The design, implementation and assessing of an agroecological cropping system by rural KwaZulu-Natal households; its effect on their diet and food security

by
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Declaration

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Abstract

This thesis documents a Participatory Action Research (PAR) project conducted from 2011 to 2013 in a rural communal area in southern KwaZulu-Natal, South Africa. The area is a microcosm of the global environmental and socio-economic polycrisis; with adult unemployment at 50 percent, 73 percent female-headed households, heavy dependence on government social grants and a food system reliant on purchased food.

Eight, mainly female-headed households (the co-researchers), assisted by the student researcher, implemented and assessed a cropping system, designed on agroecological principles, on their abandoned garden plots. The objective was to grow culturally acceptable food crops to supplement their household diets and positively affect their food security. The student researcher provided the necessary infrastructure, including goat-proof plot fences, hand tools, a grain hammermill, seed, and fertiliser.

The literature review, which also used early 1900's photographs and contemporary isiZulu language as evidence, revealed the agroecological basis of pre-colonial agriculture. However, colonial and apartheid influences destroyed this knowledge base. The cropping system design utilized practices from this pre-colonial era combined with current agroecological techniques. The agroecological techniques employed on the plots included non-inversion tillage of planting pits using garden forks, precision placement of phosphate fertiliser and animal manures, open pollinated seeds, east-west orientated strip cropping, soil surface mulches, crop rotations including legumes and the use of chickens to control pests.

Dryland crops included maize, beans, sweet potatoes, and butternuts, with small trial vegetable patches on some plots. The research identified a method to calculate the planting frequency of these vegetables to ensure a constant annual supply, however further research is needed. The dryland crops supplemented household diets between harvests.

The formation of structured groups amongst the households proved vital to the success of the cropping system, providing mutual labour assistance, shared decision-making, building knowledge and moral support. The importance of dialogue and trust, reinforced by the student researcher's ability to communicate in isiZulu with the co-researchers, formed the basis of both the PAR, and Focus Group Discussions(FGD), used to qualitative assess the cropping system. During these, the households reported a good understanding of the agroecological principles of the cropping system, a willingness to continue with it post research, and positive benefits, including better health, and money saved on food purchases, redirected to improve their asset base.

The World Food Programme (2008) Food Consumption Score Analysis Method (FCS), modified to show the percentage contribution of homegrown food to the FCS, provided the quantitative assessment of the cropping system. The FCS scores rose during the research, with homegrown food contributing over a third of the FCS at times.

The co-researchers suggested instituting group '*stokvels*'[1] to finance inputs and maintain infrastructure post research. The financial implications of these '*stokvels'* was calculated. Due to the initial success of the PAR, the research recommends a method to extend the cropping system to more households, utilizing state finance to provide the infrastructure, and the co-researchers imparting technical knowledge through farmer-to-farmer extension.

[1] A 'stokvel' is an informal group saving mechanism, regulated by peer commitment that is unique to the Black South African community.

Opsomming

In hierdie tesis word verslag gedoen van ’n deelnemende aksienavorsingsprojek wat van 2011 tot 2013 in ’n landelike dorpsgebied in die suide van KwaZulu-Natal, Suid-Afrika, uitgevoer is. Die gebied is ’n mikrokosmos van die wêreldwye omgewings- en sosio-ekonomiese polikrisis, met volwasse werkloosheid op 50%, 73% huishoudings met vroue aan die hoof, swaar afhanklikheid van die staat se maatskaplike toelae en ’n voedselstelsel wat van gekoopte kos afhanklik is.

In die studie het agt huishoudings, wat hoofsaaklik vroue aan die hoof het (die medenavorsers), met behulp van die studentenavorser, ’n verbouingstelsel, wat op agro-ekologiese beginsels gegrond is, op hul verlate tuingrond geïmplementeer en geassesseer. Die doel was om kultureel aanvaarbare gewasse te verbou om hul huishoudelike dieet aan te vul en hul voedselsekerheid positief te beïnvloed. Die studentenavorser het die nodige infrastruktuur verskaf, met inbegrip van bokbestande omheining, handgereedskap, ’n graanhamermeul, saad en kunsmis.

Die literatuurstudie, waarin foto’s uit die 1900’s en moderne Zoeloe as bewyse gebruik is, toon die agro-ekologiese grondslag van prekoloniale landbou. Koloniale en apartheidsinvloede het egter hierdie kennisbasis vernietig. Die verbouingstelselontwerp was gegrond op praktyke uit hierdie prekoloniale era gekombineer met moderne agro-ekologiese tegnieke. Hierdie tegnieke het ingesluit nie-inversie-grondbewerking van plantgate met gebruik van tuinvurke, presisieplasing van fosfaatkunsmis en dieremis, oop bestuifde sade, oos–wes-georiënteerde strookverbouing, grondoppervlak-deklae, wisselbou met onder andere peulgewasse en die gebruik van hoenders om peste te beheer.

Droëland-gewasse het ingesluit mielies, bone, soetpatats en botterskorsies, met klein toetsgroenteakkers op sommige stukke grond. ’n Metode is in die navorsing geïdentifiseer om te bepaal hoe gereeld hierdie groente geplant moet word om ’n konstante jaarlikse voorraad te verseker. Verdere navorsing is egter nodig. Die droëland-gewasse het huishoudelike diëte tussen oeste aangevul.

Die vorming van gestruktureerde groepe onder die huishoudings het noodsaaklik geblyk te wees vir die sukses van die verbouingstelsel, waardeur wedersydse hulp met arbeid, gedeelde besluitneming, die bou van kennis en morele ondersteuning gebied is. Die belangrikheid van dialoog en vertroue, wat versterk is deur die studentenavorser se vermoë om in Zoeloe met die medenavorsers te kommunikeer, het die grondslag gevorm van die deelnemende aksienavorsingsprojek asook die fokusgroeponderhoude, wat gebruik is om die verbouingstelsel kwalitatief te assesseer. In hierdie onderhoude het die huishoudings verslag gedoen van hul grondige begrip van die agro-ekologiese beginsels van die verbouingstelsel, hul gewilligheid om ná die navorsing daarmee voort te gaan, asook die voordele wat dit bied, soos beter gesondheid en geld wat op voedselaankope gespaar is, wat heraangewend is om hul batebasis te verbeter.

Die Wêreldvoedingsprogram (2008) se Food Consumption Score- (FCS-)ontledingsmetode, wat aangepas is om die persentasie bydrae van selfgekweekte voedsel tot die FCS aan te toon, is gebruik vir die kwantitatiewe assessering van die verbouingstelsel. Die FCS-tellings het tydens die navorsing toegeneem, met selfgekweekte voedsel wat by tye tot meer as ’n derde tot die FCS bygedra het.

Die medenavorsers het voorstel dat 'n stokvel gestig word om insette te finansier en die infrastruktuur ná die navorsing in stand te hou. Die finansiële implikasies van hierdie stokvel is bereken. Op grond van die aanvanklike sukses van die deelnemende aksienavorsingsprojek stel die navorser 'n metode voor om die verbouingstelsel na meer huishoudings uit te brei met behulp van staatsfinansiering om die infrastruktuur te verskaf asook die oordrag van die medenavorsers se tegniese kennis na ander boere.

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Finally, I dedicate this research to my late mother, she would have been extremely proud of our efforts.

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List of Acronyms and Abbreviations

DAE	KwaZulu-Natal Department of Agriculture and Environment
DOA	National Department of Agriculture
EFSP	Empowerment for Food Security Programme
FAO	Food and Agriculture Organization
FCS	Food Consumption Score Analysis Method
FGD	Focus Group Discussion
GHS	General Household Survey
LFS	Labour Force Survey
IAASTD	International Assessment of Agricultural Knowledge, Science, and Technology for Development
IPCC	Intergovernmental Panel on Climate Change
LER	Leaf Emergence Rate
MEA	Millennium Eco-system Assessment
NFCS	National Food Consumption Survey
NGO	Non Governmental Organization
OPV	Open Pollinated Variety
PAR	Participatory Action Research
QPM	Quality Protein Maize
SA	South Africa
SOM	Soil Organic Matter
SRI	System of Rice Intensification
WFP	World Food Programme
WHO	World Health Organization

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Chapter 1
Background to the research

1.1 Introduction

In this opening chapter, in order to give context to the background of the research and my links to the Mazabekweni community, I will firstly introduce myself and describe the Mazabekweni community. The rationale for doing the research, an introduction to the literature and the research design and methodology, as well as my research objectives will follow. Finally, I will list the limitations of the research, describe the value and relevance of the study, and give an outline of the remainder of the thesis.

1.2 Background

"Could you please help my family with our home garden plot?" The question, put to me in 2009 by one of my female staff members, was the start of a journey that would lead up to the writing of this Masters' thesis. While this thesis is complete, the journey is not over. New learning experiences and challenges continue to emerge, for myself, and the neighbouring Mazabekweni community where I conducted the research. We have all grown by being involved in this study. Our lives, transformed in ways that we never dreamt possible when we embarked on the journey, will never be the same.

For someone who is in the privileged position where access to tomorrow's food is something that has never been a concern, the level of food insecurity that my neighbours have to contend with has opened my eyes. On the other hand, my privileged position has allowed me to view the concept of 'tomorrow's food' from a sustainability perspective, and 'business as usual' is no longer an option. We have to find ways to produce our food other than the current conventional agriculture paradigm. This thesis is about finding another way to address the problem of rural food security in South Africa.

1.2.1 My personal background

I am a commercial dairy farmer, living 16kms from Ixopo (30°14' 06" S, 30° 08' 57" E) in the uBuhlebezwe district of southern KwaZulu-Natal. My agricultural career started in 1973 when I returned to the family farm after graduating from Stellenbosch University with an honours degree in Agricultural Management. My father had operated the farm since 1968, when he bought the property after moving from the Umzimkulu District, in what was part of the Cape Province. The forced move, because the district became part of the new Transkei Homeland, a cornerstone of the grand Apartheid dream, ended my family's agricultural contact with Umzimkulu, which stretched back to the late 1850s.

The time I spent in lectures at Stellenbosch was not my first contact with agriculture, as I had always spent holidays from boarding school with a free run of the farm. Apart from the tractors, cows and crops, my parents always included me in any discussions and plans relevant to running the farm. When neighbouring farmers came to visit the farm or when we visited other farmers in the district, I always listened to their discussions. Little did I realise that this was an important part of leaning to be a farmer: listening to the experiences of my parents and other older agricultural practitioners. Lately I have learnt that this learning experience, intergenerational knowledge transfer or indigenous knowledge, is vital to being a successful farmer. It is something that people outside of agriculture do not readily understand. As a fourth generation farmer in South Africa, I have benefited enormously from this indigenous knowledge. My son, who has taken over much of the day-to-day operation of the farm, will be able, in his time, to add to this knowledge base.

The family farm, to which I returned in 1973, was a typical example of conventional agriculture of the time, with extensive use of chemicals and the use of ploughs for the cropping of monoculture maize. The dairy component of the farm, which was the main enterprise, utilized the maize crop as the major forage source. Nitrogen fertiliser was an essential component of the production system. I soon realised that the excessive soil erosion, resulting from the tillage practices, was jeopardizing not only the environmental sustainability of the farm but my financial future as well. The soil erosion made increasing fertiliser inputs necessary in order to sustain production, which affected the profitability of the farm. Other farmers in the district, faced with the same predicament, sold their farms to corporate timber growers and left the district. My desire to stay in agriculture, as well as in the area, led me to a long search into other ways of trying to solve the problems confronting me. Listed are some of innovations that have transformed the farm.

No-till, innovated in the United States of America (USA) in the early 1970's, looked like an answer to my problems. At the time this was 'heresy' in South African agriculture, because of the paradigm that crops only grew if ploughs loosened the soil. However, I slowly started to adopt the technique. From these early beginnings, my interest in alternative agriculture grew, leading to its increasing implementation on the farm. Its positive benefits resulted in a slow but steady improvement in the ecology of the farm. I made many mistakes and it was challenging, but the effort was worth it.

Initially, the lack of suitable planting machines (planters) to place the seed into an un-tilled seedbed was a major constraint. The planters that were available overseas were not only expensive, but not constructed strongly enough to with stand our soil conditions and terrain. The solution to this dilemma was for me to design and build planters that would do the job. The design of our no-till pasture planter is unique, enabling me to register a design patent. (RSA patent 2009/05084).

Other practices that we have used over the years include zone-till, green manure crops, use of cattle manure for fertilization, compost, crop rotations, intercropping, mulches, and cover crops, mixed grass-legume grazing pastures, rainwater harvesting, and foliar spraying of urea nitrogen. In addition, we have bred and selected a herd of suitably adapted dairy animals that produce high quality milk under our grazing conditions.

Looking back, a significant turning point on the farm was in July 1998 when I completed a course in holistic resource management. The emphasis of the course was to view the farm as a whole, attaching equal importance to the financial, environmental, and social aspects of the business. The initial reason for doing the course was to find a solution to the increasing resistance of the tick population on the farm to the chemical tickicides that we were using. However, upon completing the course and reflecting on the learning experience, I realized that my problems with tick resistance were insignificant compared to the high levels of debt that I was struggling to service. In addition, the social aspects of my farm business were non-existent. Realizing that the ecological gains resulting from the adapting of no-till practices would not ensure the survival of the farm without confronting the high debt levels and social aspects of the farm, I introduced changes that very quickly bore fruit. The present sustainability of the farm from an environmental, financial, and social perspective is directly attributable to these changes.

1.2.2 The Mazabekweni community

The Mazabekweni communal area (30^{o} 13’ 44” S, 30° 06’ 29” E: Elevation 906m), is situated in Ward 12 of the uBuhlebezwe municipality in southern KwaZulu-Natal. The community, which lies adjacent to our farm, is very familiar to me as some of our staff members are resident here.

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The nearest towns are Ixopo (25kms) and Highflats (15kms). Ixopo is the regional centre, having both the uBuhlebezwe municipal offices, as well as the headquarter offices of the Sisonke district municipality, of which uBuhlebezwe forms a part. The town boasts a wide range of shops and service facilities that cater for the needs of the surrounding commercial farming district, as well as the local rural communal areas. Highflats also has a range of shops that cater for the requirements of the surrounding communities.

The topography of Mazabekweni is hilly, with numerous sheltered valleys and *veld* areas that serve as grazing for the community livestock. The rainfall is 800mm per annum, mainly falling between September and April, while the winters are cold with severe frosts occurring in June and July.

Figure 1, which depicts a general view of the settlement pattern and dwellings of Mazabekweni, also shows the daily routine of fetching water by the women of the area. This water comes from the nearest spring, or the municipal taps, when they are operational.

Figure 1: A typical Mazabekweni scene

Source: D Strachan; (own photograph)

The two primary schools, as well as a high school with 800 learners, in the area, are evidence of a high population density. However, none of the data that I was able to access could provide evidence of the total population of the area, or its demographics, compelling me to generate my own.

I made use of the FGD format, which I explain in section 5.2.1, to ascertain the population demographics in the valley where we conducted the research. The FGD format, which allows opportunity for debate, enabled my co-researchers, whose homesteads are scattered throughout the valley, to reach consensus on the demographics of their neighbours' households. We marked, as well as named, the individual households on a hand drawn map, and then systematically discussed the composition and employment status of each household. During the discussion, the co-researchers referred to each of the children in the households by name. This indicated to me the knowledge of the co-researchers regarding their neighbourhood, which verifies the accuracy of the data.

We grouped the children into pre-school, primary, and high school categories, with any youth who were out of school, classified as adults. The children we enumerated are resident in each household. However, because of the large number of orphans in the community, (who the co-researchers would not identify), they may not necessarily be the biological offspring of the household adult females. For a household to be 'female headed', we used the criteria of a female being responsible for the day-to-day decision-making in the household. For example, a migratory male worker, who only came home on the weekends or monthly, was not able to make day-to-day decisions, therefore designating that particular household as female headed. Regarding employment, we considered anyone involved in economic activity for remuneration, as employed. Anyone who from time to time may hold a temporary job, was deemed unemployed, as were household heads who tended the homestead rather than entering the job market. Our definition of local and migratory employment also needs clarification. We considered a person locally employed if they left the valley each morning, commuting to a regular job on nearby farms, or working in Ixopo or Highflats, and then returning home at night. A migratory worker on the other hand had regular employment further afield and only returned home on weekends or monthly. We were also able to identify the people drawing state pensions and disability grants. However, because of the 'grey area' of child grants, the co-researchers felt that they were unable to identify those households, or the beneficiary children, of the child grant system. (FGD September 2013).

The valley, approximately 50 hectares in extent, is home to 70 households, of whom 51 (73 percent) are female headed. Interestingly, 20 of the households were childless, nevertheless, we accounted for 188 children, of whom 39 were in high school, 94 in primary school, and 55 preschool. This ratio of primary to high school children reflects a dramatic increase in child numbers, starting from 2000/2001, and ending in 2008/2009, which is the age group of the present primary school population. However, the preschool population, who are under six years old, born after 2008/2009, shows a significant drop in numbers.

Table 1, shows the gender, employment, and social security status of .the adult population of the valley. I will comment on the possible reasons for these demographics, as well as the implications for the area and the research in Chapters 5 and 6.

Table 1: Gender, employment, and social security status (adults)

	Females		**Males**	
	number	**%**	**number**	**%**
Pensioners	13	11.4	9	10.8
Disability grantees	9	7.9	2	2.4
Locally employed	31	27.1	21	25.3
Migratory employment	4	3.5	10	12.0
Unemployed	57	50.0	41	49.3
Total	114	58.0	83	42.0

The area, with a long history of individual Black title deed ownership dating from before 1902, is typical of rural communal areas in KwaZulu-Natal. A resident chief assisted by *indunas*[2], looks after the traditional affairs of the residents. The Ward 12 municipal counsellor is also resident in the area.

In order to get residential rights in the community, households must pay an annual rental of R80 to the title deed holder of the farm. The individual households are responsible for the financing and erection of their dwellings. In addition, they have access to a household garden plot, which is normally adjacent to their dwellings. These plots, allocated by the landowner to the residents, are of various sizes, ranging from 0.4ha for long-standing residents, to 0.05 ha for newer residents. Residents who own livestock have grazing rights for their cattle and goats.

Despite having access to an area of land around their homesteads that is able to produce food crops, much of the land lies fallow. Soil erosion has severely degraded the land that is cultivated, resulting in low yields. As a result, community members must buy most of the food that they need to maintain an adequate diet. This reliance on purchased food, coupled with high levels of unemployment, impacts negatively on their household food security.

Eskom's (South Africa's national electricity provider) reticulation covers the whole area. Municipal services are sporadic, with the community drawing their domestic water requirements from numerous perennial springs in the valleys when the municipal taps run dry.

Mazabekweni is typical of the other rural areas of the uBuhlebezwe municipality. The uBuhlebezwe Integrated Development Plan (IDP) report of 2010/2011 lists the rate of unemployment in the municipal area at 27.6 percent, while the number of female-headed households stands at 54 percent. (uBuhlebezwe Municipal 2010).

1.3 Rationale of the research

This section starts by describing my personal motivation for conducting this research, as well as detailing the pilot project I conducted, which then developed into this Masters' research. A section that introduces some of the literature that justified the need for my research follows.

1.3.1 Personal motivation and pilot study

Whenever I travel around the country, my main interest is to look at the farms and countryside along the road. Over the years, the inability of households in communal area to grow some of their food in the plots around their houses has become more apparent. The question that I always ask myself is: 'where is tomorrow's food for any

[2] *Indunas* Male members of the community, appointed by the chief, to help him manage community affairs

particular household going to come from'? The answer always seems to be: 'the shop in the nearest local town'. Why should this be when there seems to be land available for basic food production?

Many people blame the social grant system, which, by providing cash to buy basic food items, discourages local agricultural production. I have always rejected this argument because even before the social grant system became a vital component of rural community life, the lack of food production was noticeable.

Despite efforts by the state, such as community gardens, to address the issue of rural food security, the result seems to be the same. One only has to take note of all the fenced-off areas that were at some stage a community project, that are now no longer functioning, to comprehend the magnitude of the problem. Not only is this a waste of valuable financial resources, but one must ask the question as to what these abandoned efforts do to the psyche of the people, especially the women, who looked to these projects to be the answer to improving their household food security. Are the state and other development agencies, by following the conventional agriculture paradigm, doing something wrong in their efforts to address the issue of rural food security? On the other hand, despite seemingly adequate planning and implementation, could community social dynamics be playing a role in the failure of these projects? Is there another approach that would yield better results, not only in rural areas, but also in the many new urban human settlements?

In September 2009, a female staff member, who is resident in Mazabekweni and the head of her family, asked me to assist her with the growing of some crops in the home garden plot adjacent to her homestead. The conventional method to cultivate this 0.23ha plot would be to hire a tractor from somebody in the community to plough, which would cost in excess of R400. The family would then plant the whole area to maize by hand. Due to the tractor costs, no money would be available to purchase fertiliser or manure, not only resulting in poor yields, but also subjecting the plot to severe soil erosion.

I agreed to help, on the condition that we implement as many agroecological methods and principles as possible on her garden plot. While she had no idea of agroecological methods and principles, once I had explained what I thought we should do, she immediately saw that the approach was feasible and agreed to it. I would provide a fence costing R3300, to keep the community goats and cattle out of the plot, as well as provide the tools, seeds, and manure to establish the crops. The family's contribution was to do all the work in the plot. I also undertook to provide guidance and consultation in the new agroecological methods we planned to use.

My previous involvement with the community made me aware of the dangers of giving only one family some resources. In order to prevent the possible victimisation of the family, I insisted that the broader community be included in the exercise by inviting them to view the results of our efforts, as well as giving them planting material to plant in their own plots.

The motivation for helping the family was, firstly, one of social responsibility towards my neighbours, and secondly to ascertain if, by using some agroecological production methods, the family could have access to a more adequate, secure and diverse diet.

I used this project as a case study for my Ecological Design module as part of my Honours degree in Sustainable Development at Stellenbosch University. The results that we achieved with the project convinced me that the approach could possibly become the focus of a future Masters' thesis.

The community showed a keen interest in the whole exercise, with many requests to expand the concept onto more household plots, while no victimisation of the family took place. However, one of the reasons for the success of the project was the goat-proof fence around the garden, the cost of which is in the region of R18 000/km. At the time, I did not see my way clear to spend more money on fencing in the community, because of the unanswered question of whether the project did in fact improve the food security of the study household.

Figure 2: Community field day, pilot project (March 2010)

Source: K Tenza

Figure 2 shows the interest in the pilot project from the local community when hosting a field day to explain the methods we used to grow a range of crops. We used the pit and fork method, described in the thesis, to plant the beans in the foreground.

In order to answer the question pertaining to the food security of the pilot project household, as well as the food security status of other Mazabekweni households, I decided to expand the research for a Masters' thesis in Sustainable Development.

1.3.2 Introduction to the literature

This section begins by discussing the issue of food security, including definitions of the term, as well as relevant statistics on the situation in South Africa. Following this, I will introduce the concept of agroecology, outlining why I felt it suited to the realities of my research in the Mazabekweni community and its residents, with whom I conducted my research.

1.3.2.1 Food security

Chappell and LaValle (2009:3), quoting the Food and Agricultural Organization (FAO) define food security as the " physical and economic access by all people in a society at all times to enough culturally and nutritionally appropriate food for a healthy and active lifestyle."

Drimie and Ruysenaar (2010), highlight the extent of food insecurity in South Africa, with 14.3 million people vulnerable to hunger, and 43 percent of households vulnerable to food poverty. A 2005 survey found only one in five households food secure. In addition, stunted and underweight children are common nutritional disorders. The large number of stunted children in our population, and the fact that adult and child malnutrition has increased compelled the World Health Organization (WHO) to list South Africa as one of 36 High Burden countries (Faber, Witten, & Drimie 2010).

Rural food insecurity and hunger is a serious problem. A study of 53 households in the Maphephetheni area of KwaZulu Natal found that despite having access to community gardens, "89% of these households were anxious about food supplies, consumed insufficient food, and were severely food insecure. In addition, 72% consumed poor quality food" (Shisanya & Hendriks 2011:509). The Maphephetheni area, situated 80kms west of Durban, is a rural area similar to the Mazabekweni, with the inhabitants reliant on cash income from social grants, migratory labour, and farm work to purchase their food. The inability of rural communities to grow their own food is widespread, with Drimie and Ruysenaar (2010:317) stating that most rural households are "net deficit food producers as their food access is partially or wholly reliant on household income". Baiphethi and Jacobs

(2009), confirm this statement by revealing that, in many cases, purchased food constitutes up to 90 percent of rural household diets, accounting for 60 to 80 percent of total household expenditure.

1.3.2.2 Agroecology

The first mention of agroecology in the literature was in the early 1930s, when the Russian agronomist Bensin coined the name after combining his discipline with ecology. Up until the 1960's, in what Wezel and Soldat (2009) describe as the initial phase of the new scientific discipline, the emphasis was on plot and small field trials. The next three decades saw expansion, with emphasis moving to studies of ecosystems and agro-ecosystems, in addition to the field and plots trials of the early stage. Reflecting this change in emphasis, Gliessman, (in Francis, Lieblein, Gliessman, Breland, Creamer, Harwood, Salomonsson, Helenius, Rickerl, Salvador, Wiedenhoeft, Simmons, Allen, Altieri, Flora, & Poincelot 2003:101) considers agroecology to be "the application of ecological concepts and principles to the design and management of sustainable agroecosystems".

During this mid-phase, the academic literature on agroecology expanded enormously, with many new topics entering the discourse, setting the scene for the next development. Themes that added fresh material to the literature on agroecology originated from the environmental and social fields. Economics, anthropology, sociology, political science, and geography were all disciplines that expanded the social focus, leading Francis et al. (2003:100) to define agroecology as "the integrative study of the ecology of the entire food system, encompassing ecological, economic, and social dimensions" (Wezel, Bellon, Dor´e, Francis, Vallod, & David 2009; Wezel, &Soldat 2009; Amekawa 2011).

