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Baseline and Situation Analysis Report: Integrating Crop and Livestock Production for Improved Food Security and Livelihoods in Rural Zimbabwe

Thabani Dube [1], Sabine Homann-Kee Tui [1], Andre van Rooyen [1] and Daniel Rodriguez[2]

[1] ICRISAT, Bulawayo, Zimbabwe, t.dube@cgiar.org

[2] QAAFI, University of Queensland, Brisbane, Australia

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Abstract

Farmers in Zimbabwe face many challenges, including low soil fertility, low and erratic rainfall, and poor market access. They are therefore often poor and vulnerable to risks and shocks. With increasing human populations and a dwindling natural resource base, farming systems are under greater pressure to provide sufficient food and sustain farmers' livelihoods. There is a dire need to intensify farming systems on a sustainable basis. Previous efforts have been focusing on improving either crop or livestock production, often ignoring the potential synergies mixed systems offer. We believe that substantial gains can be made by better integrating crop and livestock systems, using the resources more effectively and following a more market-oriented approach. This report describes the baseline situation of crop-livestock systems in semi-arid Zimbabwe. It informs the ZimCLIFS project, which has the goal to improve rural food security and livelihoods through promoting sustainable intensification of integrated crop-livestock systems and market participation. The report focuses on communities in Nkayi and Gwanda Districts, situated in agro-ecological zones IV and V in southwestern Zimbabwe. In each district participatory community visioning was held to identify development pathways that the communities seek to pursue. About 300 households were interviewed to compile data informing a comprehensive farming systems analysis. Descriptive statistics characterize the households, including a disaggregated gender analysis. Through factor and cluster analysis, farm households were grouped into most common-farm types based on resource endowments, agricultural production levels and market markets. Communities in both districts saw their future in market-oriented agriculture. The levels of both crop and livestock production were however very low at both districts. Maize, the predominant crop, yielded less than 400 kg per ha, during a year of relatively low rainfall. Yields of sorghum and groundnuts were even less. Farmers relied mainly on using resources within their systems. Almost all households used animal draft power to plow crop fields, more than half the households fed crop residues to their animals and a third used animal manure as organic fertilizer. The use of external inputs was more limited. Fewer than 20% of households applied fertilizers. In Gwanda about a third of the livestock keepers fed commercial stock-feeds to their animals. As a result of low production, crop sales and livestock off-take rates were also low (<5%), and financial reinvestments limited. Farm typology analysis suggests that households experienced different levels of resource endowments and their investments in agriculture varied. The majority were very poor, especially female-headed households. They need safety support to protect their assets. For them drought-tolerant crops and small stock, improved management and strong support to start marketable production could make a difference. Distinctively different were the groups of intensifying farmers. They were better endowed in resources and access to information, practiced more diversified and integrated farming systems, and earned higher income from agriculture. Even though a small proportion, these farmers are important for promoting improved agricultural production. The farm typologies will be used to simulate potential yields and welfare gains for different types of household in their specific contexts.

Keywords: crop-livestock systems, sustainable intensification, farm typologies, Zimbabwe

JEL classification: Q01, Q16:

Contents

1. Introduction

For the majority of smallholder farm households in rural Zimbabwe, crop-livestock farming is the main livelihood activity. Farmers here are often poor and vulnerable. They face many challenges, including erratic rainfall, overused and degraded rangelands and soils, poorly developed markets for both inputs and outputs, and expanding human populations increases the pressure on the natural resource base. As a consequence agricultural productivity is stagnant or declining. Here we highlight the importance of crops and livestock for ensuring food security and income generation as well as options for sustainable intensification of these systems.

Why crops and livestock for food security? Crop production is one way to provide staple food for a household, but under low and erratic rainfall it is a risky activity. In semi-arid areas most farmers are net buyers of staple food and they are able to produce enough staple crops that last a few months, especially in high rainfall years. Farmers use livestock as a way to generate nutritious food (milk, eggs and meat) and cash from sales in times of need. Livestock can be sold to buy food that cannot be produced on-farm. Livestock also contribute to crop production by providing draft power and manure, making an indirect yet important contribution to food availability. Diversifying into crops and livestock thus stabilizes food security in the face of climate variability, providing flow products and allowing households to acquire food throughout the year.

What are the current performance levels? Despite their importance, the performance of crops and livestock has been low and declining. History has proven that there is a potential for higher performance; maize yields for instance averaged 1.5 t/ha in the 1980s, but are down to 0.5 t/ha in the 2000s (Mazvimavi et al., 2012). Investment levels are currently very low. Even where crop surpluses are available at the farm gate, value chains are not providing effective links between producers and the market. We believe that using the high and increasing demand for nutritious food as opportunity, market-based solutions can contribute substantially to improving food security at the household level and attract future investments into Zimbabwean agriculture.

How can crop-livestock integration contribute to sustainable intensification of farming systems? Crops and livestock provide valuable outputs that can be used to enhance overall farm system productivity. Animal manure provides essential nutrients, improving crop productivity. Crop residues provide essential animal feed during times of shortage, improving livestock productivity. Having draft animals in good condition, farmers can prepare land on time, which improves water- and nutrient-use efficiency and increases crop yields. The cash from livestock, beyond food, can also be used to buy agricultural inputs, thus reinvestments into the agricultural system increase. Optimizing the use of these resources and strengthening their integration can increase production per unit land, especially under high-risk conditions and where access to external inputs is difficult.

It is against this background that the research project, **Integrating crop and livestock production for improved food security and livelihoods in rural Zimbabwe (ZimCLIFS**), funded by the Australian Centre for International Agriculture Research (ACIAR), is being implemented in the sub-humid region (SHR) and semi-arid regions (SAR) of Zimbabwe. This

report focuses on the SAR, Gwanda (region V) and Nkayi (region IV) districts. The overall goal of the ZimCLIFS project is to identify, test and prove ways to increase agricultural production, improve household food security, alleviate poverty and thereby reduce food-aid dependency in rural Zimbabwe through better integrated crop and livestock production and market participation. Specific project objectives are:

- to increase productivity of smallholder crop-livestock farming systems in four districts in two contrasting agro-ecological regions of Zimbabwe by identifying and adapting technologies and associated management practices
- to improve farmers' access to resources, technologies, information and markets by characterizing and strengthening crop (maize, sorghum, legumes) and livestock (goats, cattle) value chains.
- to increase knowledge and skills of research and extension services and agribusiness, enabling the former to design and implement integrated farming systems and value chain research and the latter to target and scale out knowledge generated by the project elsewhere in Zimbabwe.

This report aims at providing baseline information for farming systems analysis and reference material for quantifying impact made by or due to the project. The baseline information provided here involves three components:

1. Community visioning: We use visioning as a powerful tool to illustrate communities' perceptions of and satisfaction with their current farming practices, as compared to what seems possible for the communities and where the communities want to go in the future. Communities were engaged to further define the key strategies that would allow them to achieve their desirable future.

2. Diversity of farming systems in semi-arid areas: We compare the socio-economic situation of the two project districts with a focus on four productivity and welfare indicators:

- Increased agricultural production and productivity,
- Increased turnover and income,
- Reduced agricultural risk, and
- Increased integration of crop-livestock sub-systems.

3. Site-specific farm typologies: We identify farm types to better understand asset levels, constraints and opportunities among smallholder households within the project districts. Better understanding farmers' endowments and aspirations will help us to target interventions within a particular context.

In what follows we first describe the community visions at the respective sites. We then characterize the socio-economic situation of farm households, the levels of crops and livestock production, crop-livestock integration and market participation, disaggregated by gender of head of households. Finally, we present the farm typologies found at each site and discuss the implications for farming systems development.

2. Methods

2.1 Study sites

Nkayi (28°E, 19°S) and Gwanda (29°E, 21°S) Districts are located in Matabeleland North and South provinces of Zimbabwe respectively. Nkayi is in natural region IV, which is characterized by low annual rainfall (450-650 mm, Figure 1, Vincent and Thomas, 1957). Most of the Gwanda area is in region V and receives on average <450 mm annual rainfall. Its northern tip falls under region IV. In both districts rain fed agriculture is highly risky, as mid-season dry spells and seasonal droughts are common. Despite the unreliable rainfall, most farmers in Nkayi and Gwanda engage in rain fed crop and livestock production. Nkayi District is suited to semi-intensive farming systems in which drought-tolerant crops and livestock are produced. Gwanda District is more suitable for extensive rangeland livestock based systems.

The survey data refers to the 2012/2013 season, when rainfalls were slightly below average in Nkayi (456 mm) and below average in Gwanda (253 mm). Low rainfall and poor access to adequate inputs, among other factors, influence the actual proportion of land cultivated and yield levels.

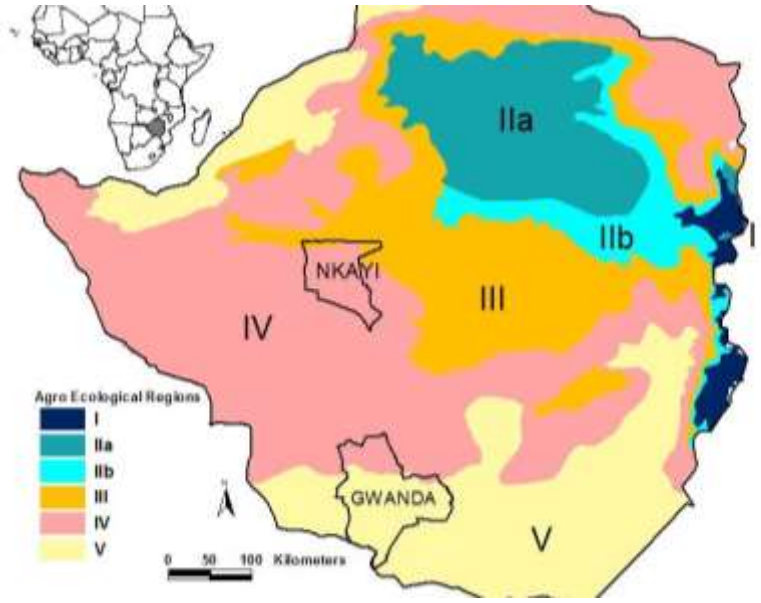


Figure 1. Agro-ecological regions in Zimbabwe (Source: ICRISAT GIS unit)

In Nkayi, deep Kalahari sands are the most common type of soil, covering more than 60% of the district; the rest is grayish brown sand (Figure 2). Gwanda District has sands and loams in the south varying in depth and color, greyish-brown sands in the center and sands and sandy loams in the north. These predominantly sand soils have limited ability to store organic matter and nutrients, such that soil fertility declines rapidly under cultivation (Ncube, 2007).

