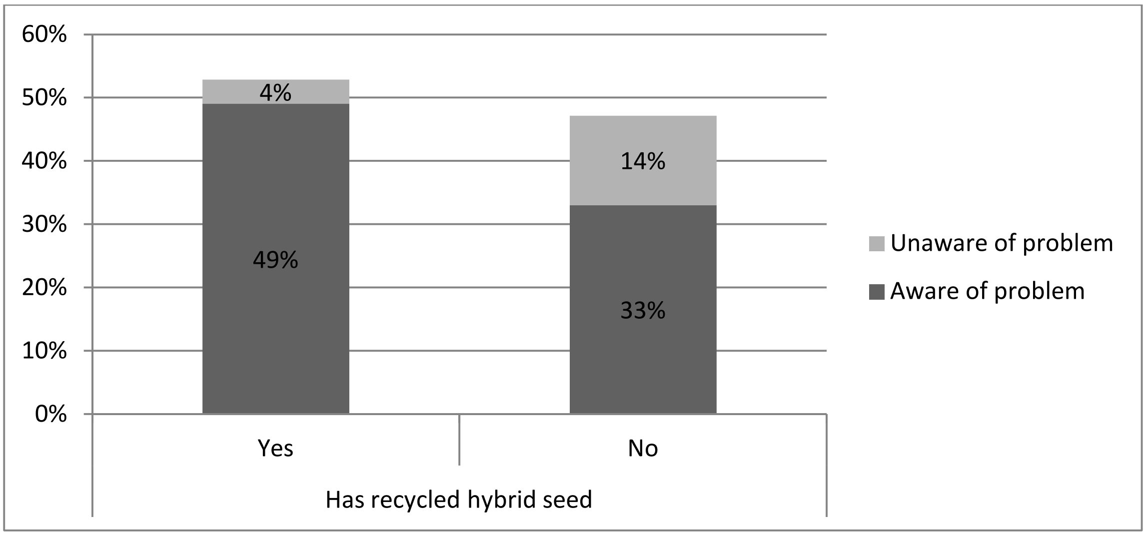


Figure 4.1: Hybrid seed recycling and awareness of its implications, 2011 survey (n=106)

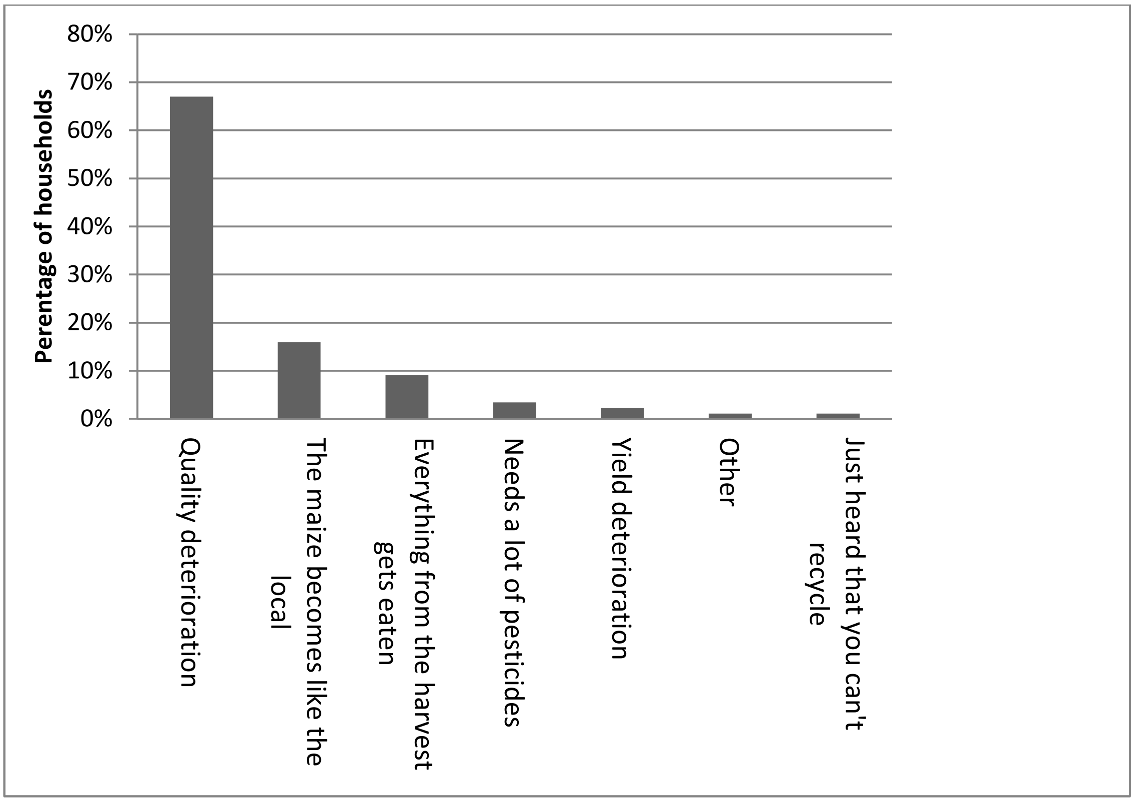


Figure 4.2: Reasons for problems with recycling, 2011 survey (n=88)

Whilst it might be logical to assume that resource-poor households would be more likely to save hybrid seeds than wealthier households, in fact the reverse was the case; wealthier households were significantly more likely to report that they had saved hybrid seeds than less wealthy households ($\chi^2(2, n=112) = 13.434, p=.001$). This reflects the fact that wealthier households are more likely to have grown hybrid maize, but it also underlines that knowledge about seed-saving does not operate as much of a deterrent (as illustrated by Figure 4.1). This reflects reports in Smale and Phiri (1998) of Malawian farmers not necessarily being dissatisfied with the results achieved from recycling hybrid seed. The following extract is taken from an interview with a better-off farmer who had been recycling MH17 for the past six years.

Respondent: I have never heard of any variety that can be recycled. The extension workers told us that we shouldn't recycle maize varieties. That's all I know

Interviewer: But you have recycled the MH17 quite a lot, so do you think personally there's a problem with recycling it or not?

Respondent: If you plant it after purchasing it in the first year, it produces bigger cobs. But if you recycle it, the cobs get smaller.

Interviewer: Will you carry on recycling the MH17? Will you grow any next year?

Respondent: Ummm, I have had a lot of experience with the MH17, so now I want to try new varieties instead

Male household head aged 40, better off household, Village B, Kasungu

This suggests that regardless of optimal practice recommendations, a considerable number of farmers will continue to save and pass on recycled hybrid seed.

Whilst the nature of farm based seed-saving means that many farmers poorly assimilate information about which recycled cultivars they are growing, some made statements that demonstrated they observed changes to phenotypic characteristics of saved seeds and made hypothesis about links to seed genetic characteristics:

"When you plant hybrid seed for the first time, the maize is shinier and whiter in colour, but when you recycle it, it looks different and not so white"

Female questionnaire respondent aged 22, middle wealth rank, Village A, Kasungu

"I saw from the way the seed coats were, the ZM has hard coats, so I made the conclusion that this one, it can be recycled. And even in the maturity, it matures earlier."

Personal history of seed use, Female aged 30, lower wealth rank, Village A, Kasungu

Since farmers make such observations, perhaps breeders could create phenotypic markers to indicate whether a cultivar is a hybrid or an OPV. Enhanced education is also needed to ensure that smallholders know about the different seed-saving recommendations in the first place.

Since maize is rarely self fertile, inconsistency of traits from one generation to the next is a standard effect of seed recycling. Reduced levels of cross-fertilization can be achieved by, for example, selecting maize seeds from plants positioned in the middle of the field rather than at the edges. Smallholders mainly reported selecting for grain size post-harvest and few reported making any assessment of the performance of plants in field as part of the selection process. Seed-saving skills and the capacity of smallholders to effectively manage the genetic pools of farm-saved seeds they are using would also benefit those that rely on recycling.

Due to high levels of cross-pollination the argument is sometimes made that a genetically true breed of local maize no longer exists:

"Although if you look at it in the true sense, the real local maize is no longer there, because it's been adulterated with a lot of hybrids being grown around. So the pure local maize is no longer there."

Manager seed company A, Lilongwe

Kydd (1989) found in his own fieldwork that farmers were critical of the new characteristics that had been introduced to their local maize through gene flow with modern varieties, and were trying to select out these undesirable characteristics. In light of this, questions arise about whether the gene pool traditionally associated with local maize, which can be considered as a public good, has been eroded by the genetic outflow from modern varieties, and to what extent, in this case, the onus should be upon those introducing new varieties to assume some level of responsibility for the potential negative cost that is being incurred by the public. At any rate, whilst smallholders still admit preferences for the flint characteristics associated with local varieties, participants in both districts confirmed that these varieties were becoming more and more difficult to find since the majority of households no longer grow them. As local varieties become increasingly less prominent in farming systems, the probability grows that genes, which could be highly valuable for future breeding efforts aimed at enhancing resistance to abiotic stresses, will cease to be available (Magorokosho, 2006).

Even when optimal recommendations about on-farm seed-saving are not adhered to in agronomic terms, where farmers do save their own maize seeds, an important range of social exchanges and meanings can be facilitated and supported as a result. Kydd (1989) points out that hand-pounding of local flint varieties produces a greater range of flour types, each of which support a different culinary application and attached cultural use. Likewise, during fieldwork for this research older villagers discussed the social value of the different types of maize flour which they used to be able to extract from the local varieties they grew in the past:

"The difference between the varieties we used to grow was in the maize flour. These two (Chofira and Choyena) used to be mixed, and this one (Chofira) it was a little foreign. We used to call it nsima from Kenya, the flour was a little bit red. People used to love it."

Local history focus group, village elders, Village A, Kasungu

At another village, smallholders explained how they organised their maize farming in complex and strategic ways which took root in their knowledge and understanding of the local varieties they were growing.

"We would choose according to the variety, we would choose some with early maturity for growing around the house so that we could eat fresh maize earlier, and then we would plant the others in the field so that they don't mature early, because we knew we would use those for flour anyway this way we could prevent thieves stealing them"

Local history focus group, village elders, Village B Kasungu

Comparatively, as we have seen, an adequate level of knowledge and understanding about modern varieties, which could be used to support a similar range of agricultural strategies and culinary uses, is not always easily obtained by farmers.

Research participants highly valued the concept of self-sufficiency, and perhaps due to a history of significant price fluctuations for agricultural inputs, they expressed a desire to return to the security of state-controlled markets which they had experienced during Kamuzu Banda's reign.

"The cost of maize production all depends on which President comes in. Thirty years ago this was the Kamuzu era. Fifteen years ago this was the Bakili Muluzi era, and now, this is the Bingu era. That's why we are able to differentiate on how much we have had to spend to produce maize."

Agricultural trends focus group, mixed, Village A, Kasungu

As such, using farm-saved seeds decreases farmers' sense of vulnerability to unpredictable market forces.

4.4.5 Malawi's maize seed AIS

Spielman and Birner (2008) present a diagram of an idealized agricultural innovation system (AIS), which was reproduced on page 36. A version of this diagram has been devised to illustrate Malawi's AIS for maize seed (see Figure 4.3), with a view to highlighting how the system differs from Spielman and Birner's conceptual framework. The key differences between the two diagrams consist of the explicit inclusion of smallholder producers in Malawi's maize seed AIS (versus their exclusion from Spielman and Birner's diagram), the greater tendency for linkages in Malawi's maize seed AIS to be unidirectional and for the arrangement of entities in its domains to be asymmetrical. In the Malawi version, control over agricultural policies and investments is attributed to the business and enterprise domain, whereas in Spielman and Birner's original agricultural policies and investments are connected instead to the knowledge and education domain and to bridging institutions. Additionally, in Spielman and Birner's diagram policies and investments are tacked onto the bottom of the AIS, whereas in the version devised for Malawi the policies and investments box (which is dominated by the AISP) is placed at the centre of the system, linking to the wider political economy through the business and enterprise domain.

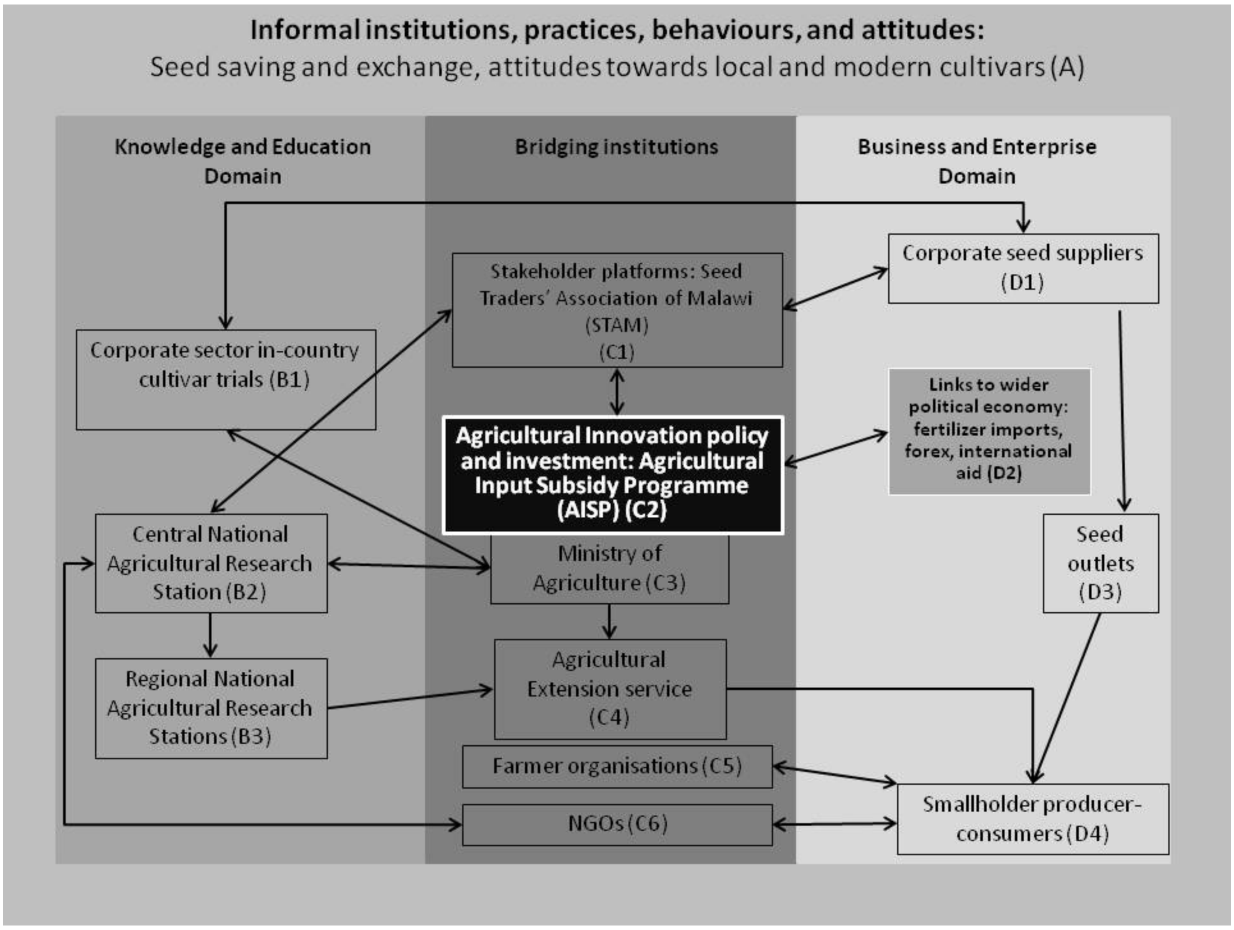


Figure 4.3: Malawi's maize seed AIS

A key to the different features of the Malawi diagram is presented and discussed below.

<u>Informal Institutions, practices, behaviours and attitudes:</u>

A) A box at the top of Spielman and Birner's diagram is entitled Informal Institutions, practices, behaviours and attitudes. The key attributes of Malawi's maize seed AIS that fit in this box are seed-saving and exchange and attitudes towards local and modern cultivars. As explained in section 4.4.4, seed saving and exchange remain important practices amongst smallholders (in particular, poorer households who cannot afford purchased seed). Many households go against official recommendations and save seed from hybrid cultivars. Poorer smallholders often rely on seed donations from wealthier households, which mainly consist of seeds from harvested maize stocks, rather than purchased seed. Reliance on recycled hybrid seed is thus relatively high. Whilst some preference for local maize remains based on its perceived superior storage, taste and processing characteristics, the majority of system actors, especially those operating at the regional to national level, exhibited a strong modernisation bias, classing modern, hybrid, quick-maturing cultivars as the most desirable type of maize for production by all Malawian farmers. Whilst powerful corporate players within the system drive it towards an ideal of modern agricultural production, the incongruity of traditional seed-saving practices continued by farmers means that hybrid seeds are not being used optimally from the corporate perspective, and seed company operations do not reflect the interests and requirements of many (especially poorer) farmers.

AIS Domains

Spielman and Birner suggest that an AIS consists of three domains, the knowledge and education domain (in their diagram this appears as the "Agricultural research and education" box), the business and enterprise domain (in their diagram this appears as the "agricultural value chain actors and organisations" box), and the bridging institutions that join the two. In Malawi's maize seed AIS three entities occupy the knowledge and education domain, six bridging entities are identified (boxes C1 to C6), and four features are identified in the Business and Enterprise domain (boxes D1 to D4). The following text describes the entities within each domain in turn.

The Knowledge and Education Domain

In Spielman and Birner's diagram this domain is subdivided into the agricultural education system and the agricultural research system. In the case of Malawi's maize seed AIS, the agricultural education system (national agricultural universities and colleges which train extension workers) does not play a specific role, although maize research may be undertaken in these institutions. Maize cultivars are mainly developed and researched by the state and by corporate seed companies.

B1) Corporate Sector in-country cultivar trials: Findings revealed that corporate research and breeding activities are carried out elsewhere in the continent and trials of pre-bred cultivars are then conducted on Malawian soil. This means that corporate materials are not developed specifically with the needs of Malawian smallholders in mind, and findings suggest that smallholders are provided with little opportunity to participate in determining the characteristics of the corporate brand cultivars that are marketed to them, apart from at the tail end of the process as consumers. To illustrate this, a unidirectional arrow leads from corporate seed suppliers (in the business and enterprise domain) to corporate sector in-country trials. Materials within these trials are also trialled by the Ministry of Agriculture to determine their suitability for release, which is illustrated by a bi-directional arrow connecting the two.

B2) Central National Agricultural Research Station: Based on findings from qualitative interviews, opportunities for smallholders to participate in or influence the direction of the national maize breeding programme also remain limited, and decision-making within the national research system remains centralized.

B3) Regional National Agricultural Research Stations: the regional research stations were found to have limited capacity to act independently and are dependent on decisions and supplies being directed from the central station (as represented by the unidirectional arrow from B2 to B3)

<u>Bridging Institutions</u>

Spielman and Birner's diagram populates the Bridging Institutions box with four sub-categories: 'political channels', 'stakeholder platforms', 'the agricultural extension system' and 'integration in value chains'. The main stakeholder platform within Malawi's maize seed AIS is occupied by STAM, with the Ministry of Agriculture operating as the political channel in this box. The agricultural extension service is an important bridging institution in Malawi's maize seed AIS, offering a connection to smallholder producer/consumers, as do NGOs and farmer organisations. The AISP is placed within this box adjoining the Ministry of Agriculture and interacting closely with STAM.

C1) Seed Traders Association of Malawi (STAM): STAM bridges between national and international corporate seed companies and the Ministry of Agriculture, with close links to staff working on maize breeding at the national research station. STAM was specifically formed with the aim of persuading the government to open up the subsidy programme to other corporate players and to include hybrid maize. STAM also represents the interests of seed users by determining guidelines for seed companies, however as these guidelines are not written, the degree to which seed companies are likely to follow them is questionable. STAM is shown to be very well connected within the AIS, with bi-directional links to the AISP and to Corporate seed suppliers in the Business and Enterprise Domain, and with the National Agricultural Research Centre.

C2) Agricultural Input Subsidy Programme (AISP): This was the most significant agricultural policy in Malawi at the time of the research. The programme aims to elevate yields and encourage smallholders to adopt modern agricultural technologies. However, the findings of this research suggest that it does not ensure unrestrained choice of cultivars, and smallholders may lack the necessary information to make such a choice wisely. The programme also fails to ensure access by poorer smallholders, since there is considerable elite capture of subsidy benefits. It also encourages maize cultivation arguably at the expense of agricultural diversification, and in areas where maize cultivation is highly risky based on prevailing environmental conditions. The AISP is dependent upon aid from international donors to operate, and the programme thus incorporates aims which align with donors' poverty alleviation objectives, as well as aims which align with the Government of Malawi's food security objectives. The compatibility of these different objectives is questionable, since the poorest households, at whom the subsidy is targeted (in line with donors' wishes) are limited in their productive capacities due to land and labour shortages. In the diagram the AISP is shown to be bi-directionally linked to STAM, and attached to the Ministry of Agriculture, which prevails over decisions about how the AISP should operate each year. The AISP is depicted in a different colour scheme because it is a policy rather than an actor within the system. It is also depicted in bold and at a greater scale than the adjacent boxes to illustrate its singular importance in the national agricultural political economy. The diagram shows the AISP as being bi-directionally linked to the wider political economy. This is because it influences markets for agricultural inputs such as seed and fertilizer, the latter of which is organized by tender, which disincentivises the growth of a diverse and competitive fertilizer market within the country. Considerable foreign exchange is needed to finance the programme since fertilizer must be purchased from outside Malawi. In 2011 there was a notable scarcity of forex which coincided with major national petrol shortages. These features of the wider political economy may have been exacerbated by the economic operations of the subsidy program according to one research participant.

C3) Ministry of Agriculture: The research revealed that communications between the Ministry of Agriculture and other entities within the system tended to be unidirectional, with control over activities undertaken by the extension service and research stations being characterised by centralization. As such the diagram connects the Ministry of Agriculture bi-directionally to the National Agricultural Research Station at Chitedze, but not directly to regional stations. A unidirectional arrow illustrates the flow of influence over the extension service. The Ministry of Agriculture takes the final decision on which corporate cultivars are permitted to be marketed nationally, based on the results of its own independent trials of such materials. This function is represented by the arrow adjoining the Ministry with the 'corporate sector in-country cultivar trials' box.

C4) Agricultural Extension Service: The extension service is depicted as being influenced unilaterally by the Ministry of Agriculture, and by regional research stations. A unidirectional arrow also connects the extension service to smallholders illustrating that the flow of extension messages goes one way with limited opportunities for smallholders to send messages back up to the extension service. The research revealed that the low ratio of extension workers to smallholder farmers can reduce the efficacy with which messages are passed down the chain.

C5) Farmer organisations: There are two main farmer organisations in Malawi, the National Smallholder Farmers' Association of Malawi (NASFAM) and the National Union of Farmers (NUF). Neither deals specifically with issues related to maize cultivars. Whilst the NUF looks to represent the interests of farmers and ensure their participation in agricultural research and development, wealthier farmers constitute most of their membership, so they may under-represent the interests of poorer sections of smallholder communities. NASFAM specifically seeks to encourage diversification away from over-dependence on maize, and hence concentrates on other crops. The degree to which either of these organisations therefore advances smallholder preferences around maize cultivars within the system is likely to be limited. They are depicted as mutually exchanging information with smallholders, but are not connected to the rest of Malawi's maize seed AIS.

C6) NGOs: Interviews with NGOs revealed different perspectives on the suitability of maize, with some participants emphasizing the importance of diversification away from maize, and highlighting the unsuitability of maize in lowland areas like Ngabu, and others emphasizing the importance of maize and highlighting their role in linking farmers with technology generators. This latter operation is represented by the bi-directional arrow between the National Agricultural Research Station and NGOs, with the work of NGOs to collect information about smallholder maize preferences represented by the bi-directional arrow connecting them to the smallholder box in the Business and Enterprise Domain.

<u>Business and Enterprise Domain</u>

D1) Corporate seed suppliers: Corporate seed suppliers are well linked to some other parts of the system such as the Ministry of Agriculture and national and international researchers via boundary-spanning individuals within STAM, however few reported much direct engagement with smallholders. Interviewees indicated that they mainly had contact with smallholders via extension service staff, and that it was rare for groups of smallholders to be organized enough to approach corporate companies directly in order to negotiate reduced prices, as commercial maize farmers do. In the diagram unidirectional arrows flow from corporate seed suppliers to seed outlets and finally to smallholder producers indicating that the flow of goods and information tends only to go in one direction, with smallholders rarely able to communicate directly with suppliers.

D2) Links to the wider political economy: This box is shown in a different colour scheme to indicate that it is not an actor within the system, but rather a channel via which agricultural policies interact with the wider economy. It is shown linked to the system via the AISP, highlighting the AISP's immense national political importance. The popularity of the AISP amongst voters means that any attempt to scale back the programme will be difficult for government to implement without alienating the popular vote. International aid is required to support the programme financially, but this means that the country is reliant on being in favour with donor governments and national policies may be swayed by the interests of such governments. Links to the wider economy are explored in the explanation for (C2).

D3) Seed outlets: Seed outlets channel commercial cultivars to smallholders and often act as points of exchange for AISP coupons. Smallholder research participants reported that opportunities for finding out about maize cultivars by asking outlet staff were limited, stating that such individuals were only interested in 'doing business'. Seed outlets were described by seed company participants as being 'massively over-supplied' due to the influence of the subsidy programme, a scenario which was described as 'very inefficient'. The seed ranges available in seed outlets within the two research areas were dominated by hybrid corporate brand early-maturing cultivars, and OPVs were scarcely available, suggesting that seed outlets were not meeting the needs of smallholders who were interested in the latter. A unidirectional chain of arrows represents the flow of products and information from corporate seed suppliers to seed outlets to smallholders.

D4) Smallholders: The smallholder box is situated at the bottom right corner of the diagram, illustrating their place at the end of the diffusion chain with regard to new maize cultivars. Smallholder research participants complained of limited opportunities to get messages across to those in control. As such, the smallholder box in the diagram receives information and products from the extension service and seed outlets, but does not feed information back. Bi-directional arrows do exist between the smallholder box and farmer organisations and NGOs, with NGOs providing the best avenue for channelling information about smallholder cultivar preferences back to those in charge of cultivar breeding. However, smallholders should not be thought of as a single homogeneous group with regard to their ability to access communication channels in order to engage with NGOs, or with regard to their cultivar preferences, with different individuals opting to grow modern, local or a combination of modern and local cultivars, and within the modern category, opting to grow OPVs or hybrids. One NGO staff member stated that poorer households can be reluctant to get involved with NGO activities, having 'checked out of development', and another from the same organisation emphasized the importance that farmers come to regard farming as a business, suggesting that wealthier more commercial farmers are likely to be able to engage more productively with the NGO in question. Some smallholders grow maize for sale as food or in some cases seed, but for the majority, production is about meeting household subsistence needs. The degree to which subsistence maize production should be classed as a business or entrepreneurial activity is thus questionable, indicating the possibility that poorer smallholder households, growing maize purely for subsistence, may be disenfranchised by the dominant developments within Malawi's maize seed AIS.

4.5 Discussion and conclusions

This chapter aimed to fulfil the first objective of the thesis by describing how modern cultivars are currently diffused to smallholders in Malawi. The description that has been provided is mainly based on qualitative analysis of data from interviews that were carried out with various stakeholders within Malawi's national seed system. Additional support was provided in places from quantitative survey data on smallholder maize cultivation and marketed cultivar ranges in the research areas. A secondary goal of the chapter was to evaluate the extent to which findings about current practices align with each of two theoretical approaches for understanding technological agricultural development, the 'Diffusion of Innovations' (Rogers, 2003), and the more recent 'Agricultural Innovation Systems' (The World Bank, 2006, Hall, 2007, The World Bank, 2012). The main channels for cultivar diffusion were identified as being controlled by government, corporate seed businesses and smallholder farmers themselves.

Government activities were found to affect cultivar diffusion via the extension service, the AISP, and national maize breeding and research activities. It was evident that the Malawian government faces challenges in communicating complex information about modern cultivars to a large population of farmers amongst whom literacy levels are low. The main techniques employed (providing direct verbal advice and mounting field demonstrations of different cultivars) reflect a DoI style of approach (Rogers, 2003) in terms of their assumptions about the social spread of information and their aim to enhance the "trialability" and "observability"

(p. 170, ibid.) of new maize cultivars. However, low funding levels meant that demonstrations were poorly accessible to the majority of smallholder research participants, and very high extension client-staff ratios meant that few households were visited directly by extension workers. Instead, a T&V style approach was pursued wherein lead farmers were visited who could then pass on information to others (Howell, 1988). It has been suggested that the T&V approach is unsustainably costly for use in SSA and has failed in rain-fed areas (Eicher, 2007). Nonetheless, the results presented here suggest that the T&V ideology still exerts a strong influence over extension practices on the ground in Malawi. The 'lead' and 'real' farmers referred to by research participants are reminiscent of the "opinion leaders" described in Rogers (2003, p. 316). Rogers (2003) suggests that, compared to other individuals in their peer group, opinion leaders "(1) are more exposed to all forms of external communication and thus are somewhat more cosmopolite, (2) have somewhat higher socioeconomic status, and (3) are more innovative (although their degree of innovativeness depends, in part, on the system's norms)" (Rogers, 2003, p. 27). Early adopters are also likely to approximate these characteristics, meaning that opinion leaders will comparatively have the least in common with those who likely would be defined by Rogers (2003) as laggards. The possibility therefore arises that diffusion strategies based on a DoI approach may alienate laggards, and, on this basis, Röling (1976) provides a critique of the DoI approach, finding that focussing extension service communications on socio-economically superior, progressive farmers may widen inequalities and reify Rogers' (2003) adopter categories (Röling et al., 1976, p. 157-158). Several of the findings reported in this thesis provide for support for Röling's argument. There was evidence that some smallholders felt alienated by the extension service's propensity to work with lead farmers, and indications that poorer households may 'check out of development' (see section 4.4.1.1). Chipande's research in rural Malawi (1987) found that a history of exclusion of poorer (predominantly female) farmers from credit-targeting had created lasting apathy towards innovation adoption. Other research suggests that the modernisation bias often evident within the DoI approach contributes to the exclusion of poorer and more traditional farmers (Grisley and Shamambo, 1993, Hogset and Barrett, 2007). This idea was reflected by comments from some participants in this project, which revealed that they felt unable to emulate demonstration practices on their own farms because the level of inputs required would be too expensive. If the DoI characteristics of the maize cultivar diffusion strategies currently pursued by the Malawian government ineffectively address innovation uptake amongst poorer households, then questions arise about how improved climate-resilient cultivars can be effectively targeted at such households. Socio-economic equity in cultivar adoption will be explored further in Chapter 5, based on quantitative data from household surveys.

Rogers (2003) writes, “a linear conception of human communication may accurately describe certain communication acts involved in diffusion such as when a change agent seeks to persuade a client to adopt an innovation” (Rogers, 2003 pp 6). Broadly, the DoI framework is associated with a unidirectional conceptualisation of innovation diffusion and communication which is allied with a ToT approach. A ToT ethic was evident throughout the national breeding system wherein ‘elite materials’ (see section 4.4.1.2) were provided by international centres of expertise and breeding took place in Malawi’s central research station at Chitedze before materials were sent to regional research stations. Smallholders occupied the final position in this chain and participants complained of having little opportunity to send messages back in the other direction. This type of unidirectional system has been blamed as a factor which can limit the effective spread and reinvention of innovations (Biggs, 1990), and alternative, networked theories of innovation, such as AIS, have been posited as a preferable. However, there was limited evidence of networking with smallholders by extension and research staff. Although participants reported conducting field trials on farmers’ plots, decisions about what to include and how to conduct such trials were made centrally. These kinds of ‘mother and baby trials’, which consist of a mother trial conducted within villages or at a research station, and several smaller baby trials in farmers’ fields (replicating a simplified version of the mother trial) have been noted as a straightforward way to enhance farmer participation that works particularly well for cultivar comparison (Snapp et al., 2002). However, despite approval at an international level, reports have found Malawian extension workers and researchers to be less convinced of the benefits of using participatory approaches and concerned about the costs of implementing them at scale (Snapp et al., 2002). Interviews carried out for this project with research station staff in Ngabu revealed that the mother and baby trials being undertaken focussed on cultivation techniques rather than cultivar comparison. Snapp (2002) suggests that trials focussing on cultivation techniques are a less effective way of incorporating participation from farmers, since the necessary costs which must be contributed (in terms of labour) are much higher (Snapp et al., 2002).

The limitations on farmer-led experimentation and communication with smallholders that were evident in reports of extension and research activities are likely in turn to limit the degree of interactive learning which can take place, potentially restricting innovation diffusion and adoption (Reij and Waters-Beyer, 2001). Meanwhile, as the range of marketed cultivars proliferates, the need for smallholders to assimilate knowledge about them is also increasing.

Despite this, extension workers reported being discouraged from giving direct advice about which cultivars to choose on the basis that they should not promote any single brand and thereby undermine market liberalisation. As commercial competition in Malawi's seed system ramps up, smallholders may fall into a state of adoption disequilibrium with the proliferating cultivars on the market, a situation described by Rogers (2003) that can occur when change happens too fast for a social system to keep pace. The increasing pace of change within Malawi's seed system that is facilitated by liberalisation in the post Banda-era (Cammack and Kelsall, 2011) signifies evolution and growth within Malawi's AIS. However, most of the changes reported reflect the interests of seed companies better than they do the needs of smallholders, and the development of enhanced communication networking appears confined to corporate and government actors. The major seed companies were found to be strongly biased towards the promotion of hybrids rather than OPV cultivars, a choice that is justified by arguments about the need to achieve 'valid' food production to ensure national food security. Pro-modernisation and pro-commercialisation perspectives on agricultural development lead to the assumption that there is one correct pathway for agricultural development to take, which inevitably ends in the use of hybrids, not OPVs. This bias translates to a seed market that is flooded with privately owned-hybrids whilst public good OPVs and public good hybrids are scarce. The non-commercial nature of OPVs is recognised by companies marketing them, who exclude information about seed-saving from their publicity materials. This further compromises the clarity of cultivar trait messages received by smallholders, and means that the poorest smallholders, who can ill-afford to repurchase new seeds every year, may fail to benefit from saving OPVs. Whilst breeders producing public goods cultivars perceive important differences between drought tolerance and early maturity, and aim to breed for both, this difference is missed by major seed companies. The market scarcity of public goods cultivars therefore means that smallholders are less able to acquire cultivars with traits developed for coping with dry spells. Instead they are more likely to rely on the short season cultivars that are available, even though these cultivars have a lower yield potential than others which might be suitable for mid-altitude and high-altitude areas. There was also evidence that the AISP, whilst having been internationally lauded for solving Malawi's food security problems (Denning et al., 2009), has served to facilitate seed market domination by multi-national seed companies and to encourage unscrupulous behaviour by competitive corporate players. In these respects, changes in Malawi's seed system reflect statements within the literature that question the value of AIS developments for poverty alleviation (Albert and Laberge, 2007, Ortiz et al., 2013). Although numbers of marketed cultivars are ever increasing, the narrow trait range which reflects a corporate vision of modern agriculture that excludes alternatives, supports conclusions drawn by other authors that the seed market is not being shaped primarily to benefit smallholders (Chinsinga, 2011). All this suggests that whilst AIS principles are being touted as a means for enhancing rural agricultural development (The World Bank, 2012), regulations are likely to be required to ensure that the needs of marginalized agricultural producers are not neglected.

The effect of the AISP on the marketing behaviours of seed companies was explored, with comments from company officials suggesting that considerable energies are expended attempting to capture coupon sales. It would be fair to conclude that the AISP increases the attractiveness of marketing maize seed for the seed companies operating nationally. A side effect of this could be that companies expend less effort in breeding and marketing seeds for other crops, which may in turn reduce the potential for farmers to diversify.

Finally the chapter presented evidence that with the growth of the commercial elements of Malawi's formal seed system, the informal seed system is in decline. Farmers are now increasingly reliant on the market and cash-based exchanges in order to access maize seed, which has introduced greater levels of inequality into inputs access compared with the situation in the past. Financial barriers to accessing maize seed are now felt keenly by poorer smallholders, providing further support to claims that poverty acts to limit to modern cultivar adoption for smallholders in Malawi (Smale, 1993, Langyintuo, 2005, Simtowe et al., 2009). Although local maize is becoming scarce and monetization of seed exchanges is now widespread, a large number of households still rely on recycled seed, often from hybrid cultivars. Whilst households across the wealth ranks reported having used such seed in the past, poorer households were more likely to rely entirely on donations that came from the harvest stores of wealthier households. Their reliance on seed donations means that such households will be particularly vulnerable in years where the harvests of wealthier households fall short and donations therefore become harder to obtain. The importance of informal seed systems for resilience to crises such as drought and as a means for maintaining genetic diversity and agro-ecological stress tolerance in-situ has been reported within the literature (Almekinders et al., 1994, Stromberg et al., 2010, McGuire and Sperling, 2013), and informal seed exchanges are likely to peak during times of crisis when households lack the means to access seeds through formal routes (McGuire and Sperling, 2013). Therefore the changes to Malawi's informal seed system that have occurred as commercial maize exchanges have increased are likely to have significant implications for agricultural and household vulnerability to climate impacts. The yield and yield stability implications of the high levels of reliance on recycled hybrid maize use which were evident amongst research participants are not well understood. Smale and Phiri (1998) report a sustained yield advantage of second and third generation recycled hybrids over saved OPVs and local varieties, but experiments reported in Pixley and Banziger (2001) found second generation OPVs to be superior to recycled hybrid seeds for yield and yield stability in low potential scenarios. More research is needed to identify whether use of recycled hybrid maize is detrimental for food security and harvest stability in the Malawian context.

This chapter has explored maize cultivar diffusion from a national perspective in qualitative terms and has reported evidence to suggest that cultivar access by smallholders is likely to be characterised by socio-economic inequalities. Additionally, the evidence presented suggests that the market dominance of a small range of corporately-owned cultivars may be narrowing the range of varieties used by smallholders on the ground. The next chapter now takes a quantitative look at maize cultivar use within the two research areas in order to explore the adoption outcomes that result from the diffusion strategies that have been described.