The concept of systems, including ecosystems, agroecosystems, and food systems, is central to agroecology. Meadows (2008:11), describes a system as "an interconnected set of elements that is coherently organized in a way that achieves something".

The growth of agroecology as a transdisciplinary scientific discipline, focusing on a systems approach, makes it eminently suitable to solve the negative consequences of modern industrial agriculture. This wider focus on the biological and cultural aspects of agro-ecosystems, rather than the narrow, economic and yield maximizing approaches of conventional agriculture lead Clements and Shrestha (2004:5), to consider agroecology to be the "new philosophy" of agriculture. Expanding further on this new role of agroecology, Amekawa (2011:120) states that "It has to date been the most effective facilitator of the concept of sustainable agriculture and at the same time the least compromised critic of modern industrial agriculture".

The wider focus of agroecology has led to its application in various forms, for example, a scientific discipline, a political or social movement, or an agricultural practice or technique, each of which aims to maintain the natural resource base. These forms can occur singularly, or in any combination (Wezel et al. 2009).

Agroecology, its principles and application, is especially suited to implementation by small-scale resource limited farmers, with many successful examples in Latin America (Altieri, Funes-Monzote & Petersen 2011). My readings on agroecology revealed that its implementation by resource poor rural households is able to improve their food security (Altieri 1995; Francis et al. 2003; Magdoff 2007; Chappell & LaValle 2009; Lal 2009a; Wezel et al. 2009; Malézieux 2011; Holt-Giménez, Shattuck, Altieri, Herren & Gliessman 2012).

1.4 The research problem statement, research aims and research questions

The background and motivation section, as well as the brief introduction to the literature, has shown that households in South African rural communal areas, of which the Mazabekweni is a typical example, are often highly food insecure, despite having access to land on which to grow some of their food requirements. The literature shows examples where agroecology is able to improve the food security of resource poor households, while maintaining the natural resource base.

1.4.1 The research problem statement

A preliminary investigation suggests that despite households in Mazabekweni having access to an area of land around their homesteads that is able to produce food crops, much of it lies fallow, with the result that they must rely on purchased food. This reliance on purchased food, coupled with high levels of unemployment, impacts negatively on their household food security.

1.4.2 Research questions

The primary aim of my research is to design, implement, and assess a cropping system, using agroecological principles and methods, by selected rural households at Mazabekweni. Coupled with this is the secondary aim, which is too ascertain if the culturally acceptable food crops harvested from their garden plots, improve the diets and food security of the households. A prerequisite to the achievement of both these aims is that the research respects the complex community social dynamics in Mazabekweni.

In order to achieve the aims of the research the following research questions need answers.

1. Can the study households implement and assess a cropping system, designed on agroecological principles, on their garden plots?
2. Have the food crops they grow and harvest from their household plots, contributed positively to the diets and food security of their households?

I will elaborate on my reasons to include both the household diets and food security in my second research question in sections 3.7.1 and 3.7.2 of the thesis.

1.5 Introduction to research design and methodology

1.5.1 Introduction

The research consists of two interrelated components, namely the design, implementation and assessing of the agroecological cropping system by the study participants, and the collection of data in order to answer the research question relating to their household diets. Appendix A details a research process time line from 2009 to 2013.

In this section, I will outline the basics of my research design and methodology that I used during the research, namely a literature review, as well as fieldwork in the Mazabekweni area. I will firstly discuss the literature review, including the fields of literature I covered, to give the research substance. Following this, I will give an outline of the research design, with reasons for choosing the particular design. I will then detail fields of agroecology, diet, and food security that I will be covering in this thesis. Finally, I will detail reasons as to why I conducted the research in the Mazabekweni area. A more detailed description of the research design and methodology will follow in Chapter 3.

1.5.2 Literature review

The initial focus of my literature review was an overview of the environmental, social, and economic crises that the world is facing from a sustainability perspective and therefore by implication, what the research participants are facing.

Narrowing the review down to focus on the two themes of the thesis, I covered the fields of agroecology and food security. In my literature searches on agroecology, mainly in the e-journals available from the University of Stellenbosch library, as well as from relevant books, I found a complete absence of literature specific to South Africa, which resulted in having to rely on overseas literature sources. A notable absence in this literature, despite the inclusion of an economic dimension in the definition of agroecology by Francis et al. (2003), is substantive in-depth analyses of economic issues relating to agroecology. However, the social and environmental fields of agroecology are extensively covered. In the field of food security, I limited my literature search to relevant Southern African material.

In order to broaden my understanding of agroecology and its systems approach, as well as its place in the broader agricultural and sustainability debates, I undertook extensive literature searches and readings on systems in general, especially food systems, cropping systems, soil systems and tillage systems. In addition, I covered the fields of sustainable and organic agriculture.

The literature review on agroecology was an essential part of the research, as I was able to identify principles and methods that I used to design the initial cropping system implemented on the garden plots. I will cover this in more detail in Chapter 4.

My literature search on communal agriculture in South Africa revealed the major role that women play in both food production, as well as utilising other strategies to survive. I will expand on this, and pre-colonial communal agriculture in Chapter 2.

The literature on food security in South Africa covered its scope, as well as reasons for the high levels of food insecurity. I also looked at ways in which one can measure food security, in order to find methods to assess whether the cropping system we implemented during the study had improved the households' food security. My research indicated that a good measurement of food security is dietary diversity, so I focussed on its importance and measurement. I will provide more detail on this in Chapter 2.

Finally, I undertook general reading on research designs and methodology, in order to find the appropriate design for the research, before deciding on PAR.

As part of my literature review, I conducted a Nexus Data Base search on 24/06/12 and again on 19/08/13, searching the current and completed research database. Using my thesis keywords, namely, agroecology, cropping system, and food security, the search revealed no research that listed the same keywords, ruling out the possibility of studying previous work in my research field.

1.5.3 Research design: Participatory Action Research

The following definitions of PAR give a broad outline of this approach. "Participatory action research (PAR) consists in an approach that includes both understanding a situation (creating knowledge) as well as changing or acting upon that situation – using participatory methods, that is, challenging the dichotomy between researchers and researched"(Lopes 2006: 217).

Building on this definition, Grant et al. (2008:589) define PAR as

> Participatory action research (PAR) is a research methodology that attempts to address power imbalances and oppressive social structures. It values the 'researched' community as a vital part of the research project and its members as experts of their own experiences. PAR is particularly

concerned with oppressed communities and attempts to create action as a catalyst for social change.

I based my choice of PAR as the research design on the fact that the study participants in the research are actively involved in all aspects of the research, and that the Mazabekweni area suffers from historic disenfranchisement through our colonial and apartheid past. In addition, the aim of the research is for the cropping system to bring about social change in the area (Mouton 2001; Lopes 2006; Grant, Nelson & Mitchell 2008).

I will include a detailed discussion of PAR in Chapter 3 under the heading Research Design, and Methodology.

1.5.4 Research methodology and methods

The research focused on selected households growing a variety of food crops on their respective plots under dry-land conditions, which they were able to harvest and then use to supplement their household diets. The households, using family labour, did all the work on their plots, as well as recording the household diet on a daily basis.

My input into the research was to do the initial cropping system design, using my agricultural experience, and information gleaned from the literature review. I consulted with the study participants on any subsequent modifications to the cropping system design, as well as the data collection protocol of the household diets.

I also supplied the assets and infrastructure necessary for the research, apart from the land and labour components, with the understanding that they would remain the property of the respective participants upon completion of the research.

The research consisted of a qualitative as well as a quantitative component, which I will detail in Chapters 4 and 5.

For the qualitative assessments, I relied on participant observations and regularly checking the growing crops on the plots, FGD’s, semi- structured interviews, and informal discussions with both the study participants as well as some of their community neighbours. As I am fluent in IsiZulu, the informal discussions were extremely helpful with the qualitative assessments. For recording purposes, I kept a research diary, in which I recorded pertinent discussions and details. In addition, I compiled a photographic record, taking photos in the research environment throughout the study period.

The quantitative component of the research, using Excel spreadsheets, was an analysis of the individual household diets, based on a weekly data sheet filled in by each household. Using the Food Consumption Score Analysis Method (FCS) developed by the World Food Programme (WFP) (2008), I was able to calculate a quantitative benchmark of the household diet before they started growing their own food, as well as dietary changes resulting from the consumption of their homegrown food. The FCS, rather than dietary standards, determined the adequacy of the study participant's diet. I will cover the use of FCS analysis in the research in more detail in Chapters 2, 3, 4 and 5.

The study encompasses the study participants growing food crops on their household plots, using agroecological principles and methods, and the effect this has on their household diet and food security. However, because the Mazabekweni communal area is the study locale, the neighbourhood community dynamics influences the research. For this reason, the research is an integrative study of the ecology of the Mazabekweni area food system, encompassing the local ecological, economic, and social dimensions (Francis et al. 2003).

1.5.5 Research area

I elected to do my research for this thesis in the Mazabekweni community, firstly because of my long association with the community, which allowed me unlimited access to the study area and the research participants.

Secondly, the study area is a ten-minute drive from my farm, which was vital given the great deal of time I put into the research.

Thirdly, the results from the pilot study provided a good knowledge base to build the extended research on.

Finally, although the research focused on nine selected households in the Mazabekweni community, the area is characteristic of most rural communal areas in KwaZulu Natal, both in available resources and social dynamic. This makes the research very relevant to the broader community.

1.6 Limitations and assumptions of the research

Firstly, given the South African context of the research, a complete absence of local academic literature on agroecology (specifically with reference to agriculture and food security in communal areas), is a major limitation. There is limited South African academic literature on organic and sustainable agriculture, which fall under the broad umbrella of agroecology. The focus of both organic and sustainable agriculture is on input substitution, in contrast to the 'study of the entire food system' of agroecology, which includes a strong focus on the socio-economic aspects of agriculture (Francis et al. 2003; Wezel et al. 2009). I referred to literature on organic and sustainable agriculture in South Africa in my preliminary reading, but found the focus too narrow for the purposes of this thesis. However, the primary aim was to develop and implement a sustainable cropping system using agroecological methods and principles, and given the systems approach of agroecology, I was able to access overseas literature on agroecology and adapt the appropriate information.

A second limitation was that because of the short duration of the research, I was not able the measure the long-term benefits flowing from the implementation of the cropping system on the food producing potential of the plots. In addition, the measurement of long-term changes in the diets and food security of the households resulting from increased availability of homegrown food was not possible. Future research could use the results of my research as a benchmark in order to quantify the long-term benefits.

Thirdly, an objective measurement of changes in the soil health in the plots was not part of the research, but other household's plots, not subject to the same agroecological methods, that are contiguous to the study plots could provide a starting benchmark for possible future research aiming to measure the changes.

A final limitation is that the results of the research are specific to this study in the context of the local agroecosystem. Due to basing the initial design of the cropping system on the implementation of universal agroecological principles, similar results would be possible with the implementation of the cropping system in a different agroecosystem.

An assumption in the research was that the food produced on the plots would supplement the household diets, rather than make the households self-sufficient in food production. Given the long-term potential improvement in the plot agroecosystem with the implementation of the agroecological methods, this could be a future possibility.

1.7 Value and relevance of the study

South Africa's colonial and apartheid past has resulted in a large section of our population living in rural communal areas, characterised by a predominantly female resident population, and a largely absent male component compelled to earn a living from the migratory labour system. In addition, a degraded physical environment, caused by high population densities and inappropriate agricultural practices, coupled with high unemployment levels, negatively influences the food security of these areas. Attempts to improve the food security, with both large and small-scale communal projects, based on the conventional agricultural paradigm, has done little to alleviate the problem.

This research, set in a rural communal area of KwaZulu-Natal, involves mainly female-headed households. By assisting one another on a structured basis, they have successfully implemented an agroecological cropping system on their individual plots, producing culturally acceptable foods, which have improved both their household diets and food security.

The research results prove that the agroecological approach is a viable alternative to current methods aimed at alleviating food insecurity in rural communal areas. However, the provision of a basic infrastructure, comprising a goat-proof fence and simple hand tools, is necessary before it is applicable in a broader context.

The study is of relevance to development agencies, both state and NGO's, involved in efforts to improve household food security in rural communal areas.

1.8 Outline of the thesis

The outline of the balance of the thesis is as follows:

Chapter 2 is a literature review, which starts by focussing on the polycrisis facing the world, from a sustainability perspective. Agriculture's role as a cause of this polycrisis as well as the impact of the polycrisis on our future food supply, are part of the discussion. An introduction to the concept of food security, as well as the food security situation in South Africa's rural communal areas follows. Finally, an in-depth analysis of agroecology and its potential to alleviate the food insecurity in our rural areas closes the chapter.

Chapter 3 details my research design and methodology. The chapter starts with an overview of the research environment, leading into a rationale for the choice of PAR as the research design. A discussion of PAR, its strengths, shortfalls and challenges follows. The method of the study sample selection, its profile, as well as the resource base of the study participants, leads into a description of research infrastructure and its cost. Finally, the chapter covers the initiation of the cropping system, its assessment, as well as the data collection protocol necessary to gather information on the household diet of the study participants.

Chapter 4 consists of a discussion of the implementation of an agroecological cropping system by households in the Mazabekweni communal area, including its practicalities and challenges.

Chapter 5 presents the research results, starting with an analysis of the Mazabekweni food system, followed by the qualitative assessment of the cropping system by myself, as well as the study participants. This section includes a discussion of the diets and food security of the study households. It concludes with a quantitative analysis of the food security of the households using the Food Consumption Score (FCS).

Chapter 6 includes recommendations and comments pertinent to the research.

Chapter 2

Literature Review

Global warming and atmospheric carbon dioxide levels are the sustainability issues that receive the most popular media attention. However, when viewing the world from a systems perspective, it becomes apparent that a much wider approach is necessary. This chapter starts with this wider focus, with specific attention on agriculture and our food supply, before narrowing down to issues pertaining to food security in rural communal areas in South Africa. Finally, I will discuss the potential of agroecology to help solve the food security of rural households in these communal areas.

2.1 Sustainable development, an elusive concept

"We already grow enough food for 10 billion people … and still can't end hunger" (Holt-Giménez, Shattuck, Altieri, Herren, & Gliessman 2012:596). This paradox, given that the projected population peak forecast for 2050 is nine billion people, is one of the symptoms of the wider malaise, from a sustainability perspective, that is facing the world. However, this food production has come with massive external environmental cost. Furthermore, poverty and inequality ensures that the 890 million world's poor, living on less than $1per day, do not have the resources to buy enough food in order to alleviate their hunger (Holt-Giménez et al. 2012; Griggs, Stafford-Smith, Gaffney, Rockstrom, Ohman, Shyamsundar, Steffen, Glaser, Kanie & Noble 2013).

The 1987 Brundtland Commission, whose report set the scene to what was supposed to be a sustainable future for the world, is considered a watershed moment in the sustainable development debate. Its definition of sustainable development namely, that 'sustainable development is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs', became the cornerstone of attempts to restore some environmental and social sanity to the world (World Commission on Environment and Development 1987). However, judging by the 2012 statement by Holt-Giménez et al. (2012), the expectations of the development community that all would now be well have not materialized.

Indeed, a series of environmental, social, and economic trends and events have converged into the 'polycrisis' that presently confronts the world (Swilling & Annecke 2012). Normally viewed in isolation and as unrelated events because of our failure to accept the world as one living system, these trends and events are interrelated and feed on each other, potentially magnifying the crisis. The problems of poverty and inequality, alluded to by Holt-Giménez et al. (2012), are but one element of this multi-faceted crisis.

In their analysis of the polycrisis, Swilling and Annecke (2012) identify seven themes, all supported by mainstream documentary evidence, which need addressing if we hope to have a sustainable future. Conventional analysis and solutions for these themes on an individual basis indicate that they are stand-alone problems.

However, when we take a systems perspective view of the world, clear links between the themes emerge. Similarly, an agricultural view of the themes, from a systems perspective, shows that our food supply is a central element of the polycrisis and the sustainability debate. Let us unpack these themes in order to get an overview of the polycrisis to which Swilling and Annecke (2012) refer.

2.1.1 Ecosystem degradation

The 2005 United Nations Millennium Ecosystem Assessment (MEA), reporting on the condition of the world's ecosystems, reached the conclusion that 60 percent are in a degraded state and unable to provide the ecosystem services that are vital to our well being (MEA 2005). The MEA highlighted our dependence on nature to provide us with life supporting conditions, products, and services, to ensure our survival.

Agriculture worldwide is a major contributor to ecosystem degradation. This degradation takes the form of biodiversity loss, soil organic matter decline, soil erosion and fertility loss, desertification, rangeland degradation, surface and ground water pollution through leaching and runoff of agrochemicals, eutrophication, greenhouse gas emissions and reduced carbon sequestration (Pretty, Sutherland, Ashby, Auburn, Baulcombes, Bell, & Bentley et al. 2010; Lal 2007; Griggs et al. 2013).

Biodiversity loss, due to the simplification of the modern agroecosystem through mono cropping, results in serious ecosystem degradation. Mono cropping, results in the loss of natural biological processes vital to the functioning of the ecosystem, necessitating the addition of increased amounts of external inputs in order for the agroecosystem to remain productive (Altieri 1999).

The degradation of soils is an increasing problem, with 23 percent of agricultural land affected by some form of degradation (IAASTD 2008).Soil compaction, considered the most serious form of soil degradation, results from management practices associated with conventional agriculture, and affects some 68 million hectares in Europe alone. These management practices include monoculture cropping, which reduces soil organic matter (SOM), the use of heavy machinery, and the intensive grazing of livestock on wet soils (Hamza & Anderson 2005).

IAASTD (2008:146) estimates that globally, 'resource impairment', caused by agricultural activity, negatively affects as many as 2.6 billion people. This massive 'hidden' environmental cost of food, alluded to by Holt-Giménez et al. (2012), puts the 'success' of modern agricultural production, based on Green Revolution[3] principles in a different light.

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[3] The Green Revolution refers to the intensification of agricultural production, particularly in developing countries, using fertilisers, improved seed, pesticides, and irrigation. This approach produced high yields, resulting in increased food for a growing world population, but with unacceptable environmental and social costs (IAASTD 2008).

2.1.2 Global warming

World temperatures are rising due to the increase of greenhouse gases in the atmosphere, and the prediction is that if they rise by two degrees C or more, we face serious ecological and socio-economic changes brought about by the resulting climate change (Swilling & Annecke 2012, citing Intergovernmental Panel on Climate Change (IPCC)). Already we can see the results of these predictions in the form of extreme weather events such as hurricanes, floods, and droughts around the world (Hope 2009).

Modern global agricultural practices are major contributors to the elevated levels of greenhouse gases in the atmosphere. Agriculture and the food system are responsible for a third of the global greenhouse emissions, more than twice that of the transport sector (Pretty et al. 2010. citing the IPCC 2007; IAASTD 2009).

Tillage, using ploughs, inverts the soil leaving it bare, which exposes carbon, stored in the soil organic matter, to oxidization, releasing carbon dioxide into the atmosphere. In addition, inappropriate use of nitrogen fertilisers results in denitrification taking place, releasing nitrous dioxide into the atmosphere (Lal 2007). Livestock production, which supports more than one billion of the world's poorest farmers, is a major contributor to global green house gas emissions. This sector is responsible for 37 percent of anthropogenic methane, nine percent of the carbon dioxide and 65 percent of the nitrous oxide in the atmosphere (Pretty et al. 2010).

Johnstone, Hachigonta, Sibanda & Thomas (2012), highlight the impact of climate changes on agriculture in South Africa. Using modelling, they predict that the harvested area of maize will decrease from 2010 through to 2050, but higher temperatures will result in yield increases, which will offset the reduction in area. The net result is that 2050 production will be similar to 2010. Exports will increase until 2020, after which increased demand from population growth will make the country a net importer of maize. This will have serious repercussions for local food security, given the importance of maize as a staple grain.

2.1.3 Oil peak

The global economy is heavily reliant on the consumption of cheap oil, which accounts for 60 percent of the world's energy. However, production of oil has levelled off, with new discoveries not being made fast enough to satisfy the demand. The term 'oil peak', coined from experiences in the American oil industry, is when the peak flow from an oil field occurs. Studies of many American oil fields show that this peak flow occurs some 40 years after the discovery of a particular oil field. Indications are that we have reached, or are close to, this point with global oil production, putting upward pressure on the price of oil (Association for the Study of Peak Oil South Africa 2007). The World Energy Outlook (2008:49), which is a comprehensive publication from the

International Energy Agency, concludes; “it is becoming increasingly apparent that the era of cheap oil is over”. This fact will have a profound effect on the way the global economy will function in the future.

A discussion of peak oil is incomplete without mentioning the links between oil and agriculture. Green Revolution agriculture, and the availability of cheap oil, are synonymous with the production of nitrogen fertiliser, herbicides, pesticides, and the transportation of globally traded agricultural commodities reliant on oil. Swilling and Annecke (2012), in their discussion of peak oil and its repercussions, mention that oil is the basis for most of the fertiliser for our food production. To understand this vital link between oil and the world’s food supply, we need to have a closer look at specifically nitrogen fertiliser, its role in plant growth, and its manufacture.

2.1.4 Oil peak and agriculture: Nitrogen fertiliser

Nitrogen, with phosphorus and potassium are essential elements for the functioning of natural ecosystems, as well as conventional agricultural production. All these elements affect plant growth, reproduction and yield (Smil 1999).Phosphate and potassium are finite mined minerals, while nitrogen is the most abundant element in the atmosphere. However, plants cannot utilize this nitrogen gas. In a natural ecosystem, the nitrogen cycle converts this gas into the nitrate and ammonium forms, which plants then utilize (Schriefer 2000).

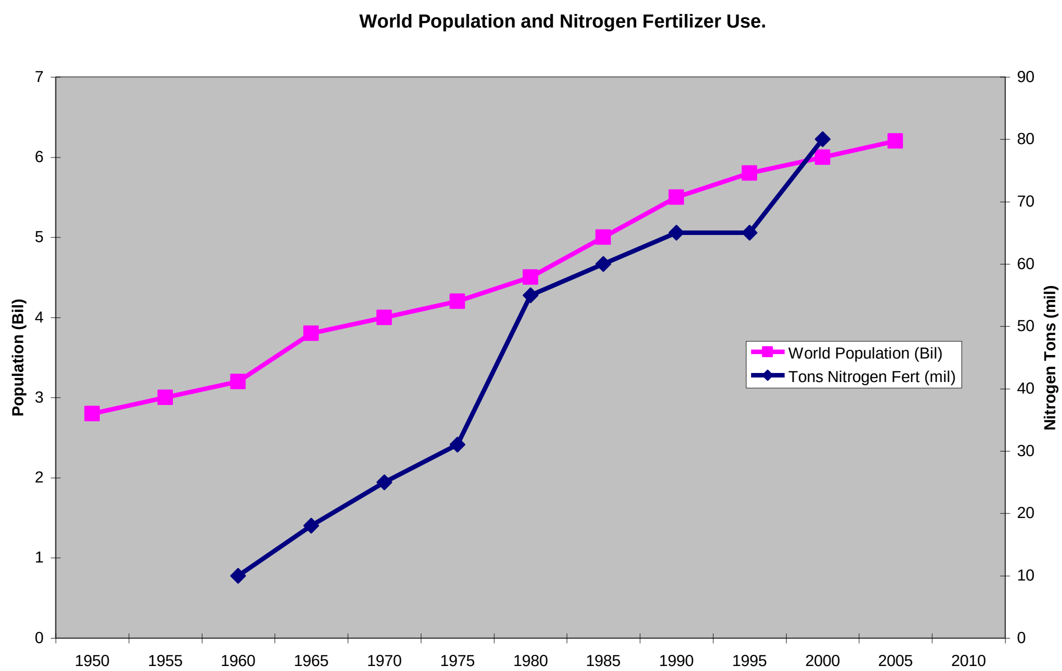
Traditionally, agricultural production relied on legumes to convert the atmospheric nitrogen, with the help of soil based *Rhizobia* bacteria, into nitrate and ammonium for use by non-legume food crops, such as grains. Additional sources of nitrogen were animal manures, composts, and green manure crops, all increasing SOM, which then slowly released the nitrate and ammonium for plant use (Zimmer 2000).

The end of the Second World War signalled a profound change for world agriculture, with the legume-based nitrogen system increasingly replaced with chemical nitrogen fertiliser produced by the Haber-Bosch process. The energy intensive Haber-Bosch process, which uses natural gas to extract nitrogen from the atmosphere for conversion into plant available nitrogen, is a vital component of modern conventional agriculture. Smil (1999) considers the Haber-Bosch process to be the most important invention of the 20th century, because of the extra food production, primarily cereal grains, made possible by utilizing nitrogen fertiliser rather than the legume based systems.

The Haber–Bosch process is a critical element of the global food system. Smil (1999:415) states, that “40% of all people alive today, and virtually all of those that will be added to the human population in the future, depend on the Haber–Bosch process as a major source of N for the synthesis of the proteins, DNA, and other N-containing molecules in their bodies”. By extrapolating this trend to 2050, using United Nations population projections, Crews and Peoples (2004:279) estimate that "as many as 5.5 billion people may owe their existence to synthetic N fertilisers".

Figure 3, compiled from data in IAASTD (2009), shows the increasing use of nitrogen fertiliser and world population growth from 1950, reinforcing the views of both Smil (1999), and Crews and Peoples (2004).