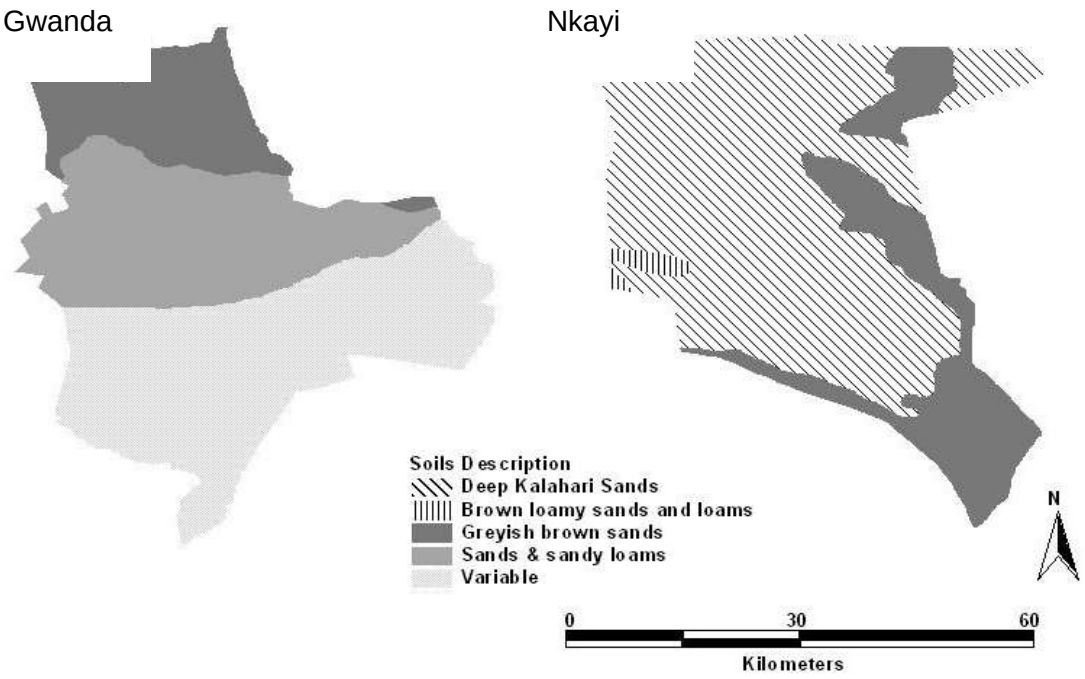


Figure 2. Soil maps for Nkayi and Gwanda Districts (Source: ICRISAT GIS unit)

In Nkayi District the most common types of vegetation are broad leafed woodlands, teak and *Brachystegia spp.* Biomass is relatively abundant (3-4 t Net Primary Production (NPP) per ha and year, Table 1), but it is of relatively low nutritional value for livestock, with protein and phosphorus deficits. In Gwanda the vegetation is dominated by dry broad leafed woodland and by *Terminalia sericea* and *Julbernardiaglobiflora* trees. Smaller proportions are with the Mopane tree Savanna and annual grasses, such as *Boscia, Aristida* and *Panicum spp.* The nutritional value of the vegetation is higher than in Nkayi (sweet veld), but less biomass is available (<3 t NPP per ha and year), and biomass shortages are a major constraint. Rangeland degradation, soil erosion and nutrient mining after continuous cropping without replenishing soil fertility affect both districts.

2.2 Socio-economic conditions

Vulnerability assessments define 76% of the rural population in Zimbabwe below the poverty line, 22% extremely poor (ZimVAC, 2013). Matabeleland North and Matabeleland South provinces have among the highest poverty rates in the country. During April 2012, the average monthly household incomes were below USD 100 in both provinces. Food insecurity is a chronic problem; prevalence of stunting affects more than 30% of the rural population. More than 60% of the population relies on purchasing food to secure their food needs. Matabeleland North and South provinces also have the highest food insecurity in the country. In Matabeleland North 40% households are food insecure, with 39% in Nkayi District; in Matabeleland South 30% of the households are food insecure, with 25% in Gwanda, but higher rates in Gwanda North.

The human population of Nkayi and Gwanda district was in 2012 109,135 and 115,778 persons respectively (ZimStat, 2013).The human population density is higher in Nkayi than in Gwanda (Table 1). High rates of female-headed households in Nkayi and in Gwanda (40% and 34% respectively) reflect the migration of men who seek economic opportunities in cities and neighboring countries, while women take over important positions in farm management.

In both districts maize is the predominant crop, followed by small grains and a smaller portion under legumes (Table 2). Areas with sorghum and legumes seem larger in Gwanda than in Nkayi. The cultivated land under maize increased sharply in Nkayi after 2009, probably due to better availability of inputs. Data for maize production in Gwanda were not available. Data for sorghum and groundnut production in Nkayi seemed incomplete.

Even though livestock densities are higher in Nkayi than in Gwanda District, total livestock populations and households herd sizes are higher in Gwanda than in Nkayi. Goat numbers show a strong increase in the recent years, while cattle numbers seem stagnant.

Table 1. Characteristics of Nkayi and Gwanda Districts

District	**Biomass (NPP t ha^{-1} yr^{-1})**	**Human pop. density (n km^{-2})**	**Livestock pop. density (TLU km^{-2})**		**Average herd size per HH (n)**	
			Cattle	Goats	Cattle	Goats
Nkayi	3-4	20	12	8	4.6	1.9
Gwanda	<3	10	8	1	6.9	7.3

Source: ZimStat, 2012, DVS, http://sedac.ciesin.columbia.edu/gpw (NPP)

Table 2. Trends in crop and livestock production in Nkayi and Gwanda Districts, 2009-2013

	Nkayi					**Gwanda**				
	2009	2010	2011	2012	2013	2009	2010	2011	2012	2013
Cultivated area (ha)										
Maize	9,115	20,461	23,077	22,080	20,342	-	-	-	-	22,836
Sorgh	625	3,238	858	5,538	2,104	13,780	10,840	8,895	9,985	10,623
G'nut	250	2,000	1,686	310	550	5,698	4,776	2,781	4,000	3,326
Livestock numbers (n)										
Cattle	110,620	100,467	100,418	98,814	101,270	103,474	112,967	129,158	112,967	-
Goats	-	37,053	31,233	35,907	87,540	40,536	118,123	136,962	192,329	-

Source: AGRITEX and DVS

2.3 Data collection and analysis

This report combines two types of data: community visioning as soft approach to capture farmers 'perceptions and priorities combined with baseline surveys to quantify household characteristics.

Community visioning: At Innovation Platform inception workshops, with about 40 participants, including farmers, government departments and extension, NGOs and agro-dealers, visioning was used as a tool to engage everybody in a discussion about their current status and a desirable future. Farmers and support services in separate groups characterized the current state of their livelihoods and the desired future state. The visions were illustrated in rich pictures, which can be used to monitor changes. Participants then identified the barriers likely to be met and the steps required to achieve the desired state. This process clearly defines the development pathway the larger community expects to follow.

Baseline surveys: For the household surveys, a multi-stage sampling approach was used. A total of four wards were purposely selected in each district, following the sampling procedures of the previous System wide Livestock Program (SLP) study. The wards were selected at different distances to a major business center and roads, in order to cover areas close and far from market influence. In each ward three villages were randomly selected from the ward's village lists. The village population ranged between 200 and 300 households. Household lists were collected and 25-30 households randomly selected per each village, using random numbers generated in Excel. A total of 331 and 350 households were interviewed in Nkayi and Gwanda Districts respectively.

A common household survey tool had been designed by the research teams for use across the two project regions. In the SAT, the data collection was carried out from March to May 2013 by a team of trained enumerators from ICRISAT and Matopos Research Institute. The questionnaire was administered to collect both qualitative and quantitative data. It had seven subsections on demographic information, access to infrastructure and asset ownership, landholding and crop production, livestock production and marketing, access to agricultural services, food security, and information on household income.

Descriptive statistics for characterizing the farming systems were analyzed mainly using SPSS. The descriptive statistics were disaggregated by male- and female-headed households. For the farm typologies a systematic classification approach was applied, developed by Rodriguez et al. (2013), using the R-Statistic software (R Development Core Team, 2011). After data cleaning, R procedures were first used for factor analysis, including a normalized Varimax rotated principal component analysis. Principal components with Eigen values>1 were examined and extracted. Around 10 variables explained most variability in the data set. In a next step the household typologies were developed using hierarchical clustering (Ward's minimum variance linkage method) with Euclidean distance as the similarity measure. The farm types were characterized using the full set of variables. They were validated at community workshops four months later.

For interpretation of farm typologies we acknowledge Dorward et al.'s (2009) concept of stepping stones:

1. Households have different dispositions to invest and sustainably move towards higher levels of production, food security and income.
2. Households need to move beyond a minimum threshold of assets and resilience – otherwise they cannot withstand shocks and fall back to lowest levels.

Three types of livelihood strategies are differentiated:

- **Hanging in:** Farmers with limited resources earn low returns on their few holdings and have little surplus after meeting their immediate needs, which perpetuates their poverty. These households aim at maintaining their livelihood levels, and require safety net support to do so.
- **Stepping up**: Farmers have minimum assets required to intensify and increase productivity within the existing agricultural activities. Investing in productive activities they expand their agricultural activities, generate more income and improve their livelihoods.
- **Stepping out**: Farmers have assets beyond the minimum threshold and accumulate assets which will allow them to move into different activities with higher or more stable returns.

3. Results

3.1 Community visioning

Following a visioning process is a powerful tool to define the current state, with its challenges and opportunities, while the future state defines the goal state to which people aspire. Once these states are documented (on paper in the form of rich pictures), an analysis of the challenges that need to be overcome, the transitions that need to be made, and the external support (infrastructure, policies etc.) required to continue along this development path can be identified. It provides a clear and stepwise strategy, which is visible to everybody. The potential changes become real and tangible as the process unfolds.

By illustrating the current situation and vision for a better future the communities in Nkayi and Gwanda portrayed perceived agricultural potentials. The differences between the states illustrate that, if supported well, change can happen and improve local livelihoods substantially. Even though the aspirations seem similar across the sites, the pathways and options to achieve these visions were slightly different, in response to the context-specific conditions.

3.1.1 Nkayi: Crop-livestock integration and market linkages to boost production

Participants believed that there is strong potential to improve agricultural production by increasing crop and livestock production and improving their integration (Figure 3). Improved agricultural production and market linkages will bring forward higher incomes from agriculture. Off-farm activities might become less important. Improvements in agriculture will translate in investments in electricity, water, sanitation and housing, health and schools, improving farmers 'livelihoods in the medium term.

Participants suggested three entry points for moving up this development pathway:

1. Intensify crop production and diversify into larger areas with legumes and fodder crops. This was expected to increase biomass production, grain yields, and the availability of crop residues for feed and ground cover. Manure management was seen as an integral component.
2. Increase cattle and goat production and offtake, and improve livestock quality to generate more income from livestock. First, the feed quality needs to be improved through crop residue and fodder production and feeding. Second, if mechanization would release cattle from draft power for cropping, this would allow farmers to use cattle more for income generation.
3. Improve market infrastructure and this greater organization will attract more farmers to sell their crops and animals at the market. Greater engagement in markets will enhance farmers trust in markets and encourage them to better plan their market operations.

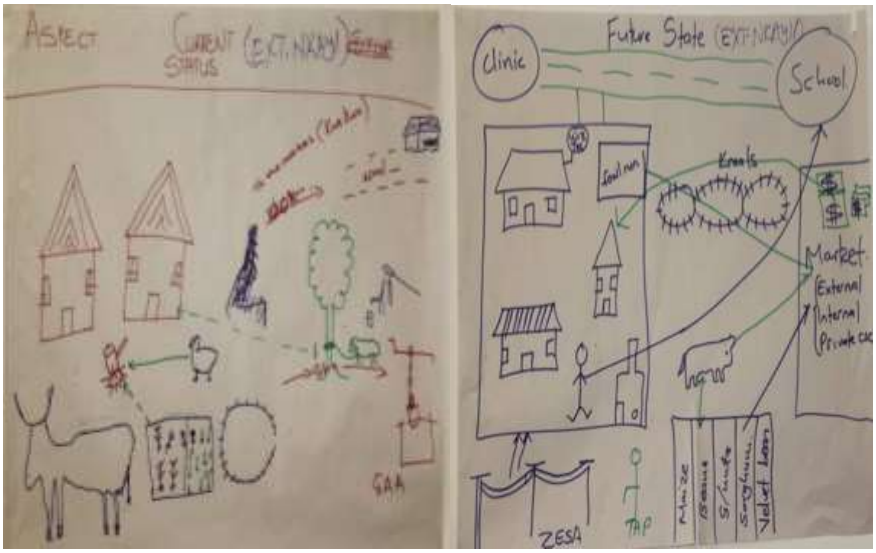


Figure 3. Visions for agricultural production in Nkayi District. 3.a. current, 3.b. future.