Chapter 5 - Maize cultivar adoption in the study sites

5.1 Introduction

There are many references in the literature to the fact that the adoption of modern maize in Malawi has not proceeded as expected and has instead stagnated or plateaued (Smale and Rusike, 1998, Lunduka et al., 2012, Katengeza et al., 2012). Various reasons have been suggested to explain this sustained low adoption, including high rates of disadoption for financial reasons (Langyintuo, 2005), sustained partial adoption or preferences for the use of a range of modern and local cultivars (Katengeza et al., 2012, Lunduka et al., 2012), inefficiencies in the seed market (Cromwell and Zambezi, 1993), inconsistent levels of political support (Harrigan, 2003) and the failure of new cultivars to meet the trait preferences of smallholder farmers (Smale, 1993). Despite the attention this topic has received in the literature, understanding of which factors currently act most strongly on the ground to inhibit cultivar adoption is lacking. Assumptions about adoption processes based on the DoI framework (Rogers, 2003) suggest (as discussed earlier) that adoption-diffusion begins with individuals of socio-economically superior status initially taking up new practices or technologies, which are then gradually spread to less innovative individuals of lower socio-economic status in a self-sustaining process that, once initiated, requires little intervention from outsiders. However, the fact that reports of modern cultivar adoption in Malawi indicate that its progression has been limited suggests that the adoption-diffusion process has not been sustained, and insights into why it has petered out are important for enabling the development of strategies that will more successfully lead to sustained uptake in future. Literature critiquing the DoI framework suggests that the assumptions about adoption processes upon which it is built do not always apply empirically (Grisley and Shamambo, 1993, Walters et al., 1999, Mwaseba et al., 2006, Hogset and Barrett, 2007). Yet an explanation of how accurately the DoI framework explains cultivar adoption processes on the ground in Malawi does not appear within the literature. The AISP can be considered as a political strategy for overcoming Malawi's historically low inputs adoption rates, but whilst the programme is considered by some authors to have transformed Malawi from a food deficit nation to a food surplus one (Denning et al., 2009), criticisms of its operation appear within the literature and the equity of subsidy impacts on the ground are not well studied (Javdani, 2012), nor is it understood how well the uptake of new cultivars would be sustained if the programme were to be scaled back. This chapter presents results which contribute to filling these gaps in the empirical knowledge of contemporary cultivar adoption amongst Malawian smallholders. To do so, cultivar adoption characteristics relative to location and household socioeconomic status within and between the two areas are presented and explored. The viewpoint taken by the chapter is thus narrowed from the national perspective on the seed system which was presented in Chapter 4, and the presentation of the two case study areas becomes the main focus.

The case study areas are introduced via an exploration of findings about the agricultural and livelihood characteristics and manifestations of vulnerability to climate hazards in each place. Following this, adoption patterns between the two areas are compared, and observed adoption within each area is evaluated against the DoI hypothesis that speed of uptake is related to socioeconomic criteria, with socioeconomic status being associated with earlier adoption (Rogers, 2003). The chapter then moves on to investigate how the AISP operates on the ground in both Kasungu and Ngabu, and evaluates the extent to which the distribution of coupons serves to overcome wealth-related inequalities in cultivar adoption. The main barriers to cultivar adoption are determined and steps are taken towards identifying the factors which result in the different adoption profiles that are revealed for each area. As such, this chapter fulfils objective 2 of the thesis, to "identify adoption outcomes in the two research areas", partially fulfils objective 3, to "identify barriers to and drivers of adoption decisions within smallholder households", and helps to lay the foundations for objective 4, wherein the implications of contemporary cultivar diffusion and adoption characteristics for climate change adaptation and vulnerability reduction amongst smallholder households in Malawi will be explored.

5.2 Chapter objectives

This chapter aims to:

1. Present results which characterise the two case study areas and the climate vulnerability characteristics of each.
2. Identify household cultivar adoption patterns in the two study areas and evaluate whether these patterns provide support for the DoI hypothesis that socio-economic status determines speed of adoption.
3. Determine the efficacy of the AISP in overcoming inequalities in adoption.

5.3 Methods

This chapter is mainly based upon data from the two questionnaire surveys that were fielded at the study villages in Kasungu and Ngabu in September-November 2010 and in June and July, 2011. Questionnaires were used to provide an accurate, quantitative overview of maize cultivar use and related livelihood decisions in the two areas (de Vaus, 2002). Although the sampling frames used for the two questionnaires differed slightly, the samples are considered to both be reliably representative based on confidence in the sampling approach used in each instance (see Chapter 3 for more details). There is a key difference between the two datasets in the case of Ngabu. The 2011 questionnaire only collected data from households which were cultivating maize. Due to an association between maize cultivation and wealth in the area, the 2011 dataset is therefore from a somewhat wealthier sample than the 2010 dataset. This does not affect the results of the analysis concerning cultivar adoption because within this analysis non-maize growing households from the 2010 sample are excluded. Both questionnaires collected socioeconomic data and data on maize cultivar use in the present, however the 2010 survey also collected information on broader farm production decisions, alternative livelihood activities and household food security and consumption habits. The 2011 questionnaire concentrated on collecting maize cultivation histories, and measures of knowledge about, and attitudes towards, maize cultivars. Findings based on questionnaire results are complemented with qualitative material from interviews and focus groups. Data from questionnaires were analysed using statistical software (PASW and Excel), and qualitative data from interviews and focus groups were analysed thematically using NVivo (Gibbs, 2002, Allen and Bennett, 2010).

5.4 Results

The results which follow are split into three sections. Firstly, in 5.4.1, results concerning the production and climate vulnerability characteristics of Kasungu and Ngabu are explored. This enables evidence to be presented which supports characterisations (that appear within the literature) of Ngabu (along with the surrounding area) as more exposed to the negative impacts of current climate variability, with the result that production in the area is insecure and households are more at risk of poverty (Phiri and Saka, 2008, Mijoni and Izadkhah, 2009, Chidanti-Malunga, 2011). The existence of a relationship between wealth and vulnerability to climate impacts in each area is also explored, which provides support for the assumption that poorer households are generally more vulnerable, and have less adaptive capacity, than wealthier households. Having established evidence for the argument that Kasungu can be regarded as an area with higher socioeconomic status than Ngabu, the next section, 5.4.2, compares adoption patterns between the two areas against the assumption that, according to the DoI hypothesis, Kasungu would exhibit higher levels of adoption of modern maize. Having compared adoption between the two areas, results are then presented for adoption patterns within each area according to household socio-economic status, and again, support for the DoI hypothesis is evaluated. The final results section, 5.4.3, looks at AISP receipt by household socio-economic status within each area, providing evidence that recommendations that subsidy coupons be targeted at poorer and more vulnerable households are not being met.

5.4.1 Research area production and climate vulnerability characteristics

5.4.1.1 Kasungu

Kasungu is viewed as a productive district, and some research participants emphasized the important role played by maize production in the area for national food security:

> *"This district is mainly the food basket of the country. If you don't produce maize in Kasungu it means other parts of the country will also suffer for sure"*
>
> *-Extension manager, Kasungu*

Despite this, some of the worst effects of the 2002 food crisis were felt in Kasungu, and harvests suffered badly again in 2005, although a crisis was avoided because food aid was quicker to arrive (Kamkwamba and Mealer, 2009). Participants recalled the 2002 food crisis with comments such as:

> *"Many people died; people would just fall in the road"*
>
> *- Focus group, local agricultural history, village A, Kasungu*

Data were collected from three villages in the rural areas skirting Kasungu town, and all within 10 km of Kasungu airport meteorological station. One village was subsequently excluded from the analysis as discussed in section 3.3. Characteristics of the two remaining villages were very similar, so their combined data are presented here.

Nearly all survey households had access to land (96.4%), with land sizes ranging from a quarter of an acre to twenty two acres. Distribution of landholdings was highly positively skewed with 72.8% of households farming three acres or less. The mean land size was 3.68 acres (St Dev =

4.16). Forty percent of households had access to a plot of land which was naturally irrigated by a stream or river, referred to in the local language as a *dimba* (n=85[3]).

All land-holding households farmed maize, even if it was their only crop (as was the case amongst a tenth of households). All households devoted at least a quarter of their land to maize, but many used much more than this, with a third of surveyed households using their entire land area for growing maize (with different degrees of intercropping). Mean land proportion for maize production was 64.2% (St Dev=27.0%). As household landholdings decreased in size, the probability increased that maize would be the only crop that was grown.

Maize was regarded as essential in terms of not only production but also consumption, with respondents proclaiming:

> *"We depend on maize!"*
>
> *Female household head, 45, Village A, Kasungu*

Ninety eight percent of households considered maize to be their most important food (n=80). Maize was consumed twice (76.3%) or three times a day (23.7%) whilst household stocks lasted, with the majority of households (65%) still continuing to consume maize twice daily basis even when their own stocks had run out. Households did not perceive many consumption alternatives to maize; 17.9% indicated that they considered there were none (n=84). Amongst those remaining, (55.9%) perceived between one and two types of food as alternatives, predominantly sweet potato (51.6%) and rice (43.8%) (n=64). A fifth of households reported growing maize with the intention of selling some of their crop (19.8%, n=81).

In addition to maize, households grew up to seven additional types of crop, although most (90%) grew fewer than four (n=80). Amongst those growing additional crops, most grew groundnuts (79.2%), followed by soya (48.6%), sweet potatoes (38.9%), tobacco (36.1%) and cassava (30.6%) (n=72). Tobacco was grown purely for sale, but the rest of the crops were grown for consumption, sale, or both. Household wealth was significantly related to crop diversification. Better-off households grew a mean 3.44 crops in addition to maize (St Dev = 1.58), whilst middle wealth ranked households grew 2.55 (St Dev = 1.46) and the poorest grew

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[3] Throughout the analysis presented here the number of cases varies somewhat. This is because certain sections of the questionnaire were not administered to households if, for example, they had indicated that they had no access to land for farming. In addition, sometimes responses were missed out for individual cases due to enumerator error. The number provided always represents the total number of valid cases included in the analysis for the specific question.

only 1.5 (St Dev = 0.85), which constitutes a significant linear trend ($F (1, 77) = 23.576$, $p < .001$).

Households engaged in a number of different livelihood strategies in order to gain income. Up to four income-earning activities were reported by some households, but the majority of households (52.9%) engaged in just two (n=85). The most common were *ganyu* (50%), general crop sales (26.2%), tobacco sales (19%), beer brewing (14.3%), vegetable sales (14.3%) and bicycle taxi work (10.7%) (n=84). However, households engaged in a wide range of activities beyond those just listed, including brick-making, petty-trading, and salaried employment. Whilst *ganyu* featured for many, a much lower number reported relying on *ganyu* as their primary means to gain income (15.7%). Household reliance on certain types of livelihood activity was somewhat stratified by wealth. Reliance on ganyu as an income source was concentrated amongst the poorer households (poor = 24%, middle = 12.1%, better-off = 12.0%), whilst better off households were more likely to rely on tobacco sales for gaining primary income (poor = 4.0%, middle = 9.1%, better off = 24.0%). Better-off households engaged in a slightly higher mean number of livelihood strategies (2.08, St Dev = 0.75) than poor (1.81, St Dev = 0.69) and middle wealth ranked households (1.62, St Dev = 1.88), but these differences were not found to be statistically significant. Just over one in seven households reported being able to employ help on their farms at some point during the year (15.3%, n=85).

Respondents ranged in age from 18 to 90 years old, with a mean of 36 years (St Dev 15.09). The majority of respondents were female (67.1%), but female headed households formed a relatively small proportion of those surveyed (12.9%). Literacy amongst respondents was relatively high, at 64.3%. Mean household members numbered 5.08 (St Dev = 2.41), with an average of 2.83 dependents (St Dev = 2.41).

5.4.1.2 Ngabu

In contrast to Kasungu, in Ngabu respondents reported experiencing major problems with maize production:

> *"Much more maize was eaten thirty years ago and production of millet and sorghum was very low, because the rains were more reliable. We are not happy with the situation today; we would like to be eating more maize."*
>
> *Focus group, Agricultural trends, Village B, Ngabu*

Production conditions were described as follows:

"Ya, here in the Shire Valley it's a funny thing. When rains are not coming we are experiencing drought. When rains come we are experiencing floods. There are some areas where flooding is taking place, especially low land areas, while the uplands are experiencing drought. At the same time in the same year, some parts of our area are experiencing drought and other areas are experiencing floods"

Extension manager, Ngabu

Questionnaire data was collected from three villages within Ngabu, situated within 15 km of the town and the meteorological station. As was the case in Kasungu, the results from the villages were similar and so are combined here.

As in Kasungu, nearly every household encountered had access to land for farming (98.8%, n=162), with size of landholdings ranging from half an acre to twenty five acres. The mean land size was somewhat smaller than in Kasungu, at 3.03 acres (St Dev = 3.30). Land distribution here was also positively skewed, with 77.5% of households owning or accessing less than three acres. Just over a quarter of households had access to a *dimba* (28.4%).

Unlike in Kasungu, only 69.4% of households that had access to land grew maize. These households devoted between a twentieth and the entirety of their land to maize production, but the majority cultivated it on between a quarter and half (73.8%, n=122). The mean proportion of land used for maize production was thus smaller than in Kasungu at 42.4% (St Dev = 18.3%), and only about one in twenty households grew maize with the intention of selling it (4.9%, n=122). The households that did not grow maize described having given up within recent years as a response to perceived changes in rainfall:

"We switched from maize to cotton, millet and sorghum; crops that can cope with how the weather is now. That's how we can adapt, by removing the crops that don't do well."

Focus group, Farmers no longer cultivating maize, village A, Ngabu

Notably, many households that were continuing to cultivate maize were choosing to do so in their *dimbas*; 82.6% of households that owned a *dimba* continued to cultivate maize, whereas only 64.0% of households without a *dimba* did, which was a significant difference (χ^2 (n=1, 160) = 5.322, p=.023). The households that had decided to stop growing maize were more concentrated in the bottom wealth rank (bottom = 46.8%, middle = 26.2%, top = 20.8%), which constituted a significant association (linear by linear association (n=2,160) = 7.457, p=.008).

Despite the fact that a much smaller proportion of households grew maize than in Kasungu, it remained a key component within diets. Nearly all households (93.7%) considered maize to be their most important food, with 3.1% considering maize equally important to millet and sorghum, and the remainder being split between millet and other foods (n=159). Whilst household stocks of maize were available, 78.5% of households reported eating two maize meals a day, and 20.3% reported eating maize three times a day (n=158). In the absence of home-grown stocks, 70.9% of households reported continuing to eat one maize meal a day, and 25.9% reported continuing to eat two. Only a small number of households indicated that they had no food alternatives to maize (4.3%), with the majority (61.7%) indicating two alternatives, predominantly millet (83.2%) and sorghum (78.1%). Just under a third of households also indicated that sweet potatoes could stand in for maize if necessary (29%) (n=155). There was a significant linear association between household wealth and the perception of a greater number of food alternatives to maize, $F(1, 159) = 5.757$, $p < .005$.

Whether or not they grew maize, all households grew at least one other crop, and a few grew up to six. The majority (63.3%) grew three, almost always millet (grown by 97.5% of households), sorghum (94.4% of households) and cotton (89.4% of households). A few households also grew beans (19.4%) or vegetables (6.9%), whilst just a handful grew groundnuts, sweet potatoes or pumpkins. There was less wealth stratification in terms of the numbers of crops grown. Poor households grew a mean number of 2.93 crops (St Dev = 0.80), middle wealth ranked households grew a mean of 3.30 crops (St Dev = 0.95) and better off households grew 3.29 (St Dev = 0.87), suggesting that there was a limit to diversification potential which prevented wealthier households from investing more in growing a wider crop range.

Cotton sales were a key earning strategy engaged in by 85.2% of households, and constituted the primary source of income for 59.3% (n=162). *Ganyu* was also common, with 75.9% of households engaging in it as a livelihood strategy, but only 27.2% relying on it as their main source of cash. A few households engaged in other activities including selling firewood (5.6%), petty-trading (5.6%) and livestock sales (3.7%) amongst a somewhat narrower range of options than in Kasungu. The majority of households (66.7%) engaged in two income-generating activities. Cotton sales and *ganyu* participation were somewhat stratified by wealth; a larger proportion of better-off households engaged in cotton sales (93.8%) than middle wealth ranked (84.8%) and poorer households (77.1%), and the reverse pattern was true for ganyu, where 81.3% of the poorest households compared to only 64.6% of wealthier households participated. There was a significant linear association between household wealth and the number of livelihood strategies engaged in, $F(1,159) = 4.311$, $p < .05$. Just over one in twenty households (5.6%) were able to employ others to help on their land (n=160).

Respondents in Ngabu were aged between 18 and 88, with a mean age of 40.81 (St Dev = 16.80). Over half (58.6%) of respondents were female, and 20.4% of households were female-headed. Literacy was lower than in Kasungu, at 41.0% (n=161). Household size averaged 5.41 individuals (St Dev = 2.26), and the mean number of dependent household members was 2.32 (St Dev 1.78).

5.4.1.3 Climate vulnerability and adaptation in the two research areas

The Lower Shire Valley is recognized as Malawi's most flood-vulnerable area, with recent flood disasters occurring in 1997, 2001, 2003 and in 2006 (Mijoni and Izadkhah, 2009). Uplands production is dependent on rainfall, which is highly variable, and the production impacts of recurrent drought and flooding are considered to account for the area being one of the poorest in Malawi (Chidanti-Malunga, 2011). Along with the lakeshore regions of Malawi, populations within the area face the highest national risk of malaria transmission (Bennett et al., 2013). Malawi's welfare monitoring survey (2012) reports that a higher proportion of Chikwawa's population is orphaned than in Kasungu (11.7% compared with 6.6%), literacy in the district is lower (63.2% compared with 76.0%), there are lower rates of labour participation (72.1% compared with 82.7%), and time spent fetching water or travelling to the nearest market is on average higher (Government of Malawi, 2012). All this supports the conclusion that Ngabu is poorer and likely to be more vulnerable to negative climate impacts than Kasungu.

Temperatures in Ngabu are much hotter than in Kasungu (with a mean annual extreme of 42.2°C compared with Kasungu's 34.7°C, based on data from 1983-2005). Historical daily data[4] (1961-2011) reveals mean annual rainfall in Kasungu as 775 mm with a standard deviation of 167.0 mm, whilst for Ngabu the annual mean is 769.8 mm with a standard deviation of 191.5 mm. The greater dispersion of annual rainfall around the mean in Ngabu is reflected in greater intra-annual rainfall variability; for example, mean longest within season dry spells are much higher for Ngabu (19.4 days, SD = 8.1) than Kasungu (13.5 days, SD = 6.04).

The effects of these climatic conditions on maize production were reflected in data collected on food security by the 2010 survey. In Kasungu, households' maize stocks lasted significantly

[4] Temperature and rainfall data were provided by Malawi Meteorological Services

longer (an average of 8.72 months, St Dev = 1.92), than in Ngabu (where they only lasted a mean 4.43 months, St Dev = 3.05), F (1,202) = 127.029, p <.000. This difference was sustained even when controlling for the land area dedicated to maize and the number of mouths households had to feed (see Figure 5.1).

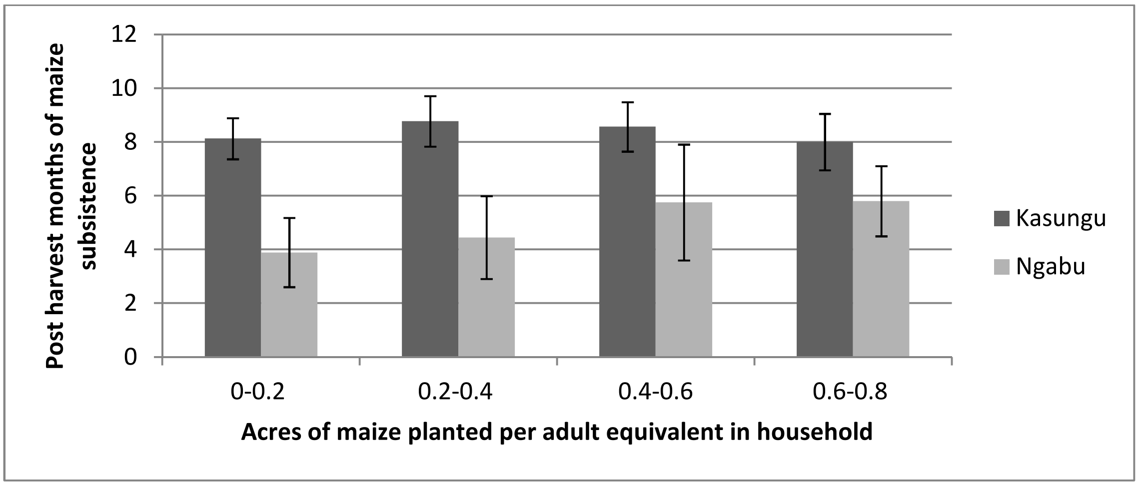

Figure 5.1: Mean months of household maize security (error bars show St Dev)

The variability in the number of months that stocks lasted between good and bad years was also significantly higher for farmers in Ngabu (4.97 months, St Dev = 3.70) than it was for farmers in Kasungu (2.70 months, St Dev = 1.71), (F (1,202) = 26.542, p< .000). Low levels of household maize security within Ngabu created greater market dependence for food purchases. A large majority (80.6%, n=160) in Ngabu indicated that purchasing maize for food was their household's top-ranking expense, whereas in Kasungu this was the case for only 12.6% of households, with the majority naming fertilizer as their top ranking expense instead (n=79).

Households were also asked about the number of poor harvests they had suffered because of drought and flood in the last twenty years. Households in Ngabu reported experiencing a mean of 3.79 (St Dev = 2.31) drought-induced poor harvests, which was significantly higher than Kasungu's mean of 1.36 (St Dev = 1.18), F (1,199) = 75.107, p < .000. Floods were also more of a problem in Ngabu; households had suffered a mean 0.78 (St Dev = 1.36) poor harvests due to flooding compared to Kasungu's 0.20 (St Dev = 0.43), F (1,199) = 13.505, p< .000. Despite suffering more losses, a smaller proportion of households in Ngabu reported having adapted their farming practices as a result; only 27.3% of households had changed anything in response to losses (n=121), compared with 40.3% in Kasungu (n=62), implying that households in Kasungu had a higher degree of adaptive capacity than households in Ngabu. In both areas higher proportions of better-off households reported changing farm practices as a response to the experience of harvest loss. Amongst those households that had undertaken an adaptation, the majority in Kasungu had changed the cultivar they were using (45.8%), after which changing planting times (16.7%), and crop diversification (12.5%) proved to be the most frequent changes undertaken (n=24). In Ngabu, by contrast, the most common adaptations were adoption of crop rotation (28.6%), followed by changes to planting row direction (22.9%), followed by changes to planting times (11.4%) and changes to crops grown (11.4%) (n=35).

Despite the greater production difficulties that were faced in Ngabu, farming was equally as culturally important as in Kasungu. Households aspired to have maize as their main dietary staple, and spoke in derogatory terms about millet and sorghum. Self-sufficiency in food was a universally-subscribed goal and having to rely on the market to purchase food was seen in a negative light:

> *"Ideally people would prefer to be farming than to work in non-agricultural employment, and besides, jobs outside agriculture are hard to find. There's nothing that can be gained by relying more on purchased foodstuffs. It's a setback to be spending money on food rather than improving our homes... Ideally households should not have any millet and sorghum in their diet at all as nsima. Such crops are only good for making tobwa or similar snacks, they do not make good nsima. Having eaten one meal of millet nsima people do not want to eat it again for a couple of days."*
>
> *Focus Group, Agricultural Trends, Village B, Ngabu*

In response to the greater exposure to climate hazards in Ngabu, many households try to reduce the climate sensitivity of their agricultural production by growing less maize and growing drought tolerant crops like millet and sorghum (in Ngabu 99.4% of households grow at least one drought tolerant crop compared with only 40.0% of households in Kasungu). However, market reliance on maize in Ngabu is not matched by employment opportunities, which were scarcer and more dependent on rain-fed agriculture than in Kasungu (in Ngabu 87.0% of households gain their primary income from rainfed agriculture compared with 57.1% in Kasungu). Whilst households in Ngabu diversify as much as possible in their production and livelihood strategies (by for example growing a significantly higher mean number of crops besides maize, and recognising a greater mean number of food alternatives to maize than do households in Kasungu[5]), the options they choose between are more homogeneous. This

[5] Households in Ngabu grow 3.19 crops excluding maize (SD = 0.89) compared with 2.54 (SD = 1.54) in Kasungu, $F(1,236) = 16.978$, $p < .001$. Households also perceive more alternative food sources in Ngabu (2.05, SD = 0.90) compared with Kasungu (1.74, SD = 1.14), $F(1,244) = 5.453$, $p < .05$.

means the overall diversity of Ngabu's production and economic systems is low compared with Kasungu; households in Kasungu reported gaining income from a very large range of livelihood activities (36 in total), whereas households in Ngabu reported a smaller range of 23 activities, and the vast majority of households only partook in two of these livelihood categories (as illustrated in Figure 5.2 and Figure 5.3).

The indication of lower adaptive capacity in Ngabu, in combination with lower livelihood and production diversity, greater reliance on rain-fed agriculture, high regional poverty and high levels of exposure to climate hazards all lend support to the assumption that Ngabu is more vulnerable to climate hazards than Kasungu. At the same time, the national importance of food production activities in Kasungu means that when harvests in the area do fail there may be knock-on effects for the rest of the country, and other regions are less likely to be to able to provide support for the needs of populations in Kasungu.

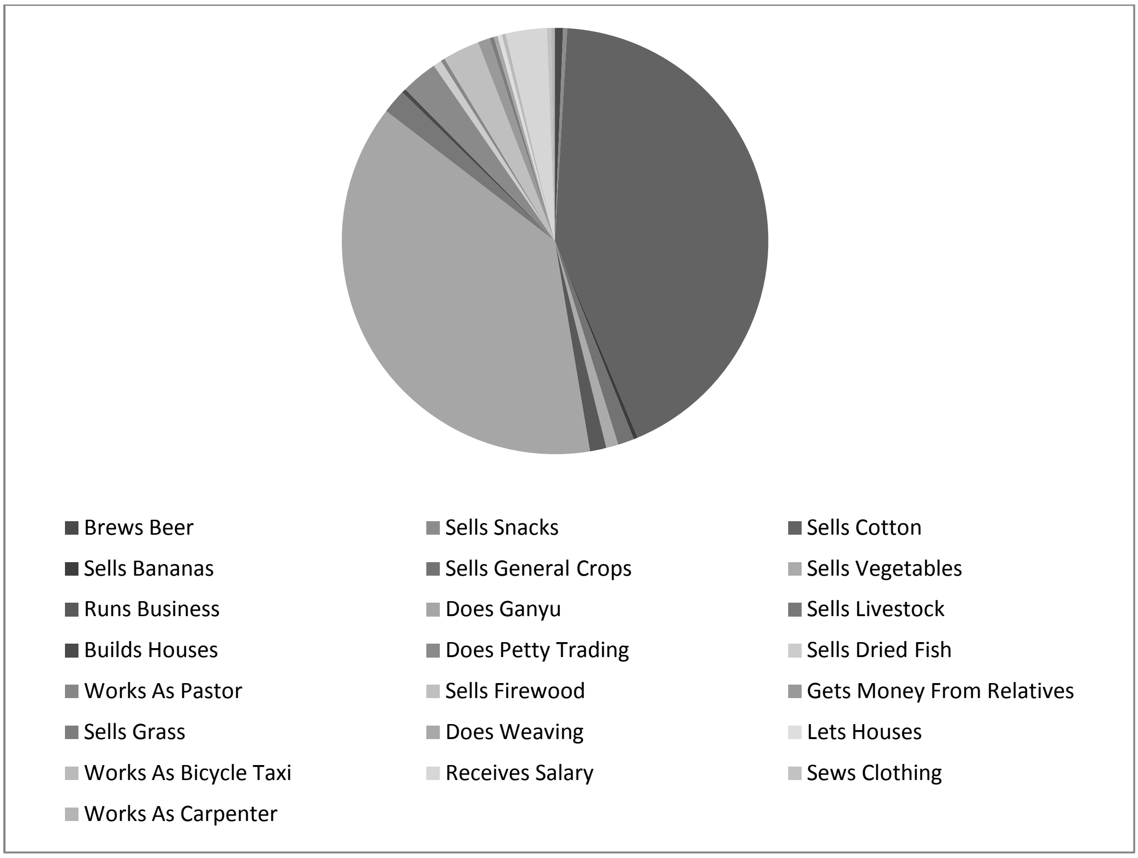

Figure 5.2: Pie chart showing income-generating activities in Ngabu

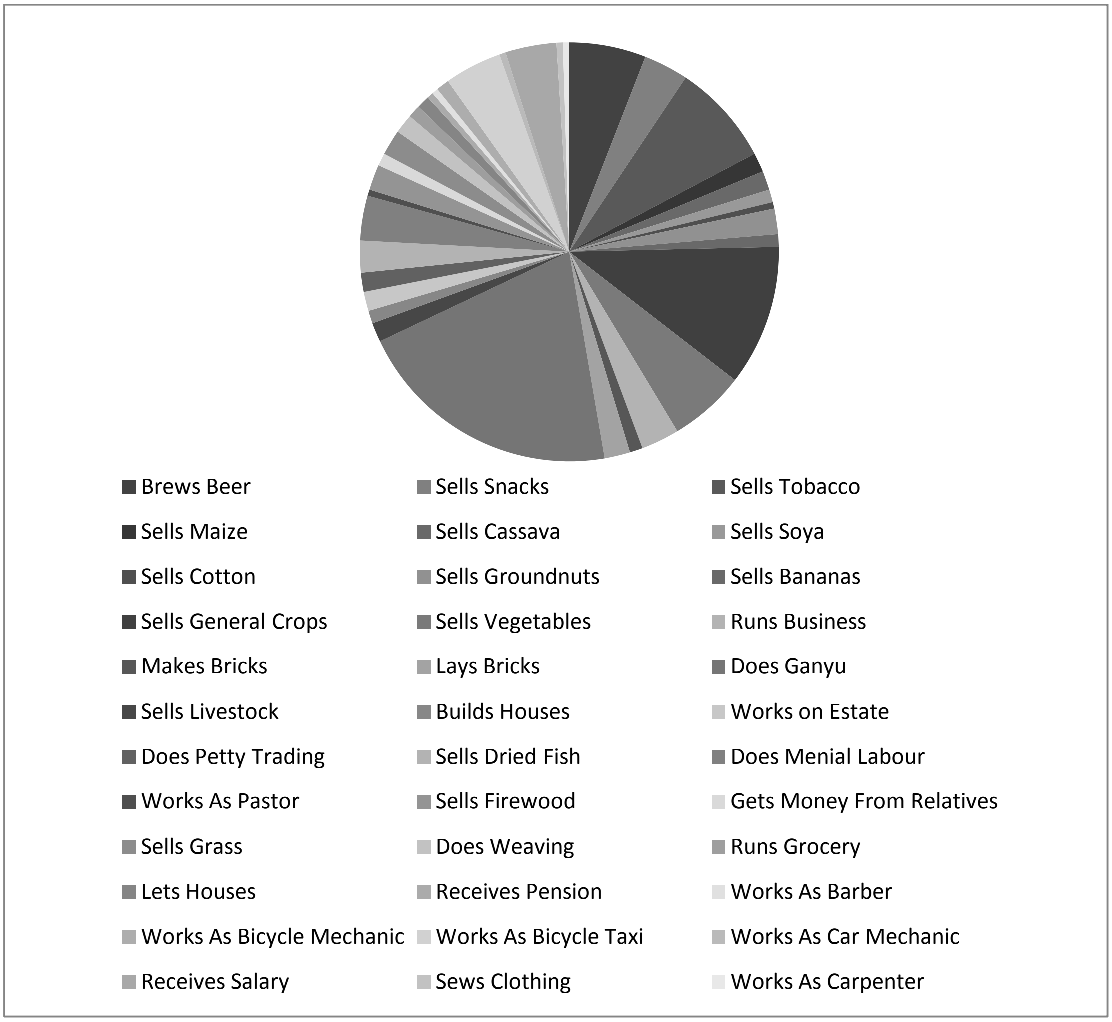

Figure 5.3: Pie chart showing income-generating activities in Kasungu

5.4.1.4 The association between climate vulnerability and poverty

The assumption of a link between vulnerability to climate change and poverty is widespread within work on adaptation, and relates to the belief that wealth enables greater access to resources which enable adaptive capacity (IPCC, 2007). However, it has also been argued that poverty and vulnerability to climate change are not necessarily always associated (Kelly and Adger, 2000). The later sections of this chapter explore relationships between cultivar use and household wealth and conclusions are drawn about the implications of these relationships for vulnerability to climate change.

In order to explore the degree to which climate vulnerability and poverty were linked in the two research areas a simple climate vulnerability indicator was produced (see chapter 3 for details) and correlated with household scores for land and asset wealth, as shown in Figure 5.4. Higher indicator scores denote lower vulnerability. From the scatter graph it is evident that there was a moderate positive correlation between household wealth and decreasing vulnerability to climate impacts in both the research areas (Kasungu, r = .312, n < .005, Ngabu, r = .296, n < 001). Although for many households greater poverty and climate vulnerability are closely associated, there are exceptions as indicated in Figure 5.4; some households have scores that indicate relatively low climate vulnerability, but are still near the bottom for asset and land wealth and there are a few very wealthy households whose indicator scores are lower than might be expected, signifying their relative vulnerability. The data therefore provide qualified support for the assumption that wealth determines climate vulnerability in a general sense, but also reveal the likelihood that vulnerability in each case is determined by specific contextual features.

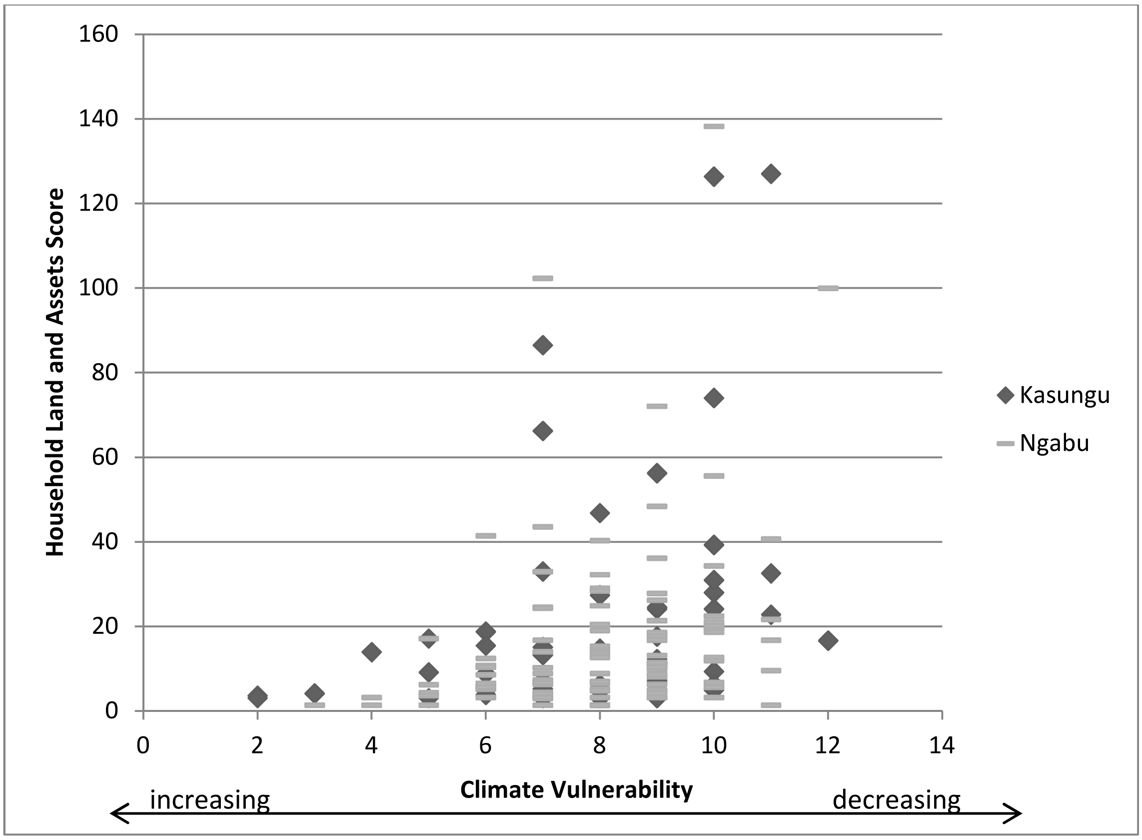

Figure 5.4: Scatter illustrating scores for land and assets by scores for climate vulnerability

5.4.2 Adoption patterns and innovations in cultivar use

This section introduces the concept of maize cultivar innovation in the research areas and then explores the prevalence of local and modern cultivars and the relationships between socio-economic wealth and cultivar use that exist in each location.

5.4.2.1 When does cultivar adoption qualify as an innovation?

An innovation can be defined simply as "an idea, practice or object that is perceived as new" by potential adopters (Rogers, 2003, p. 12). However, innovations are often linked in 'technology clusters' (the components of the AISP are an example of this) and adoption may be complete or only partial (Rogers, 2003, p. 14, Katengeza et al., 2012). These qualities mean that clarity is needed about precisely what constitutes innovation adoption within this analysis.

The most important innovation undertaken by smallholders with regard to cultivar adoption for adaptation is the decision to only grow maize cultivars which are climatically suitable. However, agreement was not absolute about which cultivars constituted the most climatically suitable choice in each area. Many households in both areas perceived local maize to be unsuitable for the current climate:

> *"Modern maize has early maturity and the local maize has late maturity. And the advantages of modern maize; it's more adapted to how the climate is these days because of how the rain is these days"*
>
> *Focus group, maize and rainfall, village B, Kasungu*

Although village participants mostly agreed that modern maize could fare better under current conditions, there were some households in Kasungu who considered that uncertainty about how seasonal weather would turn out meant that there was still some value in cultivating local maize:

> *"I have been observing how the climate is... Sometimes the rain comes and sometimes it doesn't come, so I decided it was wise to grow some local, so that when the rains come I can harvest a little and when the rains don't come I can also harvest a little"*
>
> *Female household head, 27 years old, bottom wealth rank, village A, Kasungu*

Also in Kasungu, perceptions of superior processing qualities and pest and disease resistance within local cultivars were sustained. The 2011 survey recorded that 78.5% of households considered that local cultivars made the best nsima and 77.6% thought they exhibited the best pest and disease resistance (n=107).

As discussed in Chapter 4, seed company executives and national research and extension staff were unified in their perception of local maize as undesirable. But whilst modern cultivars were broadly perceived as preferable amongst the majority of stakeholders, there was less agreement over whether OPVs or hybrids were preferable. Dominant seed companies strongly favoured hybrids (as their comments in chapter 4 demonstrated), but the extension service was not clear on the issue, and whilst smallholders were not always aware of the difference between hybrids and OPVs, some were clear that the possibility of seed-saving was a trait they highly valued. When describing an ideal cultivar, one respondent suggested:

"First of all, it should be resistant to drought. Secondly it should be possible to recycle it and thirdly, it should not be easily damaged by pests."