Figure 3: World population and nitrogen fertiliser use



Source: compiled from IAASTD 2009:6

Nitrogen fertiliser manufacture is the major energy component of conventional agriculture at farm level, accounting for 68 percent of agricultural energy consumption in developing countries and 40 percent in developed countries. However, globally, fertiliser manufacture accounts for only 1.3 percent of energy consumption (Crew & Peoples 2004). One could argue, given the importance of nitrogen for global food production, and the small amount of energy necessary for its production, that nitrogen-manufacturing plants be priority natural gas customers. Seen in isolation, this is a valid argument. However, when viewed from a systems perspective, the potential of nitrogen fertiliser to contribute to soil acidification, nitrate leaching into groundwater and waterways, and ammonia and nitrous dioxide volatilization into the atmosphere, increasing global warming, raises critical environmental issues. Notwithstanding its importance for food production, these negative environmental impacts on the ecosystem, associated with the use of nitrogen fertiliser, question its widespread use (Smil 1999; Spiertz 2009).

2.1.5 Poverty and inequality

The causes, manifestations and the steps necessary for the elimination of global poverty and inequality are the central theme in Swilling and Annecke's (2012) analysis of the transitions necessary for a sustainable future for the world. Quoting the United Nations Development Report (1998), they highlight the scale of the problem, which is that 20 percent of the global population, mainly in rich countries, is responsible for 86 percent of private consumption expenditure, while the poorest 20 percent exist on 1.3 percent. This unequal per capita consumption of finite global resources is the result of a long- term trend of what the United Nations Development Report calls 'conspicuous consumption' by the world's richest citizens. By comparison, per capita consumption in Africa has declined by 20 percent in the last quarter of the twentieth century. Meeting the basic needs for the worlds poor is only possible if wealthy countries reduce their consumption, a step that will ensure long-term sustainability (Swilling & Annecke 2012).

Rural areas, in comparison with urban areas, have greater levels of poverty and inequality. IAASTD (2009) quotes a World Bank study of 62 countries, showing that a greater percentage of the rural population, especially women, lived below the national poverty line when compared to their urban counterparts. In some cases, the gap was as much as 30 percent lower.

Looking at the situation in South Africa, ten percent of the population earns more than 50 percent of the household income, while the poorest 40 percent has to survive on seven percent (Faber et al. 2010).

The situation in South African rural areas follows a similar pattern to that described by IAASTD (2009). Aliber and Hart (2009), reporting on a Limpopo Province rural village, found that 49 percent of the villagers lived on less than US$ 1 per day. Women were the most affected, with 70 percent involved in subsistence agriculture, as a means to improve their livelihoods. In the former Transkei and Ciskei rural areas, the situation is as serious as Limpopo. Westaway (2012), quoting the Basic Income Statistics 2005/2006, which are the latest available figures, found that in 2005, the average income of these areas was R225 per month, with 73 percent of the population earning less than R300 per month, mostly from welfare payments. Only 16 percent of the population aged between 15 and 64 years were wage earners.

Swilling and Annecke (2012) list malnutrition as one of the manifestations of poverty. While we normally associate malnutrition with hungry people, it also results in stunted and underweight children. Altman, Hart and Jacobs (2009), quoting the 2005 National Food Consumption Survey (NFCS), which showed that one out of five children aged one to nine in South Africa were stunted, reveals the severity of the problem.

However, poverty and malnutrition are not synonymous. IAASTD (2009) highlights malnutrition, resulting from over-consumption of fats, sugars, and salt, coupled with a lack of whole grains, vegetables, and fruit in diets worldwide. The global pandemic of overweight and obesity, with its associated health risks, is a direct result of this type of malnutrition.

2.1.6 Urbanization

The majority of the world's population is urban, with the growth of urban slums, home to one billion people, common in cities worldwide. Many of the residents of these slums are migrants trying to escape rural poverty, only to find themselves trapped in urban poverty (Swilling & Annecke 2012). At the same time, attempts to find solutions to this urban poverty, has shifted the focus away from rural areas, which are now sinking into deeper poverty (Sumner 2005; IAASTD 2008). To illustrate the increasing neglect of rural areas, Oxfam (2009) comments on the effect of the 2008 financial crisis on agriculture in developing countries. Agricultural aid from developed countries was no longer available, because those countries needed the funds to solve the consequences of the financial crisis.

In the South African context, while rural areas are still home to a sizable proportion of the population, urban migration is an increasing phenomenon. Between 2001 and 2011, the Eastern Cape Province, which is predominantly rural, recorded a net 'out-migration' of 278 261 people, while the mainly urban Western Cape registered a net 'in-migration' of 303 823. During the same period, Gauteng Province, the urban centre of South Africa, showed a net gain of 1 037 871 residents (Statistics South Africa 2011). Linked with this urbanization, is the migratory labour system, which is a remnant of our racially structured colonial and apartheid history. Workers, predominantly males from rural communal areas, supply labour for mines and urban industry in return for a cash wage. This money is vital for the livelihoods of their families at home (Potts 2000; Frayne 2005). Before 1994, these workers had to return home when their labour contracts expired. However, with the advent of democracy in 1994, many now remain in the urban areas, living in the growing informal settlements in and around cities and towns.

These migratory patterns have a big impact on agriculture in the communal areas. Frayne (2005), found a strong link between rural and urban areas in Namibia, with significant amounts of food sent to urban migrants by their families. Potts (2000:812), reporting on Zimbabwe, found that those she calls "Farmer – Housewives" play a critical role supplying the rural-urban food flows, as well as maintaining the rural household.
The South African communal areas, although subject to the same migratory labour patterns as Zimbabwe and Namibia, are not able to provide the same food flows that Frayne (2005) and Potts (2000) elude too. Potts (2000:816) says that many South African rural households have "turned away from agriculture", confirming the conclusion of Drimie and Ruysenaar (2010) that most rural households rely on purchased food. The cash remitted by rural migrants in urban areas, as well as state income grants, are therefore critical for rural food security (Aliber & Hart 2009). The absence of men in rural areas, because of the migratory labour system,

ensures that any subsistence agriculture is the women's domain (Bembridge 1988; Potts 2000; Hart 2000; Aliber & Hart 2009).

2.1.7 Food security

Swilling and Annecke (2012), in their analysis of the polycrisis pertaining to global food security, rely heavily on the findings of the International Assessment of Agricultural Knowledge, Science, and Technology for Development (IAASTD).

The IAASTD, initiated in 2002 by the World Bank and the Food and Agricultural Organization of the United Nations (FAO) as a global multi-disciplinary, multi-stakeholder consultative process on all relevant issues facing global agriculture, published its findings in 2008. This peer-reviewed report identified the need to expand rural livelihoods, as a prerequisite for improving food security. In addition, equitable social, environmental, and economic sustainable development in rural areas would not only reduce hunger and poverty, but boost human health as well (IAASTD 2008).

The IAASTD acknowledged the complexity of agriculture, and its importance both as a supplier of food for the rapidly urbanising global population, as well as the basis for the livelihoods of 70 percent of the worlds poor, namely the 2.1 billion small-scale farmers living on less than $2 per day (IAASTD 2008).

The IAASTD report highlights important issues. Firstly, there is an increasing demand for a wide variety of food products, including meat and dairy, from the expanding global middle class. Secondly, increasing food prices, although good for surplus agricultural producers, is placing an increasing financial burden on food consumers. Thirdly, increasing levels of malnutrition are a growing problem. Paradoxically, this manifests as under-weight for 800 million of the worlds poor and overweight and obesity for another 1.6 billion people (IAASTD 2008).

The food security situation in the sub-Saharan region is of particular concern. Lal (2009), reports that this is the only region in the world where the number of hungry and food insecure individuals will still be increasing by 2030. Despite countless attempts to address the situation from an agrarian perspective

> Agrarian stagnation in SSA has defied numerous attempts at transforming subsistence agriculture, even with due consideration to issues related to biophysical constraints and the human dimensions challenges. The stubborn problem will be solved only when Africans (scientists, farmers, policy-makers and the public at large) collectively resolve to solve it in a manner pertinent to the site-specific situations (Lal 2009:27).

To counter the issues pertaining to the world's resource poor farmers, including food insecurity, IAASTD (2008) recommended that the implementation of agroecological production methods producing food locally, rather than relying on the global market, was the best strategy for ending poverty and hunger. Could this approach remedy the situation in sub-Saharan Africa described by Lal (2009)? I will expand further on food security and agroecology in sections 2.3 and 2.4 of this thesis.

2.1.8 Material flows

The final aspect of the polycrisis highlighted by Swilling and Annecke is that of material flows. Materials, some 60 billion tons per annum, comprising mainly biomass, fossil fuels, ores, industrial and construction minerals, are extracted form the earth, processed, transported, consumed, and finally end up as waste products, causing increasing levels of pollution. Except for biomass, these materials are non-renewable or derived from finite resources. Interestingly, in many cases such as with phosphate rock, a vital agricultural input that I will discuss in the next section, their quantitative limits are unknown or only estimates (Pretty et al. 2010; Swilling & Annecke 2012).

2.1.9 Material flows and agriculture: Phosphate fertiliser

Phosphate is a critical component of the global food system, without which, crop yields would be too low to provide the food necessary to feed the world's population. Unlike nitrogen fertiliser, which is synonymous with conventional agriculture, both conventional and organic agriculture use phosphate. Conventional agriculture uses both manufactured phosphate fertiliser and unprocessed rock phosphate, while organic farmers may only use the latter (Cordell, Drangert & White 2009; Lott, Kolasa, Batten, & Campbell 2011). In order to understand the importance of phosphate for our food supply, we need to look at it in more detail from a material flow perspective.

Phosphate is a mined finite resource, with 148 million tons of ore mined each year globally, producing 14.9 million tons of phosphate fertiliser (Cordell et al. 2009). This fertiliser, in conjunction with the low levels of phosphate in the soil, supplies the nutrients for our crop and animal production. However, the global food volume only contains 3 million tons of phosphate, all of which passes through our bodies as human excreta. A small volume of 0.3 million tons is recycled back to the land as fertiliser, while 1.2 million tons end in land fills as sewage sludge. The balance of 1.5 million tons ends up in our oceans, rivers, and lakes via sewerage systems, from where it is irrecoverable with present technology. Increased levels of phosphate in water bodies also causes eutrophication, which has serious environmental consequences for the ecology of these aquatic systems (Cordell et al. 2009). The ore volume figures in Cordell et al. (2009), as well as the food and sewage volume, are calculated; however, the other figures in their material flow analysis are estimates, because of the complex nature of phosphate reactions in the soil and crop residues.

Turner, Frossard and Oberon (2006), give a detailed account of the reactions of phosphate in tropical soils, which have the ability to fix a large percentage of applied phosphate onto the soil clay fraction, something not accounted for in Cordell et al.'s (2009) model. In order to balance their model, Cordell et al. (2009) estimate that eight million tons of phosphate is lost to the system through soil erosion, however this may not necessarily be the case. Irrespective of these discrepancies, the resource efficiency of phosphate fertilisation is very low, with only 20 percent of the mined phosphate ending up in the food supply, with the rest 'lost' in human excreta via sewage systems. From a sustainability perspective, this poor resource efficiency is critical, given the prediction of 'peak phosphate' within the next 30 years (Lott et al. 2011).

While Cordell et al. (2009) make a strong case for the possibility of sewage recycling in urine diversion toilets to recover the 'lost' phosphate; Turner et al. (2006), show that a substantial saving in phosphate usage at farm level is achievable through the implementation of agroecological practices, which I will cover in Section 2.5.2. These savings could make the call by Griggs et al. (2013) to halve the discharge of phosphate into the oceans by 2030 a possibility, a move which will not only reduce the amount of phosphate required to produce our food, but also alleviate the environmental consequences associated with eutrophication.

Improving phosphate material flows are one concern of the polycrisis. However, agriculture is associated with all the issues emanating from the polycrisis described by Swilling and Annecke (2012), and in the next section, I will sum up the implications of the polycrisis for agriculture.

2.2 The polycrisis, its implication for agriculture

Agriculture and rural areas are victims of, and at the same time, major contributors to, the environmental symptoms that characterise the polycrisis. The poverty and inequality that are features of the crisis, impact heavily on rural areas, particularly in developing countries (IAASTD 2008), while rural areas in developed countries, face increasing marginalization in terms of access to resources (Sumner 2005). Despite these constraints, agriculture provides a livelihood to many of the world's poor, as well as supplying an abundance of food to urban areas (IAASTD 2008). Confronted with an increasing global population, agriculture has answered with expanded food production, based on the consumption of non-renewable resources such as oil and phosphate fertiliser. However, this approach, while producing the food necessary to feed the world, has resulted in serious ecosystem degradation. In conjunction with climate change, this ecosystem degradation is threatening the viability of agriculture in both developed and undeveloped countries (Hope 2009; Holt-Giménez et al. 2012).

My readings on agroecology (Altieri 1995; Francis et al. 2003; Magdoff 2007; Chappell & LaValle 2009; Lal 2009a; Wezel et al. 2009; Altieri et al. 2011; Malézieux 2011; Holt-Giménez et al. 2012) indicate that its implementation could be a solution to the myriad of social, environmental, and economic problems facing world agriculture. The IAASTD (2008) came to the same conclusion, recommending that the implementation of agroecology, producing food locally, will restore the viability of, and reduce, poverty and hunger in rural areas.

I have highlighted conditions in rural communal areas of South Africa, described by Shisanya and Hendriks (2011), and Drimie and Ruysenaar (2010) in section 1.3.2.1. Could the implementation of agroecology, producing local food, reduce the hunger and poverty that they describe, as suggested by IAASTD (2008)? In order to answer this question, we need to look at these rural areas in more detail, before continuing with a discussion on agroecology.

2.3 Food security in South African rural communal areas

2.3.1 Introduction to food security

The concept of food security first appeared in the 1960s, and focused on the need for food availability, as a prerequisite for people to be food secure. However, by the 1980s even with an abundant food supply, hunger and food insecurity, particularly in developing countries, remained a serious problem (Anderson & Cook 1999). Kataki (2002) highlights the absence of a link between the availability of food, and food insecurity. The shift in India to rice/wheat cropping systems, because of the Green Revolution, produced an abundance of these carbohydrate rich foods. However, the increases in these crops were at the expense of pulses and legumes, which are critical elements in the traditional, mainly vegetarian, Indian diets. While the increased carbohydrate foods contributed significantly to the energy intake of the Indian population, the decrease in legume and pulse consumption reduced protein and micro-nutrient intakes, as well as dietary diversity, contributing to widespread levels of ‘hidden hunger’.

The concept of ‘food entitlement’ flowing from the work of Amartya Sen (Nobel Economics Laureate in 1998) shifted the emphasis of food security to that of access to food. This addition to the concept of food security arose because Sen found that even with adequate food available on a national level people were still food insecure because they were unable to afford the purchase of this food (Anderson & Cook 1999). In the South Africa context, Drimie & Ruysenaar (2010), quoting the NFCS of 2005, showed that despite growth in the economy, more than 50 percent of households had experienced hunger, 30 percent were at risk of hunger, and only 20 percent appeared to be food secure, confirming the link between food security and the means to access food.

The focus has since moved further, with attention on subjective aspects of food security, such as the food choices, diet quality, food utilization, as well as people’s anxieties about the accessibility of available food (Anderson & Cook 1999). Faber, Witten and Drimie (2010), quoting the NFCS- Fortification Baseline study of 2005, highlight the critical importance of food choices as an element of food security. This study showed that while only 4.6 percent of South African women had a Body Mass Index (BMI) of less than 18.5 kg/m^2, indicating chronic energy deficiency, 51 percent of women were overweight and obese, mainly because of the increased consumption of processed foods, which are more energy dense, as well as of fats, sugars and salt. Clearly, neither the underweight nor overweight and obese women are food secure, despite the availability and affordability of these processed foods.

Vink (2012) introduces another element pertaining to food security, namely that of the stability of supply of food. While adequate, affordable food, of the right quality, may be presently available, uncertainty of the future supply of this food has a direct influence on a household's food security. For example, a household may be presently food secure because of the income provided by a resident old age pensioner. However, the stability of future food supply to this household is heavily dependant on the social grant income of the pensioner, which would end on the death of this individual.

The evolution of the concept of food security from the 1970s reflects in the various definitions that have evolved to accommodate the changing emphasis of food security. Vink (2012) details all these changes, culminating in the 2001 definition by the FAO that

> Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

However, Barrett (2010) argues that the attainment of food security is dependant on the simultaneous availability of, access to, and efficient utilization of food, as each of these on their own will not guarantee it. Vink (2012) adds the stability of the food supply to these, all of which must be simultaneously present, in order to have food security. He concludes that this is a very unlikely scenario, given that the FAO definition includes the concept of food preferences as well.

2.3.2 Measurement of food security

The multiple variables that must be present in order to attain food security make its measurement both difficult and complex (Pinstrup-Andersen 2009; Barrett 2010; Vink 2012). In section 1.4.2, I presented my research questions, one of which pertains to determining if the cropping system we implemented contributed positively to the study households' diets and food security. This implies that we employ some form of measurement to determine firstly if the cropping system contributed at all to the household's food security, and secondly, if it contributed positively. Despite the reservations of Pinstrup-Andersen (2009), Barrett (2010) and Vink (2012) regarding the difficulties of measuring food security, in the context of our research, the measurement is an important element. In section 3.7, I will present the methodology we used to measure the study households' food security, as well as changes in their diets and food security resulting from the availability of homegrown food.

2.3.3 The extent of rural communal food insecurity

Altman, Hart, and Jacobs (2009), in their analysis of the household food security status in South Africa (SA), agree with the rural food security statistics I highlighted in section 1.3.2.1. However, the lack of a baseline estimate, or a consistent monitoring mechanism, hampers attempts to measure progress towards food security. In addition, conflicting interpretations of the level of food security between the General Household Survey (GHS) of 2007, and the NFCS of 2005, make it difficult to determine a true picture. However, the surveys show that levels of under-nutrition of essential micro elements is severe, resulting in stunting and poor development of children, especially in rural areas, where only ten percent of households can afford diets that would provide adequate levels of these micro nutrients (Altman, Hart, & Jacobs 2009; Faber et al. 2010).

The spread of supermarkets into rural towns has improved the availability of food for rural consumers. Highlighting this trend Baiphethi and Jacobs (2009), quoting the 2005/2006 Income and Expenditure Survey of Statistics S.A., reveal that 92 percent of the grain products, 94 percent of the meat and dairy, and 72 percent of vegetables purchased by rural consumers are from supermarkets or formal sector outlets. These purchases, seen in the light of rural households being “net deficit food producers” (Drimie & Ruysenaar 2010:317), and the fact that only ten percent can afford adequate micro nutrient rich diets reveal the extent of food insecurity in rural areas (Altman et al. 2009). The cause of this inability to afford adequate food is the lack of employment opportunities and poverty, coupled with the collapse of agricultural production in rural areas. I will discuss the reasons for this collapse in section 2.5.

2.3.4 Possibilities to improve rural food security

Strategies to improve rural household food security target the reduction of the poverty and unemployment prevalent in these areas, with the stimulation of agricultural activities critical to achieve both these aims. Emphasis must be on the agricultural empowerment of these communities, particularly the women, who make up more than 60 percent of those involved in farming (Abalu 1999; Aliber & Hart 2009; Baiphethi & Jacobs 2009; Altman, Hart, & Jacobs 2009).

Determining the number of people presently engaged in some form of subsistence agriculture is difficult because of the inconsistency of estimates between various studies. These range from 2.1 million in a 1998 study by Escom; 1.25 million or 4.6 percent of the population, in a 2008 National Income Dynamics Study; and 4 million, in the Statistics South Africa S.A. Labour Force Surveys (LFS) spanning 2001-2007 (Aliber and Hart 2009). In answer to the question in the LFS pertaining to the reasons for engaging in agriculture, the majority, more than three million, used it as a method to access additional food sources, rather than as a source of income. While this figure is substantial, 64 percent of rural households did not engage in any agricultural activity in 2005 and 2006 (Aliber & Hart 2009). This confirms the notion of minimal agricultural endeavour in these areas alluded to by Drimie and Ruysenaar (2010). In order to compensate for this lack of farming and food production, rural communities are increasingly dependant on social grant payments as a means of boosting food security (Altman, Hart, & Jacobs 2009).

The subsistence agricultural sector, because of its size, and potential to improve rural household food security, warrants further attention and support, a call made by Altman, Hart and Jacobs (2009), Aliber and Hart (2009), and Baiphethi and Jacobs (2009). However, none of these authors, in making the plea for support, recognizes security of tenure as a pertinent issue in the subsistence sector. In contrast, because of the communal tenure of these areas, Abalu (1999) cites the need for individual security of tenure as a prerequisite for agriculture to fulfil its role as an improver of rural food security. While he has the formal issues of tenure, such as title in mind, informal questions of tenure, for example, damage to crops by livestock, is equally important. Both Shisanya and Hendriks (2011) and Baiphethi and Jacobs (2009) refer to the lack of adequate fencing as a deterrent to vegetable production. Clearly, communal tenure restricts the ability of the resource-poor rural population to find financial solutions to the improvement of their food security, with the onus plainly falling on the state.

In 2002, in an attempt to find answers to the multi dimensional problems of food security facing South Africa's population, cabinet initiated the Integrated Food Security Strategy (IFFS). However, Drimie and Ruysenaar (2010), in their institutional analysis of the strategy, point out major flaws in its structure and functioning. Conceived as a coordinated approach involving various state departments, operating under the umbrella of the National Department of Agriculture (DOA), it has to date been unable to make progress in addressing issues of food security. Lack of administrative and institutional capacity in the DOA, as well as adequate budgetary mechanisms render the strategy unworkable. In addition, the emphasis by the DOA on the commercialization of agriculture, necessitating the provision of expensive conventional external inputs and technologies, even for community garden projects, does not resolve the food insecurity issues (Aliber & Hart 2009; Altman, Hart, & Jacobs 2009; Baiphethi & Jacobs 2009; Shisanya & Hendriks 2011).

The complexity of achieving rural food security is emphasised when returning now to the 2011 study by Shisanya and Hendriks, which I presented in section 1.3.2.1, and the requirements listed by Barrett (2010) and Vink (2012) pertaining to the attainment of food security. These rural KwaZulu-Natal households, were members of a community garden scheme, and as such, had access to means of growing their own vegetables, which should have guaranteed the availability and stable supply of a nutrient dense foodstuff, for subsequent utilization by the households. Yet, "89% of these households were anxious about food supplies, consumed insufficient food, and were severely food insecure. In addition, 72% consumed poor quality food" (Shisanya & Hendriks 2011:509).

Clearly, the present methods are unable to find an agricultural solution to the food insecurity dilemma in rural communal areas. Rather than a 'more of the same' tactic, to address the historic socio-economic and agronomic conditions prevalent in SA rural communities, could a grassroots agroecological approach possibly succeed, where others have failed?

In this section, I have traced the food security situation in South African communal areas and some of the efforts to rectify the present impasse. An agroecological approach has to date not been employed as a means to improve the food security of the inhabitants. In section 2.4 and 2.5, I will discuss agroecology and its potential to improve the food security in these communal areas, as well as reverse some of the elements of the polycrisis affecting agriculture in general.

2.4 Agroecology

I will begin by covering the development of agroecology from the 1930s until the present, followed by a discussion of the basic principles of agroecology. I will also cover the potential of agroecology to counter the agriculturally related issues of the polycrisis, and then discuss the similarities of pre-colonial communal agriculture practices to agroecology. This will illustrate the inappropriate application of technologies from temperate climates during the colonial and apartheid era, and its effect on the food producing potential of communal areas.

2.4.1 The development of agroecology

The development of agroecology did not show any meaningful growth, from the initial reference in the literature in the 1930s, until the 1980s. For example, in their analysis of the literature on agroecology, Wezel and Soldat (2009) found no record of any publications on the subject in the 1970s, but from the late 1980s, a rapid expansion in the literature has taken place. Their analysis, using title as well as author keywords, covered more than 700 publications in English, French, German, Spanish, Portuguese and Italian since 1928. This revealed the changing emphasis of agroecology, from the plot and field experiments phase, to the agroecosystems phase, and from 2000, the food systems phase. Surprisingly, despite the claims that the implementation of agroecology can improve the food security and social conditions of resource poor small-scale farmers, only 13 publications listed food in their titles, while nine authors listed food as an author key word. The word poverty only appeared in seven titles, and four authors recognized it as a key word. The introduction of the food systems approach may well stimulate recognition of the importance of food and poverty as an element of agroecology.

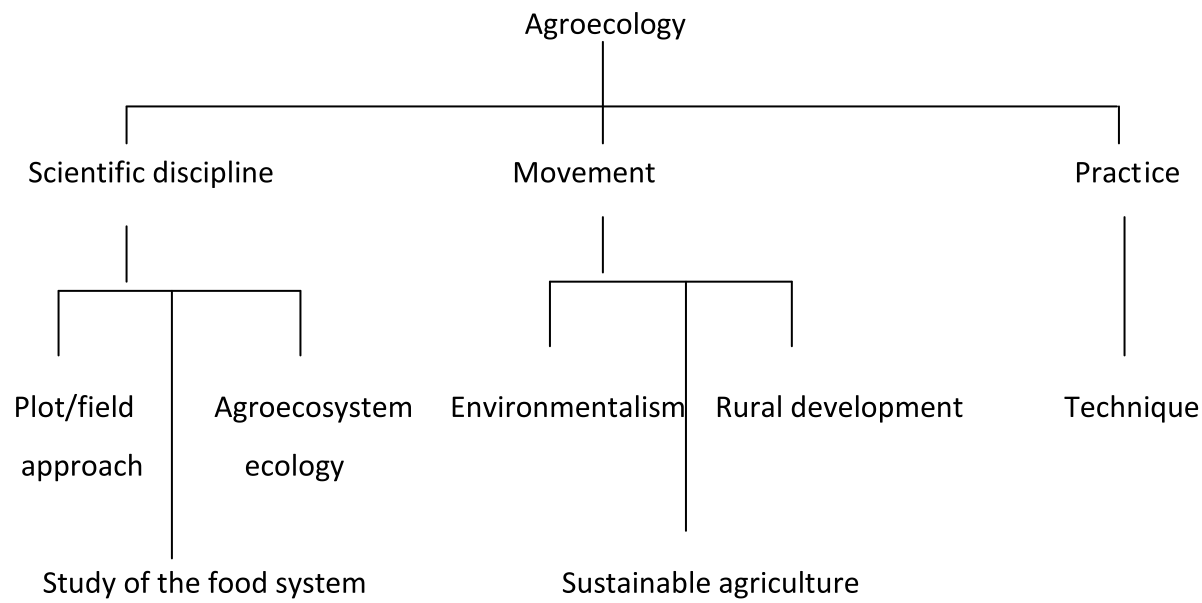
The initial focus on the plot and field scale experiments served as the foundation of agroecology as a scientific discipline. However, the emergence of the environmental movement, and its questioning of the effects of industrial agriculture on the environment, was responsible for the growth of agroecology as a movement, as well as a practice, in the late 1980s. This influence of the environmental movement, which emphasises the need to include the attributes of natural ecosystems into agriculture, reflects in the definition by Altieri (1995:5) of an agroecosystem. He considers it a "semi-domesticated ecosystem that falls on a gradient between ecosystems that have had minimal human impact and those under maximum human control, like cities" (Wezel et al. 2009; Wezel & Soldat 2009).