3.1.2 Gwanda: Livestock market improvement for upgrading the farms

Farmers in Gwanda see the promotion of livestock markets as most critical (Figure 4). They have seen recent improvement in livestock markets. They believe that the low prices for livestock are a result of poorly organized markets and poor quality production. Higher incomes from livestock sales will allow re-investments into their own farming system, e.g., selling livestock to buy stock-feeds, fertilizer, or irrigation equipment. In comparison, they see the scope for crop improvement as rather limited, due low and erratic rainfall. Higher crop yields must be achieved through low cost crop management improvement and this also contributes feed for livestock. Through greater participation in livestock markets farmers will improve housing standards, including electricity, transport and water reservoirs.

Participants emphasized two entry points:

1. Improve market development, which involves sale pen management, auctioning or direct sales to abattoirs, grading and premium prices for higher quality, better access to inputs

and market information. They aim at enhanced fodder production and pen feeding to sustain the flows of good quality animals to the market. Farmers were interested in fattening livestock for market purposes.

2. Increase crop production by improving soil fertility though better manure management, water harvesting, pests and disease control, and identifying market opportunities for drought-tolerant crops such as sorghum.

Figure 4. Visions for agricultural production in Gwanda district. 4.a. current, 4.b. future.

3.2 Diversity in farming systems

How different are agricultural systems in semi-arid Zimbabwe actually? Both districts, Nkayi and Gwanda have a lot in common: In both districts all farmers have access to cropland and rangelands. Crop production is rain fed, and croplands are used on an individual basis. Rangelands are used on a communal basis and provide the main source of livestock-feed during both dry and wet season, with dry season feeds shortages buffered through the use crop residues.

The distribution of cropland and livestock however differs, illustrating different orientations of the farming systems. Nkayi District, with higher agro-ecological potential, has a greater focus on crop production and the correlation between cropland and cattle herd sizes is stronger, depicting a stronger integration of the two sub-systems (Figure 5). Many households do not have livestock, and a few have livestock with very small cropland. In comparison, Gwanda has larger cattle herd sizes and the correlation between cropland and cattle herd sizes seems less. A number of households have large cattle and goat herd sizes but seem to invest little in crop production. There are also households who have cattle and goats but seem to practice only limited cropping.

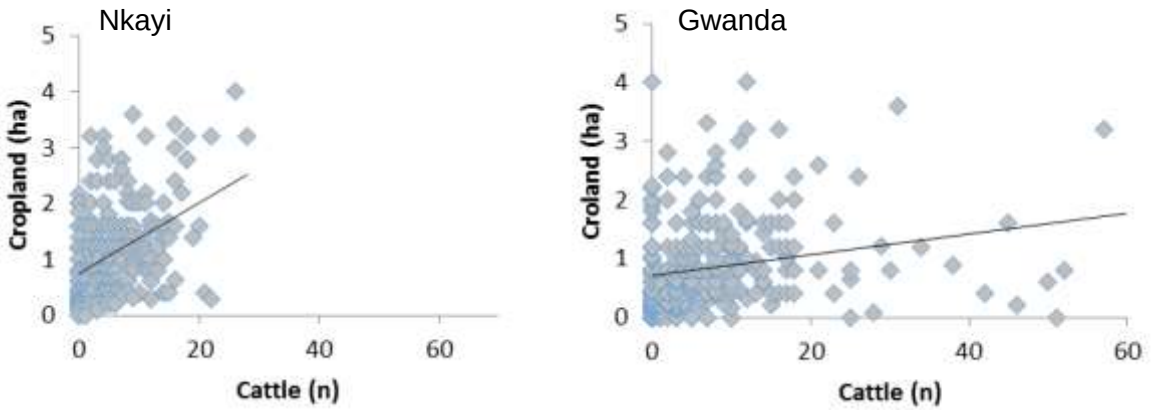


Figure 5. Distribution of croplands and cattle herd sizes in Nkayi and Gwanda Districts

3.2.1 Natural capital

Farm households seem to have similar access to croplands in Nkayi and Gwanda; most households cultivate less than 2 ha (Table 3). Male-headed households tend to own larger pieces of land than female-headed households.

In Nkayi farmers cultivate almost three quarters of their land, whereas in Gwanda they cultivate only about half of their land. The proportion of land cultivated seems not to differ between male- and female-headed households. Low rainfall during the observation period and poor access to inputs are major reasons that lead farmers to cultivate less land than available.

Table 3. Mean (sd) cropland and utilization, by districts and gender of head of households

	Nkayi			**Gwanda**		
	Male	Female	*sign*	Male	Female	*sign*
Total cropland (ha)	1.7(1.2)	1.3(1.1)	<0.05	1.8(1.1)	1.5(1)	<0.05
Proportion cultivated (%)	73.5(29.5)	71.5(32)	ns	52.9(35)	53.7(36.1)	ns

ns-not significant

In both districts most farmers (>70%) viewed the quality of their croplands as ranging from between average to poor fertility. Farmers found that the plots were easily accessible, less than 0.1 and 0.2 hours walking distance from their homesteads.

3.2.2 Physical capital

Livestock is the main source of physical capital in both districts. Almost two thirds of the households own cattle (Table 4). In Gwanda almost all households (90%) own goats. Herd sizes are larger in Gwanda than in Nkayi. While in Gwanda male-headed households own more cattle and goats, in Nkayi herd sizes seem similar across male- and female-headed households.

Table 4. Livestock ownership, means (sd), by districts and gender of head of households

	Nkayi			**Gwanda**		
	Male	Female	*sign*	Male	Female	*sign*
HH with cattle (%)	70.9	61.7	ns	72.6	53.7	$p<0.01$
HH with goats (%)	73	68.1	ns	90.4	90.9	ns
Cattle herd size (n)	7.2(5.3)	7.0(5.5)	ns	11.5(13.6)	6.8(6)	$p<0.01$
Goat flock size (n)	7.8(5.9)	6.6(4.1)	ns	14.0(12.0)	10.7(8.4)	$p<0.01$

ns-not significant

Across the two sites, cell phones are the most common assets for male- and female-headed households (>70%, Table 5). This reflects the recent development and strong improvement towards communication technologies. The majority of households also own an animal drawn plow, strong indicator for the integrated nature of the farming systems. About half of the households have access to scotch carts, solar panel and radios –with slightly higher ownership by male-headed households. Important to note that using donkeys to plow is more common in Gwanda, where farmers replace cattle with donkeys for plowing their fields, and use cattle for cash income rather than for draft power.

Table 5. Asset ownership, by districts and gender of head of household

	Nkayi			**Gwanda**		
	Female	Male	*sign*	Female	Male	*sign*
Cell phone	79.8	83.5	ns	79.3	85.2	ns
Ox-plough	72.3	70.5	ns	80.2	84.7	ns
Scotch-cart	36.4	55.3	$p<0.01$	56.2	72.5	$p<0.01$
Solar Panel	43.6	53.2	ns	47.9	63.8	$p<0.01$
Radio	41.5	54.9	$p<0.01$	44.6	56.8	$p<0.01$
Bicycle	21.3	46	$p<0.01$	43.8	67.2	$p<0.01$
Ploughing oxen	44.7	51.1	ns	23.1	26.6	ns
Ploughing donkey	7.4	20.3	$p<0.01$	50.4	59.4	ns

ns-not significant

3.2.3 Human capital

The households 'decision makers are relatively old at both sites, with the average age above 50 years (Table 6). Female household heads tend to be older than male household heads. Associated with age female-headed households tend to have more years of experience in crop and livestock production. Male-headed households seem to have more years of formal education than female-headed households. Family sizes are around six persons per household. Female-headed families tend to be smaller, indicating labor shortages.

Table 6. Human capital indicators, means (sd), by districts and gender of head of household

	Nkayi			**Gwanda**		
	Female	Male	*sign*	Female	Male	*sign*
Age of HH head (yrs)	59.1(14.4)	52.5(16)	*p*<0.01	58.4(12.9)	57.1(15.8)	ns
Education of HH head (yrs)	4.8(3.4)	6.6(2.8)	*p*<0.01	6.8(3.6)	8(2.9)	*p*<0.01
Years in crop production HH head	31.2(16.5)	23.1(18.6)	*p*<0.01	29.9(16.3)	26.1(15.5)	*p*<0.05
Years in livestock production HH head	28.0(17.7)	21.51(16.7)	*p*<0.01	28.5(15.9)	25.7(15.6)	*p*<0.05
Family size (n)	5.6(2.5)	6.8(2.6)	ns	5.5(2.4)	6.3(2.5)	*p*<0.01
Dependency ratio	69.1(69.3)	59.0(48)	ns	58.4(57.2)	59.2(54.4)	ns

ns- not significant

3.2.4 Financial and social capital

Annual household incomes are very low in both districts. According to the survey households have on average less than USD 400 (Table 7). While income levels might have been underestimated, other studies confirm high rates of households below the poverty line (Homann-Kee Tui et al., 2014). Male-headed households seemed to realize higher annual incomes than female-headed households. More than 80% of farmers in Nkayi and about 70% in Gwanda indicated that they face critical shortage of funds for agricultural activities. Access to credit to fund agricultural operations is poor. Less than 10% of the farmers managed to receive credit in the 2012/2013 season.

Agricultural extension services seem to reach less than half the households in Nkayi and less than a quarter in Gwanda. More households receive technical advice on maize production, as compared to the other crops. Technical advice on livestock production seems even more limited than for crops, despite the importance that livestock plays in the area. Farmers in Gwanda seem to receive more livestock support as compared to those in Nkayi. Main providers of extension

services as well as market information are government departments. In Gwanda NGOs are also major sources of information. There is no significant difference in the proportion of male- and female-headed households that access extension, with the exception of cattle related extension for Nkayi farmers.

Table 7. Financial and social indicators, means (sd), by districts and gender of head of household

	Nkayi			**Gwanda**		
	Female	Male	*sign*	Female	Male	*sign*
Annual income (US$)	239.6(296.4)	398.4(479.2)	*p*<0.01	267(296.5)	337(326)	ns
Access credit (% HH)	7.4	8.9	ns	5.8	10.5	ns
Access extension (% HH)						
- Maize	43.6	43.9	ns	27.3	25.3	ns
- Sorghum	3.2	3.8	ns	9.1	10	ns
- Groundnuts	1.1	1.7	ns	2.5	3.9	ns
- Cattle	5.3	15.2	p<0.05	14	21	ns
- Goats	5.3	6.8	ns	16.5	19.2	ns
- Marketing	2.1	3.1	ns	5.8	6.1	ns
	Main source of Information (%)					
- Government extension	62.8	70	ns	45.5	52.8	ns
- Other farmers	21.3	17.7	ns	16.5	17.9	ns
- NGOs	8.5	9.3	ns	39.7	27.9	p<0.05

ns-not significant

3.2.5 Food security indicators

We look at food security in terms of the ability of households to be self sufficient in staple foods and also to purchase food through sale of other agricultural commodities. Food self-sufficiency was a constraint for farm households in both districts (direct food insecurity). Farm households in Gwanda more often fail to sustain food self sufficiency: over a period of five years households in Gwanda experience four years when they do not produce enough grain to cover the households needs and in Nkayi this figure is 3 years (Table 8). Farmers in Gwanda also experience these food shortages longer. Most households have received food aid to ease the food shortage.

However, in Gwanda many households (46%) sold livestock as a way to supplement food and thereby managed to sustain their own food security. In Nkayi fewer households (19.4%) sold

livestock to buy food, which at the end leaves farmers in Nkayi with fewer options to ensure their own food security. At both sites, farmers mainly sold goats to buy food.