Village headman, aged 30 years, top wealth rank, village B, Kasungu

Finally, there were differences of opinion regarding the suitability of short season cultivars; corporate actors considered short season cultivars to be the most suitable means for adapting to drought, but national researchers expressed concerns about the decline in area specific new cultivars being produced and clearly distinguished drought tolerance from earliness. Whilst, as the comment above shows, farmers were keen that cultivars should be drought tolerant, early maturity was often also mentioned as a desirable trait. However, when asked what they were most worried about in terms of seasonal production conditions, most farmers confirmed that dry spells were their biggest concern.

On the basis that the degree to which households rely on modern or local maize, choose OPV or hybrid cultivars and select short season or drought tolerant varieties is significant for vulnerability reduction and adaptation to climate change, the analysis that follows will evaluate adoption by each of these criteria in turn.

5.4.2.2 Prevalence of modern and local varieties in the two research areas

It might be assumed that because Ngabu is in a poorer area with lower literacy levels that households here would be less likely to grow modern maize than households in Kasungu. Surprisingly, this was not the case. In Ngabu a significantly higher proportion of maize-growing households were found to be cultivating only modern cultivars in both the 2010 and 2011 surveys (χ^2 (1, n=202) = 19.537, p = .000) (2010 dataset) (χ^2 (1, n=191) = 5.709, p = .019) (2011 dataset). Additionally, significantly fewer households grew local maize in Ngabu than Kasungu in both the 2010 and 2011 datasets[6] (χ^2 (1, n=202) = 17.998, p = 000) (2010 dataset) and (χ^2 (1, n=191) = 7.162, p = .010) (2011 dataset). See Figure 5.5 below.

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[6]It is notable that data from Kasungu for 2010 and 2011 display very different adoption frequencies relating to both modern and local maize use. The analysis herein supports the idea that this change is

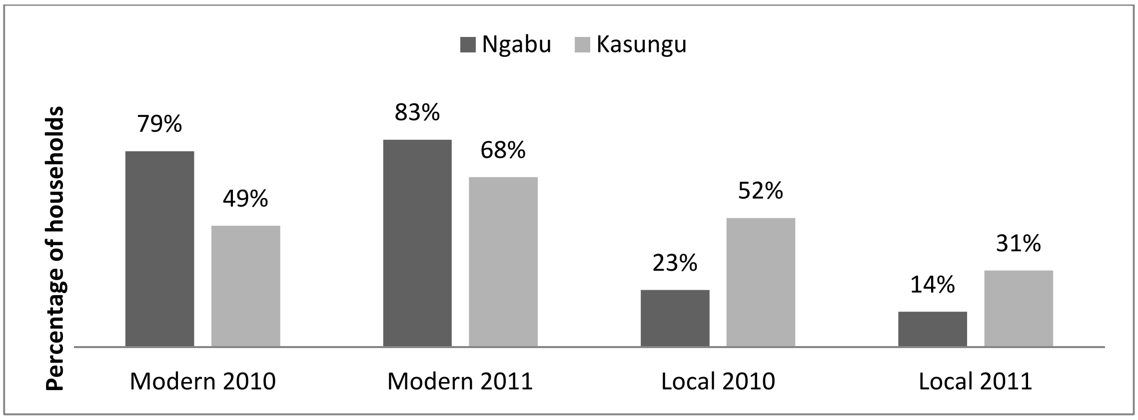


Figure 5.5: Local cultivar cultivation in both research areas in 2009-10 and 2010-11

Households in Ngabu also reported disadopting local maize earlier than households in Kasungu, although a trend of accelerating disadoption was evident in both areas. This trend had started in Ngabu around 1974, twelve years before the first survey household in Kasungu reported having stopped cultivating local maize. Elders in Ngabu and Kasungu both confirmed that hybrid maize had arrived in their areas in the sixties and seventies, so the fact that local maize was abandoned more quickly in Ngabu may be due to local climatic factors. Certainly, participants in Ngabu indicated that local droughts had figured within the adoption of hybrid maize:

> *"Throughout the 1970's and 1980's people were growing a mixture of hybrid and local, but mainly local. They started off by trying out hybrid on a small area of land. When it proved successful they would grow it on a bigger piece of land the following year. Hybrid took over local mainly when the droughts started to occur around 1994"*
>
> *Local history focus group, village A, Ngabu*

The histogram below shows the cumulative frequencies of disadoption of local maize for both Kasungu and Ngabu.

representative of a real change in maize cultivar use that occurred between the two seasons, and is not merely a result of erroneous sampling.

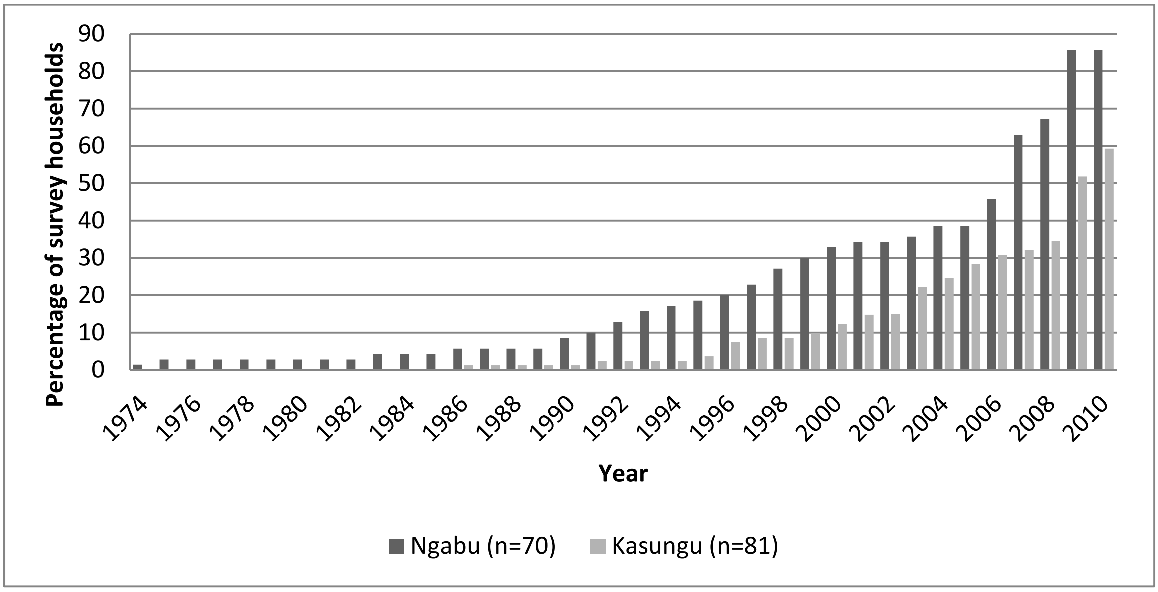


Figure 5.6: Cumulative frequency of local maize disadoption over time

Since Ngabu can be classed as poorer and less cosmopolitan than Kasungu, it is surprising (based on the expectations of DoI theory) that it should present a more modern face of maize cultivation. However, the different climatic settings of the two areas are likely to account for the difference by more strongly incentivizing local maize disadoption in Ngabu than Kasungu

5.4.2.3 Choice of specific modern cultivars in the two research areas

Although households in Ngabu might be classed as more advanced in terms of their greater uptake of modern maize, this was not a product of a better developed maize cultivar market in the area; a much smaller range of cultivars was available in Ngabu (see appendix vi). Survey households in Ngabu also grew a smaller range of cultivars (only eight in total, compared with twelve in Kasungu) and were comparatively more unified in their cultivar use. Half chose to grow ultra-short season hybrid Kanyani in 2010-11, with the remainder mostly divided between early hybrids from Pannar and Monsanto (DeKalb), and local maize. Cultivar preferences in Kasungu were split equally three ways between Kanyani, local and the drought tolerant OPV cultivar from CIMMYT, ZM621.

Past experience with cultivars was greater in Kasungu (totalling 18, compared to Ngabu's 11), and nearly all households had experience of growing local maize (92.5%), with around half having tried Kanyani, a third each DK 80:33 and ZM621, and just over a quarter MH18, with a smaller number having tried Pan 67 and Mkango. In Ngabu experience was more limited, with the majority of households having tried cultivating local maize and Kanyani, and around half having tried DK80:33. Kasungu households had grown significantly more cultivars in the past with a mean of 2.98 (*SD* = 1.03), compared with only 2.51 (*SD* = 0.840) in Ngabu, $F (1, 189) = 11.46$, $p = .001$.

The smaller range of cultivars that households had experience of using in Ngabu reflects the fact that a smaller range of cultivars exist that have production potential for the area, whereas a greater range can be grown in Kasungu. The market for maize seed is undoubtedly smaller in Ngabu, since a considerable number of households no longer cultivate maize, and those that do are cultivating a smaller amount. Seed companies are less inclined to focus attention on producing cultivars that are specifically suited to areas like Ngabu, since these areas present an inferior opportunity in commercial terms. However, given the preferences of Ngabu households for maize consumption and self-sufficiency in food production, the market appears to be failing to meet their needs.

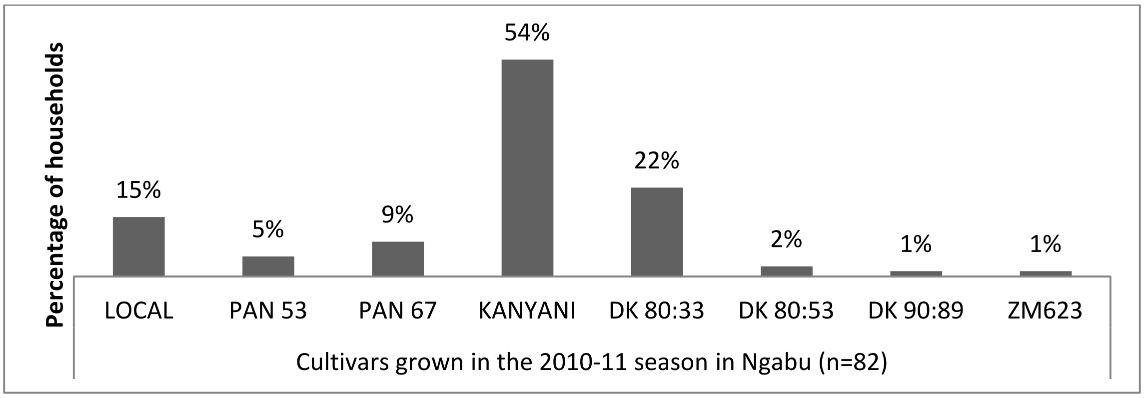


Figure 5.7: Cultivars grown in 2010-11 in Ngabu (n=82)

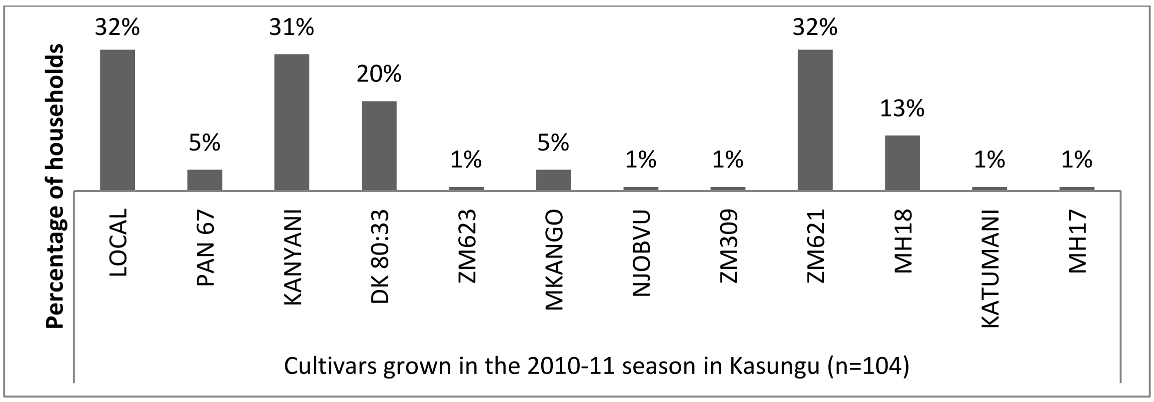


Figure 5.8: Cultivars grown in 2010-2011 in Kasungu (n=104)

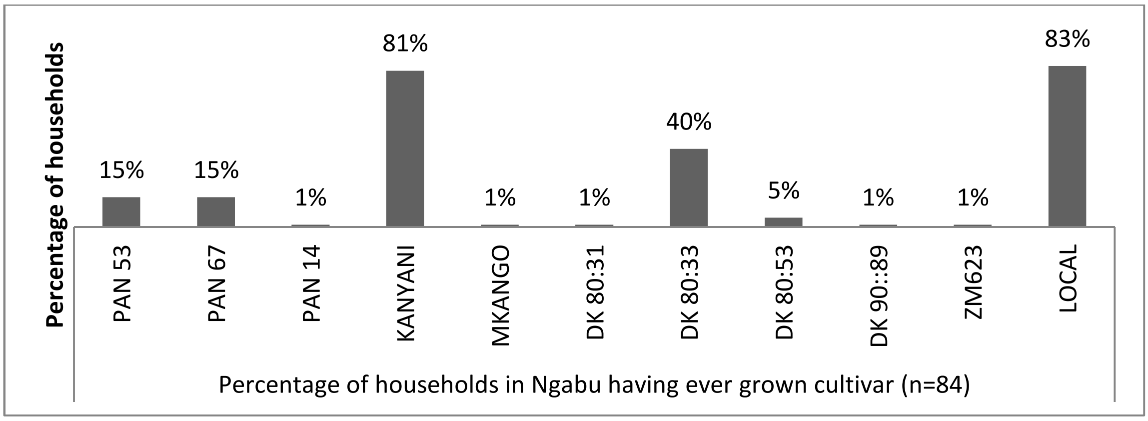


Figure 5.9: Historical cultivar use Ngabu (n=84)

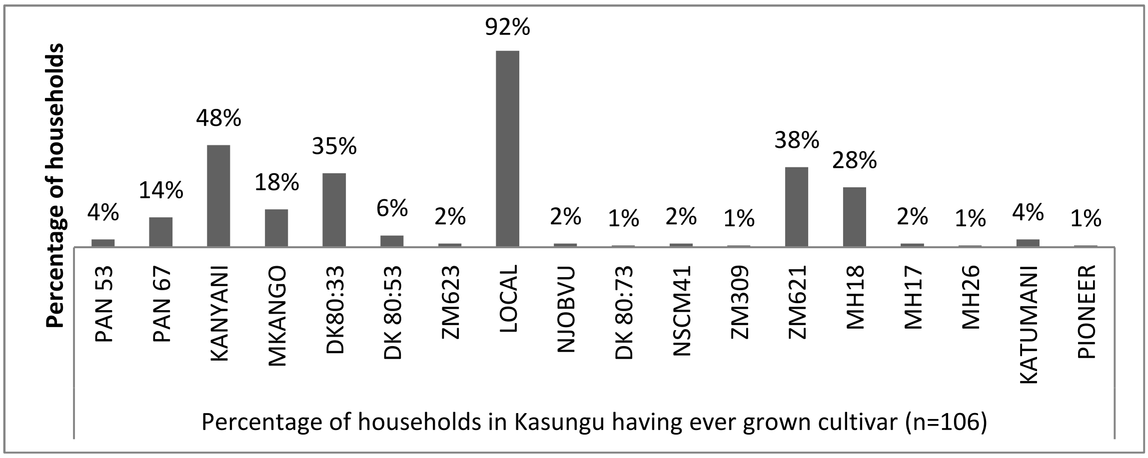


Figure 5.10: Historical cultivar use Kasungu (n=106)

5.4.2.3 Use of OPVs

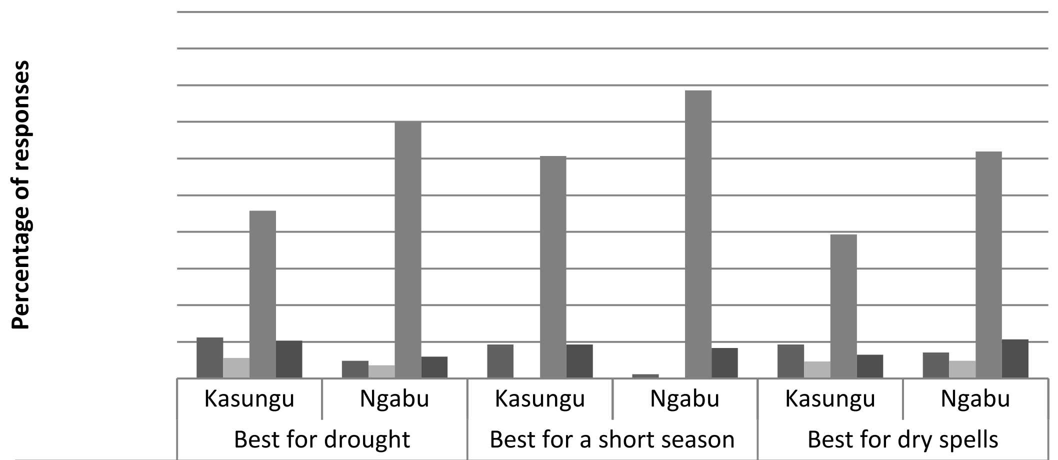
Respondents to the 2010 survey reported very low use of OPVs. No OPV varieties were reported as being used in Ngabu, and only 8.2% of households grew them in Kasungu. In 2011 use of OPVs remained low in Ngabu, where a single household reported growing ZM 623, but in Kasungu, a much higher number of households (34.9%) reported growing them.

The absence of any experience using ZM varieties (OPV drought-tolerant cultivars developed by CIMMYT) in Ngabu is notable, especially given Ngabu's greater exposure to drought. Not only was the use of ZM cultivars rarely reported by survey respondents, these cultivars were scarcely available in the area (see appendix vi), and were not included locally in the subsidy scheme in the 2010-11 season. Many households had not heard of ZM cultivars, or had heard the name but were not aware of any of their traits. However, despite the low usage and awareness of these cultivars in the local area, some households knew enough about them to want to try growing them. Ten percent of households in Ngabu (n=84) indicated a ZM cultivar when they were asked which cultivar they most desired to try out. This suggests an unmet need for ZMs exists in the area.

The high use of OPV cultivars in Kasungu that was evident from the 2011 survey data reflects qualitative reports of strong preferences for ZM varieties. Preferences were expressed on the basis of the fact that it was not necessary to add MK100 to the coupon for exchange on the subsidy scheme, that the possibility of saving seed was important, and that extension staff had given advice in favour of using ZMs. Additionally, ZM621 was made available at coupon distribution points in Kasungu in 2010, biasing access in favour of the cultivar (against official regulations regarding coupon exchange).

5.4.2.4 Use of short season and drought tolerant cultivars

The dominance of hybrid short-season cultivars (Kanyani and DK80:33) in both areas is notable. This was expected for Ngabu, since cultivars must be drought tolerant or early to produce a harvest in the area. But the high use of short season cultivars, Kanyani and DK80:33, and drought tolerant ZM621 in Kasungu was surprising. The high level of their use suggests that households were responding in a risk-averse way to uncertainty about seasonal rainfall, but also reflects the market dominance and therefore greater accessibility of these cultivars (particularly Kanyani and DK80:33) (see appendix vi). Surprisingly, no significant difference was found in terms of the use of drought tolerant and short season cultivars between the two research areas. In Ngabu (n=84), 77.4% of households were growing at least one drought tolerant or short season cultivar, compared with 69.2% of households in Kasungu (n=107). The majority of households considered Kanyani best for coping with drought and dry spells in both Kasungu and Ngabu. Although a higher number of households in both areas identified Kanyani as the best cultivar for shorter seasons than identified it as best for drought or dry spells, the degree to which drought tolerance and earliness were understood as distinct traits by respondents is not clear (see Figure 5.11).



	Best for drought: Kasungu	Best for drought: Ngabu	Best for a short season: Kasungu	Best for a short season: Ngabu	Best for dry spells: Kasungu	Best for dry spells: Ngabu
Don't know	11%	5%	9%	1%	9%	7%
Local	6%	4%	0%	0%	5%	5%
Kanyani	46%	70%	61%	79%	39%	62%
DK 80:33	10%	6%	9%	8%	7%	11%

Figure 5.11: Identification of best cultivars for drought, short seasons and dry spells, 2011 survey (Kasungu n=106, Ngabu n=84)

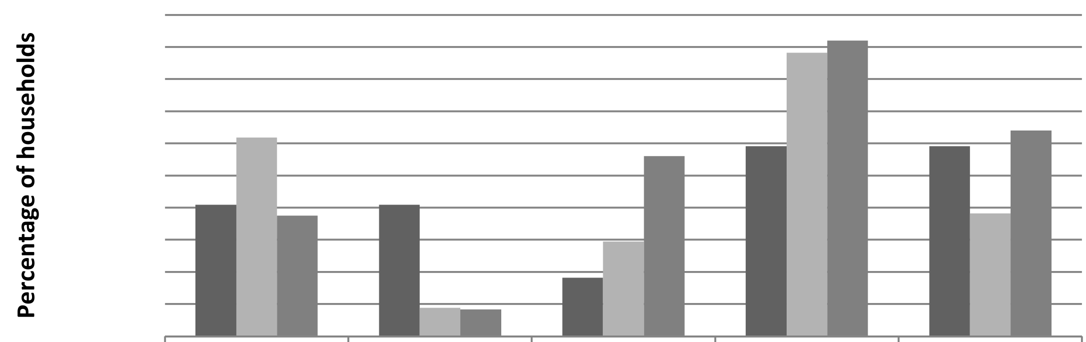
5.4.2.5 Socio-economic patterns of maize cultivar usage

In both areas and within both datasets (2010 and 2011) there was a strong and significant relationship between the use of modern cultivars and household wealth. This aligns with DoI predictions about adopter categories. However, the picture was complicated with regard to the use of local maize. As discussed already, households in both areas were tending to move away from local maize cultivation by replacing local cultivars with modern cultivars. Expectations based on Rogers' adopter categories would be that poorer households would be the last to give up cultivating local maize, and would demonstrate higher levels of local maize cultivation in general. This was not found to be the case in Kasungu in the 2009-10 season, when the data collected indicated that a higher proportion of better off households were continuing to cultivate local maize than in the other wealth ranks. Respondents mainly claimed that use of local cultivars was attributable to financial inability to access modern maize, which contradicts the findings of the 2010 dataset. The situation with regard to local maize use was different between the two areas, so Kasungu and Ngabu will be discussed separately.

Kasungu

Data for the 2010 survey in Kasungu were collected prior to the planting season commencing in November 2010, hence farmers answered questions with regard to what they had grown in

2009-2010. It was discovered that whilst better off households were more likely to grow modern cultivars and were less likely to have grown local maize on its own, a higher proportion of better off households continued to include local maize as one amongst a number of cultivars they grew.



	Exclusively modern	Exclusively local	Modern and local in combination	Modern (either exclusively or with local)	Local (either exclusively or with modern)
Poor	41%	41%	18%	59%	59%
Middle	62%	9%	29%	88%	38%
Better-off	38%	8%	56%	92%	64%

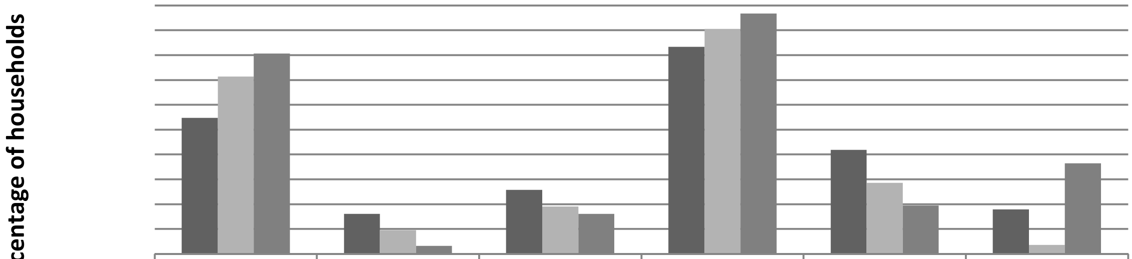
Figure 5.12: Use of modern and local maize cultivars, Kasungu, 2010 survey (n=81)

The bar chart illustrates that the proportion of households who had entirely adopted modern maize (by no longer cultivating local maize) was actually highest in the middle wealth rank. Whilst very few households in the middle and better off wealth ranks relied purely on cultivating local maize (under ten percent in both ranks), and poorer households were considerably more likely to do so, the proportion of households that grew at least some local maize was, contrary to expectations, highest in the better off rank, where 64.0% of households confirmed that they grew local maize.

Not only was this finding contrary to what DoI assumptions about adopter categories would lead one to expect, it was also curious since the perception that only poor households were still growing local maize had been voiced insistently by some of the research participants:

> *"People only grow local maize because they don't have enough money to buy modern maize, so it's definitely the wealthier families"*
>
> *Focus group, maize problem-ranking, local maize growers, village B, Kasungu*

However, in 2011 this finding was not replicated. Since a random sampling strategy was strictly employed in both cases this difference is most likely due to an actual change in households' maize varietal use. The 2011 dataset revealed a regular linear trend between wealth and the use of modern and local cultivars, with wealthy households less likely to grow local maize than less well-off households. Support for the idea that a change in cultivar use habits by wealthier households occurred between the two seasons exists within the data: many top wealth rank households (36.4%) gave up growing maize after 2009, a significantly higher proportion than in the other wealth ranks (Fisher's exact test (2, n=104) = 8.875, p = .009).



	Exclusively modern	Exclusively local	Modern and local in combination	Modern (either exclusively or with local)	Local (either exclusively or with modern)	Household gave up growing local after 2009
Poor	55%	16%	26%	83%	42%	18%
Middle	71%	10%	19%	91%	29%	4%
Better-off	81%	3%	16%	97%	19%	36%

Figure 5.13: Use of modern and local cultivars, 2011 survey, Kasungu (n=106)

Data on OPV and hybrid use show that a greater proportion of households in all wealth ranks were using hybrid than OPV in the 2010-11 season. However, this could reflect greater ease of access to hybrid than OPV cultivars, which were mainly only available through the subsidy scheme. Figure 5.14 below illustrates the proportions of households in each rank that used OPV and hybrid maize for Kasungu.

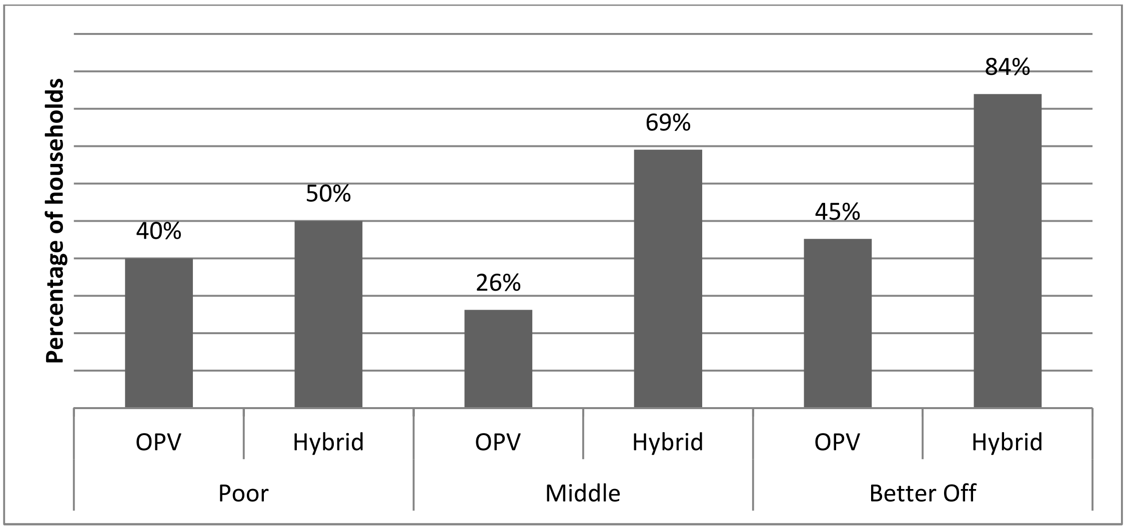


Figure 5.14: Use of OPV and hybrid cultivars, Kasungu, 2011 survey (n=106)

A significant relationship exists between the use of hybrid maize and wealth (χ^2 (3, n=103) = 8.107, p = .018), with a significant linear trend (linear by linear association = (1, n=103) = 7.942, p = .006). No significant relationship between OPV use and wealth is found, although higher proportions of households were found to be using OPV in the top and bottom wealth ranks than in the middle wealth rank.

Interviewees from seed companies promoting the use of hybrid maize suggested that data on maize cultivar choice through the subsidy scheme reveals the true preferences of farmers regarding OPV and hybrid maize, since financial constraints are removed. This narrative suggests that when farmers are given the choice they prefer hybrid maize. However, based on the survey data, households in all wealth ranks were equally likely to opt for either type of maize in exchange for their coupon. This suggests that the preference for hybrid maize is not as strong as seed companies are suggesting.

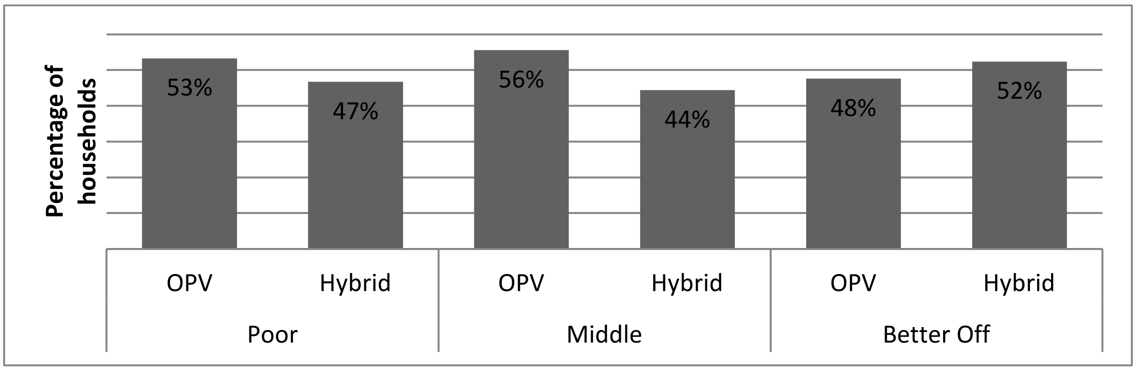
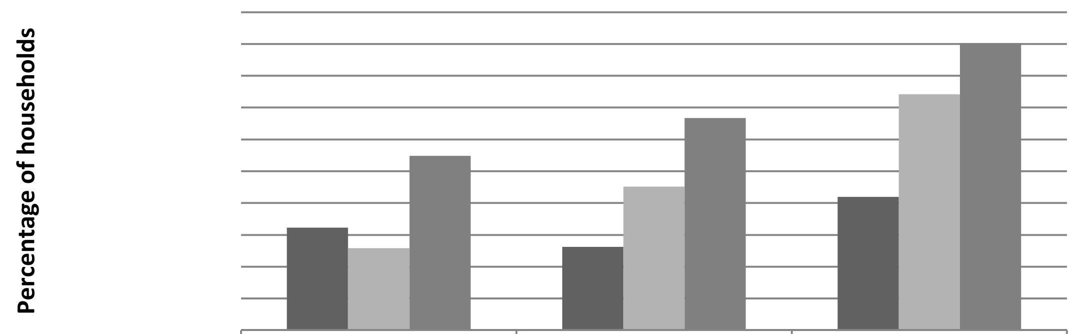


Figure 5.15: OPV versus hybrid exchange amongst subsidy recipients, 2011 survey, Kasungu (n=54)

To investigate the use of short season and drought tolerant cultivars it is necessary to categorise the maize cultivars encountered in the research sites into each of these groups. The shortest season cultivar currently available in Malawi is Kanyani from SeedCo (90-95 days), with DK80:33 (110-115 days) coming in close second. ZM 309 also qualifies as a short season cultivar (110-120 days), but it was absent in Ngabu and had only ever been grown by one single household in Kasungu. Whilst they may exhibit drought tolerance, neither Kanyani nor DK80:33 were specifically bred to withstand dry spells. Therefore, only longer season cultivars which have been specifically identified as drought tolerant by the Drought Tolerant Maize for Africa initiative are included as drought tolerant cultivars in the analysis that follows. These are Pan 53, ZM523, ZM621 and ZM623.

Wealth was significantly related to the use of either drought tolerant or short-season cultivars in Kasungu (χ^2 (2, n=104) = 9.746, p = .008). There was also a significant linear by linear association between wealth and the use of such cultivars ((1, n=104) = 9.238, p = .003). Moreover, households in the better-off wealth rank were much more likely than those less well-off to be growing both a short season cultivar in addition to a longer season cultivar specifically bred for drought tolerance (25.8% in the top wealth rank, compared with only 3.2% and 4.8% in the poor and middle wealth ranks respectively). In the middle and better off wealth ranks, higher proportions of households were using short season cultivars than drought tolerant ones. This is in line with the much greater availability of short season hybrids Kanyani and DK 80:33 in the shops. Higher use of drought tolerant cultivars was evident in the bottom wealth rank, which probably reflects the fact that most of these households accessed such cultivars through the subsidy scheme (at a shed where coupons were exchanged directly, as described in chapter 4) (see Figure 5.16).



	Poor	Middle	Better off
Drought tolerant	32%	26%	42%
Short season	26%	45%	74%
Either or both	55%	67%	90%

Figure 5.16: Use of drought tolerant and short season cultivars, Kasungu, 2010-2011 (n=104)

These findings suggest that the maize crops of poorer households are likely to be more vulnerable to drought than those with greater wealth. The greater proportion of households in the top wealth rank using both drought tolerant and short season cultivars also reflects the likelihood that these households would be growing a greater number of cultivars than less well-off households. Households in the top wealth rank grew a mean of 1.68 (SD = 0.748) cultivars in the 2010-11 season compared with 1.26 (SD = 0.45) in the middle wealth rank and 1.32 (SD = 0.48) in the bottom wealth rank. While research participants reported that growing more than one cultivar was a risk-reduction strategy, it is clear that this strategy was also more easily accessed by wealthier households.

These findings lend support to the DoI hypothesis that higher socio-economic status and innovativeness are linked. Wealthier households tend to display greater innovativeness with regard to modern maize use, and use of cultivars which are better adapted for drought. However, wealthier households in the area have been less innovative with regard to the rate at which they have given up local maize.

Ngabu

In Ngabu patterns of modern and local maize cultivation varied much less between the two survey seasons. A significant relationship between poverty and growing purely local maize was found in both the 2010 and 2011 survey data, (χ^2 (2, n=122) = 10.69, p = .004, 2010), (χ^2 (2, n=84) = 11.60, p = .003, 2011), and also between wealth and growing modern cultivars, (χ^2 (2, n=122) = 12.12, p = .002, 2010), (χ^2 (2, n=84) = 9.40, p = .004, 2011). This indicates that, in comparison with Kasungu, use of local maize in Ngabu was more strongly determined by household financial incapacity, and other factors determining the selection of local maize were not playing such an important role. A comparison between the numbers of households who had recently given up local maize reveals that a higher proportion of these households were located in the bottom wealth rank (27.3% compared to 15.4% in the middle wealth rank and 13.6% in the better off rank). This indicates that local maize disadoption in Ngabu was following a pattern which aligns with the DoI adopter category hypothesis; poorer households were somewhat behind wealthier households in their disadoption of local maize.

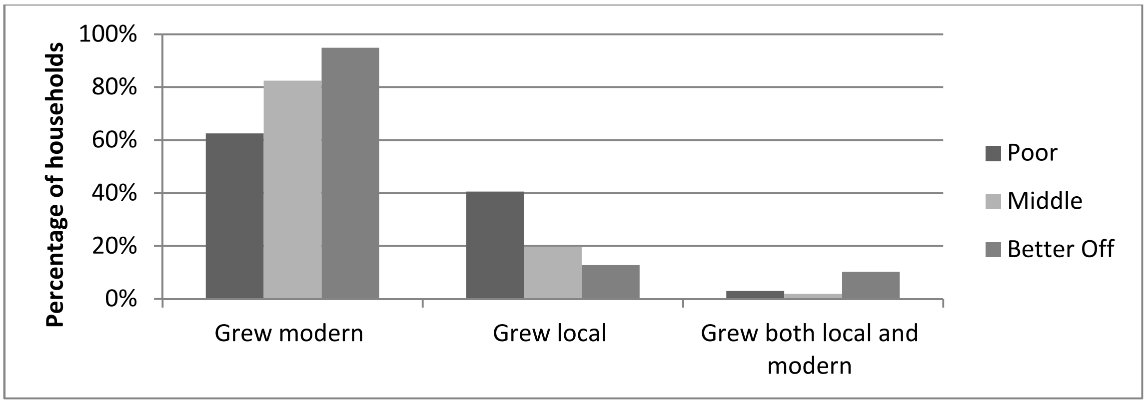


Figure 5.17: Use of modern and local maize by wealth rank in Ngabu, 2010 (n=122)

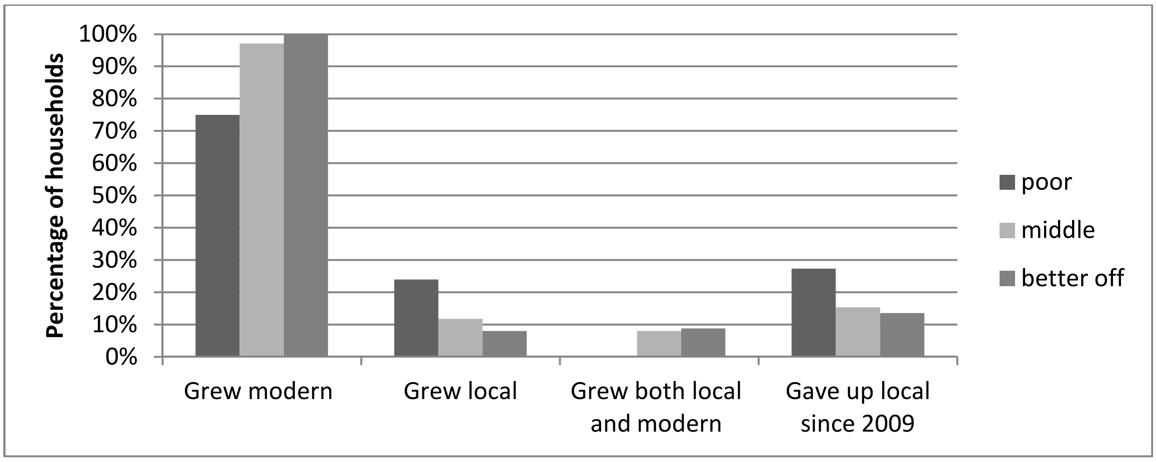


Figure 5.18: Use of modern and local maize by wealth rank in Ngabu, 2011 (n=82)

We have already seen that use of OPV cultivars in Ngabu was negligible (with a single household, which happened to be in the top wealth rank, growing an OPV cultivar in 2011). By contrast, use of hybrid cultivars was very high in all wealth ranks, but with proportionally lower use in the bottom wealth rank. In the top and middle wealth ranks 95.8% and 97.1% used hybrid maize, compared with 75% in the bottom rank. Wealth was found to be significantly related to use of hybrid maize (Fisher's exact test (2, n=103) = 7.273, p = .019).