However, the realization in the new millennium that the influence of agriculture extends beyond the farm gate, not only the environment, but the food system as well, led to a new emphasis of agroecology. For example, more than 75 percent of the energy use in the food system occurs beyond the farm gate. On the social dimension, the growth of the organic food sector, particularly in developed countries, reflects the new interest of food consumers in the origins of their food. These new realities have led to the latest definition of agroecology being the "study of the food system" (Francis et al. 2003:100; Wezel et al. 2009; Wezel & Soldat 2009).

The diverse emphasis in agroecology as a scientific discipline, a movement or a practice, or combinations of the three, is country specific. In France, the term refers more to a practice, in contrast to Germany where it refers to a scientific discipline, while in America agroecology could mean all three. In Brazil, agroecology is predominantly a social movement, concentrating on the upliftment of marginalized, small-scale farmers. These multiple meanings of agroecology have led to confusion, in both scientific and media circles, as to what the term denotes. A further confusion exists between the agroecosystem and food systems approaches of agroecology, within the scientific discipline field, because of their divergent individual focus. In their analysis of agroecology globally Wezel et al. (2009) make a strong plea for greater clarity in the use of the term, particularly in the academic literature, as the present misuse causes confusion amongst scientists, and more so to the public. Figure 4 gives an indication of the diversity of meanings attached to the term agroecology (Francis et al. 2003; Wezel et al. 2009; Wezel & Soldat 2009).

Irrespective of these divergent meanings, Wezel and Soldat (2009) suggest that in future research, the transdisciplinary and systems thinking of agroecology is stressed, whether the research is at the plot, agroecosystem or food system level. In other words, before reaching any conclusions on research directed at the plot level, the potential affect of the proposed agroecological intervention or technique, on both the agroecosystem, as well as the food system level, need consideration. Only by doing this, will agroecology as a scientific discipline, remain relevant as an alternative to the single, basic research disciplines of industrial agriculture. In addition, this research, generated by the scientific discipline of agroecology, is essential if agroecology as a 'movement' is to maintain momentum as an alternative to the conventional agriculture paradigm.

Figure 4: Diversity of meanings of agroecology



Source: Adapted from Wezel et al. 2009

2.4.2 Basic principles of agroecology

The ecological roots of agroecology determine its basic operating principles, with the primary objective being for agro-ecosystems to mimic natural ecosystems as closely as possible (Clements & Shrestha 2004; Altieri & Nicholls 2005; Magdoff 2007; Amekawa 2011; Malézieux 2011).

A natural ecosystem, which IAASTD (2009:26) defines as a "dynamic complex of plant, animal and micro organism communities and their nonliving environment, interacting as a functional unit", has a number of distinctive features. These features, if incorporated into an agroecosystem, enhance its function and sustainability. The first of these are the efficient energy flows, such as the utilization of the sun's energy to facilitate photosynthesis in green plants, which with water, produce the plant sugars necessary for production. These energy flows, in combination with the high biodiversity, both above and below ground, provide the necessary nutrients for a healthy and disease free ecosystem. The belowground biodiversity is dependent on the photosynthesis process, with as much as 30 percent of the sugars produced by plants not used for plant growth. These sugars, secreted as root exudates into the rhizosphere[4], serve as a food source for soil microorganisms (Hamel et al. 2004). The efficient energy flows and biodiversity, ensure that all natural ecosystems are self sufficient, requiring only sunlight and water to function. A further feature is the self-regulating ability of these ecosystems, ensuring balance and stability between all the components of the system. Finally, all ecosystems are subject to disruptions, both minor and major. However, natural ecosystems are able to recover from these

[4] The rhizosphere is the interface between the plant root and adjacent soil

disturbances because of their latent resilience (Seguy, Bouzinac & Husson 2006; Magdoff 2007; Malézieux 2011).

I will now discuss the potential of agroecology to provide solutions to the polycrisis by highlighting some of its techniques and approaches.

2.5 Agroecology, an answer to the polycrisis?

The polycrisis, highlighted by Swilling and Annecke (2012), is a multi-faceted phenomenon, solutions to which require an approach that recognizes both its complexity, and the interrelated systems nature of its components. The role of agriculture as a major contributor to the crisis requires that a solution to the agricultural components is essential before a sustainable solution is possible. However, Clements and Shrestha (2004:2) caution that we must be "humble" in our desire to find solutions, and while agroecology is not a "recipe", it is able to contribute to the resolution to these agricultural problems.

2.5.1 Soils and soil organic matter

The degradation of agricultural soils, particularly the loss of SOM caused by modern conventional agricultural practices, is a major contributor to global ecosystem degradation, described in section 2.1.1. Lal (2003) highlights the importance of soils and SOM by quoting a 1938 paper by the eminent American soil scientist William Albrecht. In the paper titled *The loss of soil organic matter and its restoration*, Albrecht states,

> soil organic matter is one of our most important natural resources; its unwise exploitation has been devastating; and it must be given its proper rank in any conservation policy as one of the major factors affecting the level of crop production in the future.

In the paper, Albrecht (1938) makes a strong case for the extensive use of grass/legume pastures in the rotation cycle, which will halt soil erosion, restore SOM, fix nitrogen in the soil profile, and provide feed for animals that diversify the farm income.

However, numerous authors emphasise the potential of agroecology, its implementation, and techniques, to reverse soil degradation, and build healthy and vibrant agricultural soils (Altieri 1995; Schriefer 2000; Zimmer 2000; Fageria & Baligar 2001; Clements & Shrestha 2004; Hamel et al 2004; Altieri & Nicholls 2005; Seguy et al 2006; Lal 2007; Magdoff 2007; Lal 2009; Amekawa 2011; Malézieux 2011). A common theme amongst all these authors is for the agroecological management of soils to concentrate on two areas, the first being the enhancement of aboveground crop biodiversity, and encouraging belowground microbial biodiversity, where to date 170 000 species have been identified (Hamel et al. 2004). Crop rotations, the planting of intercropped polycultures, or agroforestry systems are the preferred methods of enhancing aboveground biodiversity. Crop rotations and polycultures serve to break life cycles of destructive pests and weeds.

The second requirement for agroecologically-managed soils is to keep a vegetative cover on the soil surface at all times, primarily to build SOM. To accomplish this, a growing crop, or crop residue mulch, or a deep- rooted, legume dominated, mixed species, green manure cover crop must be on the field. A pre-requisite to achieving this aim is the elimination of soil inverting tillage, which leaves an exposed soil surface. The elimination of tillage, in conjunction with a covered soil surface, ensures the building of SOM by the undisturbed soil microorganisms, using the carbon rich soil cover as a food source. In addition, the supplementation of this in-situ organic matter with organic amendments such as animal manure or compost enhances the building of SOM, which in turn provides nutrients for the soil food web, promoting belowground biodiversity. The building of SOM ultimately leads to the sequestering of carbon dioxide into the soil. A high SOM content soil, in conjunction with the in-situ soil cover reduces rainwater run off, thereby protecting against soil erosion, aiding water harvesting, and moisture retention. In addition, the allelopathic effect of both the mulch and cover crop aids in weed control (Seguy et al. 2006).

2.5.2 Nitrogen and phosphate

The implementation of agroecology is able to address the dilemma of nitrogen and phosphate fertiliser use in conventional agriculture that I raised in sections 2.1.4 and 2.1.9.

The nitrogen cycle, operating within a natural ecosystem, consists of five processes, namely fixation, mineralisation, uptake, nitrification, and denitrification. All of these processes are dependent on specific microorganisms, mainly bacteria that are able to sustain the cycle, by utilizing atmospheric nitrogen as well as SOM, to produce proteins, needed by all organisms to survive (Harrison 2003). The nitrogen cycle also operates in an agroecosystem, both conventional and agroecological. However, management practices, which I will describe in the next four paragraphs, differ between these two approaches, and as a result have dissimilar influences on the five nitrogen cycle processes. The implementation of agroecology is able to positively address each of the first four processes, as well as limit the negative environmental consequences of the denitrification process (O'Hara 1998; Schriefer 2000; Harrison 2003; Crews & Peoples 2004; Boddey, Alves, Reis & Urquiaga 2006; Spiertz 2009).

The emphasis in agroecology of enhancing aboveground biodiversity includes the extensive use of both food and forage legume crops, which in association with *Rhizobia* bacteria, are able to fix significant amounts of atmospheric nitrogen into the soil as ammonium nitrogen. This ammonium nitrogen binds with the SOM, which through natural mineralisation, slowly releases this ammonium nitrogen for uptake by plants (Schriefer 2000).

Aerobic conditions near the soil surface, increases soil biological activity, which drives the nitrification process. The nitrification process converts some of this ammonium nitrogen into nitrate nitrogen, which plants also absorb. The emphasis on reducing soil compaction in agroecologically-managed soils encourages aerobic conditions in these soils, thereby positively influencing the nitrification process. If legumes and mineralisation of SOM are the sources of nitrogen, as in agroecologically-managed agroecosystems, the nitrate produced in the nitrification process is almost all utilized by plants. However, if the emphasis is on applying nitrogen fertiliser, as in conventional agriculture, the natural nitrification process speeds up because of the applied nitrogen, with plants unable to absorb some of the extra nitrate produced. This surplus nitrate then leaches out of the soil profile into ground water, leading to eutrophication of water bodies and ecosystem degradation. In an agroecologically-managed agroecosystem where nitrogen fertiliser is applied, the aim is to synchronize the application of the nitrogen fertiliser with the growth stage of the plant, thereby reducing the likelihood of nitrate leaching. For example, application of nitrogen fertiliser should be on well-grown plants, rather than on newly emerged ones (Schriefer 2000).

On the other hand, anaerobic soil conditions, such as those found in compacted or waterlogged soils, drive the denitrification process. Anaerobic bacteria break down the nitrate into nitric oxide and nitrous oxide gases, both potent greenhouse gasses, which contribute to global climate change. The importance of maintaining aerobic conditions through the elimination of soil compaction, and thereby reducing soil water logging, as well as boosting SOM, reduces the possibility of agroecologically-managed soil reverting to an anaerobic state, thus diminishing the potential of greenhouse gas emissions (Schriefer 2000).

The widespread introduction of agroecological management practices, such as leguminous crop rotations and cover crops, boosting SOM, and elimination of soil compaction, could replace a significant portion of the nitrogen fertiliser used in conventional crop production, because of increased nitrogen use efficiency. This would lead to a sizeable reduction in the consumption of oil by agriculture (O'Hara 1998; Schriefer 2000; Harrison 2003; Crews & Peoples 2004; Boddey, Alves, Reis & Urquiaga 2006; Spiertz 2009).

Phosphate, as with nitrogen, is unavailable to plants in its elemental state, and it must undergo transformation by microorganisms before absorption by plants. However, unlike the freely accessible atmospheric nitrogen gas, the SOM tightly binds soil phosphate, and its release relies on symbiotic relationships between plants and specific soil microorganisms. In natural ecosystems, the maintenance of the soil phosphorus pool in the soil is dependent on the cycling of decayed plant material back into the SOM, with minimal losses from the system due to, for example, soil erosion. However, in agro-ecosystems, phosphate leaves the system as harvested food, as well as from intensified soil erosion caused by inappropriate agricultural practices. These losses, as well as the rectifying of virgin soil phosphate levels too low for crop production, need adjustment by the addition of phosphate fertiliser (Hamel et al. 2004; Cordell et al. 2009).

From an agroecological perspective, improvement in the resource efficiency of phosphate requires a focus on the specific microorganisms responsible for its conversion to 'plant available' form. The implementation of agroecological practices, are able to boost the three interrelated mechanisms, which augment the flow of phosphate to plants. The first of these is the symbiotic relationship between plant roots and mycorrhizal fungi. These fungi, whose mycelium lie adjacent to the plant roots, extend into the soil, allowing the roots to access a greater volume of soil, thereby increasing the flow of phosphate to the plant. The agroecological principle of no soil inversion tillage, nurtures these fungi as any tillage severely damages them. The other two mechanisms relate to the release of enzymes, as well as organic acids by active plant roots, which cleave phosphate from the SOM and solubilize mineral phosphate. The growing of cover crops produces active growing roots in the main crop off-season, thereby lengthening the time for phosphate absorption. In addition, the adding of organic amendments, such as animal manure or compost to the soil improves the conditions for these three mechanisms to work (Hamel et al. 2004; Cardoso & Kuyper 2006; Turner et al.2006).

2.5.3 Agronomic considerations

In keeping with the concept of self-sufficiency in natural ecosystem, an agroecological approach endeavours to reduce the amount of external inputs needed to maintain the function of an agroecosystem, be they organic or chemical. For example, the integration of animals into the farm system allows for a closing of the material cycle, as well as reducing economic risk. The closing of the cycle is possible by means of the animals utilizing the biomass from the crops, and then providing manure, which in turn provides nutrients for the crop cycle (Clements & Shrestha 2004; Altieri & Nicholls 2005; Magdoff 2007).

Agroecology, unlike organic agriculture, which completely excludes the use of agricultural chemicals, follows a more pragmatic approach. While ecological approaches are always the first choice, their inability to produce satisfactory results allows the use of conventional chemical agriculture inputs, which Magdoff (2007:112) calls "reactive management". An example of this is the widespread use of Glyphosate herbicide as a technique to circumvent soil-inverting tillage, and thereby ensure the maintenance of surface residue mulch. The ecological approach is to grow an off-season cover crop, which produces a residue mulch to smother any weeds in the following crop. However, the growth of this cover crop may not always be satisfactory due to unfavourable weather conditions, necessitating the use of Glyphosate herbicide (Lal 2003; Clements & Shrestha 2004; Seguy et al. 2006; Magdoff 2007).

The focus in agroecology, because of the diversity of agro-ecosystems, is on the implementation of principles, rather than techniques. However, many context specific techniques are available, which when adapted within agroecological principles, are able to suit other situations. In light of this, I will introduce two that are relevant to my research (Altieri & Nicholls 2005).

Schriefer (2000) describes a cropping system in the American Mid-West, based on the elimination of soil compaction layers using a 'rip-on-row' technique, which apart from its effect on the soil compaction, also stimulates the belowground biodiversity by introducing oxygen deep into the soil profile. These benefits, coupled with the precision placement under the crop row of a band of fertiliser, which includes phosphate, at a third of the recommended rate, results in yields comparable to the application of the full rate of fertiliser. An additional technique described by Schriefer (2000) is the foliar spraying of Urea nitrogen fertiliser, rather than the normal soil application. This boosts plant photosynthesis, resulting in similar yields from reduced application rates.

Borger, Hashem, and Pathan (2010), report on research in Western Australia, in which the effect of row orientation on crop yield and weed biomass is measured. The east-west orientation of rows, compared with north-south, resulted in a 25 percent increase in yield of wheat and a 51 percent reduction in weed biomass. They ascribe the positive result to the increased interception of sunlight by the crop canopy, which shades the weed growth. The changing of row direction could lead to a reduction in herbicide applied to crops. Vandermeer (1992) also covers the benefits of the partitioning of sunlight in an intercropping situation, with particular reference to planting densities.

2.5.4 Socio-economic dimensions of agroecology

Rosset and Altieri (1997) in examining the farm crisis in the U.S.A., where three million farmers went out of business between 1945 and 1990, reach the conclusion that economic hardship and bankruptcies were the cause of this, rather than any environmental issues. The reliance of conventional agriculture on mono-crop agriculture, and farm agrochemicals, controlled by external capital, which coupled with static produce prices, ensures a continuous cost-price squeeze on farmers, resulting in increased indebtedness and bankruptcies. Efforts to improve the ecological and financial viability of agriculture, by substituting biological inputs for agrochemicals, will not solve the agricultural economic crisis. The only way to solve the impasse is with a total redesign of farm systems on agroecological principles. However, they offer no indication of how a farmer with severe cash-flow constraints, is to embark on the agroecological restructuring of his farm. In addition, because conventional agriculture globally mirrors practices in the U.S.A., they deduce that the same economic adversity is to blame for conditions in rural areas of developing countries, resulting in the rural-urban migration that is a feature of the polycrisis.

Savory (1988:409) on the other hand, with his "Planned Profit" approach, as an element of the holistic management of the farm, offers a pragmatic method to reverse the dependence on external capital common in conventional agriculture. In essence, the approach involves the withdrawal of the planned profit from the gross farm income, before the allocation of this income to cover other expenses. By having a smaller residual cash flow, the purchase of external inputs is reduced The investment of this money in wealth-creation activities on the farm, rather than the purchase of superfluous external inputs, allows for a rapid reversal of stressed economic conditions on farms. While the difference between this approach, and the conventional paradigm of recording profit only when all the spending is over, may appear subtle, my personal experience of instituting the 'Planned Profit' approach on my previously heavily indebted farm vouches for its effectiveness. Working with a reduced amount of cash encouraged me to be more innovative and distinguish between expenditure that was 'essential' as opposed to 'what I needed', with positive financial benefits.

The analysis by Savory (1988), as well as Rosset and Altieri (1997), while directed at larger scale farms, is also applicable at the household level. The importance of reducing external inputs, coupled with the ability of agroecology to boost household food security through the growing of a diverse home produced diet, improves the economic stability of marginalized farm families (Altieri 1995).

The economic conditions in rural areas influence the social dynamic of these areas. In an effort to escape economic constraints, rural poverty and food insecurity, people move in anticipation of a better lifestyle, leading to the disintegration of rural communities (Rosset & Altieri 1997). Sumner (2005:304), discussing the collapse of rural communities in a developed world context, identifies the neo-liberal agenda as the cause, with its emphasis on the free market, which leads to the "exclusion of rural areas". Similarly, in a developing countries context, both Altieri and Nicholls (2005) and Amekawa (2011), identify the implementation of structural adjustment programmes as part of the neo-liberal agenda, as a cause of the marginalization and collapse of the social fabric of rural areas. While Sumner (2005) calls for a societal change of values as a solution, Altieri and Nicholls (2005) and Amekawa (2011), take a more pragmatic approach by calling for the increased implementation of agroecology, in order to improve social conditions in these areas. They base their call on the successes of agroecology, particularly in Latin America, to transform the social conditions, including food security, of rural communities.

A central tenet of the social dimension of agroecology is the recognition of the value of traditional or indigenous knowledge, which Clements and Shrestha (2004:13) refer to as "human ecology". Built up over millennia, this incremental knowledge, passed from generation to generation, enables people, who form an integral part of agro-ecosystems, to produce a diversity of food in marginal environments. Dissemination of this knowledge to new areas is by farmer-to-farmer extension, thereby ensuring that the broader community benefits (Altieri 1995). The social dimension of agroecology is most prevalent in Latin America, where in Brazil for example, it is widely recognized as a method to support small-scale farmers, as well as foster vibrant rural communities (Wezel et al. 2009).

2.5.5 Conclusion on agroecology and the polycrisis

The agroecological management of soils, nitrogen, phosphate, as well as the implementation of practical agronomic techniques that I have covered in this section, if implemented on a broad scale, could reduce or even reverse the ecosystem degradation, global warming, oil consumption, and material flow aspects of the polycrisis associated with agriculture. Alleviation of the socio-economic characteristics of the polycrisis affecting agriculture, namely poverty and inequality, increased urbanization and rural food insecurity, are possible with the implementation of agroecology. However, a radical change in prevailing mindsets is necessary, before it has a major impact on social conditions in rural areas. These changes will not come easily, because of entrenched stakes in the status quo (Clements & Shrestha 2004).

Many of the basic principles of agroecology, such as polycultures, permanent soil cover with no soil inversion, and the social dynamic, result from the study by ecologists of traditional agro-ecosystems, particularly in Latin America. Altieri and Nicholls (2005) call for further urgent study of the agro-ecosystems of traditional cultures, before outside influences irreversibly transform them, and the indigenous knowledge is lost. These people qualify as the original agroecologists. In the South African context, our colonial and apartheid past has forever changed traditional communal agricultural practices. However, the question relevant to this research is: ‘could the agricultural practices of pre-colonial indigenous people in South Africa qualify them as agroecologists’? I will deal with this question in the next section.

2.6 Pre-colonial communal agriculture and agroecology

In the last quarter of the Nineteenth Century, two seemingly unconnected events had a profound effect on the agriculture and subsequent food security of South Africa’s rural communal areas. Firstly, the introduction into the Transkei of ploughs by missionaries and traders, which by 1870 were widespread, and secondly, the discovery of diamonds in Kimberly in 1867, followed by gold on the Witwatersrand in 1886 (Volk 2003).

The ploughs, brought in from Europe, changed both the methods of tillage, as well as the social dynamic of traditional agriculture. Previously, shifting cultivation was the women’s domain, but the heavy work of controlling ploughing oxen, meant that men became more involved with cropping (Volk 2003). While no indication of the speed of uptake of this new technology in South Africa is available, records from Zimbabwe show that in 1910, one in 300 communal area households owned ploughs. By 1920, the ratio was 1:45 and by 1940, virtually all households owned one (Woolmer & Scoones 2000). The animal drawn ploughs allowed households to crop an expanded area, and because of the mineralisation of SOM resulting from the soil inversion, crop yields initially increased (Lal 2009). However, yields soon dropped, with Zimbabwean records showing a decrease from 900 kg/ha in 1902 to 500 kg/ha in 1930, as the SOM depleted (Baudron, Andersson, Corbeels & Giller 2012).Grain yields in the Transkei showed similar trends. The area produced a surplus of grain at the turn of the century, but production started declining, and by 1930, a 25 percent reduction in production necessitated that more than half the grain requirements be imported (Volk 2003).

Over time, agricultural activity has declined, with up to 100 percent abandoned fields in parts of the Ciskei, Transkei, and KwaZulu-Natal (Andrew & Fox 2004). In addition, much of this land is in a severely degraded state with soil erosion widespread (Hoffman & Todd 2000). These findings confirm the statement by Drimie and Ruysenaar (2010:317), that most rural households are "net deficit food producers as their food access is partially or wholly reliant on household income".

In contrast to the decline in yields and agricultural activity, male migrant labour recruited for the mines steadily increased. From a total of 8500 male migrant mine workers recruited from the Transkei in 1893, the number grew to over 50 000 by 1910, and by 1974, up to 83 percent of the male population aged 18 to 54 years were absent for a part of the year (Volk 2003). Remittances from migrant workers, coupled with income from the state social grant system are now the foundation of rural communal household incomes (Andrew & Fox 2004; Aliber & Hart 2009).

Had these traditional agro-ecosystems, so badly disrupted by colonial and apartheid pressures, still been intact today, what agricultural practices and social dynamic would we possibly observe?

The tillage implement that the plough replaced was the hoe. Lal (2009:69) considers all of Sub Saharan Africa to fall in the "Hoe Belt" because of the stony soil, steep gradients, and the cultivation of coarse grains, such as sorghum. The use of a hoe for tillage can have two outcomes. Firstly, the removal of any vegetation in the field, and secondly, the opening of a shallow planting hole or pit without inverting the soil. In IsiZulu, this distinction is illustrated, with hoe (verb), communicated by two separate words. *Centa* describes the removal of vegetation by cutting it off with a hoe, and *hlakula,* depicts the digging motion of hoeing (Doke, Malcolm, Sikakana & Vilakazi 1990). Planting pits also have a distinctive word in IsiZulu, namely *folo*, translated by Doke et al. (1990:211) as "riddling with holes", describing a field prepared for planting. Using this method to prepare planting holes, classifies the hoe as a primary tillage implement, a category into which the plough also falls. Similarly, this common function reflects in contemporary IsiZulu language use, where *igeja,* describes a hoe (noun) or a plough (noun) (Doke et al. 1990). The use of a hoe as a tillage implement therefore complies with the agro-ecological principle of no soil inversion and the maintenance of a mulch soil cover.

Figure 5 gives an indication of the practices that would qualify pre-colonial communal agriculturists as agroecologists. In the centre foreground, as well as in the background, are the residues of the previous crop. The vegetation that the women are hoeing in the field appears to be grass, which has re-grown after the last crop. This, together, with the previous crops residue, will constitute the soil covering mulch necessary in agroecology.

Crop production, utilizing shifting cultivation, involved the growing of a diverse range of food crops. Volk (2003) mentions that the Xhosa people in the Transkei traditionally planted sorghum, maize, pumpkin, calabash, melon, beans, sweet potatoes, and some root crops. Figure 6 depicts the traditional method of planting these crops as a poly-crop. While Volk (2003) does not mention cowpeas as a traditional crop, Aliber and Hart (2009) report that in Limpopo, it classifies as a traditional crop. The pastoral base of these traditional societies, with manure to fertilize the fields, coupled with the shifting cultivation would ensure the sustainability of production. From an agroecological perspective, this wide range of food crops including legumes, not dependant on any outside inputs, would provide a low risk and diverse diet.