Table 8. Food self-sufficiency, means (sd), by district and gender of head of household

	Nkayi			**Gwanda**		
	Female	Male	*sign*	Female	Male	*sign*
Number of times food shortage occurred in the past 5 years	3.4(1.4)	2.9(1.4)	ns	3.8(1.1)	3.6(1.2)	ns
Average number of months of food shortage	5(3.1)	4.6(3)	ns	6.5(3.1)	5.5(3)	$p<0.01$
Received food aid in the past 5 years (% HH)	76.6	67.1	ns	84.3	75.5	ns

ns-not significant

3.2 Crop production and marketing

3.2.1 Crop production

Cropping patterns in Nkayi and Gwanda reflect farmers'preferences and agro-ecological conditions. Cereal production dominates the croplands in both Nkayi and Gwanda Districts (Figure 6). Maize is the most important crop at both sites. Slightly more farmers cultivate maize in Nkayi and the share of maize land is also larger (Table 9). In Gwanda almost 40% of farmers grow sorghum, which accounts for about half of their cultivated land. In Nkayi less than a fifth of the farms grow sorghum. Legume production is low in both districts, taken up by about a third of the farmers on less than 10% of the cultivated land.

The yield levels were extremely low for all crops during the observation year 2012/2013. In response to higher rainfall, yields were slightly higher in Nkayi than in Gwanda. Male- and female-headed households had similar low levels of crop yields.

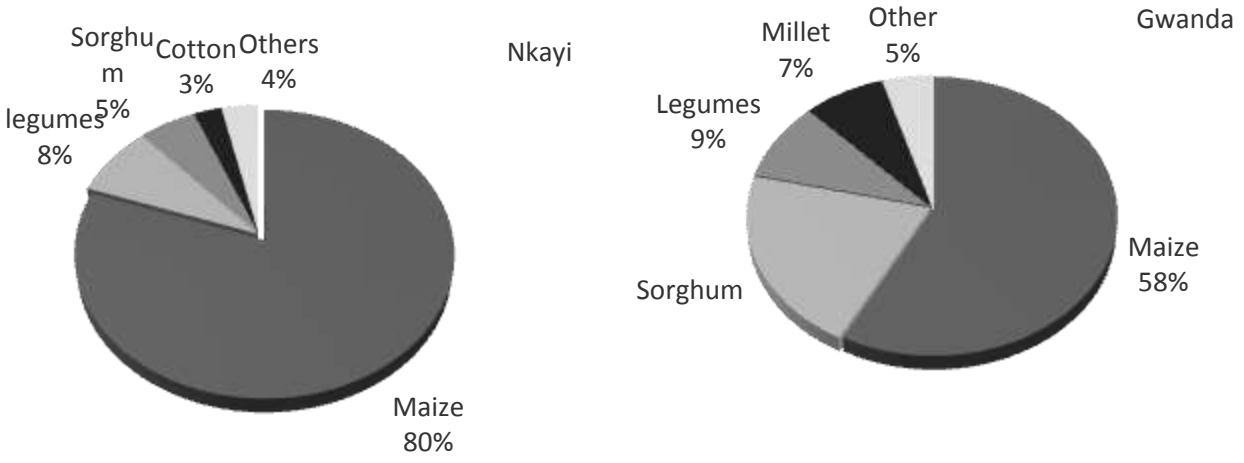


Figure 6. Crop composition in Nkayi and Gwanda Districts (% cropland cultivated)

Table 9. Crop production, means (sd), by district and gender of head of household

Variable	**Nkayi**			**Gwanda**		
	Female	Male	*sign*	Female	Male	*sign*
Maize						
- Growers (% HH)	96.8	97.9	ns	73.6	79.5	ns
- Importance (%area)	84.2(18.4)	80.3(20.5)	ns	69.1(29.2)	67.5(28.8)	ns
- Yield (kg/ha)	310.1(361.9)	387.4(375.1)	ns	108.6(147.2)	134.5(160.5)	ns
Sorghum						
- Growers (% HH)	18.1	16	ns	38	35.4	ns
- Importance (%area)	27.1(13.7)	35(24.1)	ns	58.9(27.6)	48.7(24.4)	$p<0.05$
- Yield (kg/ha)	156.4(188.5)	196.8(189.7)	ns	116.2(159.8)	173(178.6)	ns
Groundnut						
- Growers (% HH)	27.7	36.7	ns	29.8	30.6	ns
- Importance (%area)	18.9(14.0)	17(11.6)	ns	20.2(10.6)	19.4(14.2)	ns
- Yield (kg/ha)	258.7(225.8)	228.2(233)	ns	118.0(182.9)	183.8(267.9)	ns

ns- not significant

3.3.2 Intensification of crop production

Table 10 illustrates the levels of crop intensification, looking at use of external inputs (improved seed varieties and inorganic fertilizer) and crop-livestock integration (draft power and manure). Farmers invest mainly in maize; therefore we focus on intensification of maize. The majority of farmers uses improved maize seed varieties, fewer farmers use improved sorghum and groundnut varieties. Inorganic fertilizer use and application rates are very low at both sites. In Gwanda male-headed households seem to have greater access to inorganic fertilizer.

Almost all households in both districts use animal draft power to prepare their fields. Usage of manure as organic fertilizer is however low across the two sites. Only about half of the farmers with cattle seem to use manure to improve the fertility of their soils. Male-headed households seem to apply far higher volumes of manure per unit land as compared to female-headed households. Low levels of investments in crop production suggest a high potential for improvement; technical options have to be useful under high risk conditions.

Table 10. Intensification levels, means (sd) in crop production

Variable	**Nkayi**			**Gwanda**		
	Female	Male	*sign*	Female	Male	*sign*
Use of external resources						
Improved seed (% HH)						
- Maize	67	73.9	ns	72.4	70.9	ns
- Sorghum	11.8	26.3	ns	17.4	22.2	ns
- Groundnuts	16.7	15.7	ns	7.7	3.4	ns
Fertilizer on maize (% HH)	11	19.9	ns	8.3	14.3	ns
(kg/ha)	52.8(40.9)	50.2(33.7)	ns	40.4(35.4)	98(85)	*p*<0.01
Crop-livestock integration						
Draft power (%HH)	85.7	90.7	ns	75	91	p<0.01
Manure on maize (%HH)	38.5	36.4	ns	29.6	32.4	ns
(kg/ha)	467.7(292)	1144(815)	*p*<0.01	616(382.6)	1178(983)	*p*<0.01

ns-not significant

3.3.3 Marketing of crop outputs

With low yields and crop produce primarily for food security, there is rarely a surplus crop available for sale. In Nkayi more farmers sold crops, yet often to cover emergency needs but not

because they have excess for sale. About 30% of the male-headed maize producers sold parts of their maize output during the 2013 marketing season (Table 11). Fewer female-headed households sold maize. In Gwanda few (<5%) farmers participated in crop sales. The low rainfall during the previous season explains lack of surplus for crop sale, especially in Gwanda.

Table 11. Proportion of households (%) who sold crop outputs

	Nkayi			Gwanda		
	Female	Male	*sign*	Female	Male	*sign*
Maize	22	31.9	ns	3.4	1.1	ns
Sorghum	5.9	0	ns	4.3	4.9	ns
Groundnuts	3.8	9.2	ns	5.6	1.4	ns

ns-not significant

Farmers in Nkayi used their income from crop sales mainly to cover household's immediate needs such as school fees and to buy alternative sources of food (Figure 7). Fewer than 6% of the famers reinvested income from crop sales in crop production.

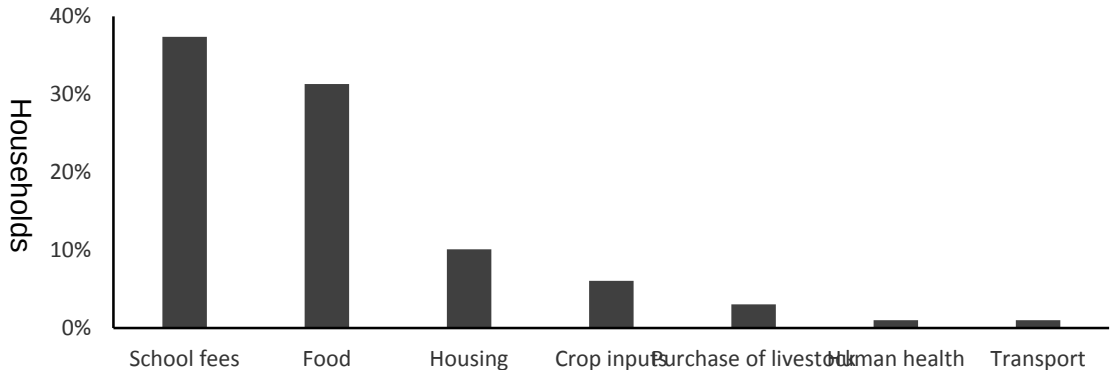


Figure 7. Expenses covered from crop sales by farmers in Nkayi district

3.3.4 Gender in decision making over crop management

Women had a strong influence in crop production (Figure 8). In male-headed households most decision are made jointly (51% and 48%), and in about a quarter of the households women seem to have most influence on crop management (25% and 33% in Nkayi and Gwanda respectively). Women decide in female-headed households.

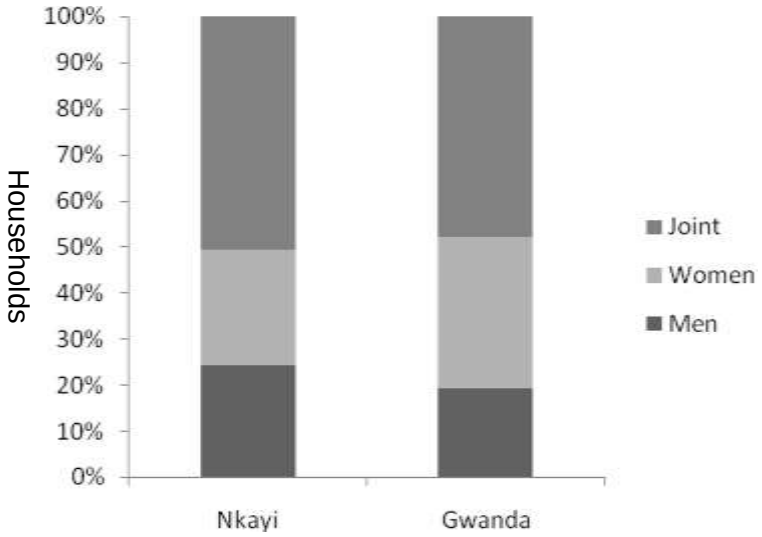


Figure 8. Women and men influence on decision making in crop management.