The use of short season or drought tolerant cultivars amongst households was not significantly related to wealth, and high proportions of households in all wealth ranks were growing cultivars of this type. This was to be expected, considering the climatic pressures governing maize production in the area. Although the relationship was not significant, a greater proportion of households in the bottom wealth rank failed to use drought tolerant cultivars (nearly a third), compared to lower proportions in the higher wealth ranks (a fifth in both cases). As with Kasungu, this finding suggests that the maize crops of poorer households are likely to be more vulnerable to drought.

In line with the lesser role of maize cultivation in Ngabu, households also tended to grow fewer maize cultivars, and growing more than one cultivar was not a production strategy that many households pursued. Nonetheless, the numbers of households growing more than one cultivar were slightly higher in the top wealth rank (mean = 1.17, SD = 0.38) compared with the middle (mean = 1.15, SD = 0.36) and the bottom (mean = 1.04, SD = 0.2).

5.4.3 The Agricultural Input Subsidy Programme (AISP)

The subsidy package represents a huge financial benefit, particularly for poorer households. In 2011 the seed element alone was worth MK 2,390 at equivalent market value (Government of Malawi, 2011). The average market cost for a single 50Kg bag of unsubsidized fertilizer would have been around MK 8,000 (AMITSA). Overall, had households sought to purchase a quantity of inputs from the market equivalent to the subsidy package components they would have had to pay around MK 18,000. This equated to nearly a sixth of the annual income of the average Malawian household in 2011 (UNDP 2011). Annual incomes for poor, subsistence-oriented rural households would have been a fraction of the GNI per capita, and were reported by some respondents to be as low as around MK 5,000 to MK 10,000 per year. Considering the relative value of the subsidy it is not surprising that the AISP is considered to have become so political (Chinsinga, 2011).

In Ngabu 68.7% of households reported never having received subsidy coupons, 16.7% of households reported having received subsidy coupons during the 2010-2011 season and a further 14.3% reported having received coupons in the past, but not in the last year (n=83). The government aimed to allocate coupons to 15% of farm families in Chikwawa district in 2010-2011 (Government of Malawi, 2011), so the amount of coupons that households reported having received in Ngabu is in line with government reported levels of provision to the area. In Kasungu however, 53.3% of households reported receiving subsidy coupons in the previous season, with an additional 16.3% of households having received coupons in the past but not in the last year, and only 28.8% of households having never received coupons (n=104). The Government of Malawi reported intending to allocate 31% of farm households in Kasungu district with subsidy coupons, so the survey findings reveal considerably higher coupon receipt in the area than should have occurred. This section will look at why a disproportionate amount of coupons were received by survey households in Kasungu and evaluate the degree to which receiving coupons affected survey household decisions about whether to use modern maize, how much maize to grow, and how many alternative crops to cultivate. It will also analyse the socio-economic stratification of subsidy coupon distribution amongst survey households, consider how sustainable the effects of receiving the subsidy are for poor households, and look at how suitable subsidy components are for reducing vulnerability to climate hazards in Ngabu.

5.4.3.1 Subsidy impacts on modern maize use

In section 5.42 we saw that there were accelerating trends of local maize disadoption occurring in both the research areas. Accounts of local agricultural histories given by village elders highlighted that government policies had contributed to these disadoption trends in the past:

> *"We used to plant the local maize seed, and then, when Kamuzu came in, he started advising us that the local wasn't good, and that's when he brought modern maize"*
>
> *Elders' focus group Kasungu, Village A*

As well as extension workers coming to promote modern farming techniques, participants in both districts reported that Hastings Kamuzu Banda's government had recruited young men from the villages for a combination of agricultural and military training, and that these individuals had gone on to promote modern maize adoption:

> *"They would pick up people from the village to be Young Pioneers. They would be taken to some place to learn about agriculture in addition to being soldiers... They were being advised, like 'this is the best variety to grow, and you can get it from these shops', so they would go and buy"*
>
> *Elder focus group participant, Kasungu, Village B*

Participants also described food crises that had occurred in the seventies and eighties as a factor which contributed to changes in cultivar use. The government responded to these crises with free distributions of MH12 or MH18, early nationally-bred hybrid varieties. Throughout Banda's rule subsidies meant that inputs were inexpensive and chemical fertilizer was easy to access.

As described in Chapter 2, structural readjustment then removed subsidies and, according to research participants, made inputs hard to access for a time. But the political support for modernising agriculture that characterized Banda's rule has since been continued by a series of national subsidy programmes encouraging the use of maize cultivars and inorganic fertilizer. These subsidies were widely perceived by extension workers and seed industry professionals to be enhancing access to seed and modifying seed preferences amongst Malawian smallholders:

> *"In the past many were refusing even to grow these composite varieties or hybrid, but nowadays they have seen the importance of it. With the coming in of the subsidy programme they are given the seed and they plant it. They appreciate it. Yes."*
>
> *Field extension officer A, Kasungu, 2010*

Many households involved in the research also had positive things to say about the subsidy. For example, the female head of a middle wealth-ranking household explained:

> *"The first time I grew modern maize was through the subsidy programme. Before that I was just growing local maize. I still grow local maize, but only on a small piece of land now, and in the future I might stop because I prefer the modern. The modern maize I have been able to try is good because it has very early maturity. If I didn't receive a coupon I would still try to find the money to buy the modern maize."*
>
> *27 year old female, Village A, Kasungu, middle wealth rank*

However, the survey data reveal that having received a coupon only marginally influenced households' decisions to grow modern maize; most households in both areas grew modern maize regardless.

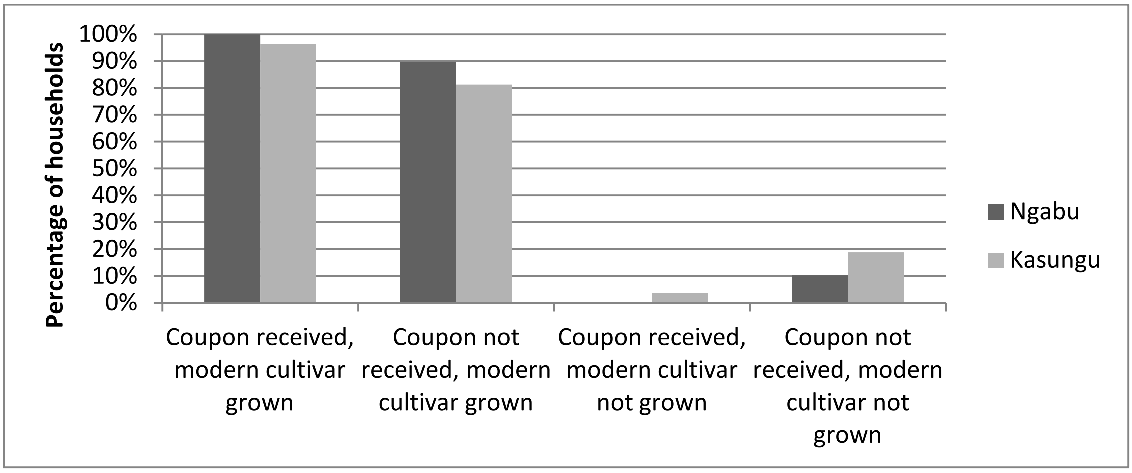


Figure 5.19: Subsidy receipt implications for modern maize use, 2011 survey (Kasungu, n= 104, Ngabu, n=82)

Since the survey also collected information on whether subsidy coupons had ever been received it was also possible to assess differences in the reported cultivar usage of households that had received the subsidy in the past (but not in the previous season) with those who had never received the subsidy. No significant relationship was found in either area between past subsidy receipt and modern maize use, although a marginally greater proportion of households that had received the subsidy in the past chose to cultivate modern maize in the 2010-2011 season than of those that had never received the subsidy (Kasungu n=46, Ngabu n=68) (see Figure 5.20). The data was also used to investigate whether having received subsidy coupons in the past affected choices regarding local maize cultivation in the present. In Ngabu, no households that had received the subsidy in the past continued to grow local maize, compared with 16.1% of households that had never received coupons. In Kasungu past subsidy receipt showed no sustained impact on local maize use. Amongst households that had never received the subsidy, 36.7% continued to grow local maize, and amongst those that had received it in the past (but not in the most recent season), 35.3% did. Whilst having received subsidy coupons seemed to discourage the use of local maize among households in Ngabu, in Kasungu the impact of the having received subsidy coupons in the past on current cultivar choice seems minimal.

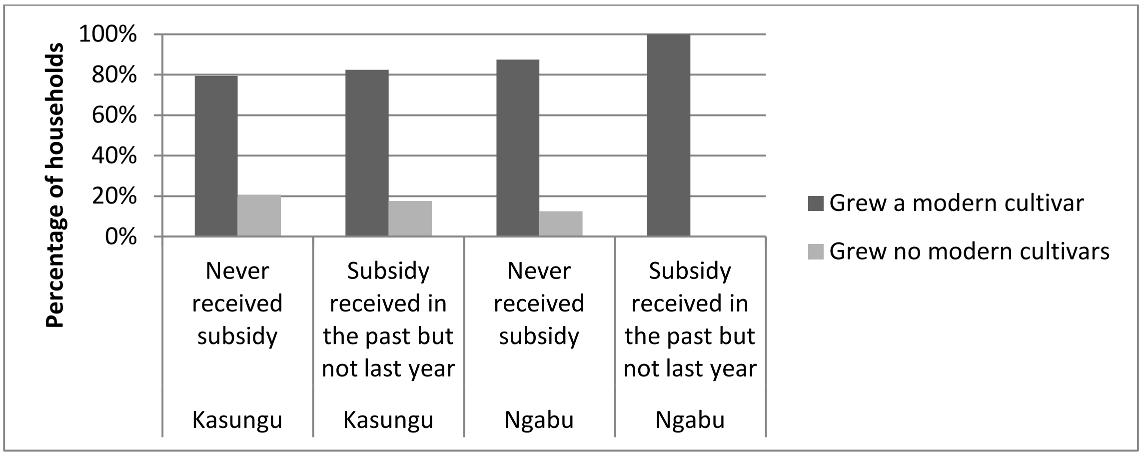


Figure 5.20: Implications of previous subsidy receipt on previous season cultivar selection (2011 survey)

5.4.3.2 Subsidy impacts on household crop diversification

It has been suggested that by enhancing maize productivity the AISP should encourage diversification by reducing the land requirements for maize production and thereby freeing up land to be used for producing other crops (Dorward and Chirwa, 2011). The 2010 questionnaire data was used to assess whether any relationship could be found between subsidy receipt and the area of maize cultivated and number of alternative crops grown, once wealth was controlled for. A significant relationship was found between subsidy receipt and the area used for maize cultivation amongst the poorest households in Kasungu. Within this sub-group, households that had received the subsidy in the past were found to grow maize on a significantly smaller proportion of their land (mean = 0.65, SD = 0.29) than those that had never received the subsidy (mean = 0.87, SD = 0.21) ($F_{(1,20)} = 4.184$, $p = .054$) although it is not possible from the data to ascertain whether having received the subsidy was the cause of the decision to devote less land to maize cultivation. Despite this difference, no significant difference in terms of the number of crops grown could be found between households that had received and had not received the subsidy in the past. No significant differences were found in terms of the land area dedicated to maize relative to subsidy receipt within the middle and top wealth ranks in Kasungu, or in any of the wealth ranks in Ngabu, and likewise, there were no significant differences in terms of the number of alternative crops grown relative to subsidy receipt. The questionnaire data therefore do not offer support to claims that the subsidy enhances diversification.

5.4.3.3 Socioeconomic distribution of subsidy benefits

Although extension workers in both areas reported that the subsidy programme currently aims to target poorer and more vulnerable households with some farming capacity, survey data reveal that in both districts coupon vouchers disproportionately ended up in the possession of wealthier households. The highest proportions of households that had never received subsidy coupons were to be found in the lower wealth ranks.

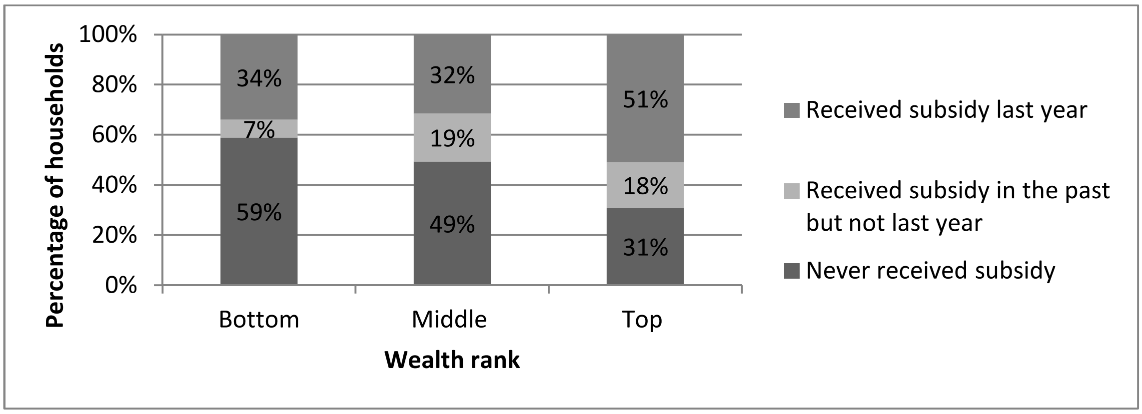


Figure 5.21: Subsidy coupon receipt by wealth rank, 2011 survey, Ngabu and Kasungu combined (n=184)

There was a significant association between household wealth and subsidy receipt (Linear-by-Linear association (1,184) = 6.619, p=.010). The relationship with wealth was positive rather than negative and was thereby the opposite of that intended according to subsidy targeting recommendations.

Qualitative data collected through interviews and participant observations reflect these trends. Better-off households frequently benefitted from the subsidy programme, with some of the wealthiest even managing to obtain, by dint of their social connections, several more coupons than should officially be included in a subsidy pack. Poorer households were bypassed by coupon distribution far more frequently. This issue is reflected in the case studies box below.

Case Study 1: A top wealth-ranking household in Kasungu, Village B
Mr and Mrs X are both in their late sixties and live in a good quality house with an iron roof. The household possesses a range of assets, including around 25 chickens and 5 goats. They own 5 acres of *munda* land and a quarter of an acre of *dimba*. They also possess a mobile phone and a bicycle and are able to apply much more fertilizer to their fields than most of their neighbours. In the past the household was composed of 6 people, including 3 dependents, but now Mr and Mrs X are living on their own because Mrs X has been unwell. They have a diverse income base, usually growing many crops including tobacco, beans, pigeon peas, potatoes, cassava, groundnuts and sweet potatoes. They also usually grow either three or four varieties of maize, including some local as well as OPV and hybrid, so they are ensured a harvest no matter what weather the season brings. They continue to grow local maize because it is poundable and tastes better as green maize than hybrid does. They obtain money through crop sales and Mr X receives a pension from a previous government job. Of the farm crops they grow, they sell maize, tobacco and groundnuts, and can afford to pay for agricultural labour on their land with cash. Fertiliser is their biggest household expense. In a good year their maize stocks will last them until the next harvest, though if their harvest is poor they may run out of maize a month or two early. They have grown a range of maize varieties in the past and judge all the varieties to be good in their own way. They think harvests are more dependent on other aspects like soil, the quantity of fertilizer applied, pesticides and management practices. The couple have a daughter who is an extension worker in Salima. Last year they received three subsidy coupons for maize, two for fertilizer and one for groundnuts. They think the coupons scheme is good; it is benefitting their household:
"Last year we received two coupons for fertilizer, one for legume seed and three for maize. The Chief gave us one of the coupons for maize and the other two we found elsewhere"

Case Study 2: A middle wealth-ranking household in Kasungu, Village A
Mrs Y is 24 years old and she and her husband live in a basic house made of traditional materials with their four children. They do not possess any assets or livestock, but do own two and a half acres of land, including some *dimba* land. They use two acres of their land to grow just one variety of maize (Kanyani) which they buy from town each year with money. Mrs Y would prefer to be growing more than just the one variety as she thinks it would ensure better harvests, but says that if the household has enough fertilizer they can still obtain a good harvest. However, fertilizer is difficult for them to obtain. In a good year their maize stocks will last them for five months, but in a poor year they run out of maize only two months after harvesting. They have frequently experienced poor harvests in the past and turn to *ganyu* in order to find money to purchase maize to eat. Maize for food is their biggest household expense. As well as maize, Mrs Y's household also grows soya and cassava for consumption as well as sale if there is enough. Other than *ganyu*, the household makes mud bricks to sell. This is an activity which the Government in Malawi has been trying to discourage because it is considered to drive deforestation due to its high requirements for firewood.
"People are now relying more on *ganyu* because they don't have enough inputs to farm their own fields properly. Sometimes money for fertiliser is scarce and by the time we obtain some it is already too late to apply it to the crops. The subsidy has had no impact on my household because we don't receive coupons."

Case Study 3: A bottom wealth-ranking household in Kasungu, Village A
Mr Z is 19 years old and lives with his mother and two siblings in a small house built of traditional materials. The family possess no livestock or assets but they do own 2 acres of *munda* land on which they grow maize as their only crop. The household grows two varieties, local maize and some OPV that they have been saving for several years. Their harvest can last them for 7 months in a good year, but usually it only lasts six months. Farming is difficult because they lack fertilizer and Mr Z felt that every year their harvest was to some extent disappointing because of this. The family mainly relies on *ganyu* to earn money but when they have the resources they brew beer and make cakes to sell. Their biggest expense is maize for food.
"We have never received a starter pack, so the subsidy program does not benefit us."

Box 5.1: Case studies illustrating wealth by subsidy coupon receipt

The failure of the subsidy program to reach target beneficiaries can be explained in terms of the coupon distribution strategy being employed. We saw in chapter 4 that extension workers are supposed to assist village chiefs with coupon distribution. However, comments made by some extension workers indicated that the lion's share of the task is left to the chiefs or village development committee members.

For the subsidy programme, the orders are given from above saying that a certain number of people are required, so we go to the village development committees and we just leave the instructions... Now the development committee are the ones who choose the ones who should be the beneficiaries of the subsidy programme.

Extension officer, Ngabu

Whilst these individuals might be well-placed to judge which households should qualify to receive coupons, they also face social pressures which might result in the diversion of coupons towards more powerful households. The task of selecting beneficiary households is a politically difficult one. It was described by one headman as follows:

"The subsidy scheme is a big burden to me, as the Chief. I don't like it because I do like a lot of people, but the number of beneficiaries, they are few. So, many people are coming to my house and complaining. The people that I don't have grudges with, the ones who are good, had it been that I was able to distribute to who I wanted, I would have just given them the coupons, but they come here with complaints, so to me it's a burden. So I think instead, maybe they should just reduce the price of all these farm inputs, so anyone who has just a small amount of money they can just go and access his or her own. They should not be targeting the poor with the subsidy program, because to us, as a family, it's a burden."

Village headman, Village B, Kasungu

These political difficulties can lead to further compromise of the programme's intentions. As discussed in Chapter 4, recipient households are supposed to receive a pack of four coupons. However, households were often instructed by chiefs to share packs with their neighbours:

"According to the law, everyone is supposed to receive three coupons, two for fertilizer, and one with which to buy the maize seed. But because of the unity in this village, some people they receive coupons for fertilizer, and some people for maize. It's not really encouraged that people should receive less than all three, people are supposed to receive all of them, but it is because it is better for unity in the village that they are divided up."

Seasonal record keeper, male, aged 40, Kasungu

This practice was frowned upon by extension workers since:

"It doesn't work when they share the inputs in that way because they are maybe left with only urea, when according to recommendations they are supposed to apply both types of fertilizer"

Extension manager, Kasungu

In addition to households with greater productive potential capturing subsidy coupons the data also indicated (as discussed at the start of this section) that disproportionate allocations of coupons were being captured in Kasungu. Whilst this partially reflects the tendency for households in this area to share out coupon packs, it also is seems likely that corruption led to fraudulent coupon use in Kasungu. Whilst 90,325 coupons were allocated to the district, a total of 130,458 were redeemed in 2010 (Government of Malawi, 2011). This issue was not unique to Kasungu. Whilst only 1.6 million official maize seed vouchers were issued in 2010, a total of 1,988,066 maize seed vouchers were ultimately returned to the Government of Malawi Logistics Unit (Government of Malawi, 2011). That 20% of redeemed coupons were fraudulent in 2010 is evidence of the huge scope for corruption within the scheme.

A level of acceptance of elite subsidy capture was evident in the comments of some interview respondents. A wealthy commercial farmer, based in Lilongwe, commented on the targeting situation as follows:

"Giving inputs to the poorest of the poor is pointless as they have so little land and are so low on labour power that they cannot really benefit from them. If the subsidy had wound up where it was supposed to wind up we would not be seeing the yield increases that we have seen. However, the subsidy all winds up with commercial or semi-commercial farmers, or at least, the richer farmers who have more land and more capacity."

Commercial maize farmer, Lilongwe

Difficulties with targeting perhaps reflect the fact that current recommendations represent a compromise between the opposing policies of the Starter Pack and the TIP, which respectively sought to boost productivity and provide social safety nets. The current aim of the AISP to directly achieve both ends is probably unrealistic. The most vulnerable households are unlikely to be the most potentially productive. For greater clarity on the issue and the possibility of more effective targeting, it might be preferable to target these two types of household with separate programmes.

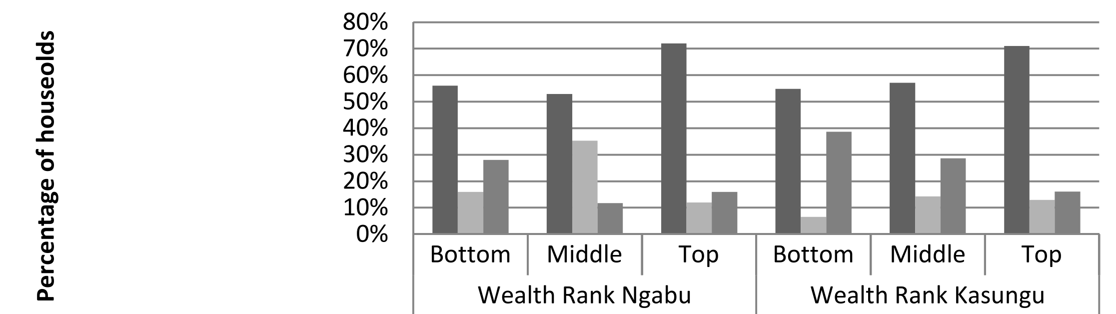
5.4.3.4 Sustainability in poorer households

Despite the generally positive views espoused of the subsidy scheme, based on the results of the 2011 survey, the sustainability of subsidy impacts for poorer households seems questionable. Some households indicated this in interviews:

> *"If it were not for the subsidy programme I wouldn't be able to afford to buy modern maize, but I would prefer to use it"*
>
> *Female head of household, middle wealth rank, Kasungu, Village A*

In Ngabu and Kasungu 18% and 19% of households respectively indicated that if they received a coupon next year they would grow modern maize, but would otherwise grow local. Further households suggested that without a coupon they would grow saved rather than purchased seeds (mainly from older national hybrid cultivars MH18 and MH17). Combining the data from both districts, proportions of households that were likely to switch from modern to local or saved seeds without a coupon were higher in the lower wealth ranks (bottom=43.2%, middle=36.4% and top=20.5%, n=44). Whilst hypothetical responses about future behaviour can be unreliable, and households may have misrepresented their probable future choices to emphasize their poverty, results indicate that for some households modern maize would be financially unattainable in the absence of the subsidy. A small number of households that had disadopted modern maize and re-adopted local were encountered during fieldwork.

> *"We don't have any income, so we can't buy modern maize anymore, so we use the local, because we can recycle that every year"*
>
> *Elderly couple, middle wealth rank, Kasungu Village B*



	Ngabu Bottom	Ngabu Middle	Ngabu Top	Kasungu Bottom	Kasungu Middle	Kasungu Top
Would not change cultivars	56%	53%	72%	55%	57%	71%
Would change to a different modern cultivar	16%	35%	12%	7%	14%	13%
Would change from modern to local or saved	28%	12%	16%	39%	29%	16%

Figure 5.22: How not receiving subsidy coupons would affect use of modern maize next year (Kasungu n=107, Ngabu n= 84)

5.4.3.5 Contextual sensitivity of the AISP

Ngabu is notable as belonging to a part of Malawi which has traditionally relied more on millet and sorghum than maize as staple foods. Despite a near universal preference for maize, millet and sorghum can, far better than maize, withstand the high temperatures and recurrent droughts which are common in the Shire valley. Many participants suggested that these conditions have been worsening over the past decade. Consequently, most smallholders who were interviewed acknowledged that they faced extreme difficulties in producing maize as a dryland crop (see Table 5.1).

Table 5.1: Perceptions of trends in maize production

District	Good maize yields are becoming easier to achieve	Good maize yields are becoming more difficult to achieve
Kasungu (n=121)	44%	56%
Ngabu (n=123)	3%	97%

In these conditions, the utility of the subsidy package components is greatly reduced. For example, village participants complained that the use of fertilizer was ill-advised in the area since it caused young plants to become more vulnerable to drought.

"Our problem here is drought, not soil fertility. The soils are fertile here anyway and we don't use fertilizer. In fact, using fertilizer can even make the plants more vulnerable to drought... Let's be honest, when we are given the fertilizer we just sell it on"

Elderly male household head, top wealth rank, Ngabu

Amongst households that do wish to use fertilizer, there was evidence that the subsidy makes manure and compost applications comparatively more expensive in terms of both labour and cost. For some households, this unfortunately incentivizes the use of chemical fertilizer over traditional organic fertilizers, which would provide the much-needed additional benefit of enhancing the water-retaining capacity of the soil.

"In monetary forms manure is expensive, for inorganic fertilizer for growth if I have a coupon I will just have to use 500 kwacha for growth and then another 500 kwacha for the finishing, for the flowers and the like, so it will be like 1000 kwacha for the farm. But for manure I would need approximately 3000 kwacha to apply to the whole field, so manure would be comparatively expensive for me to use, because of the subsidy."

Male household head, 28, Ngabu

The fact of receiving subsidy coupons also incentivizes maize cultivation amongst households that might otherwise concentrate on less risky pursuits. The same participant quoted from above also commented that:

"If the government is going to continue distributing the subsidy, I will continue to cultivate maize, but if the government stops distributing the subsidy, then it will be the end of maize cultivation for me."

Male household head, 28, Ngabu

The subsidy programme delivers inputs to Ngabu at the same time as they are delivered elsewhere throughout the country; at the start of the season for dryland maize production. Winter maize production, which is carried out in *dimba* areas begins its season several months later. Respondents repeatedly emphasized that only winter maize production has any real potential in Ngabu, hence it might be more appropriate for the subsidy programme to deliver inputs at the start of the winter season instead:

> *"In our area, most farmers, yes they do plant maize in the uplands, but due to climate change, they yield nothing, and that's why people are making the decision to plant in the dimbas. Those farmers that do plant in the upland areas are not doing well as the subsidy program would have intended it to be"*
>
> *Extension manager, Ngabu*

Since dryland maize cultivation is a particularly risky mode of crop production in the area, it is perhaps questionable why the AISP continues to encourage farmers to invest their efforts in producing it here, rather than providing subsidized inputs for types of agricultural production that are better suited to the region. One NGO staff member working in the area summarized it thus:

> *"Looking at the difficulty people have in producing maize in the area, it is true that dry field maize production is not really assisting food security here. I believe the subsidy could be better targeted towards encouraging winter production of maize along the river banks in the area, as this sort of production has excellent potential. But the reason it's like this is because the subsidy programme has a blanket approach to seed distribution."*
>
> *NGO Regional Manager for the Shire Valley*

5.5 Discussion and conclusions

This chapter began with a presentation of the production characteristics of Ngabu and Kasungu which illustrated that the two areas differ significantly with consequences for the potential to produce maize and for the degree of vulnerability to climate hazards faced by local populations. Studies seeking to determine regional vulnerability hotspots have analyzed the extent to which rainfall anomalies lead to reductions in harvest, thereby identifying certain areas as vulnerable by dint of their greater sensitivity, exposure and lower adaptive capacity for coping with climate hazards (Adger, 2006, Simelton et al., 2009, Antwi-Agyei et al., 2012). Although yield data was not available to use in this study, self-reported measures of farm household harvest sensitivity (such as inter-annual maize yield variability), measures of exposure (the number of times drought or flooding had affected harvests), and measures of adaptive capacity (whether or not adaptations had been undertaken in the past) were used to make an assessment of vulnerability. Whilst many households in Ngabu made efforts to reduce the sensitivity of their farming systems by relocating and/or reducing maize production, the findings of the survey reflect suggestions within the literature that households in the area are more exposed to drought (Mijoni and Izadkhah, 2009, Chidanti-Malunga, 2011). Adaptive capacity is considered a difficult quality to measure (Luers, 2005, Eakin and Bojorquez-Tapia, 2008), but some studies have used past adaptations as a proxy for household adaptive capacity (Below et al., 2012), and this approach was followed here. Households in Ngabu were less likely to report having undertaken adaptations in the past, and notably, diversity of production and livelihood options, considered an important component of adaptive capacity (Fazey et al., 2010, Brooks and Loevinsohn, 2011), was lower than in Kasungu. These findings support the conclusion that Ngabu is more vulnerable to current climate variability and also to the probable impacts of climate change and should therefore be considered as a priority area for programmes of adaptation. However, since the vast majority of state financial support for agriculture is currently channelled through the AISP, and since the AISP encourages maize production, its impacts could be said to be increasing rather than reducing vulnerability to climate variability for some farmers in Ngabu.

The impacts of the AISP were also explored in terms of cultivar choice, sustainability and contingent impacts on maize cultivated area and crop diversification. In both Kasungu and Ngabu the results of the analysis suggest that the AISP has a greater effect on decisions about maize cultivation in poorer households than in higher wealth ranked households. Qualitative and questionnaire data indicated that receiving the AISP had more impact on maize cultivar selection in poorer households than it did in wealthier households. In Kasungu, the poorest households that received the subsidy were more likely to grow maize on a smaller proportion of their land than those that did not receive the subsidy. This was not associated with the uptake of more alternative crops to maize however, suggesting that receiving the subsidy alone is not sufficient to encourage diversification in the poorest households.

Given that Ngabu and Kasungu display such different production profiles, where similarities are found it is reasonable to assume that these characteristics may be broadly representative of smallholder production nationally, and are not merely coincidental between the two areas. In both areas land distribution was highly skewed. Wealthier households also had greater access to cultivars and were more likely to capture benefits from the AISP. Highly skewed land distributions are characteristic of neighbouring Southern and Eastern African countries (Jayne et al., 2003) and it is logical to assume that such inequalities may pose problems for agriculture-dependent poverty reduction strategies. The targeting aims and actual impacts of the AISP should be considered in this light. It was noted earlier that the targeting goals of the AISP are somewhat contradictory and that finding poor and vulnerable households with access to sufficient land and labour to raise their production levels significantly may be difficult in the rural Malawian context. But contrary to targeting aims, the majority of subsidy coupons end up with better-off households in a process that could be thought of as elite capture. Whilst decisions about coupon distribution are devolved to the local level, they are often influenced by existing power relations which mean that the poorest households rarely get put first. Problems of corruption within the subsidy scheme appeared to occur at regional and national levels too. Issues of elite capture have been found to create problems for poverty reduction in a range of African contexts, and arrangements to allow greater accountability has been proposed as a solution (Crook, 2003). However, it is hard to see how structures for greater accountability within the AISP could be achieved without prohibitively increasing programme costs.

The chapter also revealed that predictions about adopter characteristics based on the framework presented by E.M. Rogers in "The Diffusion of Innovations" (2003) are mostly accurate. Wealthier smallholders' maize cultivar usage in the main aligns better with ideals about 'modern' maize production than does the usage of poorer households. Wealthier households are pursuing strategies for reducing the vulnerability of their maize crop to drought, by growing more than one variety and by investing in drought tolerant and short season cultivars. However, the sustained use of local maize within the top wealth rank in Kasungu suggests that it would be incorrect to assume that socioeconomic superiority necessarily confers greater 'innovativeness'. Perhaps, instead, greater socio-economic status confers greater capacity to absorb risks and as such households have therefore been able to continue cultivating a less productive cultivar for longer on the basis of cultural preference. This leaves a question mark over the adequacy of Rogers' theory and points to financial and knowledge-based constraints as the main explanations for the cultivar adoption patterns observed, rather than an innate resistance to change amongst late adopting households.

In both areas there were examples of poorer households adapting their production strategies more quickly than wealthier households. As well as the sustained use of local maize in the top wealth rank in Kasungu, poorer households were quicker to disadopt maize cultivation in Ngabu in order to try to quell harvest failures, and Ngabu, as an area, was characterized by greater levels of modern maize use than Kasungu. These findings lend weight to suggestions that adaptive capacity is determined by more than just wealth, and suggest that other pressures, including cultural preferences, are also important determinants (Adger et al., 2009, Burch and Robinson, 2007). They also indicate that the risk perceptions of wealthier and poorer households are likely to differ and influence the speed with which adaptations to curtail loss are undertaken.

The different cultivar use patterns that were observed in the two areas appear to be driven by different forces. Whilst households in Kasungu were responding to the greater availability of new maize cultivars by adding additional varieties to their portfolios and continuously experimenting, household production strategies in Ngabu were being squeezed, with very few suitable cultivars available for use in the area, and a narrowing pool of crops that could cope with local production conditions. These differences suggest that choices in Ngabu were driven by necessity or push factors, whilst choices in Kasungu were being driven by pull factors, or "voluntary and proactive reasons", resulting in declining and increasing diversity respectively (Ellis, 2000, p.291). This consideration further illustrates Ngabu's comparatively greater vulnerability.

Lower use of modern cultivars and access to information about modern cultivars within poorer households suggests that increasing the range of drought tolerant cultivars available may not necessarily directly benefit the most vulnerable households. The fact that adoption patterns do predominantly reflect the DoI hypothesis about early adoption by socio-economically more powerful individuals, and that the subsidy scheme (due to elite capture) is not effectively reaching the most vulnerable should be of concern to those wishing to reduce climate change vulnerability amongst the poorest farmers. The indications are that new ways need to be found to diffuse cultivars and knowledge about cultivars which expand cultivar selection capacities and give rise to greater levels of uptake amongst the poorest households.

Chapter 6 - Factors Determining Adoption and Adaptation

6.1 Introduction

The evidence presented in Chapter 5 has confirmed that poverty is a key barrier to cultivar adoption in the two research areas. The current chapter now seeks to better understand the specific drivers of cultivar change which create the nuanced outcomes observed in each area. An investigation of adoption drivers requires engagement with perceptions held by stakeholders within the seed system. Perceptions, and the social and cultural factors which influence them, have been increasingly highlighted as key determinants of adaptation outcomes (Dessai et al., 2004, Moser and Ekstrom, 2010, Kuruppu and Liverman, 2011). These human-oriented factors are often perceived as separate from 'scientific' understandings of climate change, and operate at, and are associated with, different scales of influence; the local and the global respectively (Vogel et al., 2007, Ayers, 2010, Khan and Roberts, 2013). Better engagement between the social and the scientific is now recognised as essential for processes to lead to successful adaptation (Lorenzoni et al., 2000, Challinor, 2008).

In the discussion section of Chapter 5 push and pull factors were proposed as a means of categorizing and helping to explain the drivers of cultivar adoption that were operating to produce the uptake patterns observed within the two research areas. The concept of push and pull factors is predominantly employed within migration studies, as a means for explaining the forces that drive people away from one location and entice them towards somewhere else (Hare, 1999, Warner et al., 2010). Within innovation studies, the concept of pull factors has arisen within the "demand-pull model" of innovation (Godin and Lane, 2013), whereby user-demand stimulates the development of new technologies. This is opposed to models where the supply of new innovations stimulates demand amongst users, as is the case within linear models such as the DoI framework (Rogers, 2003). However, as used here, push and pull factors do not reflect demand-pull usage within innovations studies, and instead mimic the migration studies application, implying the environmental factors and technology characteristics which deter farmers from using one cultivar or attract them to the use of another. Similarly, Ellis (2000) draws parallels between push and pull factors and the operation of necessity or choice as determinants of rural livelihood diversification strategies. Theoretically, as shall be seen in what follows, pull factors appear to signal enhanced system diversity and therefore support greater resilience, whilst push factors appear to reduce diversity and therefore signal declining resilience.

It has been noted that better use can and should be made of historical meteorological data to enhance farmers' abilities to adapt their production strategies to current climate variability, and that this can form an essential first step towards enabling longer term adaptation to climate impacts in future (Cooper et al., 2008). This chapter uses basic statistical techniques and simple crop modelling to contrast evidence about changing climatic production conditions based on historical climate data with the perceptions of climatic change held by research participants. Doing so reveals the gaps that lie between perceptions and scientific measurements of change, as well as indicating how such information can be used to enhance the selection of maize production strategies in each area and potentially improve crop productivity outcomes.

Chapter 5 part-answered objective three of the thesis by identifying major barriers to cultivar adoption within smallholder households. This chapter presents material which meets the rest of this objective, by identifying drivers of adoption decisions within each of the study areas. It also provides evidence for better understanding the role of cultivar adoption as a climate change adaptation strategy based on an assessment of perceptions of current climate trends and of the concept of 'climate change' held by stakeholders within the national seed system.

6.2 Chapter objectives

1. How do perceptions of 'push and pull factors' affect decisions about cultivar adoption in each area?
2. To what extent do these drivers of adoption decisions lead to successful adaptation to local climate conditions?

6.3 Methods

This chapter combines an exploration of local farmers' perceptions of the factors driving changing maize yields and their contingent cultivar adoption (and other adaptation) decisions with statistical analysis of local historical rainfall and temperature records and some computersimulated maize yields derived from them. This combination of methods enables an assessment of the degree to which meteorological factors are driving changes to maize yields (and perceptions of such changes), and allows an assessment of the extent to which scientific measures and human experiences of meteorological change are aligned, with implications for the types of adoption and adaptation strategies that are pursued.

Perceptions data were collected via questionnaire surveys, semi-structured interviews and focus groups with local farmers, extension workers, and other stakeholders within Malawi's maize seed system during fieldwork in 2010 and 2011. Survey data were analyzed quantitatively using the statistical analysis software package, PASW18 (Allen and Bennett, 2010), and qualitative data were analyzed thematically using QSR's qualitative data analysis software package, NVivo 9 (Gibbs, 2002, QSR International Pty Ltd, 2010).