Figure 5: Hoe cultivation by a group of women, early 1900s

NATIVE WOMEN WORKING

Source: Reproduced by A. Penderis, from Howard 1906

My readings on pre-colonial communal agriculture revealed a common practice of members of the community, particularly women, coming together to help each other work their respective individual fields (Poland, Hammond-Tooke & Voigt 2005; Bujo 2009). This social practice, *ilima*, (Doke et al.1990) ensured that heavy fieldwork, such as the preparation of the planting pits, was a communal and social event. Figure 5 also depicts this practice, with the women working together as a group in the field.

This evidence, illustrated through contemporary language and literature sources, points to a pre-colonial communal agriculture based on agroecological principles. Could the application of these principles in present times solve the dilemma of food security in South African communal areas, which I have highlighted in section 2.3?

Figure 6: Poly-crop sorghum and maize field protected from livestock damage by children, early 1900's

CORN AND MEALIE FIELD

(Showing Umfaans - Native Boys - and Intombis, who walk round the Fields to keep the Stock away.)

Source: Reproduced by A. Penderis from Howard 1906

2.7 Summary of the literature review

The global polycrisis (Swilling & Annecke 2012), with agriculture's role as a cause, as well as the potential of agroecology to remedy the damage, is the context in which I conducted this literature review. Conventional agricultural practices, based on the consumption of rapidly depleting non-renewable resources, such as oil and phosphate, have been very successful in producing more than enough food to feed the present world population. However, this extra food has come with unacceptably high social and environmental costs. The degradation of agricultural soils and global water bodies are visible manifestations of this cost, with the less visible, but perhaps greater cost in the form of the loss of SOM, resulting in excessive carbon emissions into the atmosphere.

The availability of abundant food has however not been able to reduce global levels of hunger, which, with rural poverty caused by neo-liberal economic policies, is a major contributing factor to the worldwide rural-urban migration patterns.

Conditions in South Africa are a microcosm of the global polycrisis. However, our colonial and apartheid history has intensified the effects of the crisis in our rural communal areas. The introduction of ploughs, which coincided with the discovery of diamonds and gold, whose exploitation depended on the migratory labour system, led to the demise of pre-colonial agricultural practices, and to the present situation, with our rural communal areas dependant on the social grant system to purchase food. This reliance on purchased food has had a negative effect on the food security of these areas.

The literature review reveals the potential of agroecology, with its ecological, social, and economic emphasis, to address the causes, as well as reverse the symptoms of the polycrisis on agroecosystems. In addition, the review using contemporary isiZulu language and 1900s photographs identifies that pre-colonial agricultural practices were agroecologically based.

I will now present the research component of my study, first starting with the Research Design and Methodology, before moving to a discussion of the research results.

Chapter 3

Research design and methodology

3.1 Introduction

This section of the thesis will detail the research design and methodology necessary to design, implement, and assess the agroecological cropping system, as well as the data collection protocol necessary to determine the household diet and its measurement. I have chosen this particular research design and methodology to answer my research questions, within the context of the research statement, and my research aims. The discussion of the agroecological cropping system in this chapter is limited to the steps that were necessary to initiate the research process, with details of the actual designing, implementing, and assessing of the cropping system covered in Chapters 4 and 5.

I will start by restating my research aims and questions from section 1.4.2, followed by a summary of the realities that my co-researchers face, within the context of the polycrisis covered in the literature review of Chapter 2. The rationale for my choice of research design, namely PAR will follow. Finally, in section 3.7 I will detail the data collection protocol necessary to determine the diets and measurement of the food security of my co-researchers households. I will use this data to answer my second research question.

3.2 Research questions

The primary aim of my research is to design, implement, and assess a cropping system, using agroecological principles and methods, in conjunction with non-randomly selected rural households in Mazabekweni. Coupled with this is the secondary aim, which is to ascertain if the culturally acceptable food crops harvested from their garden plots, improve the diets and food security of the households. A prerequisite to the achievement of both these aims is that the research respects the complex community social dynamics in Mazabekweni.

In order to achieve the aims of the research, the following research questions need answers:

1. Can the study households implement and assess a cropping system, designed on agroecological principles, on their garden plots?
2. Have the food crops they grow and harvest from their household plots, contributed positively to the diets and food security of their households?

3.3 Overview of the research environment

The global polycrisis, which I discussed in section 2.1, forms the backdrop of this research. Mazabekweni and its inhabitants are a microcosm of the situation described in Swilling and Annecke (2012) on a global scale. My observations and conversations with co-workers and staff resident there show the local ecosystem is severely degraded. Soil erosion and biodiversity loss, caused by high population density and historic tillage practices are common. South Africa's colonial and apartheid past has negatively affected the area, with the denial of access to resources, and a heavy reliance on the migratory labour system, resulting in widespread poverty. Local food production is almost non-existent, which, coupled with high levels of unemployment, results in widespread food insecurity and hunger.

My position as researcher, although only resident five kilometres from the study area, is the converse of the conditions I have described in Mazabekweni. Economic activity, coupled with high levels of biodiversity and a conserved, carbon rich soil, ensure a 'utopia' compared to Mazabekweni. As a white commercial farmer, with a long family history of privileged access to resources under the same colonial and apartheid past that denied my neighbours, I have an agroecosystem that is far from degraded.

However, the polycrisis is such that my 'utopia' and Mazabekweni are both subject to the same global warming, oil peak, and resource depletion I have described in Chapter 2. Because of this, we both face an unsustainable future, irrespective of our dissimilar history of privilege or rejection. In addition, a 'utopia' surrounded by a sea of poverty and hunger, cannot have a very long life span. Therefore, my challenge as researcher was to find a possible solution to the food insecurity of Mazabekweni, within the context of the realities of the area, as well as the restraints imposed by the global polycrisis. A solution will not only potentially end the poverty and hunger, creating a new 'utopia', but also ensure that my 'utopia' has a better chance of survival, and possibly rise to new heights.

3.4 The research design

3.4.1 The rationale for the research design

My research emanates from the 2009 pilot project in Mazabekweni, described in section 1.3.1, in which one family used a few agroecological methods on their garden plot to produce a variety of food, which they used to supplement their household diet. However, the lack of any formal data collection protocol in the project, and the fact that it was restricted to one family, raised questions about the validity of the results, even though the family acknowledged the benefits of the approach. My observation of their efforts revealed a number of shortcomings, that had they been done differently, could have yielded a more positive result. In the expanded research planned for this thesis, I therefore had two options.

The first was for me to conduct formal field experiments in Mazabekweni. The research would use small plots to evaluate various crop production methods, incorporating changes identified as limiting factors in the pilot project, such as different rotations, planting densities, intercropping, and soil amendment options. Detailed yield measurements, coupled with statistical analysis, such as described by Vandermeer (1992) would highlight the best options. Reflecting on this approach, my conclusion was that apart from perhaps identifying the superiority of one option over another, the possibility of improving the food security of the inhabitants of Mazabekweni was remote. My reasoning was that other factors, such as historic and socio-economic conditions, could be possible causes of the situation reflected in my problem statement (section 1.4.1), rather than technical issues surrounding a particular cropping option.

A further reason for rejecting this approach was the danger of repeating the mistakes described by Whyte (1991), where Mexican peasant farmers did not adapt the supposed better technologies of Green Revolution agriculture demonstrated in plots. Further analysis as to the reasons for the non-adoption of the technologies, revealed that the farmers were in fact producing much higher value through their traditional mixed cropping of beans and maize, than the mono-cropping systems devised by experts, and promoted in the demonstration plots. Whyte (1991:171) sums the situation up with the following statement

> In Mexico we have been mentally deformed by our professional education. Without realizing what was happening to us, in the classroom and in the laboratories, we were learning that scientists knew all that had so far been learned about agriculture and that the small farmers did not know anything. Finally we had to realize that there was much we could learn from the small farmers.

A different result may have been forthcoming, had the outside ‘experts’ consulted with the locals before setting up the demonstration plots.

Having ruled out this first research design, my other option was to revisit the approach I used in the 2009 pilot project, where the family was intimately involved with all aspects of the cropping system. My observation of the food producing potential of the plot, a well as changes in the agronomic abilities of the family over the short duration of the project, convinced me that this could be the best option to finding solutions to my problem statement. This approach, expanded to more households involved in all aspects of the research, and with the addition of a data collection protocol, could provide answers to my research questions.

My readings in the literature revealed that PAR, which involves the research participants in all aspects of the research, would be a suitable design for the research detail (Whyte 1991; Greenwood, Whyte & Harkavy 1993; Mouton 2001; Shortall 2003; Kock 2004; Lopes 2006; Grant, Nelson & Mitchell 2008; Greenwood & Levin 2007).

3.4.2 Participatory Action Research

"Participatory action research considers itself to be a radical alternative to mainstream research. Its objective is to transcend the distinctions between activism and research, common sense understanding, and academic expertise" (Shortall 2003:225).

Lopes (2006:216) takes this description by Shortall (2003) a step further, by stating that PAR is a response to the "conventional elitist forms" of social research, where the people involved in a research study are not considered capable of doing the research, and in fact seldom benefit from the research.

PAR grew out of Action Research, first used by Lewin in 1946 in the United States, in an attempt to improve racial relationships in the workplace. Freire, in his educational work was the first to use PAR in 1972 (Lopes 2006). The philosophical roots of PAR come from Marx and Engels, who regarded the mental forms of production, or people's knowledge, as important as the physical forms of production (Rahman 2008).

PAR has progressed since its recent inception into a Southern tradition, following the leadership of the Colombian Fals-Borda, where the emphasis is on a 'science of the people', and questions the need for an outside researcher in the research process. The Northern tradition, led by Whyte, also emphasises the role of the people in PAR, but places greater emphasis on the role of the researcher as a facilitator in the research process (Karlsen 1991; Rahman 2008).

Regardless of the Northern or Southern traditions, PAR seeks the active involvement of the study participants in all aspects of the research, including the evaluation and presentation of the results. Their active involvement normally results in better acceptance and implementation of the findings of the research (Mouton 2001; Greenwood & Levin 2007).

The goal of PAR is for the people involved in the research, selected non-randomly, to be the researchers. Their active involvement, which includes the incorporation of their local knowledge in all aspects of the research, creates conditions that can directly improve their sub-optimal living environment. Their participation empowers them with new knowledge, resulting in their emancipation from oppressive social structures and historic disenfranchisement. The creation of this new knowledge through PAR is only possible because of the inseparability of theory and practice in the research process (Shortall 2003; Lopes 2006; Grant, Nelson & Mitchell 2008).

The role of the outside researcher, regarded as a peer with the other research participants, is one of facilitator. This role is vital to the research process in that dialogue, both between the study participants themselves, and between the participants and the researcher, is a critical element of the methodology of PAR. This dialogue is critical for a number of reasons. Firstly, dialogue amongst the participants themselves, without bias from the researcher, is necessary to identify the root causes of their social problems, which need addressing in order to find possible solutions. Secondly, dialogue between the researcher and the participants, aims to reveal any local knowledge that might be pertinent to the research process, as well as jointly create new knowledge that will aid in finding possible solutions (Greenwood et al.1993; Mouton 2001; Shortall 2003; Lopes 2006).

Documenting and evaluating the research in PAR is only possible if the research participants are actively involved with the researcher in the evaluation of the results. Their participation will reflect the impact of the research, both positive and negative, on the lives and social conditions of the participants, without the subjective bias of an outside researcher as the sole evaluator (Karlsen 1991; Grant et al. 2008).

The active involvement of people in the evaluation of PAR, and with dialogue being a vital part of the research methodology, means that PAR is almost exclusively qualitative research. However, in certain circumstances combinations of qualitative and quantitative research are used (Mouton 2001; Shortall 2003).

Conditions in developing world situations, where historic conditions of disenfranchisement and exclusion are common, are eminently suitable for the implementation of PAR, and its use in agricultural situations in these countries is common. However, PAR also has a place in developed world situations, with its use in the improvement of living conditions of disenfranchised groups of people (Whyte 1991; Greenwood et al.1993; Mouton 2001; Shortall 2003; Grant et al. 2008; Rahman 2008).

While PAR seems to be the answer as a research methodology in certain situations, it is not without shortfalls and critics.

3.4.2.1 Criticisms and shortfalls of PAR

The philosophy of PAR is widely covered in the literature, but the practical applications of the approach are seldom covered (Shortall 2003). In addition, the non-random selection of normally a small number of study participants, coupled with the context specific nature of the research, makes it difficult to extrapolate the results. This is a very common feature of qualitative research. These valid criticisms, coupled with the low degree of control over the research process that the researcher has, mean that any researcher implementing PAR faces challenges (Mouton 2001).

3.4.2.2 Challenges with implementation of PAR

The challenges in implementing PAR are well summarised by Grant et al. (2008). Firstly, the researcher needs to establish a relationship characterised by a high degree of mutual trust with the community where he conducts the research, in order for honest dialogue to take place. Building this relationship is only possible if the researcher gets involved in the community outside of the research process.

Secondly, the active involvement of the research participants in all aspects of the research means that they hold a significant amount of power that will determine the outcome of the research. On the other hand, the researcher is a critical component of the research, and has a similar measure of power. Only with mutual trust and acknowledgement by each party of their respective power can the research reach a successful conclusion. Grant et al. (2008) note the importance of reflection on the part of the researcher, in order that he does not use his power to dominate the research process and thereby negate participation.

Thirdly, the researcher must encourage participation by all the study participants if the research is to have credibility. Again, the issue of trust and dialogue is paramount to foster this participation.

Fourthly, the goal of PAR is to bring about change in the lives of the study participants. However, a major challenge for the researcher is that he needs this change to take place quickly in order to complete his research, while the community may be happy with a slower speed. The only way to reconcile these differences is by honest dialogue between the parties.

Lastly, Grant et al. (2008:18) list the importance of PAR providing “credible accounts” of the experiences of the community resulting from the research. This is only possible if the study participants are involved in the evaluation of the research, without the researcher dominating this process. The researcher, in writing up the research must also accurately reflect the feelings of the study participants.

Each of these challenges highlighted by Grant et al. (2008) is pertinent to my research. In my presentation of the research design and methodology, and the research results, I will highlight how I have addressed these challenges.

3.5 Research methods

The research methodology, that I implemented to answer my research questions, needed to generate data from two sources, namely an ecological cropping system and the household diet of each of the study participants. In order to enhance the credibility of the research, the database needed expansion from the single household in the pilot study.

3.5.1 Sample selection

The 2009 pilot study that I referred to in section 1.3.1 elicited numerous requests from community members, some of whom were my farm staff, for assistance with their garden plots. At the time, I was unable to assist because of the cost involved in fencing individual plots, which I had identified as a critical success factor in the pilot study. However, with the acceptance of my research proposal in November 2010, the possibility of extending the research to more households became a reality.

I identified a valley in Mazabekweni that is easily accessible from my farm as my research area. Reflecting on the probable demands on my time of the PAR approach, given that I still have commitments on the farm, I decided that it would be helpful if I had some co-researchers who I was in daily contact with. I therefore approached three of my female staff members, who originally asked for assistance, to see if they were still keen on getting help with their plots, as part of an expanded research effort. The strategic placement of these three female's homesteads within the study area was an additional criterion for asking them. I explained how I envisaged the research and what their roles as group leaders would be, which included helping me with the data collection, and asked them to consult with their families before giving me an answer. After several days, each of them agreed to be part of the research. I used this non-random sample selection technique with the choosing of the other co-researchers.

My brief to these three women was that they each select two other households, who had access to a plot, irrespective of whether it was fallow or not, and who were willing to take part in the research. In addition, they needed to agree to work together as a group, helping each other on their individual plots.

I limited the study to nine households for a number of reasons, firstly, to keep the expected cost of the infrastructure provision for the research within my available budget, and secondly not to overburden the three group leaders with undue demands on their personal time in trying to co-ordinate a bigger group.

My reasons for insisting on a group structure were threefold. Firstly, as I had daily contact with the three women as farm staff members, it would make it easier for me to contact the other study participants during the course of the research with any queries about data collection. Secondly, in section 2.6, I discussed of the practice of *ilima* in pre-colonial communal agriculture, where members of the community, particularly women, helped each other work their respective individual fields (Poland et al. 2005; Bujo 2009). I will discuss my third reason in section 3.5.1.2, which deals with the ethical implications pertaining to the research.

The use of this method of sample selection ensured the application of the principle of people involvement in PAR from the start of the research, as well as ruling out the possibility of selection bias on my part. The heads of two of the selected households are from my farm staff, while the remainder were either close neighbours, or relatives of the three group leaders.

The ethics guidelines of Stellenbosch University stipulate the need to address the confidentiality of any research study participant. Because of this, no names of the co-researchers will appear in this thesis and I will refer to them by their group letter and number only.

3.5.1.1 Household sample profile

Table 2 gives an indication of the household demographics of the study participants at the start of the research. Aspects not reflected in the table are the temporary changes in the household size from time to time, for example, children from other areas staying with the households during school holidays.

Each of the study households has access to family labour to do the fieldwork on their respective plots, with a common feature being the predominance of female family members. In discussions with the heads of each household, I ascertained that most the households had some member who had an elementary knowledge of cropping, obtained from past efforts at cultivating their plots.

A further feature of the study sample is that most of the household members either have employment as farm workers, or have access to the state social grant system, as pensioners, or child grant recipients.

Figure 7: New water supply tanks and spring protection for the community

Source: D Strachan; (own photograph)

Table 2: Household demographics

Household	Status	Employment status	Number of biological children (age)	Number of other dependent children (age)	Other adult household members
A 4[5]	Single mother	Farm worker	4 (20;18;9;2)	1 (5)	2 mother (pensioner) sister (unemployed)
A 5	Single mother	Unemployed	3 (16;11;2)	none	1 mother (pensioner)
A 6	Single mother	Farm worker	none	none	1 brother (employed)
B 3	Single mother	Farm worker	1 (8)	2 (14; 9)	0
B 8	Married mother	Farm worker	5 (29;27;20;17;15)	2 (13;7)	0
B 7	Male pensioner	Retired	none	none	1 wife (pensioner)
C 1	Single mother	Farm Worker	1 (11)	none	2 mother (pensioner) cousin (unemployed)
C 2	Female pensioner	Retired	1 (18)	none	0
C 9	Single mother	Disabled	4 (28;26;19; 16)	4 (18;8;6;2)	0

3.5.1.2 Ethical considerations

My discussions with the study participants before the research commenced revealed some important ethical issues that needed attention. The pilot study only involved one family, and the feeling amongst the co-researchers was that the community had accepted it as an experiment. However, we were now going to extend the research to nine households, which could possibly change the community dynamic, with victimisation of the co-researchers a distinct possibility. Questions would arise as to why more households were not included in the research. In addition, getting permission from the farm owner on whose farm the co-researchers were resident, to erect the fencing was important.

[5] The numbers of the plots correspond to their physical location starting at the southern edge of the study area.

In my research proposal, I mentioned the likelihood of possible victimisation as an ethical issue in the research. My proposed solution to this dilemma was twofold. Firstly, the allocation of the participants into groups would not only help with the fieldwork, but would also be a means of moral support amongst the households in the event of victimisation. My second proposal involved the community water supply (see Figure 7). Although a municipal water infrastructure is in place, it rarely operates, necessitating long waits for the community women to draw water from an unprotected spring. I recognized that this situation was not only a potential health hazard, but a constraint on co-researchers fieldwork time as well. My suggestion to the co-researchers was that the protection of the spring and the installation of a pipe to fill water tanks would not only benefit the whole community, but negate their possible victimisation as well. They agreed, but insisted that I speak to the farm owner on whose farm they lived to get permission, before proceeding with the fencing, as well as the water supply upgrade.

I subsequently spoke to the farm owner who was more then happy to sanction the fencing and the water system, and agreed to organize his tenants to dig the pipeline trench and help with the laying of the pipe. Following the installation of the pipe, the water flow of 70litres/minute drastically cut down on the waiting time at the spring, a situation enormously appreciated by the community women.

The selection of the co-researchers, as well as attending to the ethical issues I have described was the starting point for the research. The following section will describe the initiation of the agroecological cropping system; and Chapter 4 will cover the details of the workings of the system, its challenges, refinements, and potential.

3.6 Agroecological cropping system

In this section, I will describe the resource base of the households in the study, starting with their plots, followed by their human capability. Subsequently I will cover the infrastructure provision, including its cost, necessary for the research to proceed. Finally, I will detail the start of the cropping system and the assessment methodology, before ending with a short description of the challenges I faced with the implementation of the cropping system using PAR, and how I overcame them.

3.6.1 Land resource

Each of the households in the study had access to a plot of land, either adjacent to the homestead or a short distance away. These plots, originally allocated to the households when they acquired residential rights in the community, remain as a usufruct with the household, even if they are not cultivated.

Table 3 gives details of the size, as well as the cultivation status of each household plot at the beginning of the study. Apart from small areas cultivated in two of the plots, the rest were fallow, typical of plots in the community, and had been this way for a number of years. I will cover the possible reasons for this in Chapter 5.

Table 3: Size and cultivation status of the household plots

Household	Size Ha	Cultivation Status	Fence length[6] (m)	Corner structures
A 4	0.2364	Small area cultivated	355 (A4/A5 adjacent)	8
A 5	0.2457	Fallow		
A 6	0.0939	Fallow	155	5
B 3	0.0910	Fallow	180	6
B 7	0.3360	Small area cultivated	287	9
B 8	0.3320	Fallow	293 (B8/C9 adjacent)	7
C 1	0.2223	Fallow	231	6
C 2	0.1069	Fallow		
C 9	0.1323	Fallow		

Although the plots were fallow, annual weeds, as well as a heavy infestation of 'kweek' grass (*Cynodon Dactylon),* was evident on all of them. The 'kweek' vegetative cover is normally present in compacted, long abandoned arable fields (Tainton, Bransbury & Booysen 1985). I used a soil auger to determine the soil depth in each plot, and apart from B3, all the others had adequate soil depth of 600-1000 mm of a high clay content soil, suitable for crop production. However, B3 only had a soil depth of 400mm with a solid shale stone base under this, conditions considered marginal for crop production. In addition to the soil depth determination, I dug profile pits in the plots to check for compaction layers. All the plots revealed a severe compaction layer at approximately 200mm depth, indicative of previous tillage with ox drawn, or tractor mouldboard ploughs (Schriefer 2000; Hamza & Anderson 2005; Lal 2009). The presence of the *Cynodon Dactylon* vegetative cover is an indication of this compacted layer.

At the same time as performing the physical soil check, I took core samples for soil chemical analysis, which I sent to Omnia Fertilisers for analysis. Table 4 reflects the result of this analysis, which is typical of the soils in the area, characterised by a very low phosphate status, as well as low pH, indicating very acid conditions. Low phosphate and pH levels influence crop production negatively, and require correction (Fageria & Baligar 2001). The calcium and magnesium levels in the samples showed adequate levels, which did not need any remedial action.

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[6] Plots A4 and A5 are adjacent, as are B8 and C9. I have therefore listed the fence length that enclosed their combined areas under A4 and B8 respectively.

Table 4: Household plots soil chemical analysis

Household	pH (KCl)		Phosphate mg/kg		Potassium mg/kg		Calcium mg/kg		Magnesium mg/kg	
A 4	4.4	(VL)	8	(VL)	67	(VL)	1640	(VH)	455	(VH)
A 5	4.4	(VL)	6	(VL)	128	(M)	821	(VH)	328	(VH)
A 6	4.9	(M)	5	(VL)	196	(VH)	1270	(VH)	396	(VH)
B 3	4.0	(VL)	9	(VL)	230	(VH)	674	(VH)	255	(VH)
B 7	4.3	(VL)	6	(VL)	360	(VH)	1300	(VH)	462	(VH)
B 8	4.4	(VL)	5	(VL)	235	(VH)	1530	(VH)	446	(VH)
C 1	4.7	(M)	21	(M)	468	(VH)	1350	(VH)	354	(VH)
C 2	4.8	(M)	6	(VL)	368	(VH)	1730	(VH)	474	(VH)
C 9	4.4	(VL)	6	(VL)	185	(VH)	1260	(VH)	446	(VH)

Source: Omnia Fertilisers (VL – Very Low; M - Medium; VH - Very High)

I will now discuss the steps that I undertook to initiate the cropping system on the household plots, including the provision of the basic research infrastructure.

3.6.2 Research infrastructure

The start of the cropping system on the plots was only possible after basic infrastructure was in place. In my preliminary discussions with the study participants, we agreed on steps, including fencing and tools, and who would undertake them. While some of the plots were fenced with a rudimentary fence, these were not stock-proof and served more as a plot boundary demarcation. I undertook to mark out the fence-lines in conjunction with each household who would indicate the plot boundaries, as well as provide all the fencing material. Each household undertook to dig the post-holes, after which I would provide a fence builder who would erect the fence to the specifications on which we had agreed. In addition, they undertook to provide help to the fence builder while he was busy on their respective plots. Before the onset of each winter during the study period, they also undertook to clear the fence-line of combustible material, to prevent fire damage to the fence in the event of a veld fire. To mark each fence line, I walked the perimeter with a hand held GPS, in order to measure the plot boundary length, as well as its area.