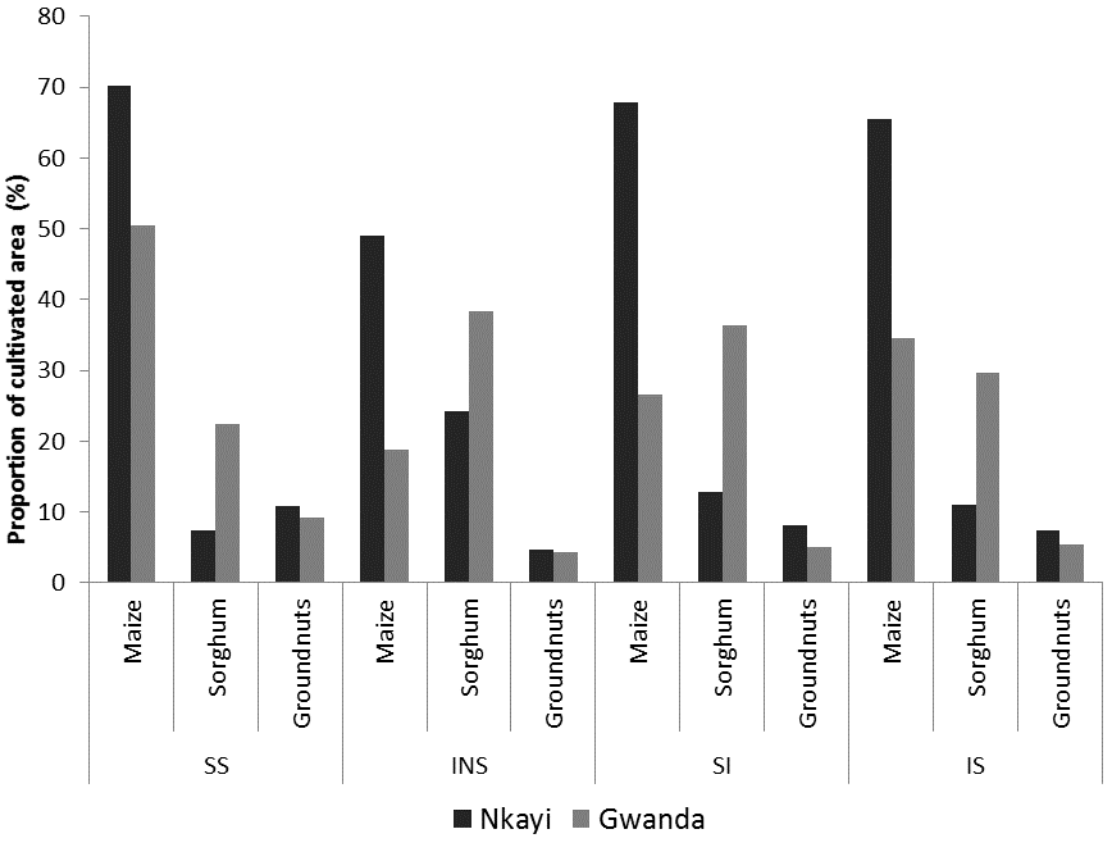
3.3.5 Perceptions of risks and uncertainties

Here we look at farmers' perceptions of risk in terms of climatic risk and risk embedded in price fluctuations. Farmers expect sufficient rains throughout the season for about 7 and 4 years out of 20, in Nkayi and Gwanda respectively (Table 12). More farmers expect that rainfall will be sufficient during the first half of the season and insufficient during the second part of the season.

Table 12. Farmers rainfall expectations during seasons (mean years)

	Nkayi	Gwanda
Sufficient rain expected throughout season (years)	6.5(4)	3.7(3)
Sufficient early season and insufficient late season (years)	7.1(3.6)	8.6(4)
Insufficient early season and sufficient late season (years)	6.4(3.7)	7.3(2.8)

When farmers expect a good rainy season (SI), they prefer to grow maize on most of their croplands (Figure 9). In Nkayi they prefer growing large proportions with maize even when insufficient rain is expected. In Gwanda farmers prefer growing more sorghum rather than maize when rain is expected to be insufficient and insufficient late in the season. At both sites, regardless of the expected rain, farmers would allocate a smaller proportion of land to groundnuts. Farmers 'preferences for different types of crops match with the level of rainfall fluctuations experienced in their environments. Small land allocated to groundnuts is largely due to labor constraints for processing the nuts.



SS-sufficient rain throughout the season**, INS-** insufficient rain throughout the season**, SI-**sufficient rain early in the season and insufficient rain late in the season**, IS-**insufficient rain early in the season and sufficient rain late in the season

Figure 9. Proportion of crop area under varying rainfall expectations

The comparison of crop output prices shows that prices are by far higher for groundnuts than for maize and sorghum (Figure 10). Groundnuts prices seem to be higher in Gwanda than in Nkayi. Crop prices tend to be at their lowest after harvests, since there is increased supply in the local markets. Prices increase later during the year. Price ranges between low and high prices are largest for maize, 65% in Nkayi and 58% in Gwanda. Groundnut prices change by 53% in Gwanda and 50% in Nkayi. Sorghum prices change less, by 43% in Gwanda and 31% inNkayi (31%).

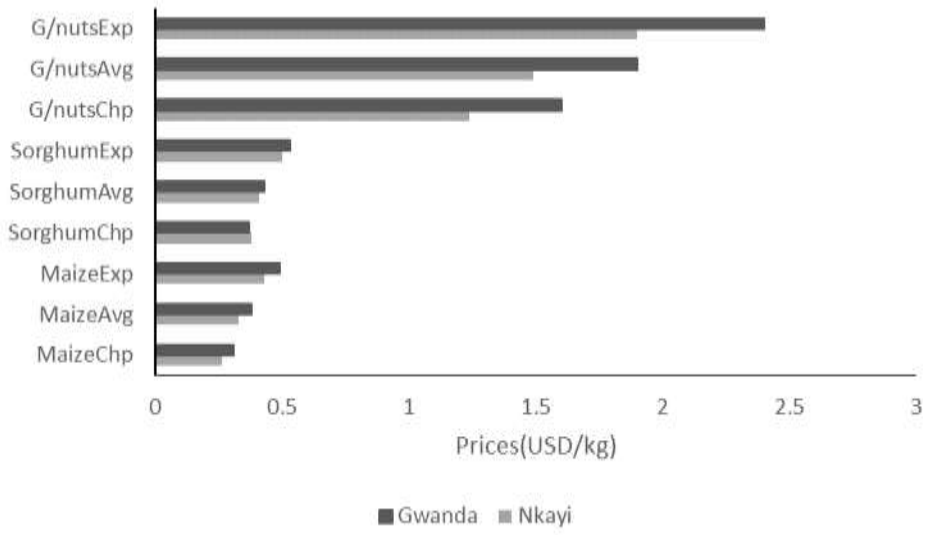


Figure 10. Crop output prices, cheap, average and peak, in Nkayi and Gwanda districts

3.4 Livestock production and marketing

3.4.1 Livestock production

Cattle and goats are the most important types of livestock types kept by farmers in Nkayi and Gwanda. Farmers in Nkayi keep cattle most importantly for draught power, manure and milk, reflecting the more crop-oriented mixed farming system (Figure 11). In Gwanda cash income and milk are the most important functions of cattle, which is in line with the more livestock market oriented production system. At both sites, the most important functions of goats are meat and cash income.

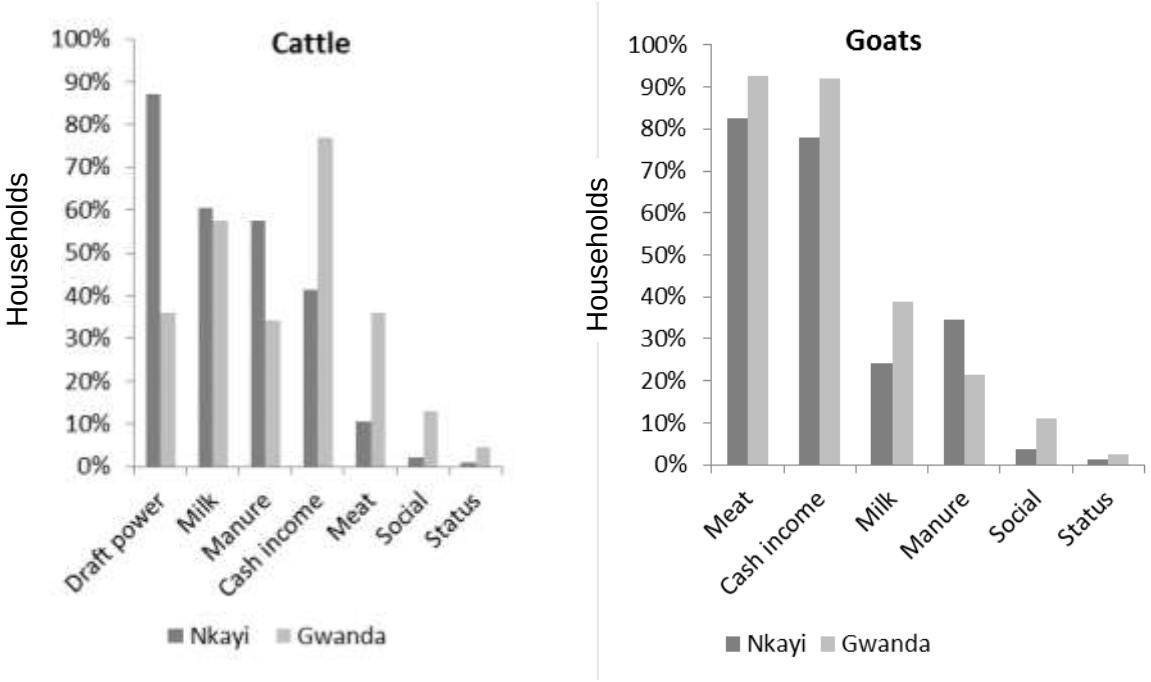


Figure 11. Reasons for keeping cattle and goats in Nkayi and Gwanda.

3.4.2 Intensification of livestock production

In both districts farmers invest in feed and animal health for sustaining the conditions of cattle and goats (Table 13). Farmers in Gwanda invest more in feed than those in Nkayi. They commonly store and feed crop residues. More importantly, about a third of the farmers in Gwanda feed commercial stock feed to cattle, and some farmers also feed the stock feeds to goats. In Nkayi using stock feeds is not common. Fodder production is not common in both districts. In both districts a higher proportion of male-headed households store and feed crop residues to goats compared to female-headed households and the difference is significant.

Farmers seem to invest more in cattle health as compared to goat health. Dip tanks are more common for cattle and government support more directed at controlling cattle related diseases as compared to goats.

Table 13. Intensification levels in livestock production (% HH) by districts and gender of household head

	Nkayi			Gwanda		
	Female	Male	*sign*	Female	Male	*sign*
Cattle						
Feeding						
Storage and feeding CR	58.6	64.3	ns	50.8	49.4	ns
Commercial stock-feed	5.2	2.4	ns	29.2	42.1	ns
Fodder production	0	0.6	ns	10.8	7.3	ns
Prevention and treatment of diseases						
- Tick-borne	93.1	98.	ns	84.6	87.8	ns
- Blackleg	55.2	65.1	ns	58.5	65.9	ns
- Lumpy skin	27.6	38.1	ns	32.3	34.8	ns
Goats						
Feeding						
Storage and feeding CR	4.7	13.9	p<0.05	15.5	24.2	p<0.1
Commercial stock-feed	0	0.6	ns	12.7	23.7	p<0.05
Fodder production	0	1.2	ns	3.6	1.9	ns
Prevention and treatment of diseases						
- Tick-borne	25	27.2	ns	40.9	43.5	ns
- Pulpy kidney	14.1	19.7	ns	10.9	14.5	ns

ns-not significant

3.4.3 Livestock performance

Despite the drier conditions, cattle performance seems to be better in Gwanda than in Nkayi, in terms of calving interval and age at first calving (Table 14). The performance of goats was similar in both districts. Livestock performance does not differ between male and female headed households in both districts.

Table 14. Cattle and goat performance indicators in Nkayi and Gwanda Districts

	Cattle			Goats		
	Nkayi	Gwanda	*sign*	Nkayi	Gwanda	*sign*
Milk yield (l/d)	1.6(1.6)	1.4(0.6)	ns	< 1	<1	ns
Lactation length(months)	12.5(2.4)	12.8(2.8)	ns	4.8(1.7)	4.5(1.8)	ns
Calving interval (months)	18.2(6.4)	16.3(5.7)	*p*<0.01	7.3(2.5)	7.6(2.5)	ns
Age at first calving (months)	43.3(9.1)	40(5.9)	*p*<0.01	18.6(2.6)	18.5(2.1)	ns

ns-not significant

3.4.4 Livestock dynamics

The predominant sources of cattle and goat herd growth are births (Table 15). Birth accounts for 93% and 85% of total cattle inflows in Gwanda and Nkayi respectively. Cattle in Nkayi tend to have higher calving rates compared to those in Gwanda. The offtake rates of cattle and goats are low in both areas, with slightly higher cattle off-take rates in Gwanda. Cattle off-take rates less than 5% are expected in a communal set up. Yet, goat off-take ratescan reach higher than 20%. An explanation for low off-take rates can be the fact that the survey was conducted in the second year of a drought period, and farmers preferred holding on to their breeding animals for recovery after the drought. Mortality rates were relatively low, despite the low rainfall. The provision of supplementary feed, especially stock-feed, might have contributed to this. There was no significant difference between inflow and outflow rates between male- and female-headed households in the two districts.