Daily climate data were obtained from Malawi Meteorological Services. In the case of Ngabu, a daily rainfall dataset, recorded at Ngabu Agricultural Research Station, and dating from 1st January 1960 to 30th April 2011 inclusive, as well as datasets of daily maximum and minimum temperatures dating from 1st January 1971 to 31st December 2005, were provided. For Kasungu, datasets recorded at Kasungu Airport of daily rainfall from 1st January 1961 to 30th April 2011, and of daily maximum and minimum temperature from 1st January 1983 to 31st December 2005 were provided. The rainfall data were analysed in Excel and PASW18 using statistical methods, and were used in combination with the daily temperature data to produce climate files for use within FAO's Aquacrop 4.0 program (Steduto et al., 2009). Aquacrop was used to simulate seasonal maize yields using crop files based on a generalized maize model (included as part of the Aquacrop programme files) that has been assessed for reliability across a range of environments (Heng et al., 2009). The growing degree days of this generalized maize model were adjusted to produce shorter and longer season cultivar files from which yield simulations could be compared.

6.4 Results

6.4.1 Pull Factors

Pull factors are those which attract maize farmers to adopt new cultivars, and as such revolve around the desirability of traits associated with new cultivars.

Kasungu

Households undertaking the 2010 survey were asked to name the characteristics they considered the most important when selecting a maize cultivar to grow. Respondents were free to give multiple responses. In order of popularity, the five most frequently cited characteristics were good storage, early maturity, pest and disease resistance, high yields and large grains (see Table 6.1 below). Good storage and pest and disease resistance are features normally associated with local cultivars by dint of their hard, flint kernels, and are characteristics that seed-breeders have found hard to emulate in modern cultivars (Smale and Jayne, 2010). The fact that respondents highlighted these preferences suggests that the attractiveness of these traits has been sustained over time, and that, in the absence of modern cultivars providing such characteristics, local cultivars are likely to still have a draw for smallholders in Kasungu.

The fact, however, that early maturity appeared almost as often as good storage is also significant. Local varieties are considered to be slow-maturing on a nearly universal basis (Magorokosho, 2006). Preferences for faster maturity therefore need to be met by modern cultivars. At the time of data collection, no single cultivar was available in Kasungu that effectively combined early maturity with full flintiness (although some modern cultivars classed themselves as semi-flint). Preferences for flint-textured maize as well as early maturity would therefore encourage farmers to plant multiple cultivars (Lunduka et al., 2012). Indeed, as we saw in Chapter 5, many households did choose to grow a combination of local and modern cultivars. This strategy was more common amongst better-off households, presumably because they could better afford the extra cost, land and labour perceived to be associated with growing multiple cultivars, as well as absorb the risk of intermittent harvest shortfalls likely to be incurred by continuing to cultivate local maize.

Table 6.1: Preferences for cultivar characteristics, Kasungu 2010 (n=81)

Cultivar characteristic	*Percentage mentioning this characteristic*	*Number of responses*
Good storage	38.3%	31
Early maturity	34.6%	28
Pest resistance	21.0%	17
High yield	14.8%	12
Large grains	9.9%	8

During the second phase of fieldwork in 2011, households participating in the survey were asked to identify the reasons why they had grown the cultivars they grew in the 2010-2011 season. Again, the survey used an open-ended questioning technique so that respondents were unrestricted in their choice of explanatory reasons, and coding was carried out following data collection. The results are shown in Figure 6.1 below.

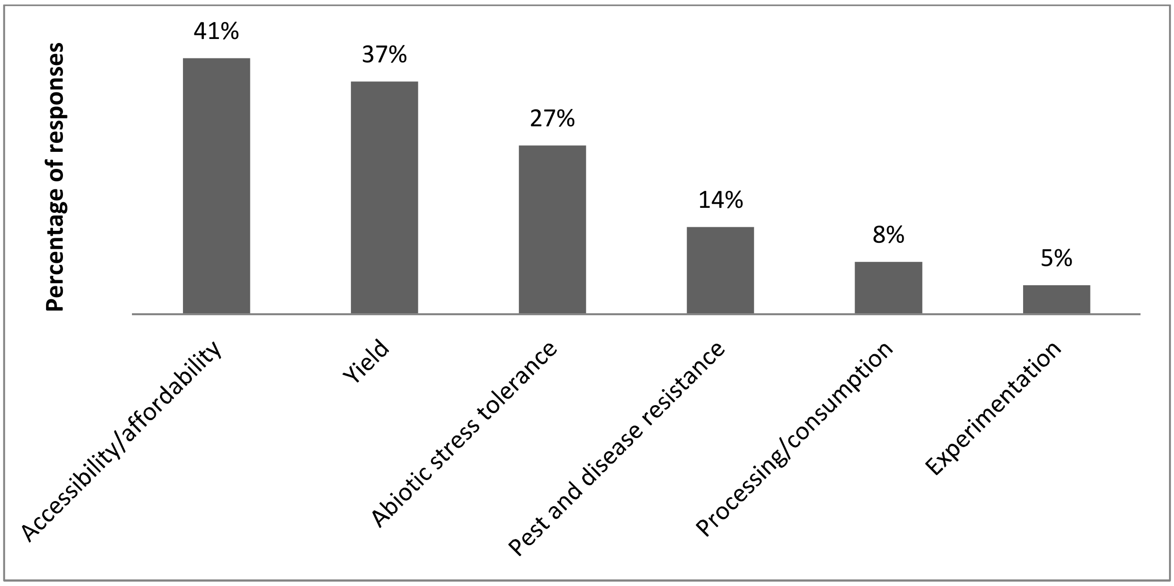


Figure 6.1: Reasons for cultivar selection in 2010-2011, Kasungu (n=107, responses=142)[7]

The high number of households indicating that they had selected to grow a cultivar on the basis of accessibility or affordability reveals that for many households cultivar choice was constrained, and underlines the significance of the Agricultural Input Subsidy Programme as a determinant of maize cultivar usage in the area. Yield was the next reason respondents identified, followed by traits contributing to stress tolerance and pest and disease resistance. When combined, concerns about abiotic and biotic stress tolerance surmount concerns about yield, indicating that even in a productive area such as Kasungu smallholders do not find themselves in a position to consider yield above all else.

[7] The survey question was open-ended, and responses were coded into the categories displayed at a later stage. The responses given were coded as follows: Affordability/accessibility = “Seed was subsidised”, “Seed was cheap”, “Seed was easy to get hold of”, “Seed came from a friend”, “Seed was recycled from last year”, “Seed was subsidized and there was no MK100 top-up to pay”, “We have always grown this cultivar”; Yield = “High yields”, “Big Cobs”, “2 Cobs per stalk”, “Big Grains”; Abiotic stress hardiness = “Early maturity”, “Drought resistance”, “Needs little fertiliser”; Pest and disease resistance = “pest and disease resistance”; Processing /consumption = “Good for nsima”, “Poundable”, “Like the local maize”; Experimentation = “Trying out for the first time”; Other = “Best for dimba”.

Ngabu

In Ngabu respondents reported preferring a more unified range of cultivar traits than in Kasungu. Again, respondents were free to provide multiple responses, and 131 responses were provided by 121 respondents, with early maturity being by far the most commonly cited important feature, followed by large grains and high yield.

Table 6.2: Preferences for cultivar characteristics Ngabu 2010 (n=121)

Cultivar characteristic	*Percentage mentioning this characteristic*	*Number of responses*
Early maturity	73 %	88
Large grains	12%	14
High yield	7%	9

When respondents in 2011 were asked to identify the reasons for their selection of the maize varieties they had cultivated in the 2010-2011 season, early maturity and drought tolerance also featured prominently.

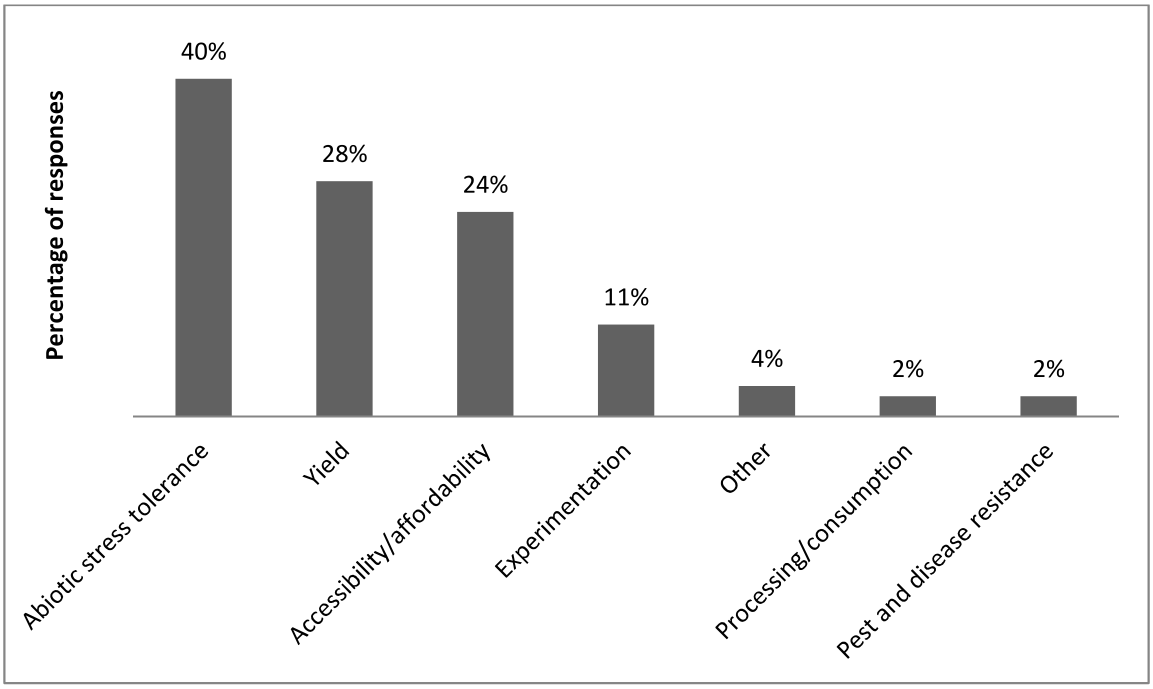


Figure 6.2: Reasons for cultivar selection in 2010-2011, Ngabu (n=83, responses = 92)

Within these results the low level of importance attributed to pest and disease tolerance contrasts notably with Kasungu, but simply reflects the fact that stocks are not expected to last more than a few months, and so storage is not a key consideration for cultivar selection within

Ngabu. Whilst susceptibility to pest and disease attacks disincentivises the cultivation of Kanyani in Kasungu, the lack of storage requirements in Ngabu means that this factor does not detract from Kanyani's attractiveness to farmers. Likewise, due to low concerns about storage, and therefore pest and disease resistance, local maize cultivars, which offer these traits, have less going in their favour in Ngabu. As was the case in Kasungu, yield appeared infrequently as a response to the 2010 survey question about cultivar traits, but appeared more frequently in responses to the 2011 question about why cultivars had been chosen. Yield is ultimately the trait with which smallholders are most concerned, as the following quote demonstrates.

> *"The first thing is hunger; that's what motivated us to do farming,"*
>
> *- Participant at local agricultural history focus group, Village A, Kasungu*

However, yield and stress tolerance traits are poorly distinguished by smallholder producers, since unlike seed breeders, they do not get to assess cultivars in ideal growing environments.

6.4.2 Push Factors

Kasungu

In Kasungu households cited their dissatisfaction with the performance of particular maize cultivars and the changing production environment as reasons for changing cultivars. The poor performance of local maize was frequently cited as a reason for abandoning it.

Of the 107 respondents surveyed in 2011, 74 respondents (69.2%) indicated that they considered local maize the worst they had ever grown, and only 12 (11.2%) considered it to be the best. Whilst survey respondents indicated that positive perceptions of the benefits of local maize were sustained in the area (for example, 84 or 78.5% of respondents in the same survey ranked local maize as the best cultivar for making nsima, and 83 or 77.6% considered it best for pest resistance), a vocal number of focus group participants placed considerable emphasis on the idea that local maize was no longer suitable for production, and that farmers had predominantly moved away from cultivating it.

> *"Local maize cultivars are not in abundance any more, and if people are growing them they are just growing them for consumption, but many people now grow modern maize because most modern cultivars have early maturity and they respond more with fertilizer. Truthfully the local maize seeds these days are not grown in abundance"*
>
> *Agricultural timeline focus group, village A, Kasungu*

Local maize was considered to be undesirable because it was late-maturing, low-yielding and because the plants grew too tall.

"People don't like the local varieties because they grow too tall and it takes a long time to get mature"

Agricultural timeline focus group Village A, Kasungu

The incidence of a mutation present within local maize crops that causes very tall plants to grow which fail to produce cobs has also been reported in the results of agronomic trials comparing landraces of maize from Malawi and Zambia with modern cultivars (Magorokosho, 2006).

As already stated, opinions on changing trends in maize production were far from unified in the area. A large minority of respondents perceived that it was becoming easier to attain a good maize harvest (38.3%) (n=81, 2010 survey data). Of those that took this view, just over two thirds indicated that this was due to improved availability and quality of agricultural inputs, whilst the rest attributed it to better rainfall (n=31). Of the remaining 61.7% who perceived increasing difficulty, just over half indicated that this was because they were unable to access inputs, 41.3% indicated that it was due to problems with the climate, and the remaining 6.5% identified other reasons (n=50). Overall, inputs figured in 53.1% of responses to this section of the questionnaire, whilst climate figured in only 33.3%, broadly indicating a greater preoccupation with inputs as the predominant determining feature of agricultural production in the area (n=81).

Many areas in Malawi suffer from exhausted soil fertility (Snapp et al., 1998), and the fact that soils in the Kasungu area did not possess sufficient fertility to attain a good maize harvest was a topic addressed by focus group participants:

"Before we started using fertilizer people would harvest, but not a lot. We would have to plant on a large piece of land to have a good harvest. And then after independence that's when Kamuzu brought the technology... and that's when people started planting on a smaller piece of land and harvesting the same amount that they used to harvest on a large piece of land. Nowadays the earth is used to the fertilizer use. That's why today we can't cultivate without any fertilizer"

- Local history focus group, Village B, Kasungu

Whilst lowered soil fertility mainly encouraged fertilizer use, (an issue with which most households were heavily preoccupied[8]), it also influenced perceptions on the suitability of local maize, which some considered to be less responsive to fertilizer, and therefore to be out of step with contemporary farming conditions.

> *"Local maize was well adapted to soils that had natural fertility available. As this natural fertility is now gone, there is no point in growing local maize. It is less responsive to fertilizer, and the yields you get are small"*
>
> *-Maize production problem ranking, Village B, Kasungu*

Figure 6.3 reveals that respondent households within different wealth ranks were relatively evenly split in their perceptions about whether it was becoming easier or more difficult to get a good maize harvest, although the proportion of respondents perceiving easiness grew slightly in line with the level of household wealth.

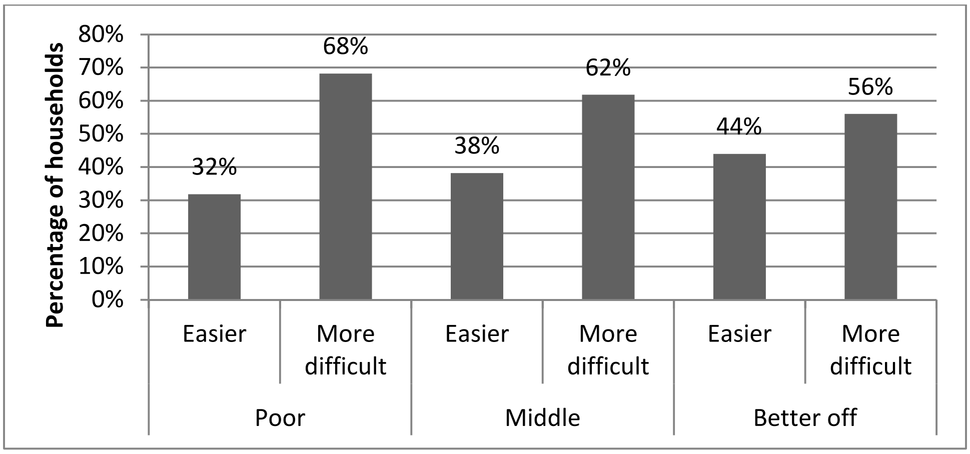


Figure 6.3: Perceptions of changing facility of maize cultivation, Kasungu, 2010 survey

However, amongst households that perceived increasing difficulties in maize production, there was a clear and significant connection between wealth and perceptions about the cause of this trend. Figure 6.4 shows that better-off households were significantly more likely to attribute problems with harvests to the climate, whereas households in lower wealth ranks were more likely to attribute these problems to their inability to access inputs[9].

---

[8] 48.1% of respondent households listed fertilizer as the most important item their household needed to purchase in the 2010 survey.

[9] Better off households were significantly more likely to attribute increasing harvesting difficulties to climate: χ^2 (2, n=50) = 10.45, p=.005, whilst less well off households were significantly more likely to attribute increasing harvest difficulties to their inability to access inputs: χ^2 (2, n=50) = 6.95, p=.031.

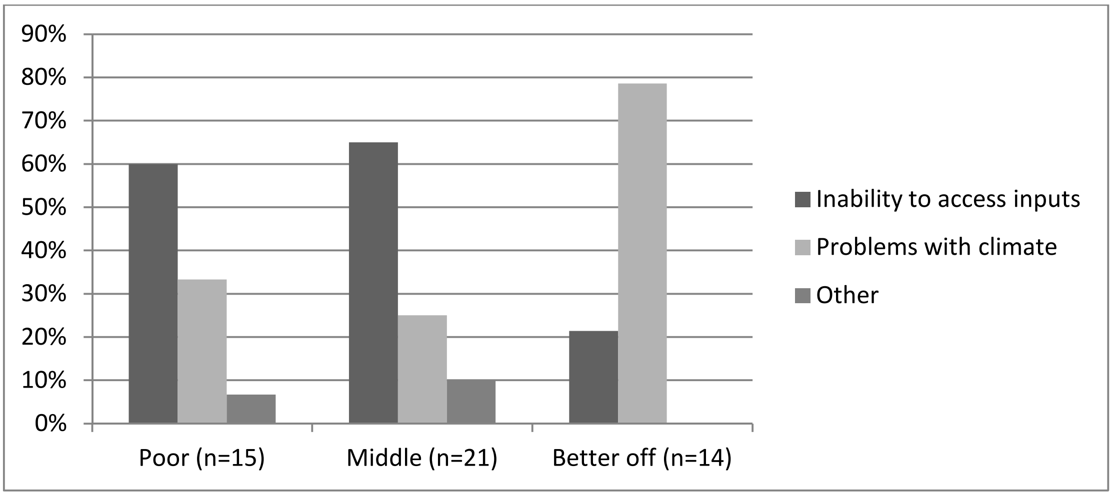


Figure 6.4: Reasons maize cultivation perceived as increasingly difficult, 2010 survey, Kasungu

Further data was collected on perceptions of changes to the weather at focus groups that were held within the participating research villages and during interviews with local famers and extension workers. Efforts were made by facilitators to avoid influencing the responses given by focus group participants and interviewees, and questions were therefore open-ended and general. This allowed participants to identify changes or trends in weather conditions that they considered important. Relevant statements are displayed in Table 6.3 below. The perceived changes to weather patterns that were reported can be summarized as follows:

1. The onset of the rainy season is later today than it was in the past.
2. The growing season is now shorter than it was in the past.
3. Dry spells are causing more production problems than they were in the past.
4. Less rains are received today

The specific comments that were made are listed in the box below.

Table 6.3: Perceptions of changes to local climate, Kasungu

Perception 1. The onset of the rainy season is later today than it was in the past	
Supporting comments	*"The rainfall pattern is changing. We would expect it to start in October/November, but now the rains are starting in December"* *- Agricultural timeline focus group, Village B* *"Thirty years ago the rains would come maybe in October. Now the rains come late"* *- Agricultural trends focus group, Village B* *"In the past, by now, the winds would stop blowing, which indicated that the rains were about to start. However, now, the winds carry on blowing and the rains do not come so*

	soon." *- Maize problem ranking focus group, Village A* *"We used to have rains in November, but this time they can come in December"* *- Extension officer A*
Dissenting comments	*"It varies. Sometimes the rains come early and also go away early, and sometimes they come late and also go away early"* *- Agricultural trends focus group, Village B*
Perception 2. The growing season is shorter now than it was before	
Supporting comments	*"Previously the rains would end in maybe April or March, but now when it starts in December, by March they are gone"* *-Agricultural timeline focus group, Village B* *"The seasons are becoming shorter"* *- Extension officer A* *"We have been experiencing a short period of rain. The rainy days have been growing maybe shorter and shorter as compared to the past seasons."* *- Extension officer C*
Dissenting comments	NONE
Perception 3. Dry spells are more of a problem today than they were in the past	
Supporting comments	*"Dry spells never used to happen thirty years ago, and today they are worse than they were fifteen years ago"* *- Agricultural trends focus group, Village A*
Dissenting comments	*"A long time ago the drought was more; it would last longer than it lasts today...* *The dry spells have always been there because even the ancestors would pray for the rain. Like the rain would stop and then they would have to pray for it. There is no trend"* *- Agricultural trends focus group, Village B*
Perception 4. There is less rainfall today than there was in the past	
Supporting comments	*"The rain comes differently from how it was coming before because people have cut down the vegetation and you can now observe that the rain starts from the game reserve. That's where the vegetation is. And when it finally gets here*

	it's just a little bit." *- Agricultural time line focus group, Village A* *"So now it's difficult for us to receive the expected rains as we did in the past, and most of the time we don't receive rains here anymore"* *- Seasonal record keeper, 35 year old male, Village A*
Dissenting comments	NONE

Ngabu

In Ngabu a much lower number of households continued to cultivate local maize, and the process of disadopting local maize had begun earlier than in Kasungu, as we have seen in Chapter 5. A total of 75.9% of respondents (n=83) indicated that they considered local maize the worst cultivar they had ever grown, and 59.5% considered that Kanyani was the best (2011 survey). Similar reasons for disapproval of local maize were cited as had been cited in Kasungu; local cultivars were slow maturing, low yielding, and often just grew tall:

> *"I stopped growing local in 2009. It takes a long time for the harvest to be ready. It just grows tall without even giving us the fruits. By the time it starts to make its cobs the rains have already stopped"*
>
> *Male, 30 years old, middle wealth rank, Village A*

A notable difference between the two areas was the lack of importance attached to fertilizer amongst smallholders in Ngabu. Participants perceived soils in the area to be fertile enough anyway and a local researcher suggested that problems with drought masked any benefits fertilizer use would have for maize production.

> *"Yes, the soils here they are still good, but they still require supplementary fertilizers, only that the farmers they are being disappointed when they apply fertilizer to maize, you just see it drying, the impact is not there. They are just thinking maybe if you go for fertilizer application in maize it's just a waste of resources"*
>
> *Research Officer, Ngabu*

In line with the preference that was displayed for growing Kanyani (a short season cultivar with good drought tolerance) by far the strongest recognised driver of maize cultivar uptake in Ngabu was the climate. In Ngabu there was greater agreement than in Kasungu that climatic conditions were increasingly causing problems for maize production. Respondents to the 2010 survey overwhelmingly reported perceiving that it was becoming more difficult to achieve a good maize harvest (96.7%, n=123), and the vast majority (91.1%) thought that this was due to changing climatic conditions. Specific reasons cited by respondents about why they perceived harvests to be decreasing are provided in Figure 6.5 below. The majority indicated "inadequate rains" as the cause, with others stating that rains had become 'worse', or more specifically that "the rains stop mid-season" and that "there is too much sun".

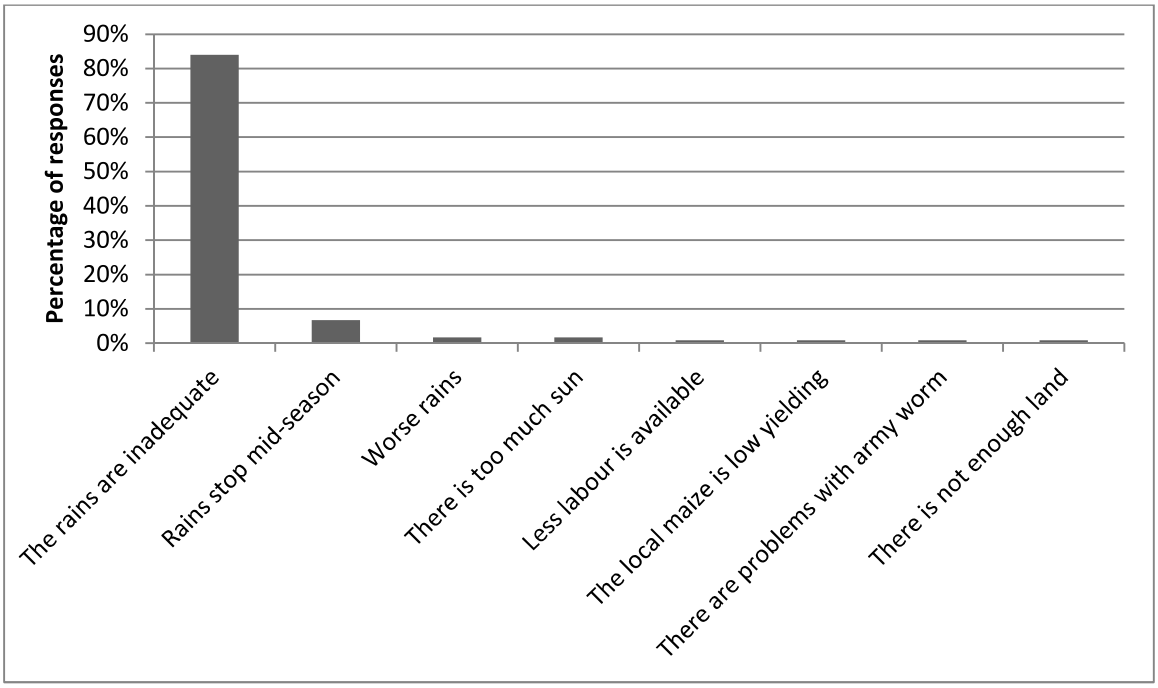


Figure 6.5: Reasons maize cultivation perceived as increasingly difficult, Ngabu, 2010 (n=119)

Focus group participants and interviewees predominantly identified dry spells as the main problem within the current climate for maize production. Additionally, rainy season onset was considered to have changed, and a few comments indicated that the sun was now harsher. Several participants made comments indicating that problems with rainfall had arisen within the past decade. A selection of comments is listed in Table 6.4 below. Whilst the range of statements collected does not indicate total clarity or agreement on the question of rainy season onset, there were no dissenting comments regarding any other features of the climate change that participants described. The prevailing perceptions of changes to rainfall were:

1. The rains have changed and negatively affected maize production
2. The rains start and then stop mid-season
3. The onset of the rainy season is later
4. The problems have mainly appeared in the last decade

Table 6.4: Perceptions of changes to local climate, Ngabu

Perception 1. The rains have changed and now maize production is not as it was in the past	
Supporting comments	*"The rains come differently from how they used to come"* *-Village B, focus group with farmers that had stopped growing maize* *"These days many people are buying food because today there are droughts, whereas in the past it was different"* *-Village B, Agricultural timeline focus group* *"Much more maize was eaten thirty years ago, as harvests were better due to better rainfall."* *-Village B, Agricultural trends focus group* *"In the past the rains used to come, it used to rain quite good compared to these days. These days the rains are not as they were in the past, in the past we experienced a lot more rainfall than we do currently"* *-Village A, focus group with farmers continuing to grow maize* *"Thirty years ago more maize was being eaten as the harvests were more successful"* *-Agricultural trends focus group, Village A*
Perception 2. The rains start and then stop mid-season	
Supporting comments	*"The past few years the rains have started at right time, and then drought comes"* *-Village B, focus group with farmers that have given up maize* *"Significant dry spells didn't used to occur in the past, not thirty years or fifteen years ago. But today they are causing major problems"* *-Village B, agricultural trends focus group* *"The rains come and the maize grows in the first place, but with time it stops. Usually the rains start in November and then it will stop in December, maybe up until February, two months later"* *-Village B, agricultural timeline focus group* *"In the beginning the rains start heavily, but when we have applied the first fertilizer the rain stops, and it stops for good. It doesn't come back until February, three or four weeks later, and by then the plants have already been scorched."* *-Village A, focus group with farmers who continue to grow*

	maize *"When the rains start in November, when it reaches January, they stop, and then in early February, they resume again"* *-Village A, focus group with farmers who gave up growing maize* *"From experience, at this time of year (June) the river that you crossed to get here, it should have running water. These days the rains just come and then disappear"* *-Seasonal records keeper, 60 years old, top wealth rank, Village A*
Perception 3. The onset of the rainy season starts later	
Supporting comments	*"The rains used to start in October, but these days they come in November"* *-Agricultural trends focus group, village B* *"These days the rain is coming late compared to the last years, because in previous seasons the rains would have already started and we would have planted by now. Today we don't even know any more when the rains will come. The rains used to start in September, but these days they don't start until November, December"* *-Village A, focus group with farmers who continue to grow maize* *"The problem now is the rains; they don't come when they are expected. In the old days the rainy season would start in October or early November, but now we are in late November and the rains still have not yet started"* *-Village A, focus group with farmers who gave up growing maize* *"It's changed now, mostly the rains come from January to March, which is the wrong time"* *-Village B, Focus group of farmers that had given up growing maize*
Perception 4. Problems with rainfall have appeared over the last decade	
Supporting comments	*"Five to ten years ago the climate was good, but recently we are having difficulties producing crops. Maize is not a hundred percent as it was. Around ten years ago people were using a lot of the land for cultivating maize, but recently, in these past ten years, people have now diverted from maize to other crops like sorghum, millet and cotton, and if they want*

	to plant maize, they go to their dimbas" *-Extension Officer, Ngabu* *"In 1990 the weather was almost fair, but since about 2000 we've been having heavy droughts, up to now. We are getting erratic rains, and sometimes continuous drought. Sometimes you are not getting any rain for at least three to four weeks, and then later on it comes again."* *-Research Officer, Ngabu research station* *"The droughts started within the last ten years"* *-Village B, Agricultural timeline focus group*

6.4.3 Meteorological records

The results just presented reveal perceptions in both research areas that the distribution of seasonal rainfall had changed. These perceptions were strongly unified in Ngabu, whilst in Kasungu, a minority perceived rainfall to have improved in recent years, and others were not sure that any change had occurred.

Rainfall records for each area were investigated in terms of the changes identified by research participants. The results will be presented for each research area in turn.

Kasungu

Participants in Kasungu identified later rainy season onsets, shorter growing seasons, dry spells, and lower total seasonal rainfall as problems for maize production in their area. However, the rainfall record for the area (recorded within 15 km of each participating research village), did not provide strong evidence to support assertions that definite changes had occurred.

Onsets

Two definitions for onset were used. The first, 'onset A', classed onset as the point when 25 mm of rainfall was accumulated within 10 days, and the second, 'onset B', used the same classification but further specified that no period of 10 consecutive days with less than 2 mm of rainfall falling each day should occur within the following 20 days. These definitions have been used in other research into maize production in southern Africa (Tadross et al., 2007), and they also coincided with the planting dates that participant farmers reported using in the 2010 season (based on the seasonal records they provided). Where a difference is apparent between the dates of the two onsets, this is interpreted as a false start to the season, and it is assumed that in this circumstance crops planted at onset A would have been at risk of failing at the seedling stage, due to the following dry spell.

Figure 6.6 illustrates mean rainy season onset by decade for the past 50 years. It is evident that rainy season onsets using both definition A and B have varied throughout the record. In particular, the dispersal of onset dates around mean onset has been larger at some points than at others, with the 1980s displaying much larger dispersal than the 1960s and 2000s. However, the data offer little evidence to support the assertion that the rainy season used to start in October. Throughout the record there are only four incidences of onset A (the earlier of the two onsets) occurring in October (1982, 1986, 1997 and 1998). Less variation is evident in the B onsets, wherein season onsets are confined to the second half of November or first half of December throughout the record. Perceptions that seasons are now more likely to start in December could be due to the fact that in the past decade A onsets have become more closely aligned to B onsets. In terms of maize production this could be considered beneficial, since the risk of seasonal false starts has diminished. The data presented thus produce a picture of rainy season onsets which vary over time, but with no evidence of a consistent directional trend.

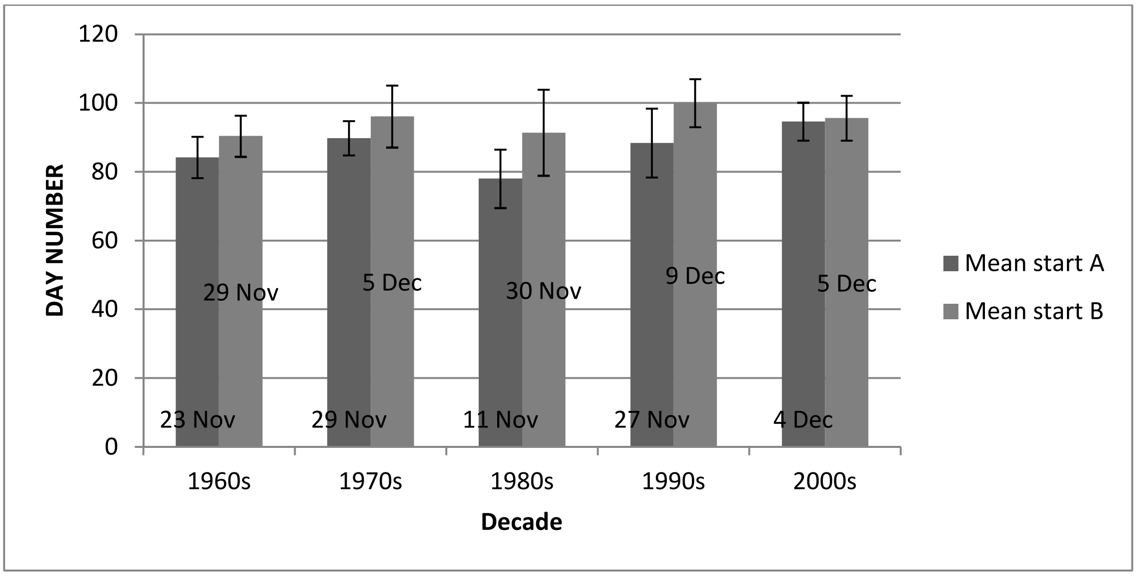


Figure 6.6: Mean rainy season onsets by decade, Kasungu airport data (error bars = St Dev)

Shorter growing seasons

Season cessation was defined as the point when three consecutive dekads (10 day periods) which each received less than 20 mm occurred after February 1st (Tadross et al., 2007). Figure 6.7 illustrates mean season length by decade for Kasungu. When definition B onsets are considered, no change over time to mean season length is apparent, although inter-annual variability of season length is quite high, as indicated by the error bars shown. Greater inter-decadal variability of season length is notable where definition A onsets are used, which could perhaps account for the perception that seasons are becoming shorter. For the A onsets, seasons were on average somewhat longer in the 1980s and 1990s, where they approached 120 days, but for the other decades mean season lengths fall between 104 and 111 days. Although slightly longer seasons (if using definition A onsets) are evident in the middle of the record, the shorter onsets apparent in the 2000s do not appear to represent a shift away from the norm towards shorter season lengths, since the earlier decades within the record also exhibit shorter season lengths. Instead, the 1980s and 1990s appear as the decades that are somewhat removed from the norm in this regard, (although a longer rainfall record might illustrate cyclical modulations between the two states to be the norm). Considered in relation to the rain data, local claims about shortening seasons perhaps indicate that onsets at definition A figure more strongly within perceptions of rainy season onset, and that perceptions of these onsets as false starts are not well developed.

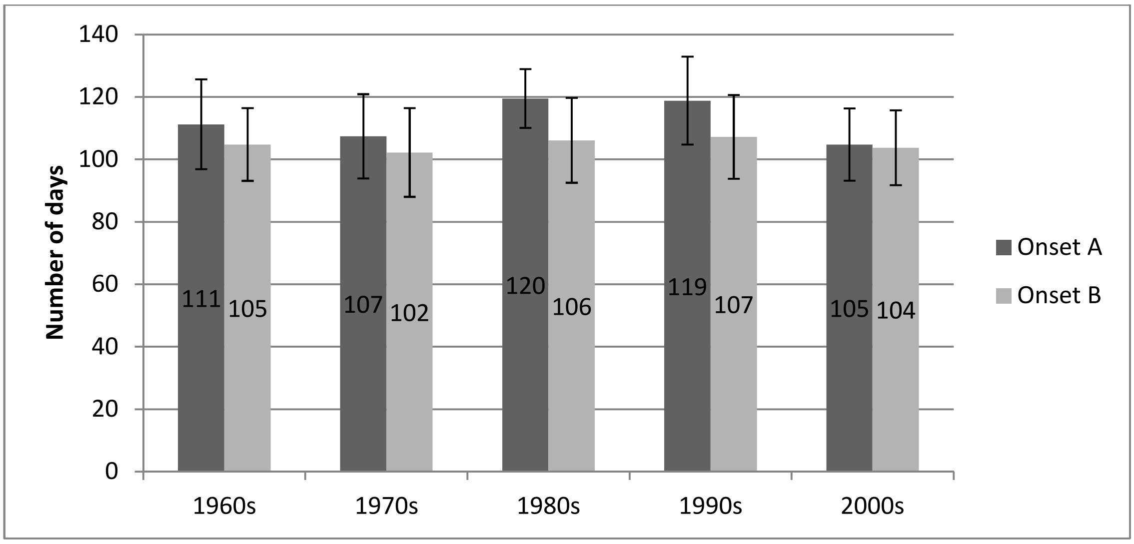


Figure 6.7: Mean season length (days), Kasungu airport (error bars = St Dev)

Dry spells

Dry spells were investigated both assessing changes to the total number of days on which rain fell within each season and during specific months, and also by assessing the incidence and length of dry spells at critical phases within the maize's physiological development. For Kasungu, November, December and January were identified as the most critical months of rainfall for maize development. The mean number of rainy days received in November, December and January was calculated (27.59) and used to produce annual anomalies based on difference from this mean, as displayed in Figure 6.8. Inter-annual variations are evident and appear to be somewhat cyclical in nature. In the last decade, seven years have received more days of rain than average during these three crucial months, whilst in the 1990s, seven years received less days of rainfall than average. Despite these variations, no clear trend indicating that days of rainfall are decreasing is evident.