Discussions with the study participants about the specifications for the fencing revealed the importance of erecting a goat-proof fence, rather than one that would only stop cattle getting into the plots. My experience from the pilot study showed that this was a valid request, as the goats in the community are not conducive to the cultivation of crops. The tethering of grazing goats in the summer months is a prerequisite for goat owners, but from May, they are no longer tethered and free range, eating anything they come across. Unfenced sweet potatoes under the ground are also not safe, as the goats dig up the tubers with their hooves, and eat them. However, even during summer they inflict serious damage to crops if they break their tether, or while returning to their respective household kraals each night. This fencing requirement ruled out the provision of a simple barbed wire fence, and we erected a 'Veldspan'[7] fence instead. For the fence, we used 1,2m high Veldspan goat-proof wire fence, supported every 10m by a treated post set in the ground, as well as a wooden fence dropper[8] every 2.5m. This construction ensured a tight fence that can withstand pressure form livestock pushing against it. At each change of direction of the fence, corner structures, comprising three treated posts set in the ground, joined by two bracing yokes with diagonal tensioning wires, provided anchor points. At the entrance to the plot, we constructed a narrow pedestrian gate for two reasons: firstly to make it easier to exclude passing livestock, and secondly to prevent possible entry of a tractor to plough, thus encouraging the households to use the fork and pit method. Figure 8 shows the type of fence we constructed around each plot, as well as a typical corner structure.

The soil chemical status tests conducted by Omnia Fertilisers showed a need to correct the soil phosphate status with an application of 57kg phosphate/ha. However, in light of the severe global resource restraint of phosphate, which I have covered in section 2.1.9, I decided to use a modified approach to phosphate fertilization of low status soils that I have successfully used on my own farm-cropping programme. I will detail this approach in Chapter 4.

The pilot project crops suffered from a severe molybdenum deficiency, due to a low soil pH (Zimmer 2000). In order to correct the soil pH, we spread calsitic agricultural lime at the rate of 2 tons/ha to the plots, which equates to a 50kg bag/250 square metres. Each group accomplished this task by hand, spreading the contents of a bag onto the soil surface over a 250 square metres area.

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[7] A 'Veldspan' fence comprises nine horizontal wires, spaced close together at the bottom and further apart at the top, and vertical wires evenly spaced approximately 200mm apart along the length of the fence, with the wires twisted together at each crossing of horizontal and vertical strands. This construction prevents goats from forcing their way through the horizontal wires, as they do with a barbed wire fence

[8] A dropper is a wooden pole 1,2m long and 50 mm thick, tied to the fence vertically at 2,5m intervals. This prevents cattle from destroying the fence by pushing down on it with their necks between the posts that are set in the ground 10m apart.

Figure 8: Fence construction, showing 'Veldspan' fence, and corner structure

Source: D Strachan; (own photograph)

Cynodon Dactylon grass infestation of arable lands is a severe constraint on crop production. The underground rhizomes make control by mechanical means, including hand hoeing, both expensive and unsuccessful because of its ability to re-establish from any broken rhizomes (Tainton et al. 1985). For this reason, I decided to use Glyphosate herbicide at the recommended rate of six litres per hectare as a control measure on all the plots. This spray, using a knapsack sprayer, killed the *Cynodon Dactylon,* allowing for a clean start to the cropping.

The provision of the necessary tools and equipment was the final infrastructure requirement to start the cropping programme. Each household received a 'Lasher' four-pronged garden fork, a pointed short-handle hoe, a wide weeding hoe, and a strong plastic teaspoon. In addition, each group receive a ten metre braided rope, which was marked at 700mm intervals by wrapping coloured electrical insulation tape around it. I also purchased a 16 litre capacity knapsack sprayer, which we used to spray the Glyphosate herbicide.

Apart from one household (C2), the entire fencing infrastructure was in place by January 2011. Household C2 had not dug the post-holes as we had agreed, so installation of their fence was not possible. I re-marked the fence-line, and for a second time they did not dig the holes or ask for assistance to do so. I therefore decided, in consultation with the other members of group C, to exclude C2 from the data generating aspect of the research, although they still received the inputs of seed and fertiliser to plant on an unfenced plot. As the household was still the recipient of the seed and fertiliser inputs, I elected not to replace them with a fresh household, but rather to observe and monitor them as a control household in the research. I will describe their activities as a control in Chapter 5.

The next sub-section details the cost of the research infrastructure. The material prices are June 2013 prices, which include Value Added Tax (VAT), obtained from the local agricultural co-operative (co-op).

3.6.3 Research infrastructure costs

All the materials for the research are available from the local agricultural supply co-op. in Ixopo. For the analysis of the costs in the research, I have used the prices as at June 2013, rather than the original purchase price (see Table 5). My reason for doing this was to present current prices to the co-researchers as regards the financial implications of them pursuing the cropping system, post research.

Table 5: Fencing material and corner block costs (June 2013 prices, incl. VAT)

Material description and price	**Quantity/km**	**Total Cost (Rand)**
1.2m Veldspan100m rolls @ R1146.00 ea	10 rolls	R 11 460.00
1.8m CCA[9] poles 50/75mm @R21.66 ea	100 poles	R 2 166.00
1.2m wooden droppers @ R11.20 ea	400 droppers	R 4 480.00
	TOTAL	R 18 106.00
Corner Block (ea.)		
1.8m CCA poles 75/100mm @R40.33 ea	3 poles	R 120.99
1.8m CCA Poles 50/75mm @R21.66 ea	2 poles	R 43.20
2.5mm diagonal bracing wire		R 40.00
	TOTAL per corner block	R 204.19

The fencing component, at 85.5 percent of the total basic research infrastructure cost, is a significant portion of the total outlay, and needs further clarification. The cost of the fence around each plot varies according to the shape of the particular plot, and the number of corner blocks. For instance, if we look at B8 and C9, which share a common fence around an almost square area, the cost is R 1.45 per square meter enclosed. In comparison, B3, which is a small, narrow rectangular plot only 20m wide, cost R4.92 per square meter enclosed. Another factor that increased the cost was the historic access pathways within the community. For example, B7 lies adjacent to

[9] A wooden pole treated with anti-fungicidal chemicals (Copper; Chromium; Arsenic; hence CCA) to prevent damage to the pole by soil microbes

B8 and C9, making a single enclosure possible. However, the pathway between them, used by the community cattle in winter to access a permanent water point, necessitated fencing a 3m wide corridor at considerable extra cost.

Because of these extraneous factors, the best indication of the cost of the infrastructure is the average cost per household, namely R5197.34 (see Table 6). I will use this figure in Chapter 5 when discussing the recommendations emanating from the research. In addition to the cost of the infrastructure, I also purchased the seed and fertiliser inputs for the plots. Each household planted differing areas and combinations of the various crops on their plots. Consequently detailing the cost of these inputs for each household is not possible. However, in Table 9, in section 5.2.3.2, I have made certain assumptions to describe a 'typical one hectare poly-crop', as well as detailing the input costs associated with this 'typical hectare'.

Table 6: Research infrastructure material cost (June 2013 prices incl. VAT)

Household	Size (ha)	Fence cost[5] (Rand)	Corner structure (Rand)	Glyphosate (Rand)	Lime (Rand)	Tools (Rand)	TOTAL COST (Rand)
A 4	0.2364	R6425.50	R1632.80	R 63.82	R194.07	R527.20	R 8843.35
A 5	0.2457			R66.33	R201.67	R527.20	R 795.20
A 6	0.0939	R2805.50	R1020.50	R25.35	R77.06	R527.20	R 4455.62
B 3	0.0910	R3258.00	R1224.60	R24.57	R74.69	R527.20	R 5109.06
B 7	0.3360	R5194.70	R1836.90	R90.72	R257.78	R527.20	R 7907.30
B 8	0.3320	R5303.30	R1428.70	R89.64	R272.53	R527.20	R 7621.34
C 1	0.2223	R4181.10	R1224.60	R60.02	R182.46	R527.20	R 6175.38
C 9	0.1323			R35.72	R108.59	R527.20	R 671.51
TOTAL	**1.6896**	**R27 168.10**	**R8368.10**	**R456.17**	**R1368.85**	**R4217.60**	**R41578.76**
R/ha							**R24608.64**
R/household							**R 5197.34**

3.6.4 The start of the agroecological cropping system

Once the basic infrastructure was in place, we could begin the cropping programme. The erection of the fencing took longer to complete than expected because of a shortage of material over December, with the result that we were well into January 2011 before any planting was possible. The co-researchers, by consensus, agreed that the crops they would like to grow for household consumption were maize, drybeans, butternuts and pumpkins and sweet potatoes, all climatically adapted to the area. Their reasoning for this combination was that they would normally eat these tasty and nutrious food types out of choice. However, because it was late in the season, ruling out the possibility of successfully planting maize, butternut, and sweet potatoes, we decided that the only option was to plant a quick maturing variety of dry-beans, which would be ready for harvest at the end of May.

My agreement with the co-researchers was that for the duration of the research I would supply all the inputs such as seed and fertiliser, as well as any other inputs that were required. All the seeds that I supplied during the research were all open pollinated varieties (OPV), the object being for the co-researches to save some of their harvest for replanting.

Having supplied the seed and necessary fertiliser, each group commenced with planting.

The methodology that I have presented in this section is how we commenced the research. However, as we were dealing with a dynamic agroecosystem, we made changes and adaptations throughout the study period, which I will detail in Chapter 4.

3.6.4.1 Assessment of the cropping system

The assessment of the cropping system took a two-pronged approach, with input from me, as well as the co-researchers. Including all the relevant parties in the evaluation enabled me to generate a comprehensive qualitative assessment of the cropping system.

My assessment relied heavily on observation of: the crops on the plots, the co-researchers input into their plots, their individual interactions within their particular group, as well as the dynamics of each group. In addition, I observed the interaction of the group within the context of the broader Mazabekweni community. I noted any relevant observations in a research diary, which served as a record of the research.

By visiting the plots on a regular basis, up to three times a week during the heavy workload times in the spring, I was able to monitor closely the progress on the plots and the growth of the crops. During these visits, I made a point of including the plot owner as well as any other group member, if they were available. While inspecting the crops, valuable dialogue between everyone took place. Again, I noted the important discussion points in my research diary. In addition, I took photographs on a regular basis of the plots, which served as a further record of the research.

Whenever possible, I engaged in dialogue with the co-researchers community neighbours, who were not part of the research. This dialogue, the pertinent points of which I recorded, formed a valuable assessment tool on all aspects of the research. The discussions not only covered topics dealing with the research, for example, what they thought of the conditions of the crops, but included general points of interest in the community as well, such as the state of the local schools.

The evaluation by the co-researchers of any PAR is a vital step in determining the validity of the research results. The researcher is unable to match their level of commitment to the design, implementation, and data collection, which means that they are able to give an honest, objective, and in depth evaluation of the practical aspects of the research (Greenwood & Levin 2007). Within the context of the research, my conclusion was that the best approach of doing this evaluation was using FGD, with all the groups simultaneously. My reasoning with this choice was that during the course of the research, my interaction with individual participants, and their groups was ongoing and extensive. However, what was missing was an opportunity to get a formal 'cross-pollination' of ideas between all the groups. A further consideration was that certain aspects of the research, such as a co-researcher description of the Mazabekweni food system, was not possible during the informal plot discussions. I will elaborate on the FGD format used in the research in section 3.7.2.1.

In section 3.4.2, I listed some of the challenges that are common in the implementation of PAR. I will now discuss how I addressed these during the research.

3.6.4.2 The challenges of PAR in the research

The importance of mutual trust, as well as the relationship between the co-researchers and me, was a vital component of the research. From my part, the investment in an expensive fencing infrastructure required a 'return', while from the co-researchers perspective, their involvement in an experiment, with possible victimization and ridicule by the community, entailed considerable commitment. Both these scenarios would not have been possible without a high degree of mutual trust in each other, both at the start, and during the course of the research.

My trust in the co-researchers is because I am acquainted with most of them personally and am aware of both their excellent work ethic, as well as their desire to draw benefit from the research by producing food for their families. In addition, my acceptance of their power to either make or break the research, allowed for a relaxed atmosphere, resulting in a productive outcome for all the parties. A rewarding aspect for me was the willingness of the co-researchers to discuss issues other than those related to the research, something not possible without mutual trust.

As I am not a resident of Mazabekweni, it would not be possible to expect the community to develop trust in me during the short duration of the research. However, my discussions with the co-researchers, on the issue of mutual trust, revealed that my involvement in the community as an employer and neighbour over many years is highly appreciated by the community at large. In addition, my involvement in other community projects such as the water supply infrastructure, as well as fund raising for schools, has earned me respect and acceptance in this community.

Irrespective of the amount of trust that I had built up over the years, abuse of my powers as researcher and supplier of the inputs for the cropping, would have brought the research to a halt. Because of this, I made every effort to consult with the co-researchers on any changes that we made during the course of the study, as well as encouraging any innovation, within the confines of agroecological principles. This approach was successful in that apart from household C2, all the other households participated enthusiastically in the research for its full duration.

The small, selected sample in my research could raise questions about the validity of extrapolating the results. However, because I have based the cropping system on universal agroecological principles and methods, other households could also acquire similar skills to those of the co-researchers, thereby expanding the findings over a bigger area. Spreading these skills through farmer-to-farmer extension, a recognized agroecological practice, is a possibility.

The final challenge listed by Grant et al. (2008) is that any account of the research must accurately reflect the experiences of the community involved, including the benefits resulting from their participation. The involvement of the participants in the evaluation of the research, highlighting the benefits and disadvantages to their households, as well as their neighbours, has given them the opportunity to express freely what they experienced during the research. My responsibility as researcher was to translate these experiences into the text of this thesis as accurately as possible.

3.7 Data collection of household diets

My second research question pertains to changes, over the duration of the study, in the co-researchers household diets and food security, resulting from the introduction of homegrown food into their diets. In order to measure this change, one needs data on a baseline reference, as well as data on the new situation, after the introduction of the proposed intervention. In the context of my research, I therefore needed to collect data on individual household diets for a period before they had the choice of homegrown food, and then track any changes to this diet with the introduction of harvested homegrown food. In addition, I needed to determine if the growing of food on the household plots had improved the food security of the households. A further requirement was that my choice of PAR as research design obliged me to involve the study participants in the collection of this data.

In order to present a complete picture of the changes in the household diets, I used both quantitative and qualitative methods for the evaluation. I will start by describing the data collection and methodology for the quantitative analysis.

3.7.1 Quantitative diet analysis

The quantitative measurement of food security is a complex issue. Food security is a function of the availability, access, and utilization of food, in addition to the stability of the food supply. All of these together are necessary, as none of them individually ensures food security (Pinstrup-Andersen 2009; Barrett 2010; Heady & Ecker 2012; Vink 2012).

In a comprehensive review of food security measurement, Heady and Ecker (2012) list three criteria necessary to quantify food security. The first is that it targets measurement at the household level, and secondly it must take the diet quality, including its diversity into account. Thirdly, increasing the frequency of measurement of food security levels will more accurately predict possible future trends and seasonality. The protocol we used to measure the household diets in the research complied with all of these criteria. In their review, they list four methodologies to measure food security levels, namely the calorie deprivation, monetary poverty, dietary diversity and subjective/experiential approaches, each using different indicators as proxies for the level of food security.

For the quantitative measurement of the study participant's diet, I decided to use the Food Consumption Score (FCS) devised by the World Food Programme (WFP) (World Food Programme, 2008). Before deciding on the FCS as a methodology for the research, I investigated each of the approaches listed by Heady and Ecker (2012), to judge their suitability as a measurement tool to quantify the food security of the study households. I rejected the calorie deprivation indicator, monetary poverty indicator and the subjective/experiential approaches because, given the PAR focus of the research, I could not devise a data collection protocol that the study households could use that would supply accurate data. However, with the FCS approach, we were able to implement a simple method to collect data. In addition, the emphasis on dietary diversity of the FCS approach is in line with the accent in agroecology of the growing of a diverse range of food crops, the benefits of which would accurately reflect in the household diets using this method.

The FCS is a simply calculated composite score, based on dietary diversity, the consumption frequency of different food groups, as well as the relative nutritional value of these food groups. By calculating a composite score of these different dietary components, the FCS is able to provide a reasonably accurate assessment of the adequacy of the household diet in the week preceding sampling. However, the FCS methodology is unable to predict future vulnerability of household food security to an external shock, such as sudden unemployment of a breadwinner, as well as measure changes in portion size.

The FCS composite score is calculated by counting the number of times a week a particular food group is eaten, for example dairy, then multiplying this number by the relevant weighting for the food group, resulting in a food group score. The composite FCS is the sum of the individual food group scores. In food security analysis, a FCS of less than 21 indicates a poor status, with the range 21.5 to 35 moderate, and over 35 is good (World Food Programme 2008)(see Table 7).

Table 7: Food Consumption Analysis

	Food Items (examples)	Food Groups	Weighting
1	Maize, maize porridge, rice, sorghum, millet, pasta, bread and other cereals Cassava, potatoes, sweet potatoes, plantains	Main Staple	2
2	Beans, peas, groundnuts and cashew nuts	Pulses	3
3	Vegetables, leaves	Vegetables	1
4	Fruits	Fruit	1
5	Beef, goat, poultry, pork, eggs and fish	Meat and Fish	4
6	Milk, yoghurt and other dairy	Milk	4
7	Sugar and sugar products, honey	Sugar	0.5
8	Oils, fats, and butter	Oil	0.5
9	Spices, tea, coffee, salt, fish powder, small amounts of milk for tea	Condiments	0

Source: World Food Programme (2008)

My approach to the design of a quantitative data collection protocol started with one on one discussion with the study participants, in which we discussed what food types typically made up their normal household diet. Apart from some minor variations, the diets were practically uniform across the sample. In the discussions, it also became apparent that the custom in the area was for all the residents of the homestead to eat from one pot of food, with unemployed household members or visitors granted equal access to the available food resources.

The information on the household diets gleaned from the discussions allowed me to compile a weekly data sheet in isiZulu (Appendix B), the front side showing all the purchased foodstuffs, and the backside listing all the potential homegrown food. Once a week, I provided each household with a new data sheet, which they filled in by ticking the relevant block, returning it the following week. After a quick perusal to detect any apparent inconsistency, which I clarified with the household head, I filed the returned datasheets by household. The nature of the inconsistencies varied, for example, if I knew that the household had homegrown drybeans, why were they still eating purchased drybeans.

In our research, the FCS, measured weekly over an extended period, showed the trends in the household diets, due to the influence of the cropping system. At the start of the study the FCS indicated the food security status of the household diets before they had access to home grown food. Once the households had homegrown food available, any changes in the FCS would be the result of the influence on the diet of this food.

In the context of our research, a change in the FCS of a household could indicate three scenarios. The first is that the household could be consuming more of a high weighting food item such as homegrown beans in addition to their normal diet. The second scenario is that the introduction of a homegrown staple in place of a purchased one, allows the household to buy a high weighted food item such as meat or dairy. However, the third scenario reveals the limitation of using the FCS as presented by the WFP as an evaluation method for my research. A household could replace a purchased staple for a homegrown one, without adjusting the rest of their diet, resulting in an unchanged FCS. In terms of the research, the replacement of the purchased food group by a homegrown one is a positive development, which the WFP analysis does not reflect. In order to rectify this situation, my quantitative evaluation of the diet and food security will track changes in the percentage of the FCS derived from homegrown food, rather than the WFP composite FCS per se.

A further anomaly in my evaluation using FCS is the assumption that the nutritive value of a purchased staple, such as maize meal, has the same nutritive value as homegrown maize meal, which might not necessarily be the case. Similarly, because the FCS methodology does not accommodate food portion size, the assumption that comparable size portions of homegrown and purchased food would have the same nutritive value, may also not be the case. However, the inclusion of a qualitative evaluation by the co-researchers of their diets and food security, which I will now cover, will deal with these scenarios.

3.7.2 Qualitative evaluation by the co-researchers of the cropping system, and their household diets

The dialogue, described in sections 3.4.2; 3.6.4.1 and 3.6.4.2 as well as FGD, the format of which follows, played a valuable part in the qualitative evaluation by the co-researchers of the cropping system, and the household diets and food security. I will cover the results of these discussions, as well as the quantitative diet analysis in Chapter 5.

3.7.2.1 Focus Group Discussion format

Barbour (2007:3) defines a FGD as "Any group discussion may be called a focus group as long as the researcher is actively encouraging of, and attentive to, the group interaction". This interaction between the group members, which ideally should be spontaneous and synergistic, generates data for the researcher that is the basis of the qualitative analysis of the research (Ritchie & Lewis 2003).

The use of FGD has its origins in marketing research in the 1970s, mainly concerning branding and product development. However, it soon spread into areas of social science research, such as community development and health services. Another common use of the FGD is for the synergistic interchange of ideas within a group to generate new concepts, theories, models, and products. The benefit of this approach is that it generates meaningful data at relatively low cost (Fern 2001; Ritchie & Lewis 2003; Barbour 2007).

The role of the researcher is to be well prepared with a topic guide, steering the interaction between the members of the group in a direction that will provide answers to the research questions, without dampening the spontaneity of the discussion. In order for this to be successful the group must be reasonably homogeneous and in the region of six to eight people (Ritchie & Lewis 2003; Barbour 2007). Mindful of the importance of the setting and venue for the FGD (Fern 2001; Ritchie &Lewis 2003; Barbour 2007), I approached one of the co-researchers for permission to use her kitchen as a venue, to which she agreed. Her homestead, situated centrally within the study area, with a kitchen large enough to accommodate everyone seated in a semi-circle, and have sight of the flip chart board, proved a very suitable venue. During the discussions, I recorded all the relevant points on the flip chart board, from which I compiled the analysis of the qualitative assessment of the research.

We held two FGD sessions, both on a Sunday, in order for employed co-researchers and their families to be able to attend. The first was held on 3/3/13, and the second on 1/9/13. Before we started with the session, I explained to the co-researchers the purpose of the afternoon, namely for them to discuss and evaluate the research, with my role limited to asking questions, and keeping a record of the debate. I explained to them that as they had been intimately involved in the design and implementation of the research, they would be better able to express opinions as to the success or not of the research, which I was not able to do because I had been an observer and recorder during the whole research process. In addition, I undertook not to express any opinions, which might influence the debate.

Both the sessions followed the same format, with discussions running from 13.00 to 16.30, breaking on the hour for ten minutes, and thirty minutes for tea. I provided the sandwiches and tea, and the host provided cake and muffins. The first FGD dealt with the Mazabekweni food system and the qualitative assessment of the cropping system. In the second FGD, we collected data relating to the demographics of the area, which I presented in

Table 1, as well as discussing the details of the proposed *stokvel*, and the extension of the cropping system to more households.

Twelve adults and three children made up the Focus Group, with each co-researcher household represented and four households having two representatives (see Figure 9). The children, who were actively involved with the research fieldwork, listened to the discussion. This group size is bigger than that suggested by Ritchie and Lewis (2003), however this did not have any negative effect on the discussions, judging by the spontaneous and rich debate during the afternoon.

Figure 9: Focus Group Discussion participants (March 2013)

Source: D Strachan (own photograph)

3.7.2.2 Discussion topics

I divided the discussion topics, intended as a prompt to generate debate, into four broad themes, with a number of sub themes or questions under each theme. I introduced each theme in turn and then allowed the co-researchers ample time and freedom to debate and come to conclusions. With the discussion in IsiZulu in progress, I made notes and spider diagrams on the flipchart pages, which served as a record as well as a future reference. As an additional record, I also taped the debate using my cell phone, fitted with a memory card (Fern 2001; Barbour 2007). However, the flipchart notes proved adequate for the analysis of the FGD.

The first topic that we covered was for the co-researchers to describe the present food system in Mazabekweni, of which they were part, before they implemented the agroecological cropping system. My objective with this topic was to generate a benchmark against which the co-researchers could measure the effect of the cropping system on their own household food system.

The second topic related to the cropping system. I firstly asked the co-researchers to describe what they had done on their plots, detailing all the steps and the reasons for doing them. My objective was to ascertain if they had grasped the principles of the agroecological approach, rather than it just being another method to produce some food. Secondly, I asked them to rate the success, or not, of the cropping system. My objective was for them to give an objective evaluation of the cropping system, detailing the pitfalls as well as the highlights. Thirdly, I asked them if they would continue the approach when the research ended, and if yes how they intended to do it. I wanted to ascertain the sustainability of the cropping system, viewed from the co-researchers' perspective.

The third topic related to the impact, both good and bad, on their households, of the agroecological cropping system, in order to ascertain if any factors, other than food production, had been a benefit or problem during the research process.

The fourth topic related to the co-researchers' community neighbours. Had the research had any impact, positive or negative, on the social dynamics of the Mazabekweni community as stated in my research aims in Section 1.4.1; and for the co-researchers to determine if, and how, implementation of the results of the research, in the broader community, were to be undertaken.

By introducing these topics as separate discussion points, my aim was to provide a structure to the debate. However, during the debate there was a free flow of ideas, which did not necessarily fall within this rigid structure. A synopsis of the discussions follows in section 4.2.5.

In the next chapter, I will discuss the design of the cropping system, starting with the rationale for the choice of the methods and techniques we used, before describing its implementation over the course of the research

Chapter 4

The design and implementation of the agroecological cropping system in Mazabekweni

4.1 Introduction

This chapter describes the methodology of designing and initial testing of the cropping system, which is the cornerstone of the research. In the next section, which covers the philosophy of the cropping system design, I will start by highlighting the basic parameters within which we designed and implemented the cropping system. Following this, I will describe what we did and why, as well as how we adhered to the agroecological principles. The short duration of the research ruled out the possibility of including long-term crops such as fruit trees in our design, as their influence on household food security would only be evident after a number of years. In addition, because we are dealing with a dynamic system, our effort to design and implement the cropping system over the duration of this research is still a work in progress. While we have identified some key principles, other aspects of the system will continue to evolve in the future. In the description that follows, I will discuss the actions and interventions individually, however as they are all interlinked and interact within the system, they should be viewed as a whole. At the conclusion of the section, I will summarize, using bullet points, the pertinent ecological, social, and economic components of the system.