Table 15. Cattle and goat inflows and outflows

	Cattle			Goats		
	Nkayi	Gwanda	*sign*	Nkayi	Gwanda	*sign*
Calving	42.6(37.7)	33.7(34.7)	*p*<0.05	54.9(42.7)	32.3(35.1)	*p*<0.01
Mortality	3.9(7.7)	4.8(9.9)	ns	10.8(19.7)	7.9(18.4)	ns
Off-take	2 (5)	5.3(10.5)	*p*<0.01	4.1(9.8)	4.7(9.2)	ns
Slaughter	0.9(3.5)	0.5(2.8)	ns	9.5(17.6)	4.9(10.9)	*p*<0.01

ns-not significant

3.4.5 Marketing of livestock outputs

Here we see a strong difference in the presence and use of market channels between the two districts. Farmers in Gwanda sell cattle and goats more at developed market centers, a reflection of a better developed market system (Table 16). Farmers in Nkayi seem to largely depend on farm gate sales.

Table 16. Marketing channels used for sale of cattle and goats in Nkayi and Gwanda Districts (% of households)

	Cattle			Goats		
	Nkayi	Gwanda	*sign*	Nkayi	Gwanda	*sign*
Farm gate	91.3	39.3	p<0.01	95	45.4	p<0.01
Local market centre	1.1	21.4	p<0.01	2	17.8	p<0.01
Regional market centre	3.3	27.4	p<0.01	0	4.4	ns
Other (includes private sales)	9.1	17.7	ns	12	13.3	ns

ns-not significant

As for crops farmers spend most of the income from livestock sales for the household's food and education requirements (Figure 12). Some farmers in Gwanda (<15%) and very few in Nkayi (<2%) reinvested income from livestock back into livestock production.

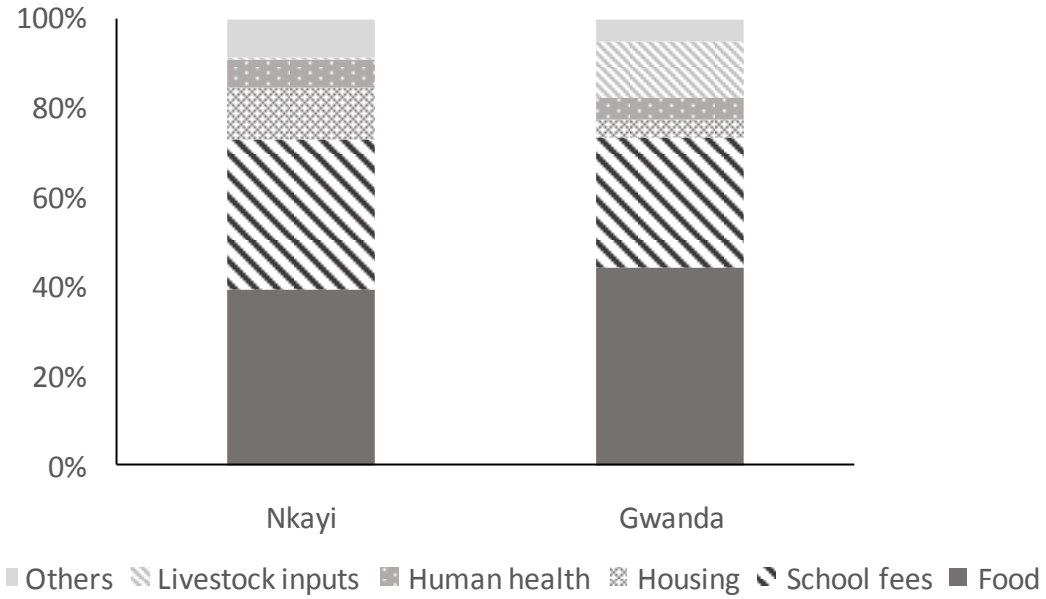


Figure 12.Expenses covered from livestock sales by farmers in Nkayi and Gwanda Districts

Farmers in Nkayi and Gwanda identified body condition as the most important criteria for determining prices of cattle and goats (Table 17). Live weight and age were also important. Few farmers indicated that sex and breed were important attributes for determining prices. Sex seems to play a greater role for determining prices of goats, and breed more than for cattle.

Table 17. Farmers understanding of factors influencing cattle and goat prices in Nkayi and Gwanda Districts, (% of households)

	Cattle			Goats		
	Nkayi	Gwanda	sign	Nkayi	Gwanda	sign
Body condition	50.6	43.8	ns	46	59	p<0.01
Live weight	39.7	47.3	ns	32.3	50.7	p<0.01
Age	33.3	31.2	ns	37.2	43.2	ns
Sex	16	23.3	p<0.05	30.1	41.5	p<0.05
Breed	1.5	4.1	p<0.01	2.2	9.2	p<0.01

ns-not significant

3.4.6 Gender in decision making over livestock management and marketing

While men play a dominant role in decisions over livestock production (feeding, medication), women seem to have a strong influence on decisions over the purchase and sale of cattle (Figure 13). Decisions over the use of income from livestock sales are also often done jointly (>50% in Nkayi and >40% in Gwanda).

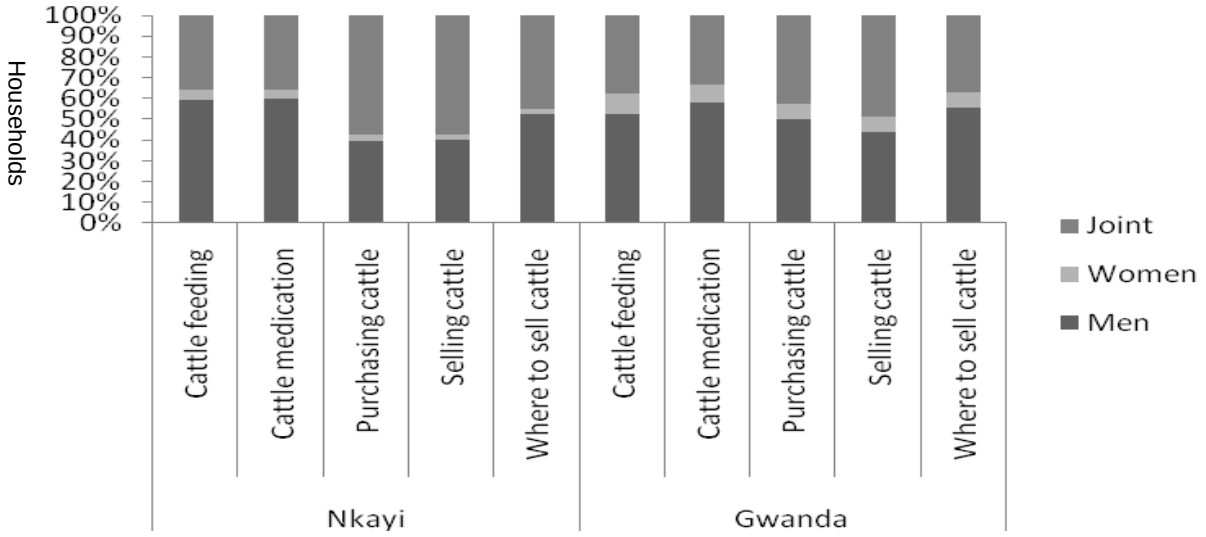
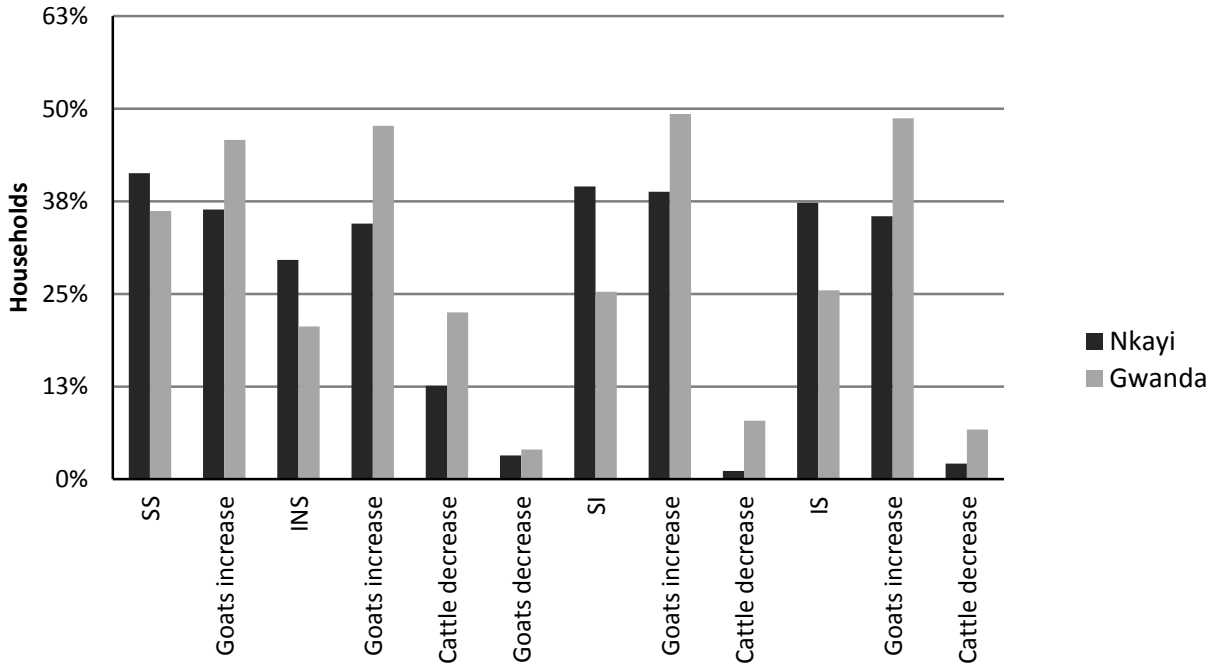


Figure 13 Decision making over cattle production and marketing

3.4.7 Perceptions of risks and uncertainties

If the season is expected to have sufficient rains, more households in Nkayi would increase their cattle herd, while in Gwanda more households would add goats (Figure 14). If insufficient rains would be expected more farmers in Gwanda would reduce cattle as compared to those in Nkayi. The responses reflect experience of more severe droughts in Gwanda as compared to Nkayi. When either the first half or second half of a season is expected to be poor, few farmers would reduce their herd sizes.



SS-sufficient rain throughout the season**, INS-** insufficient rain throughout the season**, SI-**sufficient rain early in the season and insufficient rain late in the season**, IS-**insufficient rain early in the season and sufficient rain late in the season

Figure 14. Proportion of cattle and goats in a herd under varying rainfall expectations

4 Farm household typologies

How can different types of farm households participate in the envisaged pathways of market-oriented agricultural production under the different conditions in Nkayi and Gwanda? The results of this section confirm that there are different types of farms, with different levels of resource endowments and different predispositions for engaging in the respective pathways.

4.1 Principal components and cluster analysis

The first eight principal component variables (PC, bold in Table 18) had Eigenvalues larger than 1, for both Nkayi and Gwanda Districts. These factors explained about 60% of the variance in

the data sets (Figure 15). In both Nkayi and Gwanda the first factor represents cultivated land, followed by family size and age of head of households as other important factors. The sites also shared on-farm income and herd size as common factors. In Nkayi diversity of information was also important, manure application on maize and improved maize seed. In Gwanda the factors asset index, access to extension and supplementary feed were more important. The factors match well with the characteristics of the farming systems.