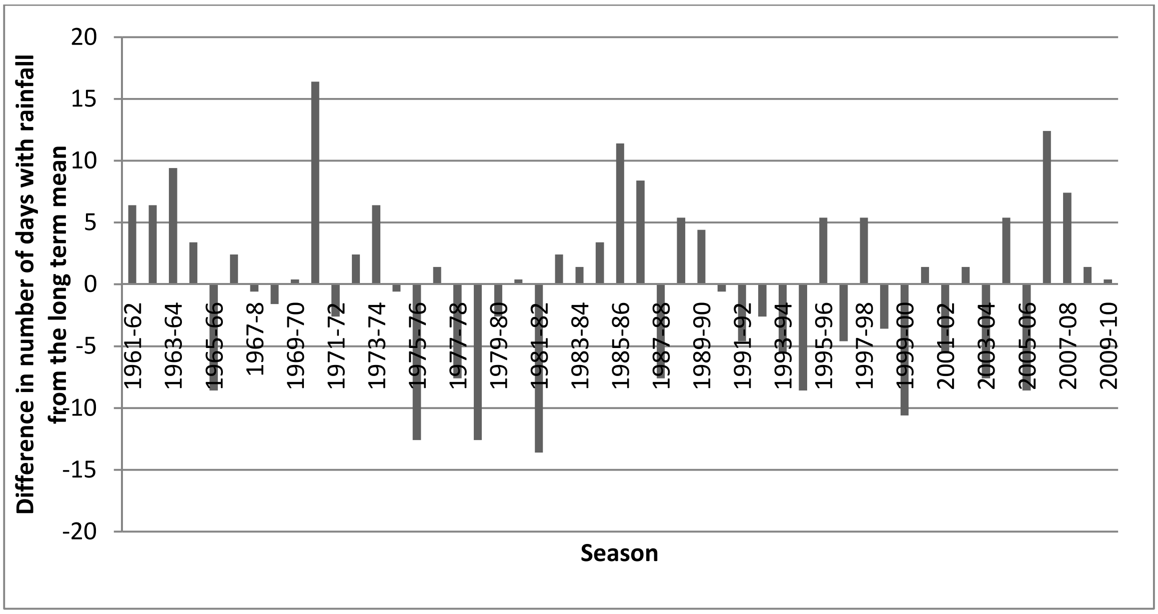


Figure 6.8: Rainy day anomalies for November, December and January, Kasungu

The data were then assessed for dry spells occurring between days 40 and 85 after planting. Based on the developmental phases of short and long season maize plants, tasseling and silking can be expected to occur between days 40-85 after planting (Food and Agriculture Organisation of the United Nations, 2013), and plants are particularly sensitive to water shortages at this stage, which can cause poor pollination and a failure to set kernels (Chen et al., 2012). Figure 6.9 illustrates the first, second and third longest dry spells occurring between 40 and 85 days after planting by year. Focus group participant farmers were asked to identify what length of time maize plants could survive without rainfall for at this stage of their growth, and responses ranged from one week to three weeks, indicating considerable variability of response to dry spells, most likely relating to a range of contextually specific factors. Based these responses, dry spells of more than ten days were considered likely to impact negatively on maize harvests at this stage, and have been labelled in Figure 6.9. Nine instances of dry spells exceeding ten days occur within the record, with five of these occurring in the latter half of the record, and the remaining four occurring in the first half of the record. These instances notably coincide with some serious food crises of historical importance, namely the Southern

African Drought of 1992, and Malawi's recent food crises in 2001-2 and 2005-6 (Richard et al., 2001, Devereux, 2002, Eldridge, 2002, Devereux et al., 2006). The mean length of dry spells from 1961-1985 and from 1985-2011 do not differ, both equalling 8.4 days, although greater standard deviation is evident in the first half of the dataset (6.1) than in the second half (3.9), which is a product of the two very long dry spells (of 22 and 31 days) which occur in the earlier half. The results from this analysis do not therefore support the assertion that dry spells are more of a problem today than they were in the past in terms of rainfall characteristics in the Kasungu area.

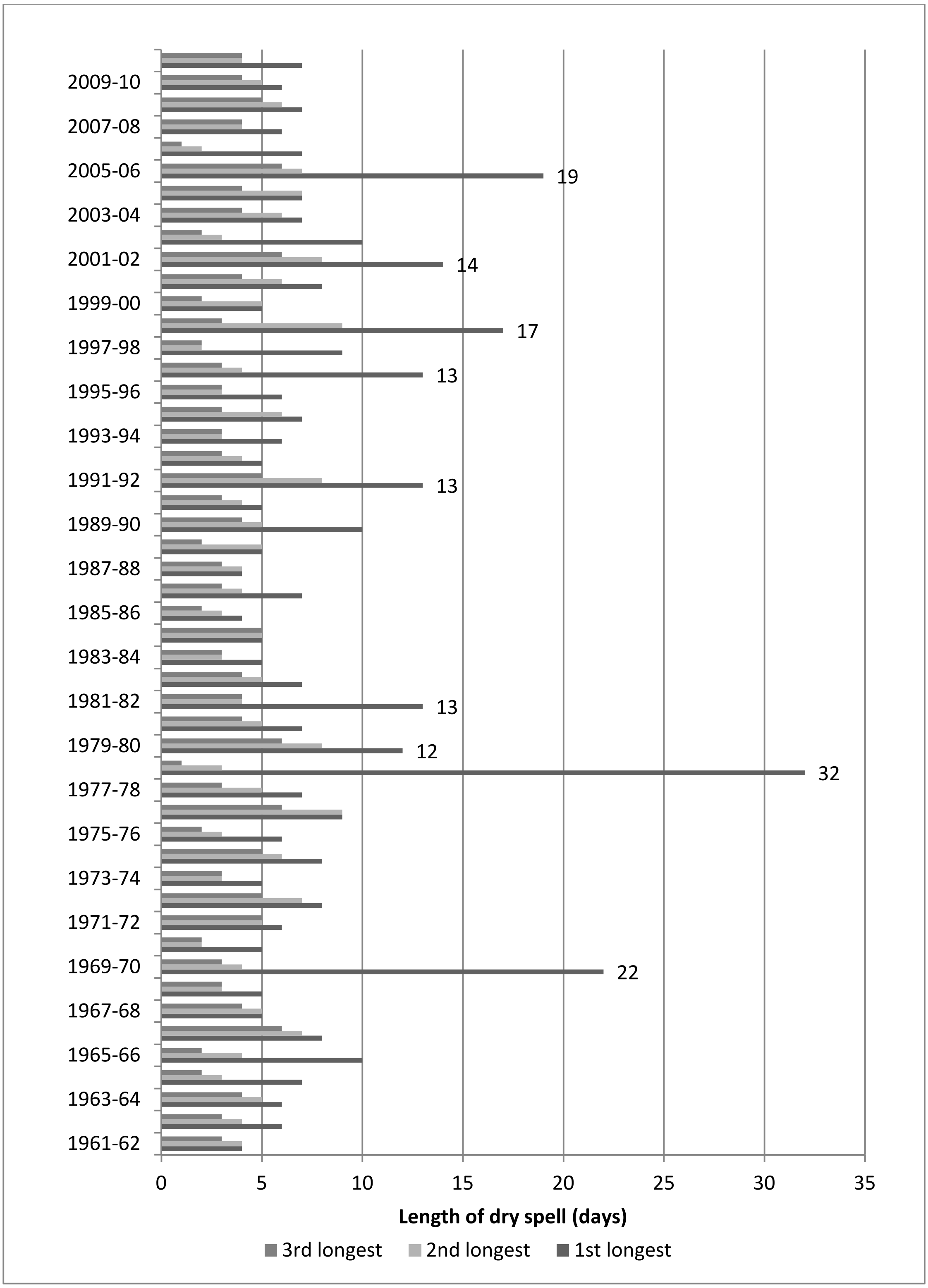


Figure 6.9: First, Second and third longest dry spells occurring between 40 and 85 days after season onset (definition A), Kasungu

Lower total rainfall

As with the other perceptions of changes to rainfall, there was little evidence from the records that total annual rainfall was decreasing. Results for the mean and standard deviation for total annual rainfall by decade are shown in Table 6.5. From these results it is not possible to discern a changing trend in the quantity of rainfall received. Higher mean rainfall was received in the 1980s and lower mean rainfall was received in the 1990s, but variation in mean rainfall between the remaining three decades is small. Standardized rainfall anomalies were calculated and these are presented in Figure 6.10. Whilst these indicate high-inter annual variability, the ratio of positive and negative anomalies in the past decade is 6:4, with negative anomalies evenly dispersed throughout the decade.

Table 6.5: Mean total annual rainfall by decade, Kasungu Airport

	1960s	1970s	1980s	1990s	2000s
Mean Total Annual Rainfall (mm)	773.2	782.4	818.5	737.1	781.3
Standard Deviation	133.1	212.0	115.7	162.2	210.8

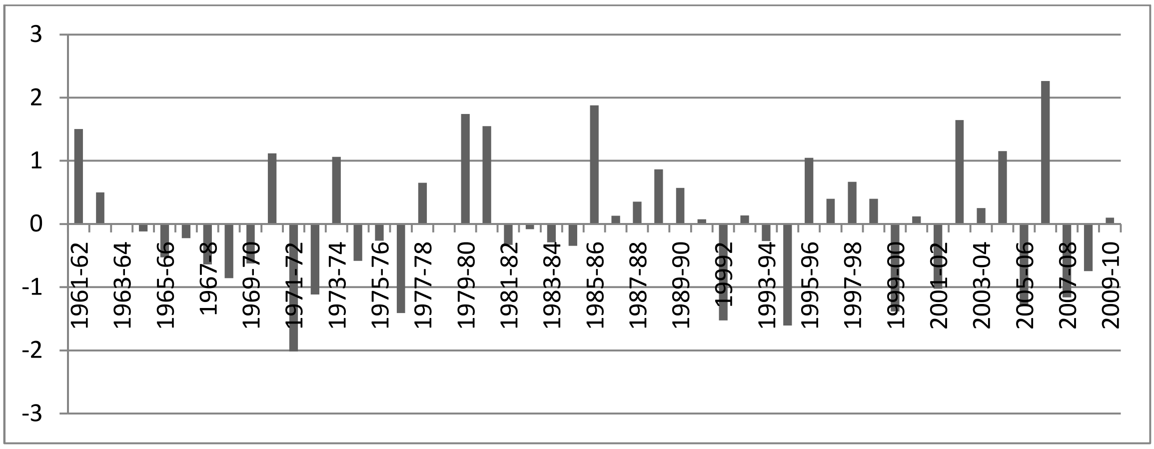


Figure 6.10: Standardized anomalies for total annual rainfall, Kasungu airport 1961-2010

Ngabu

Research participants strongly agreed that dry spells occurring within the middle of the season were increasingly causing problems for maize production in Ngabu. In addition there were suggestions that rainy season onset had changed and that these climatic problems for maize production had become more severe within the past decade. Dry spells and rainy season onset were analysed, and the results can be used to assess the statement that a decade ago rains in the area were good, and have become problematic since then.

Mid-season dry spells

As with Kasungu, the data were assessed for changes to the number of rainy days. Because participants repeatedly referred to problems with dry spells in January, rainy day anomalies for January were calculated and are displayed in Figure 6.11. From this figure it is evident that within the last decade, five years experienced less days of rainfall than usual in January, whilst four years experienced more, with one year experiencing the mean number, 10 days of rainfall. Whilst there is no clear trend, anomalies near the beginning of the record rarely exceed 4 or 5 days, but towards the end of the record they increase to eight days in some cases (notably there are two circumstances in the 1990s and 2000s where eight days more rainfall than average was received in January).

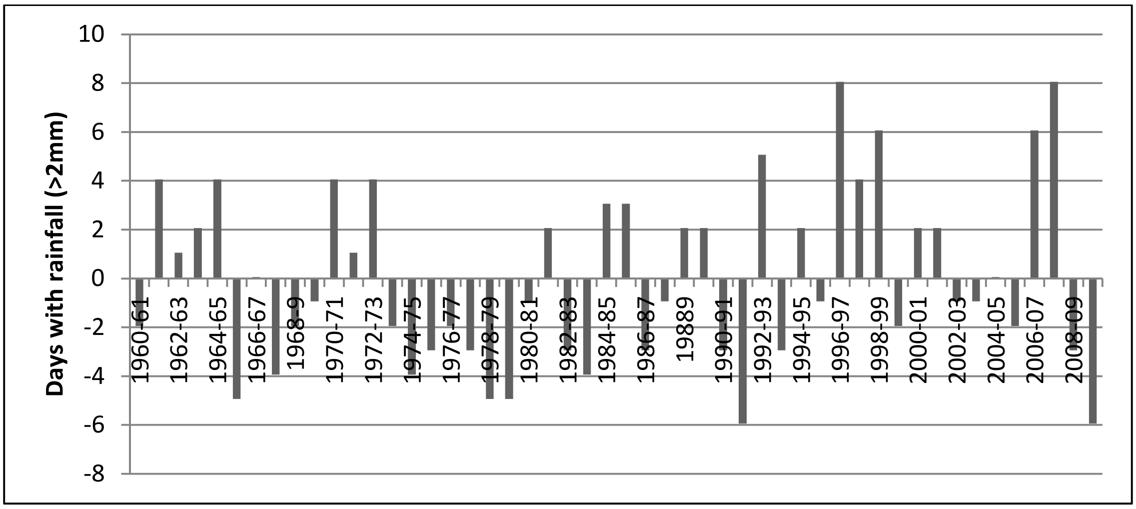


Figure 6.11: Rainy day anomailes for January, Ngabu Research Station, 1960-2010

The following chart, Figure 6.12, illustrates that there is no clear trend to the number of days of rainfall that are received within December, January and February combined, which are the key months for maize production in the area.

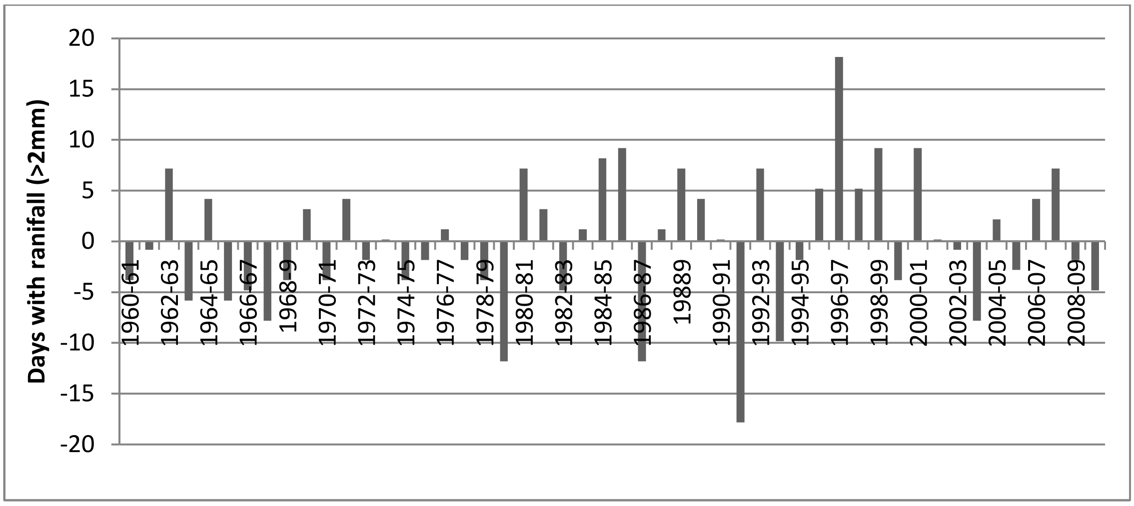


Figure 6.12: Rainy day anomalies for December, January and February combined, Ngabu Research Station, 1960-2010

Dry spells occurring between 40-85 days after planting were also assessed, as illustrated by Figure 6.13. It is immediately apparent that severe dry spells occurring between days 40 and 85 of the growing season occur with far greater regularity in Ngabu than in Kasungu. Many of the second longest dry spells exceed ten days in this dataset, which was never the case for Kasungu, and the 1991-1992 season (when the Southern African drought occurred) stands out as suffering the longest dry spell of the entire data set, with the longest at thirty days, and the second longest at seventeen days. It is also clear that severe mid-season dry spells are a recurrent feature of the rainfall in the area, and have occurred in many if not most seasons.

Table 6.6: Mean Longest dry spell (days 40-85 after planting) by decade

	1960s	1970s	1980s	1990s	2000s
Mean longest dry spell days 40-85 after planting	12.3	12.9	11.7	15.9	11.1
Standard Deviation	3.7	4.2	6.3	7.0	4.3

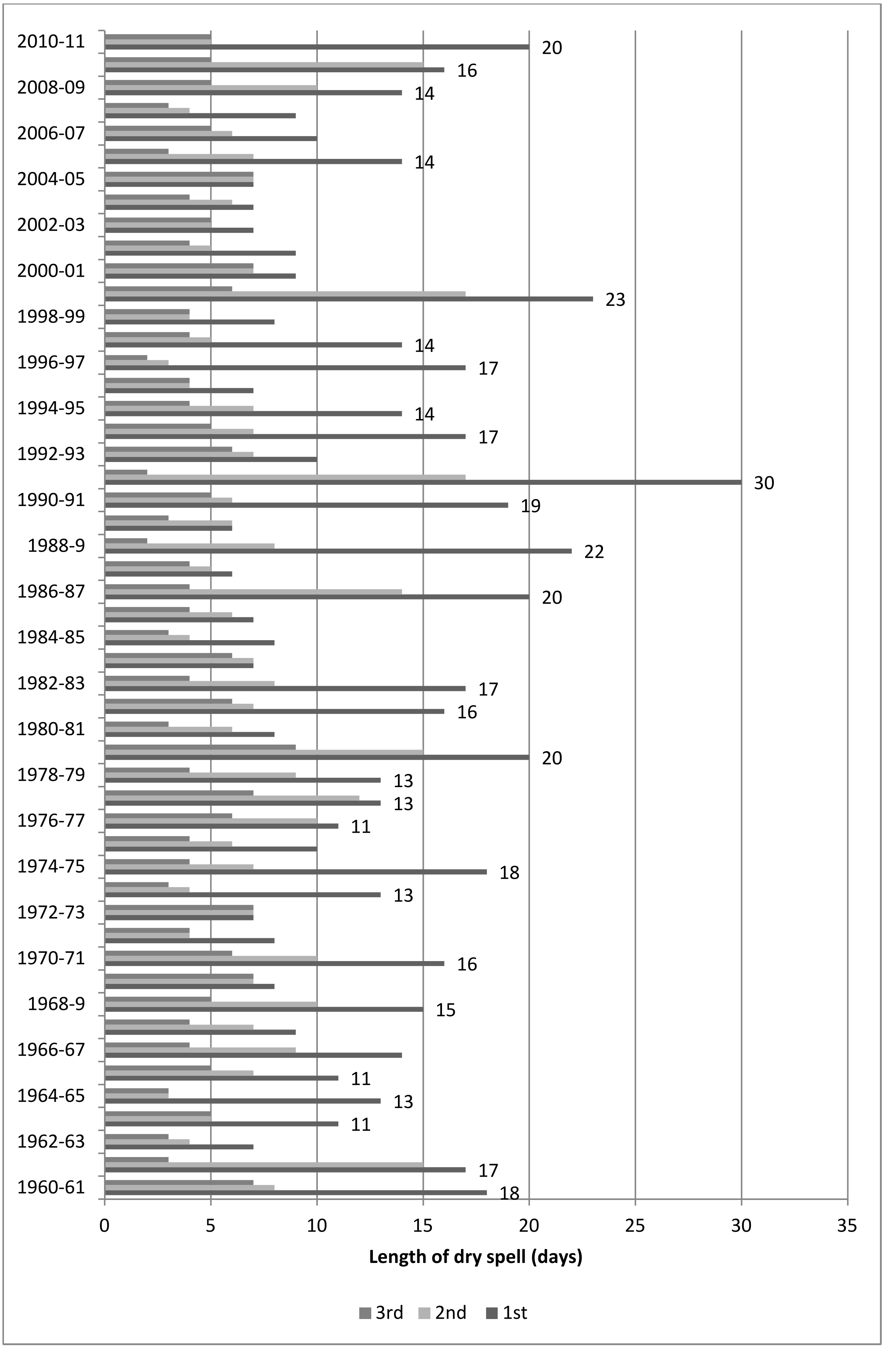


Figure 6.13: First, second and third longest dry spells occurring between 40 and 85 days after season onset (definition A), Ngabu

Table 6.6 provides mean values and standard deviations for longest dry spells by decade. No clear trend is evident from these values. Moreover, the longest dry spell over the last decade has the lowest mean value and the second lowest standard deviation of the group, which contradicts the assertion that this is a problem that has worsened over the past decade.

Rainy season onset

Figure 6.14 illustrates rainy season onsets using the same definitions (A and B) that were used for Kasungu. The data show some variability of onset, in particular for definition A onsets. The same pattern that was evident for Kasungu is also apparent here, wherein greater variability and considerably earlier definition A onsets are evident in the 1980s, with an average gap between onsets A and B during this decade of 27 days. As with Kasungu, definition B onsets show less variability, and predominantly fall within the latter part of November and the earlier part of December. Perceptions that the rainy season is starting later than it was in the past could perhaps be explained by the fact that definition A onsets were earlier in the 1980s. However, within the last decade, variability of onsets for both definitions appears to have decreased, as does the gap between onsets A and B, which should translate to a lower number of problematic seasonal 'false starts' for farmers deciding when to plant their maize. Again this contradicts the assertion that problems with rainfall have worsened in the last decade.

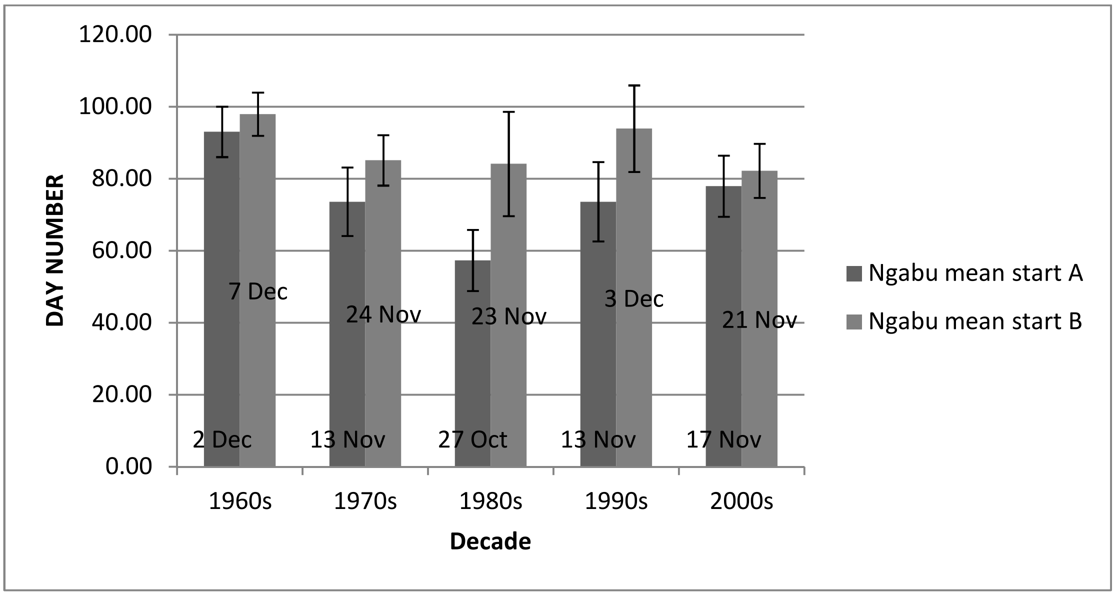


Figure 6.14: Mean date of rainy season onset by decade, Ngabu (error bars = St Dev)

6.4.4 The suitability of long and short season cultivars in the two research areas

Differences in season length between the two research areas for decades from the 1960s to 2000s are illustrated in Figure 6.15. It is evident that mean season length in both areas has fluctuated. Differences between the two locations are not as large as might be expected, and neither area has consistently longer seasons than the other, decade on decade. Overall, if seasons are defined using Onset B as the start date, Ngabu experiences a slightly longer mean season length (109.11 days, SD = 39.1) than Kasungu (104.8 days (SD = 23.99), although deviation around the mean is also considerably greater, which indicates that some seasons in Ngabu are of substantially shorter duration than those of Kasungu.

Decadal patterns of rainfall distribution are similar in both areas. In the 1980s and 1990s both areas experienced a greater number of days difference between onsets A and B, suggesting that a greater number of seasonal false starts were experienced in these decades than earlier or later in the record. Although changes in the 2000s may represent benefits for maize production because seasonal false starts appear to be less frequent and seasonal onset dates are less dispersed around the mean, the fact that this represents a change from the characteristics of the two previous decades could help to explain farmers' perceptions in both areas that rainfall has changed.

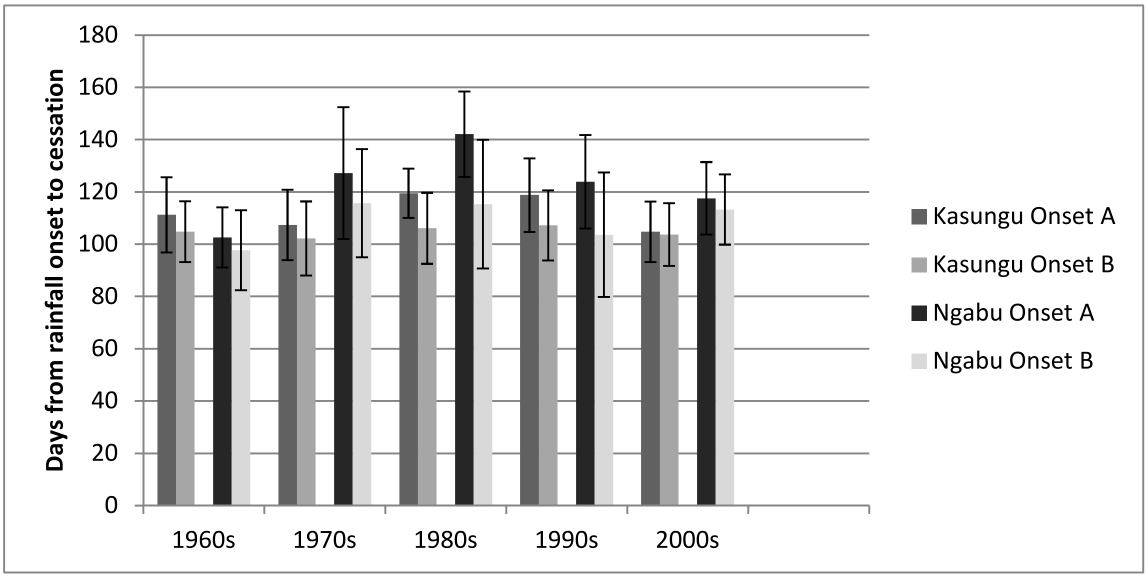


Figure 6.15: Mean season length in Ngabu and Kasungu (using onset definitions A and B) by decade (error bars = St Dev)

In order to explore the suitability of long and short season cultivars within the two areas, Aquacrop was used to simulate maize yields for two computerized cultivars using the rainfall and temperature records from each area. Other factors such as atmospheric carbon dioxide and field conditions were controlled for so that trends based on rainfall and temperature alone could be investigated. In each area, the planting date for each simulation was determined by rainfall. Three yields were simulated for each season, with the planting date occurring on the first, second and third instance where 25 mm of rainfall had accumulated within 10 days following the start of October. For each season, the best and worst simulated yields achieved were then selected. The simulated yields for each area are not representative of the yields that would have been achieved within farmers' fields in reality. The records kept by participants indicated that most only achieved yields of between one and two tonnes per hectare; hence the yields that were simulated by Aquacrop are unrealistically high relative to this. However, the results assist in determining the presence of production trends and are revealing in terms of comparisons between the performance of the long and short season cultivars in each area.

For Kasungu only twenty two years of daily temperature records were available, from 1983-2005. The results for the best and worst simulated yield achieved within each season are displayed in Figure 6.16 and Figure 6.17 below.

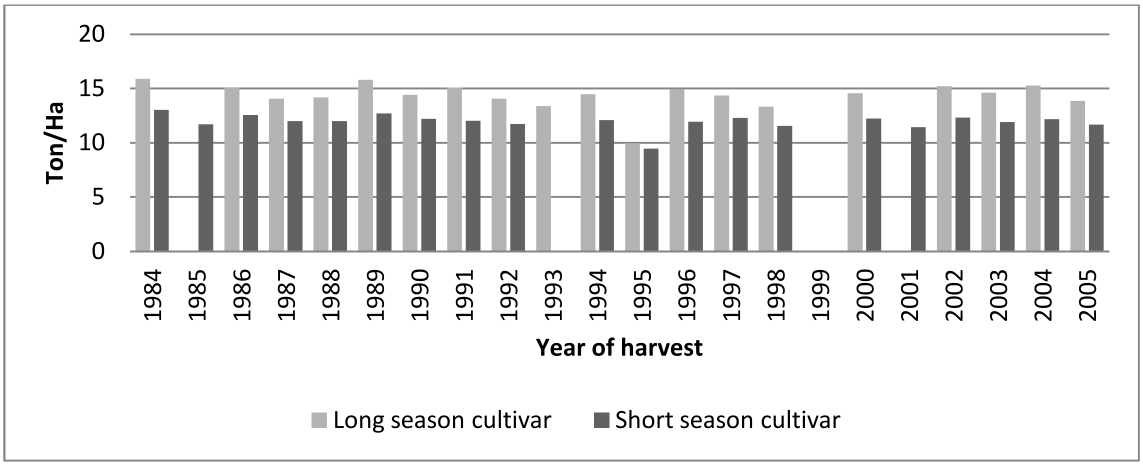


Figure 6.16: Best of three simulated yields for each season, Kasungu daily rainfall and temperature data, 1983-2005

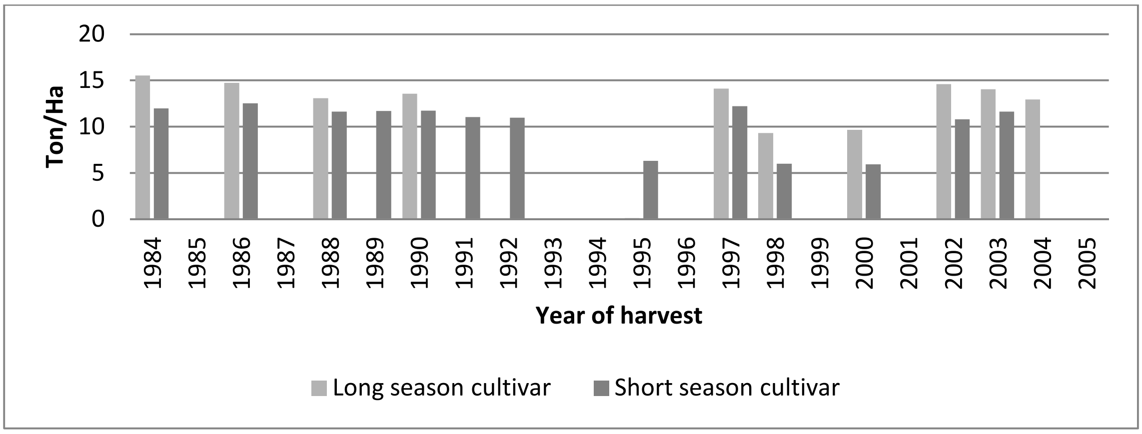


Figure 6.17: Worst of the three simulated yields for each season, Kasungu daily rainfall and temperature data, 1983-2005

The results show that for the best-timed plantings, there are two seasons in the record where the short season cultivar out-performs the longer season cultivar. However, where timing of planting is less successful (the worst of the three simulated results), the number of occasions where the short season cultivar proves more successful increases to four. This suggests that given growing uncertainty about the timing of the start of the rainy season, the benefits associated with cultivating shorter season maize cultivars may be greater. The performance of both cultivars is highly dependent on the timing of the planting date, with the long season cultivar failing to yield three times in the record when the best yields are considered, but failing eleven times in the record when the poorest yields are considered (with a difference of eight years). For the short season cultivar, yields fail twice at best, and nine times at worst (with a difference of seven years). This suggests that the risk of accruing poor yields because of bad luck in the selection of the planting date is practically identical for the two cultivars, with the shorter season cultivar only appearing to very marginally reduce this risk.

Simulated yields for Ngabu are displayed in Figure 6.18 and Figure 6.19 below.

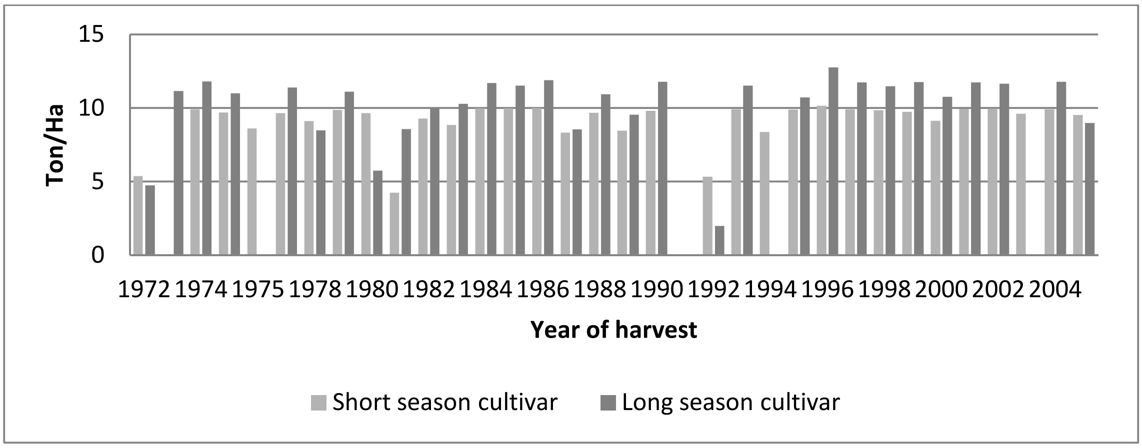


Figure 6.18: Best of three simulated yields within each season, Ngabu, daily rainfall and temperature data, 1971-2005

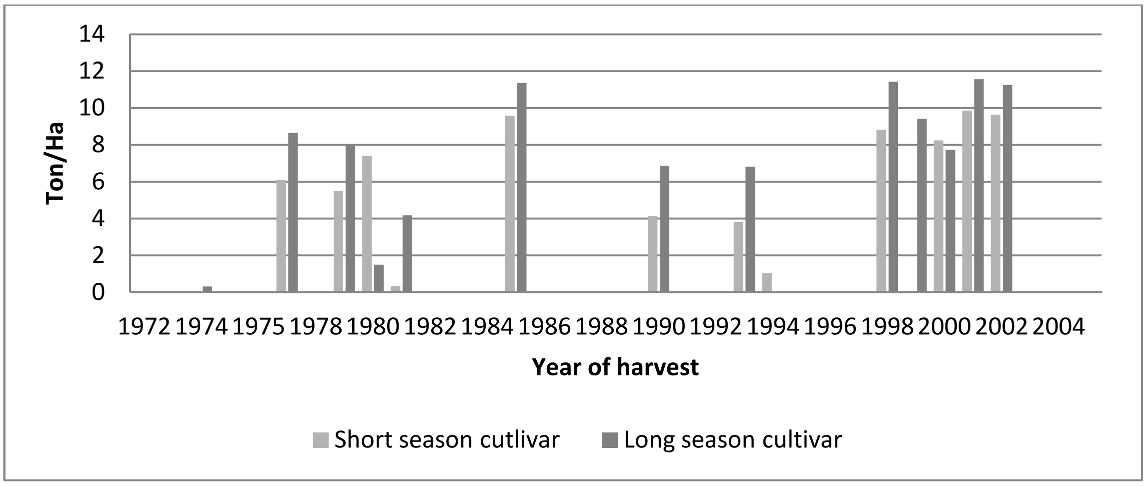


Figure 6.19: Worst of three simulated yields within each season, Ngabu, daily rainfall and temperature data, 1971-2005

Throughout Ngabu's simulated record (when considering the best of the three yields achieved in each season) there are eight occasions where the short season cultivar out-yields longer season cultivars. For the less successful plantings (the worst of the three simulated yields), there are only three occasions where the short season cultivar performs better. Whilst the difference in outcomes for the long and short season cultivars is overall greater than in Kasungu, it should also be borne in mind that the data record for Ngabu is longer by twelve years.

Even a single season of crop failure can be catastrophic for a smallholder household so reducing this risk is clearly a paramount consideration for farmers deciding whether to grow longer or shorter cultivars. The results therefore help to explain strong preferences for short season cultivars in the area, however given the strength of the preference expressed the difference in performance of the two cultivars is perhaps less high than might be expected.

For the most successful planting dates, only four harvests failed outright for the long season cultivar, and only two failed outright for the short season cultivar. However, for the least successful planting date, failures rose to twenty one seasons for the long season cultivar and twenty two seasons for the short. These strikingly different outcomes indicate that, for farmers in the area, being fortunate enough to select an optimal planting date is crucially important for their maize production. Here, as with the simulations for Kasungu, it does not appear that there are any major differences between long and short season cultivars in terms of the risk of harvest failure based on mistimed plantings.

Spearman's rank correlation coefficient was used to explore linear trends in the simulated yield datasets, but no statistically significant trends were found within the results from either area. However, as Table 6.7 illustrates, year by year simulated yields in Kasungu were consistently characterised by small negative correlations, whereas simulations over time in Ngabu were characterised by small positive correlations. The fact that in each case the results for each location all had the same sign suggests that this outcome was not purely random, and that small trends in each area may be occurring in rainfall with small implications for productivity. Given that perceptions of negative rainfall changes were so unified in Ngabu, but that respondents were near equally split between perceptions of positive and negative changes to rainfall in Kasungu, the fact that positive trends appeared in simulated results for Ngabu, and negative trends in results for Kasungu, is surprising.

Table 6.7: Spearman's rank correlation coefficients for simulated yield datasets against time in Kasungu and Ngabu

		Long season cultivar	**Short season cultivar**
KASUNGU	Best yields	-.098	-.295
	Worst yields	-.016	-.364
NGABU	Best yields	.184	.303
	Worst yields	.152	.171

6.4.5 Understandings of 'climate change' and future impacts

Kusintha kwa nyengo, meaning climate change, (or literally, changing seasons) was a familiar phrase in the research areas. However, participants' explanations of climate change illustrated that it was often perceived as a local problem with local causes, and climate change as a global issue was not well-conceived. Many participants understood climate change as an experienced change in local rainfall and most cited the cause to be deforestation:

> *"The rains come differently from how they were coming before because people have cut down the vegetation and you can now observe that the rain starts from the game reserve; that's where the vegetation is, and when it finally gets here it's just a little bit."*
>
> *Agricultural history timeline focus group, Village A, Kasungu*

This sentiment was also echoed by extension workers in both districts:

> *"If we are not planting more trees as I am saying our climate will be growing worse and worse and I don't know what we will have in the near future"*
>
> *Extension manager, Ngabu*

Additionally, some participants indicated that they thought the climate was changing as a result of the growth of factories in the local region:

"When the climate... at the time it has been changing people have been having thoughts that there is this cement company which makes cement in Kasungu and it usually produces fumes, and people have thought that that was the thing which was disturbing the climate, so people were suggesting that they should be chased away."