The design of the cropping system, on agroecological principles, which I covered in section 2.4.4, as well as the implementation of this design, is the cornerstone of the research. These principles include the maintenance of a vegetative ground cover, which, in conjunction with tillage that does not invert the soil, promotes below ground biodiversity. Above ground biodiversity, enhanced by the use of crop rotations and polycultures/ intercrops, guarantees efficient photosynthesis and energy flows, which in turn nurtures the below ground biodiversity. An agroecological cropping system, as with natural ecosystem, is dynamic experiencing disturbances and changes, which necessitate adaptations. In addition, it should strive to be a closed system, with as few outside inputs as possible. Finally, people, which in our research are predominately women, are an integral part of the system.

4.2 The philosophy of the cropping system design

4.2.1 Initial design criterion

The crucial role of rural women in agriculture, historically, nationally, and in our research, necessitates that they are the focal point in the cropping system design. Due to their multiple roles as ‘matriarchs’, household heads, food and income providers, exceptional demands are placed on their time. If the outcomes of the research are to make positive changes to their household’s social conditions and food security, then the system must be able to operate within their physical capabilities, as well as their time and other social constraints, especially with the added workload of being a farmer. Figure 10 highlights the ability of rural women, even though disabled, as in the case of household head C9, to achieve excellent results with implementing the research cropping system.

Figure 10: Disabled household head (C9), with her daughter and their crops

Source: D Strachan; (own photograph)

A second criterion for the design is that all the interventions in the study must be affordable, accessible, and technically feasible post research, both to the co-researchers and rural women in general. One could argue that the fencing infrastructure we erected for the research would not normally be within the reach of rural communities. However, the primary role of the fence was to ensure that we had a secure environment in which to research the potential of the cropping system as a means of improving household food security. Nevertheless, the co-researchers identified fencing as a crucial component of the system. In Chapter 5, I will present a possible scenario regarding the fencing as a prerequisite for the extension of the agroecological cropping system to the broader community.

The third criterion was because we were designing a cropping system on agroecological principles, which was the pre-colonial communal agriculture paradigm; we aim to incorporate ideas and methods from this earlier era into our design. By doing this, we could possibly start to revive some of the traditional knowledge and skills, particularly agricultural confidence, disrupted by colonialism and apartheid.

A further consideration was the recognition of the 'stable' condition of the plots at the start of the research. While they were in a degraded and compacted state, the vegetative cover of *Cynodon Dactylon* ensured that no further soil erosion could take place. Our research aim of growing food crops required that this 'stable' state be disturbed, possibly resulting in renewed degradation. However, the literature review revealed the potential of agroecological practices to regenerate both soils and agro-ecosystems, which would counter this threat.

4.2.2 Ecological considerations

Moving on now to the details of the design, starting with the technique we used to bring structure to the cropping system. My observations of communal agriculture revealed the need for a method to establish the optimum plant population for a particular crop or polyculture. For example, maize is generally over-planted, while beans not seeded thick enough, both scenarios resulting in reduced yields. To overcome this dilemma, we used the stretched out braided rope to mark the first row of planting pits[10], by placing a pinch of agricultural lime on each 700mm spacing indicated by the insulation tape. By moving the next row of pits 700mm away, we ended with a 700mm x 700mm grid of pits, which translates to roughly 20 400 pits/ha. When compared to the somewhat haphazard appearance of a traditional agriculture field, this symmetrical grid pattern displays a distinct Eurocentric approach. However, it served a number of very valuable purposes, which I will discuss later.

In our initial planting, we laid the rows out following the ground contour. However, because we were planting crops with differing heights adjacent to each other, we observed that severe shading occurred, particularly from the dense maize foliage, except when the rows ran east - west. From a subsequent literature search on row orientation, I discovered the substantial yield and weed reduction benefits of east - west planted rows, as well as of strip cropping. Strip cropping is a management practice, with different crops planted in narrow strips of a few rows wide, adjacent to each other. This approach not only allows for efficient light interception by the individual crop species, but also helps eliminate soil erosion (Omielan, McRae, Samson, Quinn &Gasser 1997; Borger et al. 2010). During the second cropping season (2012/2013), we orientated all rows east - west, with good results. This was possible because of the hand planting of the pits, in many cases up and down the slope, without causing soil erosion loss. Figure 11, taken in the late afternoon, shows the excellent growth of the maize and butternuts resulting from the strip cropping, and the pit planting method.

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[10] A planting pit is a small area of loosened soil, necessary for good seed/soil contact. I describe the method to prepare these pits in the following paragraphs

Figure 11: Maize/ butternut strip cropping on plots B8 and C9

Source: D Strachan; (own photograph)

The next step, using the marked pit positions as a guide, is to push the fork into the ground, the full length of its prongs, and then '*pull back on the handle, just enough to crack open the soil without inverting it'*. Figure 12 shows this action, with the fork fully inserted into the ground. This movement serves three purposes; firstly to break the compaction layer in the planting pit, so that crop roots can access a bigger volume of soil, and secondly to introduce oxygen into the root zone in order to stimulate the soil microbiology. The third role is that of water harvesting, permitting rain to penetrate and be stored in the subsoil for later use by growing crops. This tillage technique is a modification, using hand tools, of the tractor drawn rip-on-row method we successfully use on our farm. The sharpened points of the fork allow for the penetration of the compacted soil by women, permitting them to prepare planting pits (*amafolo)*, as in pre-colonial agriculture, as well as rectifying the compaction caused by ploughs. The depth of the compaction layer at 200mm rules out the possibility of using a hoe to prepare the pit, which would cause severe soil inversion. This preparation, done at least two weeks before the expected planting date, allows for increased microbial activity and oxidation, resulting in friable soil essential for good soil/seed contact and improved germination.

Figure 12: Demonstrating the cropping system tillage method: *'pull back on the handle, just enough to crack open the soil, without inverting it'*

Source: K.Tenza

The elimination of the compaction layer under the planting pit, using the long-pronged fork, is an essential part of the cropping system. Over time, the moving of the planting rows across the field will result in the elimination of the compaction layer over the whole area.

The control of growing weeds in the field is essential before planting can commence, as well as for the first third of the crop life, because of competition for moisture and nutrients (Altieri 2005). To control weeds we used hand hoeing, leaving the weed biomass on the soil surface. The use of Glyphosate to kill the *Cynodon Dactylon,* also controlled the initial weed growth on the plots, however because of the time lag between this spray and planting the crops, new weeds emerged that needed control with hoes. This weed biomass, with all the previous crop residues, created surface mulch, which aided with water-harvesting, moisture retention; weed suppression, as well as helping to control erosion.

Unlike the pit preparation and hoeing, which an individual could perform, the planting operation consists of multiple, simultaneous tasks, which either require the assistance of all the household labour force or cooperation with other group members.

The co-researchers devised an efficient 'assembly line' type procedure, which they used to complete the planting operation when the weather conditions were favourable for good seed germination. Moving down each line of prepared pits, the first person places a cupped handful of dry manure on each pit. The following person then creates a mini seedbed, approximately 250mm in diameter, by twisting the digging fork back and forth, mixing the manure and topsoil about 50mm deep. The twisting motion produces a fine soil tilth, ideal for good germination, as well as killing any small weeds that may have emerged since the initial soil loosening with the fork. The third and fourth people in the line, usually a woman assisted by a young girl, are responsible for the precision placement of the fertiliser in the mini seedbed (I will discuss the fertiliser in more detail in later paragraphs). Using the short-handle pointed hoe, the women first opens a hole about 50mm deep in the centre of the seedbed, after which the girl, using the plastic teaspoon, places a teaspoon of fertiliser in the hole. The woman then covers the hole, again using the hoe. Right behind them follows the planter, who accurately places the required number of seeds in a circle, about 50mm from the buried fertiliser. The final person in the line pushes the exposed seed into the ground with her finger, judging the seeding depth by how far her finger is in the ground. Using this finger gauge method ensures the correct seeding depth for the different crops, promoting even germination. The final action is to gently compact the soil around the seed, either with her hand, or foot. Figure 13 shows group activity planting beans. The photograph also shows the different colour of the soil in the planting pit, resulting from the cupped handful of manure applied to each pit, as well as the even spacing of the pits down the row.

The accurate placement of a teaspoon of fertiliser, which includes phosphate, in a single hole is a critical requirement for the production of satisfactory crops in low phosphate status, acid soils such as those in the research plots. Using this method reduces the volume of soil that is in contact with the phosphate, reducing the potential of the soil to fix the added phosphate, which would make it unavailable to plants. Fageria and Baligar (2001) reporting on phosphate applications on acid, high phosphate fixing Brazilian soils, found that by precision placing the fertiliser in a narrow band, the application rates could be cut by 80 percent compared to broadcast spreading, without sacrificing yield.

The teaspoon per pit application method, in conjunction with the grid pattern of 20 400 pits/ha, regulates the amount of fertiliser applied to approximately 100 kg/ha. Similarly, the cupped handful of dry manure, depending on the size of the person hands measuring it out, weighs approximately 220g, which translates to roughly 4 500 kg/ha. The fertiliser we used is a commercially available fertiliser blend (31.11.20. (31) + 0.5% Zn) from Omnia Fertilisers, containing 15.5 % N; 5.5 % P; 10% K, which, when applied at 100 kg/ha supplies 5.5 kg P/ha.

Figure 13: The planting 'assembly line'

Source: D Strachan; (own photograph)

The chemical analysis of manure used by Manna, Swarup, Wanjari, Mishra, and Shahi (2007) is 6.5 g/kg of nitrogen, 2.5 g/kg of phosphate and 4.5g/kg of potassium. The manure application of 4 500 kg/ha would therefore supply approximately 11kg/ha phosphate, giving a total of 16.5kg/ha, well short of the 57kg phosphate per hectare recommended by Omnia.

This reduced rate of phosphate gave satisfactory results over the two cropping seasons, although the long- term effects would need further investigation. However, Manna et al. (2007), reporting on a 30 year long term experiment in India, found that a combination of manure and fertiliser was able to maintain both yields of a wheat/soybean cropping system, as well as soil quality. In comparison, the fertiliser only combinations resulted in both yield and soil quality declines. Similarly, in a meta-analysis of 90 peer reviewed African research papers on agronomic use efficiency of nitrogen in maize production; the fertiliser/manure combinations had the highest values, with 38 kg maize/kg N. In contrast, fertiliser nitrogen alone averaged 25kg maize/kg N, with yields from fields far from homesteads dropping to 17kg maize/kg N. This research shows that a combination of manure and fertiliser at reduced levels, result in a synergistic response, leading to increased yields. Because African smallholders generally do not have enough manure to use as the only source of fertiliser, or cash resources to afford only chemical fertilisers, combining them as shown in this research, is in fact the best option (Vanlauwe, Kihara, Chivenge, Pypers, Coe & Six 2011).

While Vanlauwe et al. (2011) give no indication of the amounts of manure applied, in the Indian trials described by Manna et al. (2007), the rate was 10 tons /ha, spread over the whole field, which at first sight is far more than we used. However, if we consider the spacing of the planting pits, as well as the size of the mini seedbed, our 4 500 kg of manure is concentrated on only 12 percent of the field area. This concentration correlates to 37.5tons/ ha if spread over the whole field, emphasising the tremendous benefit of using planting pits and mini seedbeds, with the manure applied at the plants root zone. I have not been able to ascertain if the practice in pre-colonial agriculture was to spread or concentrate the manure, however the merits of concentrating it point to a very efficient use of a scarce resource.

The importance of manure, as an organic soil amendment, covered in the research papers of Manna et al. (2007) and Vanlauwe et al. (2011), reinforces the emphasis in agroecology for the integration of livestock into any cropping programme. Accessing manure for our cropping programme was not difficult, as five of the study households have access to a limited amount of manure from their own, or family member's, small herds of cattle, while the other three were able to collect manure from my dairy cows. I will cover the dissimilar crop production results between these two groups in Chapter 5.

In spite of the potential negative ecological implication of nitrogen fertiliser application I raised in section 2.1.4, the historic cultivation of the plots with ploughs, resulting in depleted SOM levels, and the long time that would be required to improve these levels through legume rotations and cover crops, necessitated the use of nitrogen fertiliser in the cropping system. With the pit planting method, the fertiliser and manure application at planting supplied approximately 45kg N/ha. Once the maize, beans, and butternuts were well established, we used the teaspoons to apply 100kg/ha of Limestone Ammonium Nitrate; specifically Omnia Fertilisers Greensulf, which added another 30kg N/ha. By applying the Greensulf on the soil surface in the centre of the planting pit, and at the correct growth stage of the plants, we had a very good visual and yield response to the applied nitrogen. Using this method, we were able to comply with the constraints of nitrogen application I listed in sections 2.4.4.1 and 2.4.4.2. In the future, this application of nitrogen may not be necessary, dependant on the increased availability of animal manure, and the successful incorporation of both legume rotations and cover crops into the cropping system.

The co-researchers, through their choice of food crops, which I will now discuss, dictated the area planted to each one, as well as the rotation possibilities on the plots. In section 3.6.3, I mentioned that in my preliminary discussions with them, they indicated that they would like to grow maize, dry beans, pumpkins and butternuts, as well as sweet potatoes. No locally adapted dry bean, pumpkin or butternut seed was available, however I was able to access OPV seed from seed merchants, with the intention of saving seed from the harvest to replant in subsequent seasons. As far as the maize seed was concerned, the co- researchers requested that we plant a white variety for green mielies production, and a yellow variety for chicken feed. The white seed was an OPV, which, because of the long pollination period, produces edible green mielies over an extended period. However, for the yellow variety, I sourced a Quality Protein Maize (QPM) hybrid, which because of its high lysine content, was more suited for mono-gastric animals, as well as human consumption. The release in 2012 of a newly developed, OPV white QPM variety[11], allowed us to plant this for the 2012/2013 season. In the pilot project, the maize, beans, and butternuts suffered from molybdenum deficiency, caused by the low soil pH, and needed correction with a foliar spray of Sodium Molybdate. An alternative control measure is to treat the seed with Sodium Molybdate, at the rate of 50g/ha, which is the method we used with all the seed for the plots. I will discuss the role of this seed treatment on the quality of the dry beans in Chapter 5.

The sweet potatoes, propagated from vegetative runners, required a different approach. During the initial pilot study, I was able to locate a small packet of runners of an orange-fleshed, sweet potato variety. Orange-fleshed sweet potatoes are high in Vitamin A and play an important role in alleviating deficiencies in this essential vitamin, especially in children (Faber et al. 2010; Mukhopadhyay, Chattopadhyay, Chakraborty & Bhattacharya 2011). Using this original plant material as a source of vegetative runners, we were able to propagate additional runners to plant a small section in each plot, which in turn provided plant material to establish a bigger area. To plant the sweet potatoes, we used the same pit method, placing a length of runner, with at least one leaf above the ground, into the loosened soil, before standing on the pit to compact the soil. Figure 14, taken on the pilot project field day, shows the marking out of the position of the planting pits using the marked rope. The new pits, in amongst the growing sweet potatoes, were to plant runners in from this original plant material. This bulked up the runner material in each of the research plots.

My readings in the literature revealed the potential of cowpeas (*Vigna unguiculata*), an indigenous African legume, as a source of high protein food, with both the leaves and seeds edible. In addition, it is a valuable cover crop, providing both nitrogen and biomass for soil improvement (Van Rij 2005). Discussing cowpeas *(imbumba)* with older members of Mazabekweni revealed that, in the early 1950's, this was a common crop, grown in polyculture with maize or sorghum. Following these discussions, I raised the possibility of including it as an additional crop in the cropping programme with the co-researchers, to which they agreed. However, the availability of seed of a suitable grain variety proved a problem, ruling it out as a cropping option.

[11] Nelsons Choice QPM, supplied by Capstone Seeds, Howick, KwaZulu Natal: Tel 086 1113167.

Figure 14: Demonstrating the marking of planting pits (pilot project field day)

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Source: K.Tenza

My original plan for the cropping design was to divide each plot into four roughly equal areas, with the first section planted to cowpeas, the next to beans, followed by maize and butternuts and finally sweet potatoes. The idea was that the crops would follow each other, moving to a new section each year for the crop rotation, with the cowpeas and beans, both legumes, providing nitrogen for the maize and butternuts, and finally the root crop, which requires minimal nitrogen. However, the unavailability of cowpea seed at the start of the research, and the shortage of runners to plant a quarter of each plot to sweet potatoes, meant that we had to adapt the programme for the 2011/2012 season by increasing the maize and bean areas.

Figure 15 shows a pile of harvested orange-fleshed sweet potatoes. This demonstrates the potential of this high yielding and easy to grow crop. The co-researchers observed after they had dug up some of their crop, that the shelf life of the tubers out of the ground was not long. They later moved to the preferred method of storage of the tubers, namely leaving them in the ground until they needed them.

Figure 15: Harvested sweet potatoes

Source: D Strachan; (own photograph)

A valid question is why did we not plant a poly culture of all the crops over the whole area, as was historically done in a traditional field, instead of this rigid rotational design? My feeling was that, in order to assess the production methods, as well as the food producing potential of each crop, we needed to plant them individually. In addition, I was of the opinion that seeing the potential of butternuts, beans, and sweet potatoes growing under field conditions would perhaps break the local tradition of planting a whole field to maize. By the end of the first season, we achieved both these objectives, with the co researchers acknowledging the benefits of having multiple crops, producing a variety of food.

The study households ate some of the white maize planted in the 2011/2012 season as green mielies, but a significant amount, including all the yellow maize, was kept for feeding their free-range chickens as whole grain. The reason for using it as chicken feed was the lack of a means to grind the white maize into meal suitable for cooking. However, in August 2012, I was able to source a Brazilian manufactured, single-phase electric hammer mill (see Figure 16). The mill, a Trapp TRF 400[12], costing R5500 (August 2012), uses 0.3 kWh of electricity to mill 25kg of maize meal. Using the high Escom tariff for the Mazabekweni area at the time of 127c/kWh, this translates into a cost of R0.38 for the 25kg, which is an insignificant amount considering the R150 purchase price for the equivalent size bag of maize meal.

Figure 16: Checking the quality of the milled maize

Source: D Strachan; (own photograph)

Because of the mill, the co-researchers requested that we adapt the cropping system in 2012/2013, in order to plant an increased area of maize for milling. The modification that we settled on was to incorporate strip cropping, as well as east-west row orientation. With this method, we were able to allocate half the plot to maize, planted in four row wide strips (2.8m wide), with the alternate four row strip occupied by the beans or butternuts or sweet potatoes. This design accommodates a much higher degree of intercropping than the first year system, with the butternut crop for example, able to grow into the maize rows, while still enjoying full sunlight in its own

[12] Supplied by Turner Morris, Pinetown, KwaZulu Natal .Tel. 031 7011482.

strip. A further benefit of this system is that each maize strip has two edge rows, which are able to grow without light competition, and consequently 'over yield', when compared with the internal rows. In addition, by switching the crop strips each year, crop rotation is still possible.

The increased yield of the 'edge row effect' in strip cropping can be significant, with Omielan et al. (1997) reporting up to a 30 percent yield increase in maize from the edge rows, when grow in combination with shorter crops such as wheat and soybeans. Where the row orientation was north south, there was a significant yield reduction in the shorter soybeans, however with east-west rows, there was no reduction in soybean yield.

Returning now to the grid pattern of the pits, this has a number of benefits that warrant its retention as a feature of the cropping system. Firstly, because of the fixed number of pits/ha, achieving the optimum plant population per hectare for each crop in the system is possible by adjusting the number of seeds planted per pit. For example, Pannar Seeds (2013), in recommendations for the area, advise a plant population of 40 000-45 000/ha for maize and 148 000/ha for drybeans. To achieve this, we planted two maize seeds or seven bean seeds per pit. In addition, because of the even germination rate in the mini seedbeds, any missing plants are immediately visible, making blanking up with extra seed easy.

A second benefit is the possibility of efficient partitioning of light, moisture, and nutrients, a point raised by Vandermeer (1992). The grid pattern lets each plant access its equal share of these resources, allowing it to yield to its full potential. Pretty, Toulmin and Williams (2011), confirm the benefits of this approach, describing the System of Rice Intensification (SRI), in which evenly spaced, single rice plants, yield far in excess of the conventional practice of dense seeding in rows. Uphoff (2012) reports that SRI innovated in Madagascar and increasingly applied worldwide, uses even spacing in conjunction with other practices that stimulate root development, and enhances belowground biodiversity. Yield increases of between 20 and 100 percent, compared to conventional methods are achievable, using 80 percent less seed, and 50 percent less irrigation water and fertiliser.

The third benefit involves the weeding of the plot. Because each mini seedbed is a zone of deeply loosened soil and high fertility, the plants quickly establish a weed suppressing canopy. In addition, by growing in a concentrated area, the plants are easily visible, making hand hoeing of any germinated weeds very quick and easy. Figure 17 shows the excellent critical early weed control the co-researchers achieved with the concentration of the plants in the pits. The butternuts in the photo are now starting to spread in the weed free open space towards the maize, with the east-west row orientation ensuring enough light for the low growing butternuts.

Figure 17: Strip cropping maize/butternuts: early season weed control

Source: D Strachan; (own photograph)

A further benefit of the grid pattern of pits is the ability of the household chickens to control any pests in the plot. Again, because of the concentrated nature of the plants, the chickens freely access the whole area in between the pits to scratch, eating cutworms and other pests. This has ensured that there has been no need to spray any pesticides to control cutworms or aphids during the research. However, the household chicken flocks, in addition to these positive benefits, also have some negative contributions in the cropping system.

At the start of the research, each household had a number of chickens, which I was never able to count because they were free ranging, and more often than not mixed with neighbouring households flocks. The potential importance of this asset became apparent when the households started filling in their daily diet sheets, revealing their regular consumption of bought, frozen chicken pieces. However, a common feature of these flocks was the small number of chicks that hatched, or reached maturity, because of predation of eggs and nesting hens by the community's dogs, as well as black-shouldered kites and sparrow hawks catching the chicks. From a food security perspective, this high attrition rate ruled out the possibility of homegrown poultry ever replacing the purchased chicken portions.

However, the fencing of the plots, coupled with the availability of the QPM maize as chicken feed, transformed both the study household's chicken flocks, as well as those of their neighbours. The fenced plots provided a secure area, free from dogs, for the hens to set, as well as cover in the growing crops for the chicks to escape capture by hawks. In addition, the hens laid larger clutches of eggs, because of improved nutrition from the extra grain and worms in their diets, resulting in a population explosion in chicken numbers. The neighbour's chickens also benefited from the extra food because they visited during feeding time in the late afternoons, and consequently increased in number. While these extra chickens are positive for food security, they have had a negative impact on our efforts to introduce a winter cover crop into the cropping system, which I will now discuss. I will start by giving a brief overview of what a cover is, its functions and its benefits to both a cropping system and the soil.

Cover crops, which include the concept of a green manure crop, are an important intervention in agroecologically managed cropping systems. Normally planted during the main crop off-season, but in some instances acting as a break crop, they replace the main crop for a season. Their primary function (as their name implies) is to provide a photosynthesising vegetative cover for the soil, but they have a number of other benefits, which enhance the sustainability of a cropping system. These include the fixing of nitrogen by legumes in the cover crop seed mix, as well as increasing SOM, through the addition of biomass. The increased SOM leads to greater soil biological activity, as well as soil enrichment with essential nutrients, including nitrogen for use by the following crop. By acting as a nutrient pump, the deep-rooted cover crops draw nutrients from within the soil profile, accumulating them in the aboveground biomass. Once the biomass decomposes, these nutrients become available for use by the subsequent crop. The surface biomass decreases soil erosion and conserves soil moisture by reducing evaporation, as well as suppressing weeds through shading and allelopathic[13] action. A cover crop can also reduce the incidence of insect pests, by breaking the main crop pest cycle. All these benefits lead to improved yields in the following crop (Fageria, Baligar & Bailey 2005; Seguy et al. 2006; Altieri, Lana, Bittencourt, Kieling, Comin & Lovato 2011).

In the context of our research, with each household only having limited land available, replacing food- producing crops for a season with a cover crop is not realistic. Therefore, the only option was to grow a winter cover crop. However, even with this option, the co-researchers asked if they could eat any of the plants in the crop mixture, when we initially discussed the necessity of planting a winter cover crop.

In order to determine the feasibility and benefits of a cover crop, we planted a small area in one of the plots to a mixture of black oats, vetch and fodder radish in autumn 2011. We successfully use this mixture for the winter cover crops on our dairy farm, which we graze with the milking herd. The vetch, a deep-rooted legume, provides the nitrogen, while the oats and radish supply large amounts of green grazing for the cows. The leaves of the

[13] The crop mulch residue of certain crops, of which oats is an example, exude leachates when they decompose, that inhibit the germination of weed seeds

fodder radish are also edible for humans. Altieri et al. (2011) discuss the use of this particular cover crop seed mixture for vegetable production systems in Brazil.

We planted the seed into small furrows, about 300 mm apart, made with a pointed hoe. The initial growth was slow, but speeded up when we received some early spring rain, after which the crop grew very fast, reaching chest height, and producing a substantial amount of biomass. The growing of the crop did not seem to present a problem, especially as it was inside the fenced area, which prevented grazing by the community goats and cattle.

The plot owner indicated that he would like to plant beans in the area planted to the cover crop. However, because of the height and dense stand of the oats/vetch mixture, we would first either have to cut the biomass down, or hoe it out, or spray it with Glyphosate to desiccate it for successful bean establishment. Because this area was adjacent to his other crops, the potential damage to these crops by the drift of Glyphosate spray ruled this intervention out. Both cutting down as well as hoeing the biomass down would require substantial labour input, which was unavailable at the time, because the plot owner was busy weeding his other crops. Faced with these dilemmas of how to how to prepare the area for beans, I consulted the literature on cover crops and their management.