These variables together with other variables were selected for clustering the surveyed households in farm types. For Nkayi three types were defined, which contain 55%,31% and 14% of the sample population (Figure 16). For Gwanda four were defined, which contain 12%, 30%, 43% and 15% of the sample population.

Table 18. Eigenvectors from the factor analysis for Nkayi and Gwanda Districts

	Nkayi								Gwanda							
	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Age of household head		**0.91**									**0.90**					
Asset index	0.28		0.18	0.19	0.37	0.18	0.53	0.39	0.19	0.13	0.13	0.24			**0.85**	
On-farm income	0.10	0.21	-0.25	**0.83**						-0.28	0.19			**0.81**		
Family size	0.16		**0.90**	0.22						**0.95**				0.18		
Diversity of information	0.14						**0.87**					0.12	0.74		0.42	0.24
Access to extension					0.12		0.21						**0.91**		-0.10	
Cultivated land	**0.93**		0.13					0.11	**0.84**	0.14	0.11					
Manure on maize	0.16				**0.90**				0.25							
Improved maize seed	0.27							**0.90**	0.35						0.11	
Herd size			0.15			**0.95**						**0.91**	0.13			
Supplementary feed					0.11								0.20			**0.96**

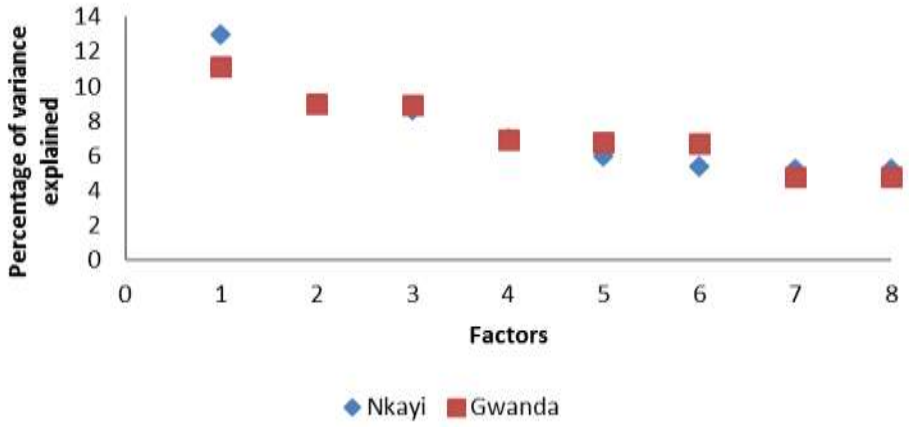


Figure 15. Percentage of variance explained through factors with Eigenvalue >1 for Nkayi and Gwanda Districts.

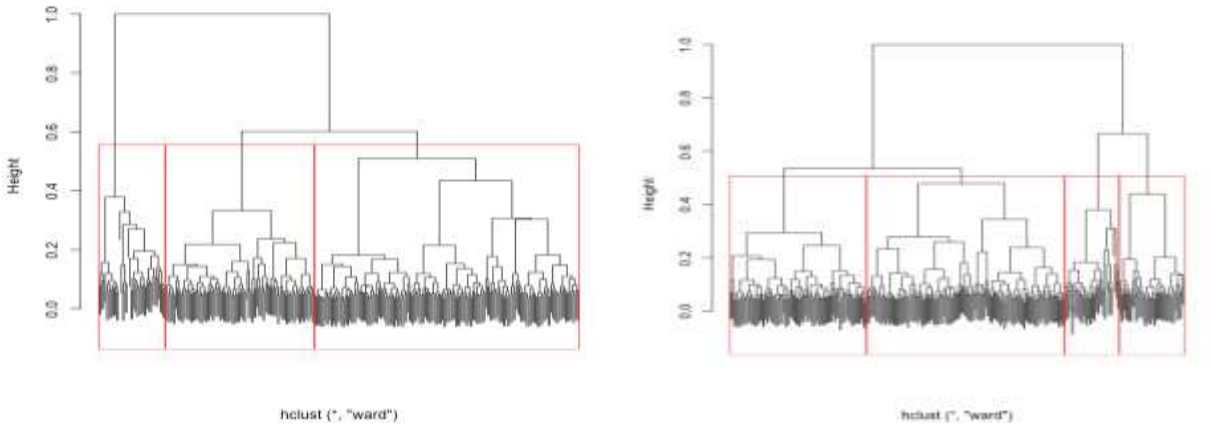


Figure 16. Ward dendogramms for Nkayi and Gwanda Districts.

4.2 Livelihood characteristics of the different farm types

Following Dorward et al. (2009) we characterized the farm types for both districts as very poor in resources, those who are still poor but stepping up, and those who are more advanced in intensifying crop-livestock production. The distances in the ward dendograms illustrate that in both districts the intensifying farms (the first cluster in Nkayi, the third and fourth clusters in Gwanda, Figure 15) differ distinctly from the resource-poor farmers. The socio-economic characteristics of the clusters are as follows (Table 19 and Table 20):

Table 19. Summary characteristics of common farm types in Nkayi and Gwanda.

Farm types	Summary of farm type characteristics
Nkayi	
 C1	Very resource poor farms: The largest proportion of farm households falls under the very resource poor type, least endowed in terms of assets, croplands and livestock. This group also has the least access to information. The proportion of female-headed households is larger than in the other clusters. Income levels are the lowest and these households face greater food shortages.
 C2	Poor but stepping up farms: A large number of farms are at an intermediary stage, in terms of assets, income, croplands and herd sizes. Household heads tend to be older. Farmers in this group make the highest proportion of off-farm income, supplementing the limited income from agriculture.
 C3	Intensifying crop-livestock farms: Better off-farms make up a small proportion. They cultivate more than double the lands and own more livestock than the other types. They also have access to more diverse sources of information and make more contacts with extension in a year. They have larger family sizes and fewer female-headed households. With less off-farm income but substantially higher income than the other farms they illustrate the potential that improved agricultural production can gear up to in Nkayi.

Gwanda

 C1	Very resource poor farms: These farms cultivate the smallest area and have the smallest herd sizes. Household heads are relatively old, least educated and family sizes are small. They have least contact with extension and the least diverse sources of information. The proportion of female-headed households is high. They have lowest incomes and face greater food shortages.
 C2	Poor but stepping up farms: Households have limited cropland and livestock, but highest proportion of off-farm activities. Household heads are slightly younger. Their annual household income is three fold that of the resource poor households.
 C3	Intensifying cattle maize farms: These farmers are mainly located in Gwanda North, with higher rainfall and cultivate more than double the land than the other types. Herd sizes are intermediate. Household heads are older. Female-headed households are few. Their income levels are low.
 C4	Intensifying crop-livestock farms: These farms are the wealthiest, owning more than four times the number of livestock as compared to the resource poor farms. They also have the highest number of contacts with extension. Female-headed households are few. In contrast to C3 with large croplands, these farms with large herds earn the highest annual incomes.

Table 20. Livelihood characteristics in Nkayi and Gwanda Districts, means, standard deviation and p-values for all farm households and farm types

	Nkayi						Gwanda						
	All	sd	C1	C2	C3	*p*	All	sd	C1	C2	C3	C4	*p*
Proportion of households (%)	100		55	31	14		100		*30*	*43*	12	*15*	
Female headed households (%)	28.4		37	18	18	<0.05	34.6		43	38	17	24	<0.05
Education of HH head (years)	6	3	6	6	7	<0.05	8	3	7	8	8	8	<0.01
Age of HH head (years)	54	16	52	58	55	<0.05	58	15	62	52	63	59	<0.01
Assets													
Family size (n)	6	3	6	6	8	<0.01	6	3	4	7	8	6	<0.01
Cultivated land (ha)	1	0.9	0.8	1	2.3	<0.01	0.8	0.7	0.5	0.7	1.8	0.9	<0.01
Herd size (TLU)	7	7	3	9	15	<0.01	10	14	6	6	16	25	<0.01
Information													
Freq. extension contact (n/year)	7	9	6	6	11	<0.05	8	14	3	9	7	15	<0.01
Information diversity (index)	11	9	9	13	16	<0.01	12	12	7	12	14	26	<0.01
Income													
Total income(USD)	502	1017	319	694	807	<0.01	518	988	224	693	221	853	<0.01
Proportion off-farm income (%)	69	44	66	82	53	<0.01	61	46	36	76	55	75	<0.01
Food security (index)	32	25	37	25	26	<0.01	42	26	49	40	41	34	<0.05

4.3 Crop production characteristics

In both districts we see that levels of crop production differ among the farm types, and the farm types are also differently distributed within the districts. In Nkayi, many of the intensifying crop-livestock farmers (C3, 55%) are based in ward 6, which is in the northern

tip of the district and receives more rainfall than other wards. They cultivate the largest areas of maize, sorghum and groundnuts, invest more in improved seed, draft power and manure, and realize the highest maize and groundnut yields (Table 21). The stepping up farmers are mainly located (>53%) in the southern part of the district, with less favorable agricultural conditions and higher human population densities. The very resource-poor households invest the least in improving crop production.

Similar trends are found in Gwanda. The cluster of intensifying cattle maize farmers mostly live in ward 4 with higher rainfall (C3, 86%), they cultivate the largest maize and groundnut area, often use improved seed, draft power, fertilizer and manure. The other cluster of intensifying crop-livestock farmers with more focus on livestock and sorghum (C4) produce in the south of Gwanda, under less rainfall. They cultivate the largest area and produce highest sorghum yields. The resource poor and the younger farmers (C1 and C2) also produce under very low rainfall conditions, and invest little to improve crop production.

Table 21. Crop production characteristics in research sites, means, standard deviation and p-values for all farm households and households by cluster

	Nkayi						Gwanda						
	All	sd	C1	C2	C3	*p*	All	sd	C1	C2	C3	C4	*p*
Crop production (% households)													
Maize	98		96	99	98	ns	77		72	74	98	78	<0.01
Small grains	17		20	9	22	<0.05	36		40	40	17	56	<0.01
Groundnuts	34		24	44	53	<0.01	30		19	28	69	24	<0.01
Crop areas (ha)													
Maize	0.9	0.7	0.7	0.9	1.6	<0.01	0.6	0.7	0.4	0.5	1.5	0.4	<0.01
Small grains	0.3	0.3	0.4	0.1	0.4	<0.01	0.5	0.4	0.4	0.5	0.2	0.6	<0.05
Groundnuts	0.2	0.2	0.1	0.2	0.3	<0.01	0.2	0.2	0.2	0.2	0.3	0.1	<0.01
Crop yields (kg/ha)													
Maize	366	373	261	420	674	<0.01	125	156	100	123	132	181	ns
Small grains	245	313	218	323	278	<0.01	202	247	200	145	264	313	<0.05
Groundnuts	236	230	222	206	375	ns	136	192	127	115	170	138	ns
External technologies on maize													
Fertilizer (% households)	17		11	26	25	<0.01	14		8	12	34	10	<0.01
Improved seed (% households)	75		69	80	87	<0.05	55		41	50	93	70	<0.01
Crop-livestock integration													
Draft power (% households)	89		86	91	100	<0.05	86		75	85	98	96	<0.01
Manure user (% households)	43		30	54	70	<0.01	34		22	36	54	28	<0.01
Use of manure on maize (kg/ha)	357	600	282	418	519	<0.05	452	924	264	384	1099	394	<0.01

4.4 Livestock production characteristics

In Nkayi the intensifying crop-livestock farmers (C3) own the largest cattle and goat herd sizes, more of these farmers invest in supplementary livestock-feed (stock-feed and crop residues), and they also have significantly higher off-take rates than the poor (Table 22). The poor farms keep fewer cattle and goats, and their off-take rates are lower. All types of households seem to engage in animal health.