Focus group, mixed cultivar growers, Kasungu Village B

Similarly in Ngabu, problems with the rains were sometimes blamed on the local sugar estate:

"It's being caused by companies like Illovo; they are the ones polluting the air, hence they are destroying the ozone layer"

Focus group attendee, Ngabu, village A

When asked what changes they expected would occur in future, some participants suggested that they thought the situation would worsen, whilst others indicated that they thought it would stabilize:

"Maybe the rain will definitely stop, not be coming anymore"

Focus group, farmers that gave up maize, Village A, Ngabu

However, many households did not think that it was possible for human beings to know what would happen to the weather in future, suggesting that the future was in God's hands and could not be understood:

"We cannot tell what God wants. The changes that have been brought here; we cannot tell what God has in store for us. We cannot tell anything. The situation is like this, say my wife is pregnant. I can't tell whether the child inside is dead or alive, so I just have to expect anything. So with the weather, we are just expecting anything"

Focus group, Ngabu, farmers that continue to grow maize, Village A, Ngabu

Not all households considered that a solution was possible, but amongst those that did, tree-planting was usually cited:

"Human beings could change the climate by planting trees. If the whole world could agree on this strategy, climate change could be stopped. But everyone would have to agree."

Focus group, maize problem ranking, men, village A

Similarly, when asked what they could do to adapt to climate change, households in both districts pointed out that they did not think adaptation was possible, particularly for poorer households:

"Only wealthier families are the ones who can adapt"

Female focus group, maize problem ranking, Kasungu, village A

Some participants also pointed out that changing weather conditions would drive maladaptations such as theft of sugar cane:

"If the dry spells continue we will stop growing maize and start stealing sugar cane from the fields so that at the end of the day everyone will be arrested... It's true, a lot of people have been arrested for stealing from the fields."

Focus group, farmers who continue to grow maize, Ngabu, Village A

Households also expressed different opinions about what degree of communalism was a good idea for coping better with drought. Some considered that it would be better to work together, whereas others indicated that households should work alone, since some community members could not be trusted to contribute:

"People should organize to cultivate as a family, not as a village, but as a small group. A lot of people here they are lazy, so maybe they'll just sneak out, they won't be participating in the village things. Instead everyone should have his own land, should be cultivating on his own, so that when hunger strikes it should strike him alone, not so that the village as a whole should suffer"

Focus group, farmers that gave up maize, Village A, Ngabu

Themes of laziness and blame commonly appeared in discussions around issues of assistance with poverty, being mentioned by focus groups in both areas, as well as by seed company managers discussing the Agricultural Inputs Subsidy Programme:

"There are some farmers out there who are always there waiting for handouts, whatever they get"

Manager of seed company A, Lilongwe

Village participants explained that they had heard about climate change from elders within the village, or from the radio:

> *"We heard about climate change through the radio, and we observe it in terms of a comparison between the current situation and that in the past."*
>
> *Focus group, males, maize problem-ranking, Kasungu, village A*

Amongst stakeholders elsewhere in the network, understandings about climate change, and the sources of information on climate change that were referred to, were also quite locally-oriented:

> *"Apart from getting information from the meteorological department, physically we are seeing what is happening. So when the meteorological people tell us there are these changes and these changes, on our own we see that fully things are changing. It's not as it used to be. So we don't have more sources of getting the information apart from this; apart from the meteorological department, CIMMYT and our own observations."*
>
> *Manager, seed company D, Lilongwe*

This was reflected in seed companies' aspirations with regard to breeding for drought tolerance. Breeders suggested that they did not refer to climate projections in order to prepare for future market requirements, and no commercial companies conducted seed breeding under controlled water shortage conditions; selection could only occur under the prevailing environmental conditions that were being experienced at large:

> *"Yes, we do, we don't really... er... it's a difficult one, like if there's a drought site that is under stress then obviously we can test for it, but it's not like we go and plant them indoors and only water some, we haven't got to that stage yet. But then we do do a lot of marker assisted breeding, so we can identify the gene that is drought tolerant, and then breed that into a new hybrid. But there's no, not at this stage any specific testing."*
>
> *Manager of seed company B, Lilongwe*

6.5 Discussion and conclusions

Reports by African farmers of changing climatic conditions in their local environments have been noted within academic and grey literature concerning regional climate change impacts (Magrath and Sukali, 2009, Rao et al., 2011, Yaro, 2013, Tambo and Abdoulaye, 2013). However, a number of analyses that have undertaken comparisons between local perceptions of changes to weather patterns and evidence for changes within meteorological data have found that perceptions do not always match scientific measures of change, and may tend towards over-estimation of negative impacts (Rao et al., 2011, Osbahr et al., 2011, Simelton et al., 2013). Similarly, the analysis undertaken here found that claims about changes to rainfall (consisting of problems with increasing dry spells, changes to seasonal onset and duration and changes to total seasonal rainfall) were not reflected statistically within the meteorological data. This is significant because authors writing about barriers to climate change adaptation have highlighted signal perception as a key initial stage in processes leading to successful adaptation (Moser and Ekstrom, 2010). For farmers within this study, whilst a climate signal was perceived by most, the accuracy of perceptions about this signal appears limited, and the degree to which such perceptions may therefore lead to the selection of inappropriate adaptations is therefore in question.

There was clear evidence that farmers perceived cultivar adoption as a strategy for adapting their agricultural production practices to changes in the climate, since comments were made that traditional maize cultivars were no longer suitable given current climate characteristics, and modern cultivars with early maturity were identified as superior. Preferences for short season cultivars are not strongly referenced in earlier literature on maize trait preferences amongst Malawians smallholders, where preferences for flint texture and associated processing and consumption characteristics (ease of hand-pounding, limited waste, and high nsima-yield) have taken centre stage (Kydd, 1989, Smale and Rusike, 1998, Smale and Jayne, 2010). This suggests that strong preferences for early maturity may have developed recently. However, the results of the rainfall analysis and crop modelling that have been carried out in this chapter do not suggest that consistently better yields can be achieved with short-season maize, particularly in Kasungu. Resource poor farmers are wise to be risk-averse (Bryceson, 2002) and the prerogative of avoiding harvest failure in any season is an over-riding concern which contributes to preferences for short season cultivars that can reduce yield variability. However, based on the results presented it is likely that enhancing the drought-resistance of medium-duration maize cultivars, particularly in areas where variability in season-length is not extreme (such as Kasungu) would reduce risks of harvest failure whilst also avoiding the yield reductions that are associated with growing shorter-season cultivars.

The question of why perceptions of change did not better reflect meteorological records is an important one which merits further research. There are multiple possible explanations. In their research on rainfall perceptions in Malawi, Simelton et al. (2013) suggested that changes to institutional support for farming and the increasing burden of poor health may have increased the sensitivity of the farming system to drought and influenced farmers' negative perceptions of rainfall trends. The findings for this thesis illustrate a particular incongruity between strongly unified perceptions of negative rainfall trends in Ngabu and the lack of support for evidence of an actual change in rainfall characteristics over time, as well as the indication from simulated yields, based on temperature and rainfall alone, that maize productivity should be characterised by a slight positive trend in the area. The highly variable nature of Ngabu's climate and the fact that local maize production has always been challenging are both evident within historical accounts (Mandala, 2005). At the same time, Mandala (2005) suggests that perceptions of current and past conditions in the Shire Valley are characterised by narratives which portray a contemporary crisis against the backdrop of a golden age of past productivity. These two narrative types are reflected in comments made by research participants in the area and could explain perceptions that present-day production conditions are far worse than they were in the past. Alternatively, environmental changes not measured within this thesis may have occurred which have caused problems for maize production including changes to wind, sunlight, soil structure or fertility and groundwater levels. The vast irrigation requirements of sugar plantations in the area stood out clearly as a landscape feature, and since the closest plantation to the research villages appeared within the last decade, it is possible that heavy water use for sugar production has affected groundwater supplies with implications for smallholder production.

Perceptions about changes to the local climate were undoubtedly also influenced by narratives about climate change arriving through contact with NGOs, extension workers and the radio. The term 'climate change' now features as common parlance amongst rural farmers in many parts of Africa (Yaro, 2013, Tambo and Abdoulaye, 2013), and the contribution of a 'desertification narrative' to perceptions of declining rainfall has been asserted in Ghana (Yaro, 2013, p. 1260). In the study areas, it is likely that perceptions of local changes to rainfall gained credence due to narratives about climate change filtering in from international discourse. However, understandings of climate change as a global problem are rare, and participants tended to attribute the cause to local developments such as deforestation and growth in industry. This perception meant that blame for poor harvests was sometimes apportioned to local actors which caused some participants to consider theft or vandalism directed at the supposed perpetrators to be a reasonable response.

Perceptions and attitudes about what could be known about future climate (and therefore prepared for), as well as how to respond, were also shaped by religious and cultural beliefs. The perception that only God could know the future contributed to a sense of fatalism about what was in store, reflecting other literary accounts of unwillingness amongst religious communities to prepare for climatic events that are deemed as 'acts of God' (Grothmann and Patt, 2005, p.202). Cultural attitudes which blamed poverty on laziness limited the degree to which collective action appeared likely in future. As such, findings here support the suggestion that cultural and religious factors strongly influence adaptive capacity (Kuruppu and Liverman, 2011). Perceptions of risk are also understood to be strongly influenced by social and economic conditions (Yaro, 2013). Findings in this study, which revealed wealthier households to be less likely than poorer households to perceive increasing problems with agricultural production, and to be more likely to attribute any problems to weather rather than inputs access, further support this idea.

This chapter adds another layer to understandings about how cultivar adoption as an adaptation strategy might be limited for smallholders in Malawi. In Chapters 4 and 5 we encountered financial and knowledge-based limits to cultivar access. This chapter has shown that even where access to cultivars is unrestricted by these factors, its value as an adaptation strategy is determined by how climatic problems for agricultural production are perceived and understood.

Chapter 7 - Discussion and Conclusions

7.1 Introduction

This chapter concludes the thesis. It starts with a section summarising the main results which reiterates the original aim and objectives and looks at how they have been achieved. The following section then situates the findings in relation to relevant literature and reflects on what the evidence presented by the thesis means for theoretical and empirical assertions made by other authors. Section 7.4 moves on to look more broadly at implications for practice and policy relating to cultivar adoption for climate change adaptation within smallholder settings in Malawi and elsewhere in rural SSA, and section 7.5 considers the limitations of the research. Finally section 7.6 discusses further avenues for research arising from the findings herein.

7.2 Summary of findings

This thesis has aimed to build understanding about how social dimensions (specifically asset and land ownership, cultural preferences and perceptions of climate risk) affect the potential for cultivar adoption to enable equitable adaptation to climate change amongst smallholder maize farmers in Malawi. It set about achieving this by investigating the mechanisms that shape maize cultivar diffusion within Malawi's seed system, and by exploring the barriers and drivers that determine adoption and its role as an adaptation strategy. The thesis sought to assess the equitability of cultivar adoption outcomes and implications for vulnerability to climate impacts at both the regional and household level by comparing two areas with contrasting production characteristics, and by comparing patterns of household cultivar use within them. Empirical findings were analyzed to determine similarities with and differences from two major theoretical models of agricultural innovation with the aim of determining the utility of these models for supporting the development of systems which can enable equitable adaptation and climate change vulnerability reduction.

Chapter 4 assessed the main maize cultivar diffusion strategies currently pursued within Malawi based on data from interviews with stakeholders within the national seed network from the local to the national/international level. By doing so, it sought to fulfil the first objective of the thesis, which was to, "describe the diffusion of modern maize cultivars to smallholders in Malawi". The data collection that was undertaken enabled learning about the strategies that are currently relied upon for maize cultivar diffusion and also provided insights into the attitudes held by actors within the seed system about the efficacy and desirability of the different strategies used. Many of the formal strategies being pursued were found to reflect assumptions that are characteristic of a 'Diffusion of Innovations' approach. Recognition of the importance of the "observability" and "trialability" of new cultivars as part of the persuasion stage in the "innovation-decision process" (Rogers, 2003, p. 170) was evidenced by the use of demonstration plots and the implementation of the AISP. Reliance on the diffusion of messages about new cultivars via interpersonal communication from higher status research centres, to extension agents, to 'lead' or 'real' farmers and finally to lower status farmers is strongly reminiscent of another set of DoI assumptions about the spread of communications from change agents to opinion leaders or innovators to early adopters, late adopters and finally laggards (Rogers, 2003, p. 279).

Although the strategies by which cultivars are diffused to smallholders mirror the 'Diffusion of Innovations' model, developments occurring within the seed industry are closer to the functions of an Agricultural Innovations System. 'Bridging institutions' (Spielman and Birner, 2008, p. 27) such as STAM are being employed to enhance communication between state and corporate actors, and the AISP has provided a 'protected space' (Hekkert et al., 2007, p. 424) for the growth of new marketed cultivars. These developments have particularly benefitted the major corporate actors within the seed system, who have massively increased their sales potential by negotiating participation in the AISP. However, the degree to which seed system development of this nature directly serves the needs of smallholders is questionable. Whilst competition amongst seed providers means that many more cultivars are being released, many smallholders (particularly those with low literacy) have limited capacity to learn the traits of the array of cultivars on offer. The market is flooded with privately-owned hybrids, whilst public goods cultivars, which include OPVs, are scarce, being insufficiently marketed by the large corporations that take them on, and ineffectively marketed by small national organisations who lack the power and reach of larger organisations. At the same time, larger companies are concentrating on supplying and producing more short-season cultivars, which can be grown throughout Malawi, and can be more easily substituted between areas to capture subsidy coupons sales.

A version of Spielman and Birner's conceptual diagram of an AIS was drawn up for the innovation system around maize seed that the research explored in Malawi. This revealed that the system falls short in terms of enabling input about maize cultivar preferences by smallholders, who have no way of directly influencing seed companies, the AISP, or the extension service. NGOs act as an important bridge for smallholders to the rest of the system, but may fail to interact with poorer smallholders and importantly do not link up with STAM in order to influence corporate players in the system. There are no farmer organisations dealing explicitly with maize cultivars. Power within the system to influence policy and link up with the wider political and economic arena is concentrated within the business and enterprise domain. This means that smallholders with greater commercial potential are likely to benefit more from the operation of the system than those who are growing maize purely for subsistence.

Chapter 5 sought to fulfil the second objective of the thesis, "to identify the adoption outcomes of the diffusion strategies being employed". To this end, data on household socio-economic characteristics and seed use within the two research areas were analysed to determine the patterns of cultivar use and knowledge that existed in each place. In both research areas household socioeconomic wealth was found to be associated with greater levels of use of modern cultivars. These findings indicate that access is currently not equitable, and poorer, less-educated households tend to be more disadvantaged with regard to accessing modern maize cultivars. Wealthier households were found to implement more diverse production regimes, to be more likely to grow a larger number of maize cultivars and to have experience of growing a greater range of cultivars in the past. In line with this, in Kasungu wealthier households were more likely to grow a mixture of hybrid and OPV or local cultivars, thereby meeting cultural preferences for a range of cultivar traits that are currently not all embodied in a single cultivar. Their sustained use of less productive local cultivars was facilitated by greater household capacity to absorb losses, meaning that wealthier households have been able to prolong the use of local maize compared to less wealthy households. Middle-wealth rank households were more likely to grow a single cultivar of modern maize, whilst the poorest households were more likely to rely on local cultivars alone. These bottom-wealth rank households had little or no past experience of growing any other cultivars, and (particularly in Kasungu) cultivated a less diverse range of alternative crops. The probability that households would produce maize as their only crop increased as household land sizes decreased. In both areas positive correlation between the cultivation of drought tolerant or short-season cultivars and household wealth was also observed (although this was only statistically significant in Kasungu). On the basis of these findings, lack of wealth clearly formed a significant barrier to modern cultivar adoption. Whilst the relationship between wealth and adoption observed in both areas was in agreement with Diffusion of Innovation predictions that socioeconomically superior households will adopt more readily, some features of the observed adoption practices (such as the sustained use of local maize amongst wealthier households in Kasungu, and the disadoption of maize cultivation amongst poor households in Ngabu) fit poorly with the DoI hypothesis, suggesting that notions about the innate innovativeness of households do not effectively explain why households had or had not chosen to adopt, and indicating that other factors were at play which the theory fails to account for.

Qualitative data (reported in both Chapters 4 and 5) indicates that many smallholder farmers face barriers to cultivar selection because their knowledge of what is available, of which traits are associated with certain cultivars, or even of which cultivar they have grown in the previous season, is often poor. As such the evidence presented in Chapters 4 and 5 also went some way towards fulfilling the third objective of the thesis, "to identify barriers to and drivers of adoption decisions within smallholder households". Chapter 6 then continued with this objective by looking in detail at drivers of adoption.

Chapter 5 reported some key differences between the two research areas, both in terms of production characteristics, and in terms of maize cultivar usage. Ngabu was found to qualify as a more vulnerable area than Kasungu on the basis that households were found to choose between a narrower range of crops and livelihood strategies and experience much more erratic rainfall and higher temperatures. Households in Ngabu gave up growing local maize cultivars sooner than those in Kasungu, and poor households were likely to have given up growing maize altogether in recent years, as a way of reducing production risk. Conversely, households in Kasungu were more likely to have adopted maize varieties in response to the perception that the available cultivar range was expanding. Push and pull factors, or the predominance of necessity or choice in determining responses (Ellis, 2000), were put forward as the cause of this difference. Push factors, or a narrowing of options due to necessity, appeared to operate more strongly in Ngabu, whilst pull factors, or the choice to diversify, appeared to operate more strongly in Kasungu.

The operation of push and pull factors in the two areas reflected the different perceptions of changing environmental pressures that were reported by participants in Chapter 6. In both areas, perceptions that the weather was changing were driving assumptions that cultivar change was increasingly necessary. However in Kasungu, uncertainty about how the weather would turn out supported cultivar diversification, whereas in Ngabu, perceptions that drought was increasing drove some households to abandon maize cultivation altogether, drove others to grow maize in their *dimbas* rather than their *mundas*, and inclined the rest towards the use of a single maize cultivar (Kanyani) which was considered to have the best chance of success based on the difficult production conditions being experienced. As well as identifying cultivar traits as an important factor driving decisions to adopt, Chapter 6 thus pinpointed the growing importance of perceptions of changes to seasonal climate characteristics as a major factor currently driving seed choice in both areas.

Based on the observed adoption patterns in the two research areas, traditional diffusion mechanisms do not appear to effectively overcome socioeconomic inequalities in cultivar adoption. Moreover, whilst the targeting recommendations of the AISP aim to overcome lower access to modern maize amongst poorer households, the nature of coupon distribution resulted in elite capture of AISP benefits, which may have broadened socioeconomic inequalities rather than narrowing them. In the cases where the AISP did reach its targeted recipients in the form of poorer households, it appeared to have more influence over maize cultivation decisions than within wealthier households. However, subsidy receipt was not associated with greater levels of crop diversification in any of the wealth ranks in either research district, suggesting that it is not successfully reducing high levels of dependence on maize which characterise Malawian production and consumption habits. Results also indicated that the AISP may encourage maize cultivation in areas where it is highly risky such as Ngabu, suggesting that in certain circumstances subsidy receipt may contribute to maladaptation. As such, the conclusion can be drawn that the AISP is not effectively overcoming inequalities in access to improved inputs, or helping to reduce over-reliance on maize, and alterations to the programme's distribution mechanisms and its contextual sensitivity in maize-marginal areas would need to be addressed before it could stand a chance of doing so.

Beyond questions of equitability, the question of efficacy of adaptation through cultivar adoption was also addressed via an evaluation of the fit between perceptions of changes to seasonal weather, and meteorological measures of changes to rainfall and temperature. Claims were made in both areas that the timing of the rainy season had changed and that dry spells had become more of a problem. These claims were reflected in comments by national research staff and seed company managers. However, it was difficult to find clear support for these statements within rainfall data for the last fifty years for each area. Perceptions that these changes had occurred were reinforced by narratives about climate change arriving from a range of sources including the Malawi Meteorological Services and NGOs working nationally, but outputs from GCMs were rarely referred to by stakeholders anywhere within the national seed system. Commonly, changes to rainfall were explained by farmer participants and local extension workers in terms of vegetation reduction in the local area or the growth of local industrial activity. Climate change was thus not often viewed as a global phenomenon by local level participants. Narratives concerning changing seasonal duration are encouraging seed companies to increase their production of short season cultivars, and smallholders, even in mid-altitude areas like Kasungu, are increasingly adopting these. However, whilst such cultivars may provide greater yield stability, which is an important consideration for resource-poor smallholders, it is likely that longer season cultivars with enhanced drought tolerance would also provide stability, but with somewhat higher yield potential in similar mid-altitude areas.

The discussion sections at the end of chapters 4, 5 and 6, in addition to discussion within the current chapter, combine to fulfil objective 4 "to explore the implications of the findings for objectives 1, 2 and 3 for climate change adaptation and vulnerability reduction amongst smallholder households in Malawi", and sections 7.4 and 7.6 of the current chapter fulfil objective 5, "to identify policy recommendations for facilitating equitable distribution of adaptation benefits for improved maize uptake and distribution".

The thesis makes an original contribution by updating empirical knowledge on the state of modern cultivar adoption in Malawi with reference to the impacts of recent agricultural policies such as the AISP, using these empirical findings to critique the utility of key academic approaches to agricultural innovation as strategies for enabling equitable cultivar adoption, and scrutinizing the value of current adoption scenarios for climate change adaptation and vulnerability reduction.

7.3 Implications for the literature

The research findings indicate that neither DoI strategies for channelling new cultivars to smallholders, nor AIS developments within the seed industry, are likely, by themselves, to effectively address issues of vulnerability or to lead to equitable climate change adaptation amongst smallholders (Rogers, 2003, The World Bank, 2012). Whilst DoI was found to accurately describe some of the patterns of cultivar uptake that were observed, there were also indications that relying on farmers of high socio-economic status to transmit messages to lower status farmers was not always effective and resulted in the alienation of some poorer households. This reflects Röling's suggestion that whilst the DoI framework may adequately describe actual diffusion processes, as a strategy for organising adoption it may fail to lead to optimal technology uptake (Röling et al., 1976). Other authors have similarly questioned the equity impacts of technology transfer, finding, for example, that an effect of the green revolution in Asia was the widening of income inequalities (Falcon, 1970), and that opportunities for learning and genuine engagement can be missed by the DoI approach in rural development settings (Bordenave, 1976).

New models which recognise a broader range of sources of innovation have been proposed as a means for enhancing the empowerment of resource poor farmers, reducing poverty and enabling and strengthening research capacities amongst poorer groups (Biggs, 1990, Reij and Waters-Beyer, 2001). However, as the AIS approach has developed, its commercial emphasis has grown without due attention to poverty reduction (Spielman and Birner, 2008). The AIS style developments that are ongoing within Malawi's seed system were found to have transformed the power of corporate actors within the seed sector and greatly enhanced competition between them. However the result of this development was the market proliferation of a homogeneous range of hybrid cultivars about which many smallholders were unable to effectively assimilate information. Rogers (2003, p. 471) uses the term 'disequilibrium' to describe situations where changes occur too fast for the social system to adjust. Based on the difficulties smallholders face in interacting with the rapidly evolving modern maize market, it would be fair to say that a system of disequilibrium currently prevails; the speed with which new cultivars arrive on the market looks set to quicken (based on the statements made by participating seed companies in Chapter 4), whilst the capacity of most smallholders to absorb the information needed to choose between cultivars remains limited. Maize seed market developments over-represent corporate interests by concentrating almost entirely on hybrids (Chinsinga, 2011). The burgeoning array of cultivars on the market does not include greater choice in terms of OPVs or public goods cultivars bred specifically for drought tolerance. However, there is no agreement in the literature that hybrid cultivars are best for all types of smallholder farmers. Some research has found that in marginal areas, where household finances are limited and recycling of hybrids is likely to occur, OPVs may represent greater profitability over a series of years (Pixley and Banziger, 2001). These findings suggest that the development of Malawi's AIS is not serving the needs of the most vulnerable smallholder farmers, and indicate that a reconsideration of issues concerning vulnerability reduction may need to be introduced into strategies for developing Agricultural Innovation Systems in order to avoid contributing to a power imbalance in favour of stronger corporate actors within the system.

Neither the DoI nor the AIS framework specifically sets forth to deal with issues of inequality and social vulnerability. However, given that reducing vulnerability to climate change is a key step for agricultural adaptation policies, the implications are that if adoption of climate-resilient cultivars is to be enhanced amongst the poorest households, the breeding and extension approaches currently employed (which remain centralized and heavily reliant on the T&V philosophy), along with the growth of corporate power in the seed market, will need to be moderated in order to ensure that socio-economically marginal smallholders and regions are not excluded from benefitting from better adapted cultivars. New technological developments within agricultural extension, such as the use of mobile phones to provide information to smallholders, have been proposed as a way to overcome the "information asymmetries" that characterise agricultural knowledge amongst poor farmers (Aker, 2011, p. 363). However, as mobile phone ownership is largely concentrated amongst wealthier households, it is unlikely to solve problems for the most vulnerable. Brooks and Loehvinsohn (2011) suggest that innovation systems have low user accountability in Sub-Saharan African settings because civil society organization is low. They recommend the use of Monitoring and Evaluation systems in which farmers and farmer organizations are able to have a strong voice, and suggest that genuinely participatory processes for producing new cultivars should be developed. This suggestion echoes the comments made by some of the participant farmers within this project, who complained of a lack of opportunities for communicating their needs back up the chain to those determining policies and technologies for agricultural development.

Literature dealing with adoption in Malawi has questioned why the uptake of modern cultivars seems to have stagnated (Smale, 1995, Smale and Jayne, 2010, Lunduka et al., 2012). Proposed explanations have focussed on financial barriers (Simtowe, 2006, Simtowe et al., 2009), risk aversion amongst poor smallholders (Denning et al., 2009), the appropriateness of cultivar traits given smallholder preferences (Kydd, 1989, Smale and Jayne, 2010, Lunduka et al., 2012), and knowledge (Smale and Heisey, 1993, Tripp and Rohrbach, 2001). The results indicate that most of these barriers do operate to different extents depending on the type of farmer being considered. Within the research areas, the least important barrier in terms of modern cultivar adoption appeared to be knowledge. Whilst smallholders rarely had good knowledge of cultivar traits across the range of modern cultivars that were available (which has implications for which modern cultivar they might choose), there was a very widespread perception across both sites that modern cultivars were preferable to traditional local cultivars for production in current conditions. This reflects the fact that modern maize has been available in Malawi for several decades and it is highly likely that most farmers are aware of it (Simtowe et al., 2009). However, poorer households were shown to face financial difficulties in sustaining the use of modern cultivars and were more prone to disadopt, or to rely on donated recycled hybrid seeds from wealthier households. Strong preferences for flintiness and the processing qualities and pest and disease resistance it confers were particularly apparent in Kasungu, and explained why many households had sustained the use of local cultivars for longer (especially those in the top wealth rank who could afford to do otherwise). The findings of this research therefore support findings by Lunduka et al. (2012) that preferences for a range of traits have contributed to plateaus within modern maize adoption nationally. However, over the two field seasons it was observed that households were continuing to disadopt local cultivars and that the primary reasons for doing so were perceptions that production conditions had changed. This indicates that growing perceptions of changes to production conditions may drive modern cultivar adoption (or conversely, the disadoption of local cultivars) beyond the level reached in the past. It also suggests that, in the main, those households that continue to fail to disadopt local maize and to experiment with modern cultivars are most likely inhibited by a lack of financial capacity.

Literatures concerning the impacts of the AISP paint a mixed picture from one of wild success (Denning et al., 2009), to one which questions the value of the programme in terms of poverty reduction, environmental and agricultural resilience and political and market impacts (Chinsinga, 2011, Mhango and Dick, 2011, Buffie and Atolia, 2009). The findings that have been presented here reveal that whilst the AISP is likely to increase inputs usage for many households, benefits are skewed towards wealthier households, and AISP receipt within poorer households is lower than intended. Poorer households that have received coupons in the past are less likely than wealthier households to sustain the use of modern inputs if they do not receive subsidy coupons in future years, suggesting that the subsidy may not sustainably transform inputs usage for those that are supposed to be targeted. These results support literature that points to complications in terms of how the programme works to reduce poverty (Buffie and Atolia, 2009). Whilst increasing maize productivity nationally reduces the cost of maize purchases which represents a benefit for poorer houses reliant on buying maize for food (Dorward and Chirwa, 2011), the results presented here indicate that wealthier households benefit disproportionately and the impacts of the subsidy therefore risk widening economic inequalities between smallholder households. The claims made by Chinsinga (2011, p. 59) that the programme is contributing to a narrowing 'product portfolio' with questionable benefits for smallholder farmers were supported by the empirical findings about the increasing market dominance of short season hybrids. The research did not produce many findings on the environmental impacts of the AISP, however there was some support for Mhango and Dick's claim (2011) that ecosystem services may be reduced by the suggestion that coupon receipt may disincentivize organic matter soil additions within some households. Whilst the potential of the programme to contribute to crop diversification by reducing the land area required for maize production has been discussed by some authors (Dorward and Chirwa, 2011), the results here do not indicate that this happening. Instead they suggest that within areas that are risky for maize production, such as Ngabu, subsidy receipt may be encouraging farmers to continue to grow maize when they would otherwise abandon the crop.

Whilst the findings support the notion that asset wealth often largely determines adoption decisions and adaptive capacity (Rogers, 2003, IPCC, 2007), they also indicate that this relationship is mediated by cultural considerations. The fact that in both areas wealthier households were more likely to sustain more climatically vulnerable production practices for longer (as evidenced by the use of local maize in Kasungu, or the continuance of maize cultivation in Ngabu), complements Grothmann and Patt's (2005) suggestion that cognition and particularly risk perception strongly affect individual decisions about adaptation. The findings here suggest that wealthier households can better afford to be less risk averse in their production choices than poorer households can. This implies that poorer households may opt to implement those adaptations that are available to them sooner than wealthier households would. It also suggests that it is wrong to assume that households with sufficient asset wealth will simply adapt at the optimal time and highlights the importance of engaging with cultural and individual perceptions of risk for adaptation policy makers.

Finally the research findings support those elsewhere concerning disparities between farmer perceptions of changing weather conditions with statistical analyses of change within scientific records (Rao et al., 2011, Osbahr et al., 2011, Simelton et al., 2013). Such findings suggest that human perceptions of changing environmental conditions may result from a combination of variables which complicates the attribution of causality. In order to ensure appropriate adaptation strategies are selected for dealing with current climate variability, historical records as well as stakeholder perceptions should be considered, and where accounts do not match up, the reasons for this lack of fit should be sought.

7.4 Broader implications and policy recommendations

The research sought to understand how effective the adoption of new cultivars might be as a strategy for reducing climate change vulnerability based on an analysis of the social factors which currently govern cultivar adoption and adaptation. In doing so it compared a marginal and a productive area, and also looked at how poorer and wealthier households are currently served by the cultivar market and the support of the AISP. The findings have broader implications for how policies should be shaped to enable equitable adaptation for more vulnerable areas and poorer households.

Overall, the findings of the research suggest that unless specific measures are adopted to solve current inequalities in access to maize cultivars, the adoption of climate-resilient varieties is not a strategy that the poorest will find easy to follow in Malawi, due to a combination of financial incapacity, elite capture of AISP benefits, and limited capacity to engage with the modern market for maize seeds. It was suggested that the AISP combines conflicting goals by seeking to target the poorest and most vulnerable farmers yet also aiming to transform national food security. Policy-makers working in Malawi should seek to resolve this conflict, and neighbouring countries that are considering whether or not to implement targeted inputs subsidies should make efforts to choose either poverty alleviation or productivity enhancement as a predominant goal, rather than trying to achieve both ends with the same programme. Arguments in favour of concentrating on productivity gains can be made via claims that poorer households can benefit indirectly from improved cultivars and inputs usage if this leads to yield increases which cause maize purchase costs to fall. However, additional steps need to be taken to ensure that such households have sufficient income-earning opportunities, and that these opportunities are resilient in the face of current climate variability and the probable negative impacts of climate change. At present in Ngabu, for example, poorer households are heavily reliant on rain-fed income-earning strategies for purchasing maize, which means that climate hazards causing poor harvests and high maize prices are likely to coincide with a slump in the purchasing power of poor households.

The impacts of Malawi's maize subsidy are of interest to many surrounding countries in East Africa where maize reliance is also high (Smale and Birol, 2013, Poulton, 2009). Based on the findings of this thesis countries considering employing similar programmes to Malawi's AISP need to think carefully about whether geographic targeting would be more appropriate for meeting local contextual needs; subsidizing maize production in areas where local climatic conditions make it a highly risky pursuit constitutes a maladaptation. Whilst hybrid seed and fertilizer use may lead farmers to dedicate smaller land areas to maize production, in order to engender crop diversification and thereby reduce over-reliance on maize it seems likely that additional barriers need to be overcome. For example, subsidizing the production of drought tolerant crops such as cassava may help to boost resilience to drought whilst also decreasing dependence on maize. If countries wish to ensure that subsidy provision results in poverty reduction, careful attention needs to be paid to programme administration, voucher targeting and more broadly, the management of maize seed and grain marketing.

For poorer households to be able to benefit directly from cultivars with increased climate tolerance, opportunities for learning and experimentation throughout the seed system need to be enhanced so that such households can make their preferences with regard to cultivar traits known and engage effectively with marketed cultivar ranges. There are several mechanisms by which this could be achieved. It would make sense to boost the provision and availability of drought tolerant OPVs, since poorer households may particularly benefit from seeds which can be recycled for three years. Currently the subsidy only provides maize in 5Kg packages (for hybrid seed, or 7.5Kg packages for OPV). However, if coupons could be exchanged for more than one cultivar of a smaller pack size, recipient households would be able to grow and compare a larger number of cultivars on their land. Alternatively, regulated local maize exchange schemes could enable households to access small quantities of a range of cultivars, and local demonstration plots could be arranged and undertaken by smallholders within clubs to ensure a broader range of farmers are involved, with a wider range of social network ties.

The AISP was found to operate in a 'one-size-fits-all' manner (Chinsinga, 2008), which lacks contextual sensitivity for dealing appropriately with some of Malawi's heterogeneous production conditions. Ngabu is in an area where maize production is highly risky, and yet the AISP has continued to encourage the production of maize in the area when support could have better been given to production and improvement of millet and sorghum, cotton, or research into whether alternative drought tolerant crops exist which may be suitable for the area, such as sisal. Given that Ngabu is an area that can be classed as highly vulnerable to climate hazards, it is surprising that greater consideration has not been given to providing more appropriate support for production in the area. Deep-seated household preferences for maize consumption in the area mean that less risky subsistence crops, such as millet and sorghum, are culturally under-valued. The national focus on maize has resulted in a narrative which strongly associates maize consumption with claims to Malawian national identity. However, food consumption habits are not fixed and government support for millet and sorghum production as a regional speciality could help to change local attitudes towards these crops which at one time constituted the main dietary staples in the area.

The research revealed that although asset wealth is an important component of adaptive capacity, it does not lead directly to adaptation. Therefore adaptation policies should not rest on the assumption that wealthier households will make the best choices with regard to adaptation; cultural factors and preferences also need to be taken into account and brought into dialogues around adaptation planning. Likewise, it should not be assumed that optimal adaptation decisions will be made based on human perceptions about how the environment is changing. Adaptation policy decisions should be based on a broad understanding of current climate variability (bringing together historical climate data analysis with local perceptions) and potential future change (based on downscaled GCMs) whilst incorporating awareness of additional drivers of productivity change, such as technological, population-related and land-use changes.

7.5 Limitations

The nature of the research design enabled the collection of in-depth information from the two study areas such that a detailed case study for each could be produced, providing insights into the contextually specific features of climate vulnerability and maize cultivar usage patterns in each place. However, this type of research design (which employs the use of a small number of case studies) necessarily limits the broader generalisability of the findings. Because data was sampled only from two geographically limited areas (incorporating three villages in each case), it is not possible to say with confidence whether the findings are reliably representative of adoption levels in other locations. A particular issue is that the data in both areas were collected from villages that were located within a 10-15 km radius of a meteorological station. A side-effect of this sampling decision was that all the villages were located relatively close to a major trading centre. This sampling approach was pursued in order to ensure that comparisons between local perceptions of trends in seasonal rainfall and the historical records collected from the local stations were justified (since beyond a distance of 15 km spatial variability of rainfall may have been great enough to exclude a reasonable degree of correlation between the two). However, proximity to the trading centre likely would have strongly influenced the degree of access to maize cultivars which study participants experienced, meaning that the adoption levels recorded are unlikely to represent cultivar access and use in more remote farming communities. A bias towards more accessible areas, which are situated near tarmac roads for example, has been noted for some time as a characteristic problem for rural development research which can lead to under-estimations of rural poverty (Chambers, 1981). Here, a similar type of bias applies and may have led not only to the representation of greater levels of modern maize adoption, but also of lower levels of climate vulnerability than would be the norm for more remote areas. In the case of this particular research, this bias was unavoidable on account of the desire to incorporate local climate records. More broadly, the tendency for this kind of bias to apply, and the probability that remote areas are at greater risk of vulnerability to negative climate impacts by dint of lower levels of access to resources, means that there is a need for research into climate change vulnerability to make efforts to incorporate fieldwork in remote communities.

A second limitation of the research was that no historical yield data for either area was available, and therefore there was no way to corroborate claims in both areas that maize productivity was changing. This fact also made it impossible to compare the yield advantages of specific cultivars in either location, or indeed to make an assessment of the degree to which rainfall and maize productivity in each location have been correlated in the past. Based on the statistical analysis of rain records which was carried out it seems likely that if reports of changes to maize productivity were accurate, the cause or causes of this change were not mainly attributable to rainfall. Instead, various other causes could account for this change, including changes to other environmental factors such as sunlight, wind speed, groundwater levels, soil fertility or structure, or changes to agricultural practices, such as the types of inputs used or the amount of labour employed. However, without historical data on these factors in addition to a dataset on maize yields with which comparisons could be drawn, identifying the specific cause of the reported changes is impossible. This lack of historical data also meant that a highly accurate calibration of Aquacrop could not be achieved. As such the Aquacrop results reported in the thesis purely reflect the probable impacts of local rainfall and temperature on yields and fail to accurately reflect local field conditions or to approximate the actual yields that might have been achieved in reality.

In hindsight, failing to undertake a comprehensive pilot survey for the questionnaire was a key shortcoming of the research which reduced the comparability of the data and limited its analytical potential. As new ideas evolved during the fieldwork process, survey questions were added or changed slightly. Whilst this enabled new leads to be explored, the resultant data had only partial coverage and had to be excluded from analysis. Had a comprehensive pilot survey been undertaken at the outset the need for a second questionnaire might have been avoided. Undertaking a longer scoping trip and carrying out more qualitative research earlier in the fieldwork process would have helped avoid this pitfall.

Systematic care was taken in the analysis of the qualitative interview data, and opinions were only reported when they represented a recurrent theme or indicated an oppositional viewpoint. Nonetheless, the sample of qualitative interviews used was fairly small and it is possible that had different actors been interviewed (particularly in the case of the research and extension services), different opinions and reports might have predominated.