The intensifying farmers in Gwanda (C3 and C4) keep more cattle, while goats seem common for all household types. The C4 farmers keep more than double the number of goats as compared to the other farmers. The C3 and C4 farmers invest more in animal health and feeding crop residues. Some C4 farmers also engage in fodder production. About a quarter of all clusters seem to feed stock-feeds. Offtake rates are higher for C4 farmers, the more market-oriented livestock producers, while C3 farmers are more oriented towards crop production and use cattle more for their input functions to crops, rather than sale.

Table 22**.** Livestock production characteristics in research sites, means, standard deviation and p-values for all farm households and households by cluster

	Nkayi						**Gwanda**						
	All	sd	C1	C2	C3	*p*	All	sd	C1	C2	C3	C4	*p*
Livestock ownership (% households)													
- Cattle	68		53	85	96	<0.01	65		53	61	88	86	<0.01
Goats	72		60	89	80	<0.01	91		91	89	86	100	<0.1
Herd size (n per HH)													
Cattle	7	5	5	7	13	<0.01	10	12	7	6	14	20	<0.01
Goats	8	6	6	9	9	<0.01	13	11	11	10	11	25	<0.01
External technologies on cattle (%HH)													
Animal health	93		91	95	93	ns	92		88	92	95	93	ns
Stock-feed	3		1	2	11	<0.01	26		28	24	25	24	ns
Crop-livestock integration (%HH)													
Storage, feeding CR	44		29	52	64	<0.01	50		29	40	78	72	<0.01
.. Fodder production	0.7		1	1	0	ns	8		7.1	8.7	3	9.3	ns
Livestock sales / off take rates (%)													
Cattle	2	5	0.5	2	5	<0.01	5	11	5	5	2	9	<0.05
Goats	4	9	3	5	5	ns	5	9	5	5	2	5	ns

ns-not significant

5 Discussion and recommendations

An integrated systems approach requires research ‘in ‘rather than ‘for ‘development (Coe et al., 2014). It involves addressing three key issues: 1. capturing local diversity and the requirements for context specific engagements, 2. the importance of appropriate markets and delivery services, 3. co-learning by stakeholders involved. This baseline report informs about the local context (1), and is reference for measuring outcomes of developing 2 and 3 within the specific contexts and engagements.

Here we discuss baseline information with regards to the project’s main indicators on increasing agricultural production and income. We then discuss the different types of farms, and specific options that are likely to match well with what communities defined as overall development pathways and farm households particular circumstances. Appendix 2 provides an overview on key aspects for both sites.

5.1 Production and welfare indicators

Increased integration of crop-livestock sub-systems: In their visions farmers at both sites expressed increased crop-livestock integration as critical for improving the productivity of their farms. The sites differ in terms of magnitude of crop-livestock integration**.** In Nkayi farmers tend to use more of the livestock inputs to enhance crop production. At this site extension support is more geared towards crop production, and livestock markets are largely informal. In Gwanda farmers use more crop residues, commercial stock-feed and fodder to enhance livestock production. Farmers in Gwanda also reinvest cash from livestock sales back into livestock production. We believe that better developed markets and support structures in Gwanda are strong drivers for farmers to reinvest within their farming systems as a way for enhancing overall production.

At both sits farmers do make greater use of crop-livestock integration than purchasing external inputs (e.g., 40% of the households practice manure management, while less than 20% apply inorganic fertilizer). Animal draft power is most commonly used across the sites (<90% of the households), labor saving technology for soil preparation. Farmers with more draft power animals are able to prepare larger land in time. Limited application of manure management can be explained by the fact that volumes of available manure are not sufficient to fertilize all crop fields (required are 8-10 t manure/ha; production/cow/year is 3 t). In Nkayi, practices of improving manure collection and management were reported. There is high pressure on using crop residues as feed, due to low crop yields and high livestock-feed demand. Collecting and storage of crop residues is the most common practice for supplementary feeding, by 70% and 60% of households in Gwanda and Nkayi respectively. In Gwanda some farmers use new technologies for processing crop residues and farmers also engaged in fodder production. It seems that farmers in Gwanda have greater incentives and are more aware of feeding livestock. Cash flows within agricultural systems are another form of integration: Currently about 15% of the farmers in Gwanda and less than 5% in Nkayi reinvest income from sale of agricultural produce back into agriculture. Market development (input and output markets) that enhances financial flows within a system, contributes to overall systems productivity.

Increased agricultural production and productivity: Low levels of investment (<20% of farm households applying fertilizer and <40% manure on crop fields, <10% engage in fodder

production) and low agricultural production (<400kg crop yields; < 5% offtake) suggest high potential for improving farmers' livelihoods, if done properly, in both districts. A critical constraint for increasing crop and fodder production is the limited farm size (< 2ha) and the fact that farmers only manage to cultivate a proportion of that land. Farmers themselves were confident that agricultural production can be enhanced to higher levels and provide surplus for sale, as reflected in the community visions. Different types of improved food feed crop and forage technologies were prioritized at IP meetings at each site. In Nkayi, with higher agro-ecological potential, crop diversification and intensification could provide substantially more biomass for food and feed, which could contribute towards intensified and market oriented livestock production. Despite its potential, most of these crops were new for farmers and extension services and are now in process of being demonstrated and promoted through the ZimCLIFs project's on-farm activities. In Nkayi access to inputs and poor soil quality were listed as the most limiting factors for farmers to raise production on the available land. The inputs are often locally not available and under the existing cash constraints many farmers do not have the means to purchase inputs. Farmers rely on government input program and some extent NGOs. Farmers in Nkayi expressed an interest to expand cultivated land and increase production if adequate inputs were available in time. In Gwanda, through recent development interventions, farmers and extension services are more advanced in piloting food feed crops and forages. Low and erratic rainfall, and thus high risk in production seems the most limiting factor. The year of observation (2012/2013) was a year with very low crop yields and half of the land was left uncultivated. To increase production areas like Gwanda need strong support for exploring and scaling out drought-tolerant dual purpose crops, e.g. sorghum, millet, perennial forages.

Increased turnover and income: At the time of the baseline data collection most farmers focused on producing food crops, with strong dominance of maize (80% of croplands in Nkayi, 50% in Gwanda). Farmers however generated very little maize surplus for sale. In Nkayi, despite low yields, barter trading maize was reported a commonly used form of trading, due to shortage of cash in the local economy. At this point it is important to highlight that despite higher agricultural potential, farmers in Nkayi who depend largely on maize production are less food secure than those in Gwanda. At IP meetings farmers confirmed maize as crop of low profitability and high risk, whereas cattle and goats ranked high, confirming that farmers are clearly interested in diversifying into livestock production. New attention was brought to groundnuts. Especially women farmers preferred groundnuts for high profitability, if market linkages could be developed. Sorghum was associated with food security, but less market potential and high labor costs. In Gwanda more income was generated from livestock sales; households frequently sold livestock to buy food, reflected in higher food security levels than in Nkayi. Gwanda illustrates a case where livestock markets have recently been developed. Farmers now participate more in formal market structures, with attendance of large buyers and gain higher prices for their animals. It confirms that where markets reward production and fodder technologies are made available, farmers respond and re-invest, and improve food security and income even under high risk conditions. It confirms also that investments need to go beyond the farm gate, so that farmers can benefit and make changes happen on-farm.

Reduced agricultural risk: Farmers in Nkayi expressed interest to diversify their farming systems from dominant maize production into drought-tolerant groundnuts and sorghum. They clearly see a potential for high quality feed biomass and livestock production as ways

to reduce agricultural risk. In Gwanda high preference for sorghum and goats is an adaptation to the drier farming conditions. As an adaptation to high risk, farmers have taken up fodder production, motivated by markets and various project, private sector and government initiatives. Diversifying into livestock and fodder production has become an important option to deal with the high risk of crop failure. Improved markets provide higher income from livestock sales, more food can be purchased per unit livestock sold. At both sites IP meetings and feedback from on-farm demonstrations confirm interest in forage legumes, perennial fodder, dual purpose legume and sorghum varieties. Local seed multiplication is another way to sustain availability of these technologies. For farmers to trust market mechanisms as a way to reduce risk, it requires demonstrations and exposure.

5.2 Tailoring intensification options

The participatory approach at IP meetings brought out market oriented crop livestock systems as overarching development pathways for both districts. While the overall pathways are similar for both districts, interplay among agro-ecological potential, development support and markets clearly resulted in different orientations. It follows that context-specific re-alignments are required for improving these agricultural systems: For instance, in Nkayi and Gwanda North conditions favor mixed crop-livestock production, with high potential for food feed crops and forages. Agricultural support has been focusing on maize production and conservation agriculture. Re-alignment would mean a stronger emphasis on crop diversification and crop production for market purposes, particularly legumes. In Gwanda South the potential is towards market oriented livestock production. Here we found that a re-orientation has successfully taken place, towards strengthening the livestock system, notably through market development, feed and fodder management.

The farm typologies confirm different levels of assets and incomes among households in the two districts, and thus different predispositions to engage in and benefit from the local development pathways. The better off households diversify and intensify more their production of crops and livestock. These households are less vulnerable, engage more in markets, and high on-farm income levels confirm mixed crop-livestock farming as pathway to earn more income. For resource poor households diversification and crop-livestock integration is more difficult. They often don’t have many animals and lack of investment capital, productive assets, labor and also biomass, including manure and high quality feed.

Gender analysis illustrates that female-headed households tend to be more among the resource poor and stepping up farm types. It is a reflection of resource constraints, as female-headed households also tend to have less access to cropland, livestock, farm implements, labor, education and overall household income. No difference was however found in terms of crop and livestock productivity.

We used community feedback and information from IP workshops to sketch out technical interventions that could be suitable for the different farm types. Table 23 lists the suggested options for the different farm types. The potential impacts of alternative options on reducing the households’ vulnerability and profitability will be further explored using simulation modeling.

Worth noting that farmers across the types preferred ways of improving communication and learning: Farmer field school approaches, field days, demonstration days and demo plots, as

well as broadcasting information on technologies and markets through cell phone, radio and newspapers.

Table 23. Farm types and technical options for support

Characteristics of farm types	**Site-specific technical options generated at IP meetings**	
	Nkayi	Gwanda
Very resource poor farms are most vulnerable. Limited productive resources, access to information and markets, often female headed. Solving immediate food needs prevents investments. Safety net interventions are important to maintain assets. High benefits from agronomic practices that increase production per unit land cost effectively, reduce yield variability and allow income generation.	 Dual purpose groundnuts and sorghum, maize under CA Crop and soil fertility management (spacing, weeding, compost) Market support for groundnuts	 Drought tolerant dual purpose sorghum, legumes, perennial fodder Improved management of dual purpose crops Market support for goats
Poor but stepping up farms engage incrop and livestock production, with medium agricultural performance. Off-farm income helps to sustain the farms. They can cover immediate food needs, and have some land to invest in non-food and/or cash crops, good candidates for evaluating benefits and trade-offs from alternative technologies and land use options.	 Production of maize under CA, dual purpose groundnuts and sorghum Collective marketing of cash crops, e.g. groundnuts, sorghum, forage seed Post harvesting technologies to avoid losses. Crop-livestock integration, herd building Advice for lucrative investments of off-farm income	 Dual purpose legumes, forages, perennial fodder Test alternative land use options Business services in agriculture Enhance market oriented goat production

Intensifying farms invest in agricultural production and participate in markets. They are important for attracting agro-dealers and buyers of produce. They are in a better position to negotiate with buyers, explore credit options, test innovative practices and specialize in lucrative activities and services. They are important for scaling out technologies for market oriented production.	 Dual purpose forage legumes, maize Prioritize high value crops to generate more income, Mechanize crop production Contract farming with private sector for legumes Cattle as business at auctions and bulk sales Links to agro-dealers, buyers, local government, farmers union	 Dual purpose sorghum, perennial fodder, forage legumes Prioritize livestock for income generation Improve livestock market arrangements Test and promote technologies towards livestock quality improvement Represent farmers interests towards better organized livestock markets

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