Some of the shortcomings of the research may be characteristic of the difficulties involved in undertaking a mixed methods approach. There are inherent complications involved in trying to combine qualitative and quantitative social research data. Each kind of data fulfils a different kind of aim, with qualitative data providing in-depth detailed insights which may not generalise easily to the larger population, and quantitative data providing a more superficial perspective on individual cases, but achieving a representative overview of the population (provided sound sampling procedures are followed). The advantage of combining these two types of data is that they can mutually support one another to provide a more complete understanding of the social realities being researched. However, in order to be combined effectively, the mixed methods researcher needs to be exacting in the way they organise data collection, iteratively building on the data obtained by each method in a layered fashion. As such, collected survey data can be used to determine the sampling strategy for qualitative data collection, and qualitative methods can be used to enhance the design of questions within surveys. Researchers thus may need to jump between the two methods whilst adhering strictly to a sampling frame and to their survey tools. There are complications with achieving this in any context, but especially so within that of rural fieldwork, where reliance on face to face communications predominates and the same respondents may not always be available for further questioning. Meanwhile, because the researcher's perspective on the importance of various questions to the research project may change as new discoveries are made, there is a need for flexibility around methods and sampling which is at odds with maintaining the strict control of the sampling frame and survey tools mentioned above. This project employed quantitative methods not only in terms of the questionnaire survey, but also in its analysis of the rainfall data. In this respect, the skill set required was very broad, and considerable time was spent in attempting to master the different techniques employed. Ultimately, efforts were spread more thinly than is perhaps desirable and sounder results could have been obtained had less research tasks been undertaken.

The difficulties of combining qualitative and quantitative methods also extend to the style of reporting that is undertaken. Qualitative research is often reported in a discursive fashion wherein thematic findings can be strung together into a satisfying narrative, whereas quantitative research tends to adopt a stricter scientific format. The mixed methods researcher needs to determine how to merge these two reporting styles in order to best convey their results. The experience of trying to do so here has produced a compromise which is perhaps less clear than would have been the case had the approach adhered entirely to just one of these reporting styles.

7.6 Further research

The findings of this research and indeed the limitations which have just been reported summon up several further avenues of research which could be usefully pursued as a result of this project.

A key result is the indication that smallholder knowledge of different modern cultivars and their suitability for local conditions is limited. Additionally, local perceptions of maize productivity change, which feed decisions about which maize cultivars are considered most suitable for current cultivation, are decoupled from scientific measures of this change and its causes. Both factors point to the importance of providing learning opportunities for smallholders such that they are better empowered to realise and articulate cultivar preferences, to exert clear demands on the market, and to better understand the nature of the environmental and production challenges they are currently facing and will face in the future. This project incorporated an element of participatory record-keeping to a small degree, by asking selected farmers to record their observations of seasonal weather conditions in addition to some features of their maize production. Participatory record-keeping on a much greater scale could help to enhance learning for adaptation if research projects were facilitated wherein farmers gain experience with collecting records of environmental and yield observations. Over time these types of projects could lead to the development of a much broader network of available datasets facilitating analysis of local and regional changes. This source of data would provide the evidence base that farmers need for making decisions about how best to adapt their agricultural practices according to conditions being experienced in their local area. Such activities could incorporate involvement from remote rural areas, since reliance on proximity to meteorological stations would gradually be overcome. Literacy was encountered as a barrier to record-keeping within the local area, however record-keeping could be undertaken within groups convened by a literate individual to help overcome this problem. Record-keeping activities could also incorporate involvement from local school children who may be able to assist illiterate family members and who may benefit from putting their literacy skills to use in the home farm environment.

A shortcoming of the research was identified as its inability to determine which cultivars were most suitable in each research area. A very different research project would have been required to undertake this objective, since longitudinal yield data from many different production contexts in each research area would have been required. Participatory records could contribute to the production of this type of dataset, and could be used to enhance understandings of the true implications of the use of hybrids or OPVs for resource poor farmers. In a similar vein, this project revealed that drought may be thought about and experienced in various different ways, and the question of which types of cultivars are best suited to the types of drought experienced in each location remains unanswered. In particular, it would be useful to know whether short-season or drought-tolerant cultivars fare better under current conditions so that smallholder farmers can determine which they should be using in order to procure the highest (and longest-lasting yields). The complexities of how yield can be understood in local terms (where losses in storage are a major concern) also suggest that research providing information about which cultivars yield best post-storage rather than simply post-harvest would be beneficial for enhancing farmer cultivar selection capacities.

The project also identified that input from farmers into seed-breeding decisions was limited. Whilst maize-breeding is complicated due to high rates of out-crossing, participatory maize-breeding has been undertaken elsewhere and has proven useful for improving yields of farmers own local cultivars, with this type of activity being found particularly beneficial in marginal, low-yielding environments (Smith et al., 2001). Since this thesis has revealed that there are farmers who still rely both exclusively and partially on local varieties, undertaking participatory maize-breeding projects in Malawi would clearly be worthwhile. Similarly, this project has also revealed that rates of recycling of hybrid cultivars are high and that poor households are considered particularly likely to wind up planting this type of seed due to their reliance on seed donations from the harvests of wealthier households. Common narratives about the undesirability of recycling hybrids suggest that use of such seed may be more detrimental for farmers' yields than would be use of OPVs or even local maize. However, sufficient data to prove or disprove this assertion is lacking. It may be the case that certain hybrids perform well when recycled whilst others perform poorly. Such information would not only enable farmers to make better informed decisions about what seed to use, but might also suggest directions that private seed companies could take with their breeding to produce hybrids that fare better with recycling (although it is unlikely that many companies would find that to do so aligned well with their business interests). Private seed companies were also found to concentrate mainly on producing short-season hybrids, such that longer season hybrids that have been specifically bred for drought tolerance are lacking. Efforts to research the drought tolerance of new cultivars to the market should be undertaken, and seed companies should be encouraged to incorporate specific measures of drought tolerance into their breeding criteria.

The research highlighted the unsuitability of upland maize production in Ngabu. Further research into alternative crops to maize which could be suitable in this area would be an obvious next step.

Finally, this thesis has indicated that seed system developments that are in line with an Agricultural Innovations Systems approach do not necessarily lead to vulnerability reductions for the poorest and most marginal. It would be of interest to determine whether the tendency towards increasing dominance of corporate actors is necessarily always associated with AIS development, or whether there are instances wherein vulnerability reductions are effectively produced, and if so, what kinds of regulations lead to this eventuality. Comparative research on this subject would be of value.

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Appendix I – Information and consent forms in English and Chichewa

Investigating maize cultivar choices for drought and flood adaptation in Malawi

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask the researcher if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

Climate change is likely to impact on agricultural productivity and concerns are growing over our ability to produce enough food for an ever growing population in light of climate change. New cultivars of maize are being developed with a better level of resistance to some of the impacts of climate change, such as drought. The aim of this PhD research project is to investigate the extent to which farmers are able and willing to adopt these new varieties, in addition to collecting information on alternative adaptation strategies which are likely to be put to use. Malawi has been chosen as the location for the research because the impacts of climate change are likely to be significant for local production systems, and because maize is a prevalent crop, playing a role in both food security and in the economic development of the country.

Research is to be conducted within three districts in Malawi, chosen to illustrate drought and flood impacts. Data will be collected from participants using a household survey, focus group discussions and semi-structured interview questions. Enhancing understandings of the extent to which farmers are likely to adopt new maize cultivars will provide useful information for developing policies for adaptation to climate change. The fieldwork is being conducted from September to December 2010, and from April to May 2011. Outputs from this project will be made available in 2012.

You have been chosen because of your involvement in research and practice in the study area, or because you live and work in one of the six study sites. The study will seek to complete thirty or more questionnaires per study site, and conduct semi-structured interviews with six households per study site, and three individuals per agricultural station. If you live in one of the study sites you may be asked to participate in a focus group to discuss past experiences of drought and flood, and adaptation strategies. The questionnaire will take thirty minutes to complete. The interviews will take about forty minutes, and the focus groups will take about one hour. If you give an interview or attend a focus group your response will be recorded using an audio device and your words will later be transcribed in English. These transcriptions will be made anonymous, and voice recordings will be destroyed once transcriptions have been completed.

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this information sheet to keep (and be asked to sign a consent form) and you can still withdraw at any time without it affecting any benefits that you are entitled to in any way. You do not have to give a reason.

Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will inform future climate adaptation policies.

All the information that we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any reports or publications.

The main output for this research will be a PhD thesis to be submitted to the University of Leeds in 2012. Additionally, the results of the research may be used in academic publications and reports for the Centre for Climate Change Economics and Policy. The data may also be used in subsequent research in anonymised form. If you would like to receive an electronic copy of the PhD thesis in 2012, please inform the researcher and provide an email address to which it can be sent. Alternatively, should you require access to the results of the research sooner than this, preliminary findings can be made available in the form of a fieldwork report. Should you wish to receive such a report, please inform the researcher.

The research is funded by the UK Economic and Social Research Council through the Centre for Climate Change Economics and Policy.

If you would like further information please contact:

Chloe Sutcliffe, eecajs@leeds.ac.uk, +44 7748 960 233, Sustainability Research Institute, School of Earth and Environment, University of Leeds, LS2 9JT, UK

You can keep this information sheet and a copy of the accompanying consent form.

Thank you for taking part in this project.

Kufufuza njira ya mbeu ya chimanga chatsopano chomwe chingapime chilala ndi mvula yosefukira

Muli kuitanidwa kutenga nawo gawo pa kafuku-fuku wa malimidwe. Musanachite chiri chonse mumvetsetse zolinga komanso zimene kafuku-fuku atapange. Muwerenge kaye malangizo onse ndikukambirana ndi anzanu ngati mungathe kuti mudziwe zimene zingafunikire Pa kafuku-fukuyu. Komanso ngati simukumvetsa za nkhaniyi, funsani wofufuzayu (mphunzitsi) kuti akulongosolereni mfundo zina. Ganizani mofatsa musanabvomereze zikomo Powerenga.

Kusintha kwa nyengo kukuopsyeza malimidwe moti malingariro akubwera pankhani imeneyi chifukwa chakudya chikuchepa kwambiri pomwe chiwerengero cha anthu chikuchulukira-chulukira. Pali mbeu za chimanga chatsopano zomwe zakonzedwa mogwirizana ndi kusintha kwa nyengoku monga chilala. Maphunziro apamwamba a PhD ali ndi maganizo ofufuza za kafuku-fuku ameneyi ndinso kuti aone kuti ndi alimi anji angafune mosaumirizidwa kugwiritsa ntchito mbeu zatsopanozi, komanso kuti aonjezere ulangizi watsopano wa mbeu zimenezi omwe ungakhazikitsidwe Boma la Malawi lasankhidwa kuyendetsa kafuku-fukuyu chifukwa likukhuzidwa kwambiri ndi kusintha kwa nyengoku komanso chakudya chikuchepa moti chitukuko cha dziko sichingayende bwino ngati pali chilala.

Kafuku-fuku ameneyu achitika m'maboma awiri a dziko lino, osankhidwa malingana ndi kukhuzidwa ndi chilala komanso mvula yosefukira. Mfundo zitengedwa kuchokera kwa onse otenga mbali mukuwunguzaku kupyoleranso mukukambirana kwa m'magulu pomanga mfundo zamafunso. Kufuna kuti alimi onse amene angafune ulimi watsopano wa mbeu amvetsetse zoyenera ku chita ndinso zofunikira kugwiritsa ntchito pakusintha kwa nyengoku. Ntchito ya kafukufukuyi iyamba mu September 2010 mpaka December 2010 komanso April mpaka May 2011. Zonse zochokera mu ulimi watsopanowu zidzakhazikitsidwa mu chaka cha 2012.

Mwasankhidwa popeza mukutenga nao mbali mu kafuku-fuku ameneyu komanso kugwiritsa ntchito ulimi wamakonowu wa chigawo kapena chifukwa mukukhala ndikugwira ntchito m'modzi mwa zigawo six za kufuku-fuku ameneyu. Kafukufuku ameneyu ayenera kumaliza ma fomu amafunso opyolera makumi atatu pa chigawo chirichonse, ndikukonza mafunso komanso kukumbirana ndi mabanja six pa chigawo chakufuku-fukuyu ndiponso anthu atatu pa siteshoni ya ulimi. Ngati mukukhala pa limodzi mwa magawowa, muzapemphedwa kutenga nao mbali mukukambirana za chilala, madzi osefukira, zimene zakhala zikuononga mbeu muzaka zomwe zapitazo komanso zomwe zingathandize kutsata njira za makono za ulimi. Mafomu amafunsowa angatenge mpindi 30. Kufunsanso kungatenge mphindi 40 komanso kukambirana m'magulu kungatenge ora limodzi. Ngati mukufuna kufunsa mafunso kapena kukambirana m'magulu yankho lanu lisungidwa mumakina otenga mau kuti zomwe mwanenazo akamasulira muchingerezi. Zonse zimene mungakambiranezi zikhala za chinsisi komanso zonsezi zifafanizidwa kumasulira konse kukatha.

Ziri kwa inu kubvomereza kutenga mbali kapeni ai. Ngati mungabvomereze mupatsidwa chipepala cha mfundochi kuti musunge (mukupemphedwa kuti musayine kuti mukugwirizana nazo) komanso ngati mungafune kusintha maganizo muli ololedwa popanda bvuto liri lonse.

Pakadali pano anthu amene atatenge nawo mbali mu kafukufukuyi, palibe chimene angapindule (ngati kupatsidwa ndalama) koma pali maganizo oti mtsogolo muno malangizowa athandiza pakusintha kwa nyengoku.

Mfundo zimene tatenga kuchokera kwa inu pamaphuziro amenewa a kafuku-fukuyu asungidwa mwachinsisi. Palibe amene angalembe zainu kapena kukudziwani.

Zonse zotsatira za kafuku-fukuyi ndi phuziro la PhD lomwei lidzaperekedwa ku sukulu yayunivesite yaku Leeds m'chaka cha 2012. Kuonjezera pamenepo, zotsatira zonse za kafuku-fukuyi zidzalembedwa komanso kusindikizidwa ku likuku la maphunziro a kusitha kwa nyengo, chitukuko cha chuma ndi malangizo. Zotsatira zonse za kafuku-fukuzi zidzagwiritsidwanso ntchito mosatchula munthu aliyense. Ngati mukufuna kulandira mapepala a mapunziro a PhD ankhani imeneyi m'chaka cha 2012 auzeni alangizi ankhani imeneyi amene akuphunzitsa zankhani imeneyi ndikuwapatsa e-mail yanu kuti azakutumizireni zonse. Komanso ngati mungafune kuona msanga zotsatira za kafuku-fuku ameneyi, mayambiriro onse angapezeke mumalipoti onse akafukufukuyi. Ngatinso mukufuna kwona lipoti limereli mfuseni amene akukuphunzitsaniyo.

Kafuku-fuku ameneyi wakonzedwa ndikulipiriridwa ndi a UK Economic and Social Research Council kupyolera ku likulu la kusintha kwa Nyengo, Chitukuko ndi Malamulo.

Ngati mukufuna kumva zambiri funsani:

Chloe Sutcliffe, eecajs@leeds.ac.uk, +44 7748 960 233 (U.K.), 0991 029 557 (Malawi), Sustainability Research Institute, School of Earth and Environment, University of Leeds, LS2 9JT, UK

Mungathe kusunga chipepalachi mogwirizana ndi chipepala chinanso chachilo lezo.

Zikomo pololera kutenga nawo mbai pa ntchito ya kafuku-fukuyi.

Investigating maize cultivar choice for drought and flood adaptation

Name of Researcher: _Chloe Sutcliffe___________________________

Initial the box if you agree with the statement to the left

1. I confirm that I have read and understand the information sheet dated September-December 2010 explaining the above research project and I have had the opportunity to ask questions about the project. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason and without there being any negative consequences. In addition, should I not wish to answer any particular question or questions, I am free to decline. ☐
3. I understand that my responses will be kept strictly confidential. I give permission for members of the research team to have access to my anonymised responses. I understand that my name will not be linked with the research materials, and I will not be identified or identifiable in the report or reports that result from the research. ☐
4. I agree for the data collected from me to be used in future research ☐
5. I agree to take part in the above research project and will inform the principal investigator should my contact details change. ☐

________________________	________________	____________________
Name of participant (*or legal representative*)	Date	Signature

_________________________	________________	____________________
Name of person taking consent (*if different from lead researcher*) *To be signed and dated in presence of the participant*	Date	Signature

Copies:

Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

Kufufuza njira ya mbeu ya chimanga cha tsopano chomwe chingapime chilala ndi mvula yosefukira

Dzina la wofufuza: _Chloe Sutcliffe___________________________

Chongani mubokosi ngati mukugwiriziana ndi zimene zalembedwa

1 Ndikutsimikiza kuti ndawerenga ndikumvetsa zonse zimene zalembedwa pachipepalachi chap pa September-December 2010 kulongosola za kafuku-fuku ameneyi ndipo ndina patsidwa mwai wofunsa ngati ndamvetsetsa za nkhani imeneyi. ☐

2 Ndamvetsa kuti kutenga nawo mbali mu kafuku-fukuyu palibe amene wandiumiriza komanso ngati ndingasinthe maganizo palibe chobvuta. Ndipo sipadzakhala bvuton lina liri lonse, komano ngati sindikufuna kuyankha funso kapeno mafunso palibe wondiumiriza. ☐

3 Ndamvetsa kuti mayankho anga asungidwa mwachinsisi. Ndikupereka chilolezo kwa anthu amubungweli kugwiritsa ntchito mayankho onse mwachinsisi. Ndamvetsa kuti dzina langa silidzatchulidwa mukafuku-fuku ameneyu kapena kuti wina aliyense akandidziwe ine muzotsatira za kafuku-fukuyi. ☐

4 Ndabvomereza kuti zonse ndalongosola pakafuku-fukuyi akhoza kudzigwiritsa ntchito mtsogolo muno. ☐

5 Ndabvomereza kuti nditenga nawo mbali muntchito ya kafuku-fuku ameneyu komanso ngati ndingasinthe malo okhala (kusamuka) ndiwadziwitsa atsogoleri.. ☐

___________________	___________________	___________________
Dzina la mulimi	Date	Sayini

___________________	___________________	___________________
Mtsogoleri	Date	Sayini

To be signed and dated in presence of the participant

Copies:
Once this has been signed by all parties the participant should receive a copy of the signed and dated participant consent form, the letter/pre-written script/information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

Appendix II – Household survey 2010

Household Maize Questionnaire
DATE: ____________ AM/PM Village Name__________________ Interviewer _______________

Household ID code: _______ Respondent Code: _____________

[DO NOT ASK] Observations: House construction

Number of rooms: ________________ *Electricity: Y/N*

Roof- material and condition: ____

Floor- material and condition: ____

Windows- material and condition: ____

Door- material and condition: ____

Questions

Gender: M/F Age [ ] Literate: Y/N Head of HH? Y/N

How many in household? [ ]

How many dependents in household *(children/elderly/unwell)*? [ ]

Does HH own...	Bicycle	Radio	Mobile phone	Cattle	Goats	Chickens	Dimba	Treadle pump	Plough
How many?									

1a. Does household own any land? Y/N *(If yes go to 1c, if no, go to 1b)*

1b. Does household have access to any land for farming? *(If yes go to 1c, if no, go to section B on the last page of the questionnaire)*

1c. *Determine size of land as a fraction of known area (exercise using white cards)* _____________.

1d. Is all the land being used by the family for cultivation? Y/N

1e.Why not? ____

____

____

1f. When is your busiest time of year?

Preparing the land ☐ Planting ☐ Weeding☐ Harvesting☐ Other________________

1g. How many people do you need at this time? __________

1

Household Maize Questionnaire

DATE: ____________ AM/PM   Village Name__________________   Interviewer _______________

Household ID code: _______   Respondent Code: _____________

1h. How many household members are usually occupied in farming the household's land at non-peak times? _______

1i. Who decides which seeds to plant? ____

1j. Does your household ever get help with farming from non-household members? Y/N

1k. Does the household pay for this extra help with money or food or something else? *(If something else please specify)* ____

2a. Does household grow maize? Y/N *(If Yes go to 2b, if No go to question 3)*

2b. What fraction of the household's land is being used for growing the main maize crop? *(Use white cards)* ____

2c. What varieties of maize are being grown currently?

	i. Cultivar Name	ii. How much land is in use for each cultivar?
1		
2		
3		
4		
5		

	iii. Where did the seed come from?	iv. What was given in exchange for seed?
1		
2		
3		
4		
5		

2cv *(If household is only growing traditional maize)* Have you ever grown any modern maize? Y/N (If yes go to 2cvi, if no go to 2cvii)

2cvi. Why aren't you growing any modern maize this year? __________________________________

____

2cvii. How often do you buy new maize seeds? ____

2d. Please would you consider the following statement, "I am happy with the number of maize varieties that I am currently growing".

Do you Strongly Agree/ Agree/ Neither agree nor disagree/ Disagree/ Strongly disagree? *(please circle one)*

Household Maize Questionnaire

DATE: ____________ AM/PM Village Name__________________ Interviewer _______________

Household ID code: _______ Respondent Code: _____________

Why? ____

____

____

2e. Please would you consider the following statement, "I am happy with the types of maize that I am currently growing".

Do you Strongly Agree/ Agree/ Neither agree nor disagree/ Disagree/ Strongly disagree? *(Please circle one)*

Why? ____

____

____

2h. *(If the household has purchased no maize this year)* When was the last time you purchased maize seed for cultivation? ____

2i. Does your household grow a surplus of maize in order to sell it? Y/N

2j. In a good year what month do your maize stocks last until? ______________

2h. In a bad year what month do your maize stocks last until? _______________

2k. What characteristics are most important to you in selecting which maize variety to grow? ____

____

____

2l. Are your neighbours growing different maize varieties from you? Yes/ No/ Don't know *(If Yes go to 2m)*

2m. What are your neighbours reasons for growing these different varieties?

____

____

2n. Do you think that getting a good maize harvest is becoming easier or more difficult? *(circle one)*

2o. What are your reasons for thinking this?____

____

____

Household Maize Questionnaire

DATE: ____________ AM/PM Village Name__________________ Interviewer _______________

Household ID code: _______ Respondent Code: _____________

____

2p. How many times in the last twenty years has your maize harvest been very poor?___________

2q. How many of these times were caused by drought? ___________

2r. How many of these times were caused by flooding? ____________

2s. When your maize harvest has been very poor, how have you coped? _______________________

____

____

____

2t. Did you change anything about your maize farming practices following to try to avoid suffering losses from drought or flood in subsequent years? Y/N *(If yes, what did they do differently)*

____

____

____

3. What crops excluding maize are grown, and what percentage of each is grown for sale and consumption?

CROP NAME	Percentage of crop grown for sale (%)	Percentage grown for consumption (%)

4a. What fraction of household's land is currently fallow? ______ *(If any go to 4b, otherwise go to 5)*

4b. Why is land fallow (regenerate fertility/labour shortage/other)? _______________________

____

4c. How long will the land be left fallow for before it is cultivated again? _______________________

Household Maize Questionnaire

DATE: ____________ AM/PM Village Name__________________ Interviewer _______________

Household ID code: _______ Respondent Code: _____________

5a. Was your household farming here twenty years ago? Y/N *(If YES go to 5b, if NO go to 6)*

5b. Has anything changed about the way you farm since that time? __________________________

____

____

____

____

5c. What maize varieties were you growing ten years ago? _______________________________

____*(Go to Q7)*

6. What was your family doing twenty years ago, and where were you?

____

____

____

7. Can you list the items your household spends money on in order of importance?

Household expenditure item	Rank given

8. Can you list the sources of income for your household in order of importance?

Type of job?	Rank	Time of year?	Village or elsewhere?
			Village/elsewhere
			Village/elsewhere
			Village/elsewhere
			Village/elsewhere
			Village/elsewhere
			Village/elsewhere

Household Maize Questionnaire
DATE: ____________ AM/PM Village Name__________________ Interviewer _______________

Household ID code: _______ Respondent Code: _____________
9a. What is the most important food to your household? Maize/other *(If other please specify below)*
____

(If household grows maize ask 9b and 9 c. If household does not grow maize, go to 9d)

9b. How many times a day does your household eat maize whilst your own stocks last? __________

9c. And when they run out? __________

9d. What alternatives you can feed your family instead of maize?
____

____

9e. Do you prefer to eat maize to the alternatives you have given? Y/N

Why? ____

____

____

10a How has your household been affected by the government subsidy programme?

____

____

____

____

Thank you very much for answering our questions. We are coming back to carry out more research activities within the village. We will be choosing a few people to participate in these coming research activites. Would you be happy to participate if you were chosen? Y/N

Appendix III – Household survey 2011

Research Assistant name _______________ Questionnaire number: _____ Village A, B, C District: A, B

Age______ Sex_____ Household head: Y/N *(If not HhH): HhH M/F When will HhH be back? Today/days/weeks/months/years/never* Number in HH____

Livestock: chickens/pigeons/ducks_____ goats/pigs_____ cows_____ Munda land: _______ acres Dimba land: _______ acres

Mobile phone____ Bicycle_____ Radio______ Iron roof: Y/N Used F last year: Y/N Provided ganyu last yr: Y/N

Seed company	1. Ever grown any maize from this company? (Y/N)	Cultivar	2. Ever grown cultivar (✓)	3. Top-ranked two ever grown (1,2)	4. Worst one ever grown (✓)	5. Which varieties were grown last year (✓)	6. Subsidy received last year? Used for (✓)	7. Which would they grow next year if they get subsidy? (✓)	8. Which variety would they grow next year if no subsidy? (✓)	9. Any variety they haven't tried but want to try (✓)	10. DROUGHT TOLERANCE	11. SHORT SEASON	12. DIMBA	13. DRY SPELLS	14. YIELD	15. NSIMA	16. PEST RESISTANCE
PANNAR	*If other PANNAR write name* →	PAN 4M-19															
		PAN 53															
		PAN 67															
SEEDCO		SC403 (Kanyani)															
		SC627 (Mkango)															
		SC719 (Njobvu)															
DEKALB/ MONSANT		DKC 80-33															
		DKC 80-53															
		DKC 80-73															
		DKC 90-89															
		NSCM 41															
DEMETER (OPV)		ZM309															
		ZM523															
		ZM621															
		ZM623															
		ZM721															
SEEDTECH PEACOCK FUMWE ASSMAG	← *If yes circle the name.* *If other write name* →	MH18															
		MH26															
		MH27															
LOCAL																	
OTHER																	
Don't know																	

17. Why did you grow the variety they grew last year**?** ____

____

(If last year's cultivar(s) are not listed as top-ranking cultivar(s) in question 3 ask…) Why did you not grow your preferred maize variety last year? _________________

____

18. Why have you not tried growing the variety you mentioned in question 9? ____

____

Why do you want to try that variety? ____

____ Did you find out about that variety from a neighbor/ field trial/ radio/ poster/ extension/ agri-dealer?/ Other?

FERTILIZER (*If the household used fertilizer last year, ask…)*

19. How much did fertilizer did you use last year? __________ plates/ ______bags (if bags, please find out size of bag used e.g. 1kg, 2kg, 3kg and fill this info in)

20. Were government vouchers used to purchase fertilizer? Y/N

SUBSIDY (*If there has been no mention of receiving any subsidy for maize seed, ask…)*

21. Have you ever received government vouchers for purchasing maize seed? Y/N

RECYCLING HYBRID SEED (i.e. seed from these companies: Seedco/Monsanto/Pannar)

22. Has your household ever recycled (or used recycled) ***HYBRID*** seed? Y/N

Are you aware of any problem with using recycled hybrid seed? Y/N What is the problem…? Quality deterioration/ Becomes like the local maize/ Everything from harvest gets eaten/ don't know/ other (If other, what?)____

LOCAL MAIZE

24. How many years since the last time the household grew local maize? ______ Why do you/ do you not grow local maize? __________________________

____

MAIZE DEMO FIELDS

25. Have you ever heard of any maize demonstration fields in this area? Y/N Have you been to see any maize demonstrations in this area? Y/N

Why not? ____

Appendix IV – Interview topic guide example

Questions for seed companies

Objectives: The aims of this interview is to obtain information about the range of cultivars marketed by the company, about the businesses perspective on smallholder maize use, strategies for marketing and patterns of uptake of new maize cultivars.

Introduction:

- Thank the interviewee for taking part
- The interview should take about an hour, if they would like a break at any point just let us know.
- The purpose of the research is to understand more about the role of maize cultivar change as one of a range of strategies for adapting to climate change amongst smallholders. Data is being collected at the household level to illustrate current maize uses and preferences for maize cultivars and characteristics. The research is particularly concerned with identifying barriers to adaptation and vulnerable groups. A range of stakeholders are being interviewed to help situate the research in the wider political context. Any information provided to us will be represented anonymously in the thesis and subsequent publications, their comments will not be identifiable as belonging to them or their organization, unless they specifically request otherwise.
- The usefulness of the research to organizations operating in Malawi is also an important concern. This interview should also be used as an opportunity to find out about the organizations key research concerns and to assess whether the organization would like any input into the next stages of data collection.
- Check whether the interviewee is comfortable and happy to continue. Do they have any questions they would like to ask first?

Product range:

- Is it possible to obtain a list of the maize cultivars you marketed last year and are marketing this year?
    - Including details such as cultivar characteristics, prices, package sizes?
- Can you describe the process by which you produce and select maize cultivars to market?
    - Do you undertake market research? What kind of research is undertaken?
    - Who is/are your target customers? Which varieties are targeted at which customers?
    - Have you ever dropped any cultivars from your product range? How does this decision come about?
- How does the company ensure adequate supplies of seed are produced?

Demand:

- Which of your cultivars are the most popular?
- Why do you think this is so?
- How long has that been the most popular cultivar for, and which cultivars were selling well before then?
- Which are least popular?
- Why do you think this is so?
- Do you think there is more demand for composite or hybrid varieties? Why?
- What sorts of customers prefer what kinds of cultivars?
    - o Is this dependent on wealth, farm size, labour, whether they are planning to sell the maize they grow? Other factors?
- What factors do you think are the most important to smallholders in terms of deciding what maize cultivar to purchase?
    - o And in terms of maize cultivar characteristics, what kinds of qualities are most important?
- Have preferences for cultivar characterstics changed since you've been working for the company? How have they changed? How do you expect preferences to change in future?
- Does your company participate with the subsidy programme – how does it operate?
- Which, if any, of your cultivars were included in the subsidy programme last year?
- How does the government decide which cultivars to include in the programme?
- Has the subsidy programme had a big impact on which cultivars you are selling the most of?
    - o Would you say it has had a positive impact on your business in Malawi? In what ways?
- Are you aware of any differences between the customers using the coupons and those that don't?
    - o Either in terms of specifically what is purchased using the coupons and what is purchased by cash-paying customers, or in terms of research the company has done into coupon recipients
- Do you produce seeds for other crops besides maize? If so, is demand for different types of crop seed that you sell fairly constant, or do you notice trends in preference for different types of crop? For example…?
    - o Which crop type is your best seller? (Both in terms of quantity sold, and in terms of economic share of sales)
    - o Is the popularity of maize vis a vis other crops changing at all?
- Do you have a personal opinion about which is the best of the maize cultivars you produce? Why that one? In your opinion, what sorts of maize characteristics are most important for production given the current range of pressures faced in Malawi?
- Do you think smallholders face barriers in obtaining their preferred cultivars? What are the barriers they face and how can these be overcome?

Advice and information:

- How do you provide information about your cultivars to smallholders?
- Do you offer best practice advice in terms of maize cultivation?
- What sort of advice do you offer? How is it communicated? Why is this advice offered?

Marketing and uptake:

- How do is marketing and advertising organized for your company's seed products?
- Do marketing campaigns by the different seed companies differ? How do they differ?
- Do you think some approaches to seed marketing are more effective than others? Which would you say work particularly well and why? Which work less well and why? Do different seed companies target different types of maize farmer? Do you think smallholders are strongly influenced by the marketing campaigns of seed companies?
- In your experience have certain new cultivars met with a very successful level of uptake by farmers? Which cultivars? Why was uptake so successful? How many years before this cultivar was widely grown? What was prompting farmers to start demanding this cultivar specifically?
- In your experience have certain new cultivars met with poor levels of uptake? Can you give an example? Why do you think this was the case?

Climate change:

- Do you think climate change is affecting Malawi?
    - Will it affect Malawi in future?
- What kinds of impact do you expect climate change to have on demand for cultivars?
- Do you plan to change the range of cultivars you stock to reflect this?
- How do you expect your company's operations in Malawi to be affected by climate change?
- What strategies do you think are most important for farmers adapting their production to climate change? And for food security?
    - What is likely to happen/ should happen in terms of the dietary role of maize within the country?
    - How diverse do you think farmers should be in terms of numbers of cultivars/ crops grown?

Appendix V – Assets scores 2010

		N	Min	Max	Mean	St. Dev	Asset Score
NGABU	Hh owns bicycle	162	0	1	0.506173	0.501512	0.984676
	Hh owns radio	162	0	1	0.41358	0.494002	1.18708
	Hh owns mobile phone	162	0	1	0.209877	0.408483	1.934287
	Hh owns cattle	162	0	1	0.080247	0.272517	3.375024
	Hh owns small livestock	162	0	1	0.438272	0.497714	1.128618
	Hh owns middle-sized livestock	162	0	1	0.148148	0.356348	2.390503
	Hh owns a dimba	162	0	1	0.283951	0.452311	1.58309
	Number of treadle pumps owned by household	162	0	1	0.04321	0.20396	4.691074
	Number of ploughs owned by household	162	0	1	0.012346	0.110766	8.916623
	Hh employs help	162	0	1	0.055556	0.229772	4.11036
KASUNGU	Hh owns bicycle	130	0	1	0.453846	0.499791	1.092764
	Hh owns radio	130	0	1	0.592308	0.493306	0.826448
	Hh owns mobile phone	130	0	1	0.492308	0.501875	1.011591
	Hh owns cattle	130	0	1	0.015385	0.123553	7.969171
	Hh owns small livestock	130	0	1	0.476923	0.501399	1.043234
	Hh owns middle-sized livestock	130	0	1	0.161538	0.369451	2.269482
	Hh owns a dimba	130	0	1	0.307692	0.463324	1.49422
	Number of treadle pumps owned by household	130	0	1	0.015385	0.123553	7.969171
	Number of ploughs owned by household	130	0	0	0	0	
	Hh employs help	130	0	1	0.169231	0.376406	2.207109

Appendix VI – Cultivar stock list for Kasungu and Ngabu

DISTRICT	SHOP NAME	CULTIVARS AVAILABLE	PACK SIZES STOCKED	PRICES (MK)
NGABU	Kwa Issa	Kanyani (SeedCo 403)	1Kg	400
			5Kg	1750
		DK 8033	2Kg	800
		ZM (shop assistant did not know the specific cultivar name)	5Kg	750
	Nkhoma Enterprise	Kanyani (SeedCo 403)i	1Kg	350
			2Kg	700
		DK 8031	2Kg	700
	Chipiku	Kanyani (SeedCo 403)	5Kg	1720
		DK 8033	5Kg	1720
			2Kg (very few packs available	800
		Pan 67	5Kg	1720
	Agora	Kanyani (SeedCo 403)	2Kg	800
			5Kg	1780
		DK 8031	5Kg	1780
		DK 8033	5Kg	1780
		ZM621	7.5Kg	Subsidy coupon exchange only
		Pan 67	2Kg	800
			5Kg	1780
	ADMARC	Kanyani (SeedCo 403)	5Kg	Subsidy coupon exchange only
		DK 8053	5Kg	Subsidy coupon exchange only
		Pan 67	5Kg	Subsidy coupon exchange only
KASUNGU	Kulima Gold	Kanyani (SeedCo 403)	2Kg	800
		DK 8033	5Kg	1750
		DK 8073	5Kg	2300 (not available for subsidy exchange)
		Pan 53	5Kg	1950
		Pan 67	5Kg	1950
	Farmer's World	Kanyani (SeedCo 403)	5Kg	1980
			2Kg	850
		DK 8053	5Kg	1750
		ZM621	7.5Kg	Subsidy coupon exchange only
		DK 8033	2Kg	750
	Chipiku	Kanyani (SeedCo 403)	2Kg	690
			5kg	1710
		Mkango (SeedCo 627)	2Kg	690
			5Kg	1710
		DK 8033	2Kg	690
			5Kg	1710
			10Kg	3580
		DK 8073	2Kg	690
			5Kg	1710
			10Kg	3580
		Pan 53	2Kg	690
			5Kg	1710
		Pan 67	2Kg	690
			5Kg	1710
	Malawi Agricultural	Kanyani (SeedCo 403)	1Kg	400
			2Kg	700

	Commodity Exchange	DK 8033	5Kg	1750
		Pan 53	5Kg	1500
		Pan 67	5Kg	1500
	Smallholder Farmers' Fertilizer Revolving Fund	Kanyani (SeedCo 403)	5Kg	1980
		DK 8033	2Kg	830
		DK 8053	2Kg	830
		DK 8073	2Kg	930
	People's Supermarket	Pioneer 30D79	5Kg	1105
			10Kg	2100
		Pioneer 30G19	5Kg	1105
			10Kg	2100
		Pioneer P2859W	5Kg	1050
		Kanyani (SeedCo 403)	1Kg	400
			2Kg	785
			5Kg	1925
			10Kg	3850
		SeedCo 513	1Kg	400
			2Kg	785
			5Kg	1925
			10Kg	3850
		Mkango (SeedCo 627)	1Kg	400
			2Kg	785
			5Kg	1925
			10Kg	3850
		Njobvu (SeedCo 719)	1Kg	415
			2Kg	820
			5Kg	1990
			10Kg	3910
		DK 8031	2Kg	820
			5Kg	1865
			10Kg	3965
		DK 8033	2Kg	820
			5Kg	1865
			10Kg	3965
		DK 8053	2Kg	860
			5Kg	1865
			10Kg	3965
		DK 8073	2Kg	935
			5Kg	2330
			10Kg	4080
		NSCM41	2Kg	820
			5kg	2330
			10Kg	4080
	Metro	Kanyani (SeedCo 403)	1Kg	400
			2Kg	785
			5Kg	1925
			10Kg	3850
		Mkango (SeedCo 627)	1Kg	400
			2Kg	785
			5Kg	1925
			10Kg	3850
		Njobvu (SeedCo 719)	1Kg	415
			2Kg	820
			5Kg	1925
			10Kg	3965
		DK 8033	2Kg	820
			5Kg	1865
			10kg	3965
		DK 8053	2Kg	820
			5Kg	1865
			10Kg	3965
		DK 8073	2Kg	935
			5Kg	2330
			10Kg	4080
		Pan 53	5kg	1925
		Pan 67	5Kg	1925