The literature search revealed papers of Fageria et al. (2005) and Altieri et al. (2011), both of whom mentioned the use of roller/crimpers to role down cover crops in Brazil. A subsequent internet search revealed the Rodale Institute (2012) website, which highlighted the development of an innovative roller/crimper at the Institute. They use this tractor-mounted implement to roll down cover crops in their trials to develop organic no-till farming systems. The website provided detailed engineering drawings of the design, available as open access, subject to acknowledgement of the source. I modified the design to allow for human traction by two or three people, and built a prototype in our farm workshop. Using this implement, we were able to roll down the oats/vetch cover crop, resulting in a thick surface mulch of biomass, into which we planted beans, using the pit method I have described. Figure 18 shows the roller in action pulled by two people. The photo also shows a green growth of the vetch in the standing oats. When the sharpened edges of the roller blades make contact with the vegetative material, they damage the stems, resulting in the desiccation of the green plant material. This desiccated material is visible as mulch in Figure 19. Figure 19 also shows the allelopathic effect of the oats mulch, with no growing weeds visible between the beans in the planting pits.

Figure 18: Rolling down the oats cover crop

Source: D Strachan; (own photograph)

The beans grew very well, yielding 68 kg of dry beans from the 300m² we planted to the oats cover crop. This yield translates to 2.2tons/ha, and is comparable with those achieved under the best local commercial agriculture conditions. There was a noticeable increase in the soil moisture content under the mulch, and the allelopathic effect of the mulch eliminated all weed pressure, making hoeing unnecessary. The co-researchers immediately saw the benefits, in that it would significantly reduce the labour requirement for hand hoeing of the plots, and agreed that we should establish a cover crop along the lines of the test area in autumn 2013. We devised a method of under-sowing the seed in the standing bean and maize crops, using the pointed hoes to draw furrows between the planting pits. However, once we started to plant, the chickens followed right behind, scratching out the seed, and eating it. The small amount of seed that remained germinated well, but the chickens immediately grazed it off, leading to a total crop failure.

Figure 19: Beans growing in oats cover crop mulch

Source: D Strachan; (own photograph)

At this point, the only feasible option to control the chickens is to restrict them in a cage while the cover crop is establishing. Once the plants are well rooted, the chickens would benefit tremendously from the green plant material in the winter. However, this option would also require locking up the neighbour's chickens. Therefore, the growing of a winter cover crop as part of the cropping system is an area that still needs future research.

The cover crop is not the only area negatively affected by the chickens, as they have also inflicted damage to the vegetable patches, which I will discuss while explaining the vegetable production aspect of the cropping system. However, I will first introduce some important social characteristics of the cropping system.

4.2.3 Socio-economic considerations

In section 4.2.1, I indicated the necessity of the cropping system being within the physical capabilities of the women involved in the research. From my observation over the duration of the study, the meeting of this criterion was never in contention. I will present confirmation of my observations by the co-researchers in

Chapter 5. However, the issue of time and other social constraints, many of which are beyond their control, is more problematic.

The limited time available in the spring, for pit preparation, planting, and hoeing of the plots, demand that the co-researchers utilize every opportunity to perform these tasks. Interruptions from rain are inevitable at this time of year, however, time constraints imposed by social customs regarding community funerals, place undue limitations on the ability of the co-researchers to complete these tasks on time. On funeral days, mainly Saturdays, but with certain religious groups, Sundays as well, nobody may touch, or dig in the soil, ruling out the possibility of fieldwork in the plots. The origins and purpose of this tradition are obscure, though a number of discussions with older inhabitants could possibly provide some explanations. Their feeling was that in earlier days, when the population was much lower, the whole community, of necessity, needed to be involved in the funeral proceedings. The men were required to dig the grave, while the women prepared the food for the mourners. However, whereas beforehand only old people died, nowadays, most of the funerals are for young people.

The extent of these funerals is such that they took place on at least 15 of the potential 24 weekend workdays from mid September 2012 to mid December 2012, which is the window period to plant the summer crops on the plots. This forced the five employed women co-researchers to work on their plots in the evenings during the week. However, during this period we received above average rainfall, mostly during the week, which ruled out fieldwork, adding to their frustration of not being able to work over the weekends. My concern was that our inability to plant the 2012/2013 seasons crops, because of the excessive rain and weekend funerals, could potentially put a stop to our research efforts. An additional consequence of the excessive rainfall was the prolific growth of annual weeds, which needed controlling before we could plant. Because of the funerals and weather conditions, as well as the fact that by the end of November no seed was in the ground, I decided to spray the weed growth with Glyphosate in order for the planting operation to commence. This use of Glyphosate to control these annual weeds had not been necessary in the 2011/2012 season, when we did all the pre-planting weed control by hoeing. I will add to this discussion of funerals and the limited time window for fieldwork in Chapter 5.

The multiple social roles of the women co-researchers impose a limit on the amount of time they have available to work on their plots, well illustrated by the community burial customs. These time constraints dictated activities, such as compost making, that we were unable to include in the cropping programme. At the start of the research, we did initiate compost manufacture on one plot as a demonstration, however, the additional burden of collecting composting material, as well as carrying water to the site to maintain the desirable moisture content, proved to be excessive. Because of these time constraints, we did not pursue the making of compost, relying on the collection of manure and its direct application on the planting pits instead.

A further social aspect of the cropping programme is the frustration of ‘theft’, both human and post harvest insect damage of the crops. One of my concerns at the start of the research was the potential of crop theft to jeopardize our efforts. This could happen two ways, firstly, measuring the full benefit of the cropping system on the study households food security would not be possible because of pilfering of the crops before they could eaten. My second concern was the effect of major theft on the motivation of the study households, resulting in them abandoning the research effort.

During the 2011/2012 season, to the community’s credit, apart from a few green mielies, no theft took place. However, in the 2012/2013 season, theft of green mielies and butternuts became a problem. The OPV maize, because of its long pollination period, has edible cobs over an extended period, making it particularly prone to theft, in comparison with the hybrid maize of the previous season. The hybrid maize, which pollinates over a limited period, only has soft edible cobs for a short time. A possible solution to the theft problem is for more households to start growing maize, a trend that is already apparent, stimulated by the possibility of grinding homegrown maize with the hammermill. I will introduce possible solutions to the extension of the cropping system in the community in Chapters 5.

The other ‘theft’, both pre and post harvest of the crop, can possibly be more easily solved than the theft by humans. At the start of the study, the plots were devoid of any signs of biodiversity, covered only by the *Cynodon Dactylon* grass and some annual weeds. However, once we started cropping and applying the manure, the chickens, and a variety of birds soon followed. The constant scratching by the chickens showed that the belowground microfauna were improving, which in turn attracted an increasing number of moles. However, the moles soon found the sweet potato patches on each plot, causing damage by eating out the centre of the tubers. Because of the dense foliage of the sweet potatoes, the molehills are difficult to find, making efforts to control them impossible. Owls are predators of moles; however, because of their use in witchcraft rituals, these birds are taboo in communal areas, ruling out encouraging their roosting in the area for biological control. While complaining of damage, the co-researchers are philosophical about the problem, acknowledging that they have more sweet potatoes than they can possibly eat.

A serious frustration for the study households is the weevil and rat damage to the stored beans and maize. Having done all the fieldwork, to loose a substantial amount of potential food in this way, is a total waste. The strategy that the households employed to counter this problem was either to sell or give away the beans, as well as to eat them faster than necessary. The possibility of using chemical treatment on the stored grain to control the weevils was not an option because of a safety and health consideration, especially since the beans and maize is stored in the household kitchens.

As a solution to the problem of storing the 2012/2013 harvest, I investigated the possibility of storing grain in plastic bags under vacuum, with anaerobic conditions in the bag ensuring that weevils are unable to survive. To accomplish this, I designed and fabricated a hand- operated vacuum pump, which we used to draw a vacuum on a plastic vacuum bag filled with either beans or maize, and then sealed with a commercial heat impulse sealer. (see figure 20) To protect these bags from damage by rats, we stored them in a box we made using 16mm shutter-ply boards. The prototype box, (see Figure 21), which cost R580, has a 500litre volume, capable of storing 550kg of beans and maize. The material and manufacturing cost of the vacuum pump was approximately R600, and the heat sealer cost R850, while the re-useable 7.5kg vacuum bags cost R1.40 each. We only put the first produce into bags in August 2013, which leaves three unanswered questions: if, and for how long, will the maize and beans stay weevil free in these vacuum bags, and is the shutter-ply box rat-proof? If this method is successful, it could possibly be the answer to a practical, cost effective, and chemical free method to store rural household's homegrown produce.

Figure 20: Hand operated pump for vacuum packing maize and beans

Source: D Strachan; (own photograph)

Figure 21: Storage box and vacuum-packed maize and beans

Source: D Strachan; (own photograph)

The original goal in the research was to grow food crops on the household plots under dryland conditions, which ruled out the possibility of vegetable production. However, studying the household diet sheets revealed a negligible consumption of vegetables. Discussions with the households attributed this to the cost of bought vegetables, and the lack of knowledge to grow them. We therefore decided to investigate the possibility of growing them using the same agroecological principles as in the dryland cropping.

4.2.4 Vegetable production

The quantitative assessment of the household diets, using the FCS, discussed in section 3.7.1, showed that the WFP, in allocating weights to the various food groups, assigns a weighting of one to vegetable consumption, compared with a two, for a staple food such as maize. In contrast, meat and dairy score a four, because of their high protein and micro nutrient content. The possibility of vegetables also providing high levels of micronutrients is raised by Keatinge, Yang, Hughes, Easdown and Holmer (2011), who call for the increased consumption of vegetables world wide, in order provide “food and nutritional security” rather than just food security, through the emphasis on high starch staples. Citing research on vegetable consumption in more than

150 countries worldwide, they show a high correlation between the amount of vegetables eaten per person per day, and the levels of both under five child mortality, as well as child stunting. At a threshold intake level of 200g per person per day, both child mortality and stunting decline dramatically, which they attribute to the micronutrient dense vitamin and mineral content of vegetables. Given the importance of vegetables, how did we include them in our agroecological cropping programme? As with the dryland cropping system, our efforts at vegetable production are also still a work in progress, needing further refinement and adaptation over time.

The first step I took was to discuss with the co-researchers what vegetables they would eat and like to grow. They identified cabbage, spinach, broccoli, and cauliflower as the leaf species of choice. For roots, they favoured carrots, beetroot, and onions, with green beans for summer and broad beans and peas for winter, making up the legume vegetables. Significantly, their choice did not include any indigenous species such as amaranth or cowpeas. The choice of a diverse range of vegetables, including legumes, fulfils a basic requirement of aboveground biodiversity in agroecology. In addition, all these species are able to grow year round, which would also satisfy the agroecological requirement of maintaining permanent vegetative soil cover.

However, to grow vegetables successfully in winter, as well as consistently in summer, requires a means of regular irrigation. In the context of our research, with no piped water supply, this would entail the co-researchers carrying water in 20 litre plastic containers from the nearest water source. Because of this constraint, and the fact that we were still developing a system, we decided that the trial would proceed at the edge of two plots that were close to a perennial stream, making the drawing of water easier. Production would start in the other plots once a system was in place.

The following question that needed an answer was the size of the vegetable patch, mindful of the need to both carry water for as small an area as possible, as well as the requirement to provide a sufficient quantity of mixed vegetables year round, for household consumption. In order to determine the size of the plot, I could have used two methods. Firstly, calculate, using dietary standards and norms, the amount of vegetables necessary to make the household food and nutrition secure in terms of vegetable consumption. However, I ruled this approach out as being contrary to the PAR nature of the research. I therefore used the second alternative, namely to ask the household head the question: ‘If the household had access to a selection of the mixed vegetables they had indicated, how many of each would their family eat in a week?’ Working back from the recommended space requirements per species, I calculated that an area of between 1.5m² and 2m² would provide the necessary vegetables. Assuming that in a period of slow growth, the vegetables would be in the ground for at least 18 weeks before replanting with the following crop meant that a total area of 36 m² was required to supply the household with the necessary produce. This corresponds well with the recommendation given by Keatinge et al. (2011), of an area of 6m x 6m, for a family vegetable patch.

However, the question of how to maintain a supply of the diverse range of vegetables every day, given that the growth rates change with the seasons, the differing agroecological requirements of a crop rotation, and the need of a green manure cover crop, remained unanswered.

The answer to this question came from the adaption of the grazing strategy from our farm, which, within the seasonal constraints of variable pasture growth rates, provides fresh, high quality ryegrass/ legume pasture daily, to our milking cows on our farm. An additional constraint is that the total area of pasture, our so-called ‘milking platform’, is fixed, similar to the 36m² research vegetable patches. In order to understand the link, I will now briefly describe the grazing strategy, and the calculations necessary to drive it.

The allocation of an area of fresh pasture every day revolves around the monitoring of the rye grass leaf emergence rate (LER), expressed as the number of days it takes for one grass leaf to emerge fully. The LER is a function of the prevailing environmental conditions, which include daylight length, ambient temperature, and moisture availability. The morphology of the ryegrass plant dictates that it only carries three vegetative leaves, because when a fourth leaf starts to grow, the oldest leaf dies, and is not utilized as grazing, resulting in a 25 percent loss of production to the grazing system. Therefore, to achieve optimum productivity, the pasture needs grazing at exactly the time when the plants have three full leaves. By regularly monitoring the LER, which is the number of days it takes for one leaf to emerge, and we multiply this by three, which is the optimum number of leaves for grazing, we can theoretically calculate the rotation length at that time, as well as determine the grazing area for the day. For example, if in early May the LER is 15 days, then the rotation length should be 45 days. To allocate the daily area at that time, assuming a 10ha milking platform, we divide 10ha by 45 days to get an allocation of 0.22 ha/day. However, although the calculated rotation length at the time is 45 days, we will not be able to regraze this area in 45 days time because of future changing environmental conditions, with shorter days and colder temperatures, as we move deeper into winter, resulting in longer LER, not only for the first leaf, but also for each subsequent leaf. By regularly monitoring the LER, we know when to extend the rotation length and reduce the allocated area, which by mid June will be 0.16ha/day, based on an LER of 20 days i.e. $10ha \div 20 \times 3 = 0.16ha/day$. By grazing a smaller and smaller area each day using this calculation method, allows for the rationing of the available green grass on a systematic basis. To make up the daily feed requirements of the cows, we use stored feed in the form of hay and maize silage during the slow winter growth period. Similarly, as we move into spring and summer, with warmer temperatures and longer days, the LER will decrease, resulting in a shorter rotation length and a bigger daily grazing area. How does this method relate to the vegetable patches?

The growth rate of vegetables, as with pastures, varies through the year, dependant on environmental conditions. In summer, a cabbage, for example may mature in approximately 110 days, compared to 130 days in autumn and 150 days in winter. Using cabbage as an example, and assuming the 36 m² fixed size of the vegetable patch, then we would need to plant 36m² ÷ 110 days or 0.327 m² per day in summer and 36m²÷150days or 0.24 m² per day in winter, to always have cabbages available.

However, in the context of our research, we need a diverse mixture of vegetables and not just cabbages. In order to accomplish this I used two strategies, firstly, dividing the 36m² vegetable patch into 18 subsections or beds of 2m² each, and secondly, assuming a seasonal crop rotation length. These 2m² beds match the area indicated by the co- researchers as sufficient to provide a weeks supply of mixed vegetables consumption. The rotation length, or time that each bed would be occupied by plants, was 110 days for October, November, December and January plantings, 130 days for February, March, August and September, and 150 days for April, May, June and July. The reason for assuming these rotation lengths was to have a starting point from which we could work out the planting intervals through the year. However, because we are dealing with a dynamic agroecosystem, these rotation lengths would possibly need adjustment and refinement.

Returning now to determining what total area of vegetables to plant each day; using the same method as we used to calculate the daily grazing area for the dairy cows, we arrived at an area of 0.327 m²/day for the 110day rotation length i.e. 36m²÷110= 0.327m². However, it would be impossible to plant this exact area every day, but we could accumulate these small daily areas to plant a bed after a number of days, for example 2m²÷ 0.327 m² = 6 days in summer and 2m²÷0.24m² = 8 days in winter. However, we still needed a method to introduce a crop rotation and a cover crop into the system.

We did this by dividing each bed into four quadrants, with one planted to a green manure, and moving clockwise, the root crops, then the leaf vegetables, and finally the legumes. By moving the sequence clockwise each time we planted, we would initiate a green manure, followed by a legume, followed by a leaf, followed by a root crop rotation, as well as bring in a green manure cover crop, both agroecological requirements. By planting this mix of vegetables in the bed on each planting occasion, we ensured a continuous and diverse supply for the households, with the green manure quadrant providing the cropping break, as well as mulching material for the other quadrants. The cover crop that we used was seasonal dependant, with teff grass and cowpeas in summer, and oats, vetch and fodder radish in winter

Figure 22, shows the result of the staggered planting of the mixed species vegetables. The photo shows two lines of three beds each. The bed in the right foreground has carrots, beetroot, and spring onions as the root vegetables, spinach, and cabbage as the leaf, and green beans, visible in the top left hand quadrant, the legume vegetables. The teff /cowpea cover crop is visible in the top right hand quadrant of the bed. The vegetables in this bed are the oldest, followed by the bed to its left, which has the same mix of species, but are younger. The bed in the top left of the photo, is being prepared for planting. This will be planted next, after the top right bed, which the group is presently planting. The photo also shows how the vegetable crop rotation sequence works. The planting position of each vegetable group moves clockwise around the bed at each subsequent replanting.

For example, in the bottom right hand bed, the root vegetables will move to the position presently occupied by the cabbages and spinach, with these leaf vegetable species moving to the position presently occupied by the green beans.

To accommodate the agroecological requirement of 'no soil inversion', we used the fork in the same manner as in the planting pits, except here, we loosened the entire 2m² bed. Each bed then received a 5litre bucket of dry manure spread all over it, before planting the vegetables, in rows, approximately 300mm apart. We added a teaspoon of the Omnia fertiliser blend per row at planting.

Figure 22: Vegetable beds; showing results of staggered planting

Source: D Strachan; (own photograph)

The seeds that we used were all OPV, because of reduced cost. For example, a hybrid summer cabbage seed cost in the region of R1 each, compared to the approximately 0.8cents each, for the OPV. While the hybrid varieties may have superior disease resistance, the extra cost did not warrant us using them. We also ruled out the possibility of seed saving from the vegetables, because of the limited production area at our disposal, as well as the relatively small cost of the seed. Allowing plants to go reproductive would not only reduce the amount of edible material available, but also occupy the limited bed area for too long. For the green manure, we sowed a mix of oats, vetch, and radish in winter and teff with cowpeas in summer. Although cowpea seed was unavailable at the start of the research, I had been able to find a source of cowpea seeds by the time we started the vegetable production.

In our first plantings, we sowed the seed directly into the ground, however, because of insect damage, and the need to keep a big area watered to germinate the seed, we subsequently moved to using seedlings. A further advantage of using seedlings is that of a 'virtual' vegetable patch, allowing for a shorter rotation-length and consequent increased production from the 36m²area, because the plants are five to six weeks old before transplanting into the beds. While we could have bought commercial seedlings, in order to reduce the cost and learn new skills, we decided to grow our own. However, the growing of seedlings proved both problematic and time consuming, as we first tried unsuccessfully to grow a mixed tray of seedlings in cut off 20litre plastic containers, followed by using commercial seedling seed trays. Both of these methods were unsuccessful, because of the varying growth rates of the different species, with shading a major constraint. We finally solved the dilemma by planting individual seeds into 40mm plastic waste water pipes, cut 50mm long and filled with growing medium. Being open at the bottom, drainage was good, and by moving them further apart, we eliminated the problem of shading. Before transplanting, we watered them well, and then removed the seedling from the pipe by pushing it out from the open-end bottom. After washing them, we reused the pipes for the next seeding (see Figure 23).

Figure 23: Mixed species vegetable seedlings growing in cut off waste water pipes

Source: D Strachan; (own photograph)

This vegetable system worked very well, so much so, that we were at the point of extending it to all the plots by the end of summer 2013. However, at this time birds discovered the trial beds, causing damage to the leaves of the transplanted leaf vegetable seedlings. The worst was still to come, when the chicken flocks also found the beds, destroying our efforts, by eating all the leaf vegetables, both seedlings and ready to harvest, as well as scratching out all the root crop seeds. While this was a frustration, the preliminary success of the system demanded that we find a solution (see Figure 24).

Our proposed solution to the bird and chicken problems is to cover the 36m² vegetable patches with a hail netting enclosure. We considered fencing round the patch with a 1.8 m high chicken wire fence, but ruled this option out because of the flying ability of the chickens, as well as not excluding the birds. However, this is still a work in progress, requiring further research, with many unanswered questions not least the estimated cost of R1500 per vegetable patch. This cost includes a treated pole structure, as well as the hail netting.

Figure 24: Bird and chicken damage to the vegetable beds

Source: D Strachan; (own photograph)

In Chapter 5, I will discuss the co-researchers' assessment of the vegetable production as well as add my own comments.

The next sub sections are the summaries of the main points that I have covered in this chapter, leading into Chapter 5, which details the results of my research.

4.2.5 Summary

Ecological factors

- evenly spaced, grid pattern, planting pits, using a marked rope
- east-west row direction
- strip cropping
- break compaction layer using a fork without inverting the soil
- seedbed preparation for good seed/soil contact
- precision placement of fertiliser and manure to planting pits
- optimum seeding rates
- open pollinated seed varieties (OPV)
- quality protein maize (QPM)
- multi-crops, including legumes
- rotations
- weed free environment at planting
- critical early weed control
- retain weed and crop residue as surface mulch
- water harvesting
- integration of animals including cattle, and chickens
- minimal agro-chemical use
- cover crop

Social factors

- women and family labour
- building intergenerational knowledge
- positive contribution to social conditions and self esteem
- diverse food crops for food security
- workload
- funerals
- cattle /goats control dynamics

- clearing fire breaks on plot fence lines
- hammer mill
- vacuum bag storage of beans and maize
- mole, weevil and rat damage

Economic factors

- affordable and accessible resources, post research (for detailed costing see Chapter 5)

Chapter 5

Research results

5.1 Introduction

This chapter consists of two sections. The first deals with the qualitative assessment of the cropping system and the household diets. For the qualitative assessment of the cropping system, I made use of FGD with the co-researchers, and other discussions conducted during the research process with the co-researchers, and their neighbours who were not involved in the research. In addition, I have also included my personal observations during the research process. The second section details the quantitative assessment of the cropping system, by means of an analysis of its effect on the study household diets, using the Food Consumption Score. Both these sections will provide answers to my research questions.

5.2 The qualitative assessment of the cropping system

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In the section, I will start with the co-researchers' assessment of the Mazabekweni food system, as part of a benchmark against which we could measure the effects of the cropping system on their household food security. Following this will be a comprehensive assessment of the cropping system, by the co-researchers, to which I will add my observations. For the assessment, I will collate the data into two themes namely, ecological and socio-economic, which for clarity I will present separately. However, because we are dealing with a system, these themes are interlinked. My observations and comments, which are included in the following section, emanate from discussions with the co-researchers and members of the broader community during the research process, which I recorded in my research diary.

At the end of the section, I will present all the relevant points of the discussions in bullet form.

5.2.2 The Mazabekweni food system[14]

"*The people, especially the children, are getting hungrier, the situation is serious, and unless something is done about it we are going to have terrible trouble"* (FGD March 2013).

This comment from one of the co-researchers captures the main message from the discussion on the local food system. At first, I had difficulty describing the concept of a food system to the co-researchers because of the lack

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[14] A food system entails all of activities from production ('the field') to consumption ('the table') of food, including the processing and marketing, between 'the field' and 'the table' (Ericksen 2007).

of a suitable translation for it in the dictionary that I had. However, they grasped the concept, after I explained that the food system was not just about the pot of food each household would eat that evening, but about where the food came from, why that particular menu, and whether all the household members sleep with a full stomach that evening. With this explanation, a free flowing debate ensued.

A significant feature of their initial analysis was the total omission of any link between available land and home produced food, as an element of the food system. Land only featured in the debate when the discussion moved to possible causes of the present food system. The co-researchers identified money, its various sources, and food transported into the area, as the central elements of the present food system.

The debate around money focused on the lack of significant employment opportunities in the formal sector, both local and urban, resulting in high unemployment levels. My question as to how the people were then able to purchase the small amounts of basic food to live on moved the debate towards the alternative sources of money and other coping mechanisms employed in the community.

The co-researchers identified the social grant system, its positive and negative influences, and its consequences, as a critical element of the food system. While acknowledging the positive contribution of the availability of money to old age pensioners, enabling them to purchase food for themselves and their extended families, the consensus was that the abuse of the child grant system far outweighed these positive benefits to the food system.

A positive benefit of the child grant system was that while it provided an income to committed mothers, the small amount of money was not able to buy food as well as cover other essential expenses, such as doctor's visits and school uniforms and shoes. However, the abuse of the system was rife, with uncommitted mothers always pregnant and using the grant as personal income, rather than for child support.

Another positive benefit was that as live children now qualify for child grants, physical infanticide has stopped, only to be replaced with what the co-researchers described as 'virtual infanticide'. Newborn children are only cared for as long as it takes to get the correct documentation, and then 'abandoned' to family members, especially female old-age pensioners, with the biological mother drawing the grant money. While the person caring for the children has access to state social workers to rectify the problem of the biological mother taking the money, it is an extremely long and costly process for the carer, because they must travel to Ixopo many times to finalise the documentation in order for them to be paid the grant money. Many times their efforts to access the grant money is not successful because of corruption in the system. In addition, the deaths at a young age, of mothers who were always pregnant, mean that the community has a large number of orphans in the care of family members.

"What is happening now they might as well be killing the children, as what kind of a life have these abandoned children got , no mothers, always hungry, and most times dirty and uncared for, that's not how life is supposed to be" (FGD March 2013).

The co-researchers identified the school-feeding scheme, which is supposed to provide one balanced meal a day to children at school, as the only food available to many of the community children. However, corruption and mismanagement in the administration of the scheme results in this meal often not being provided, or balanced. In addition, during school holidays this source of food is not available.

An insidious by-product of the social grant system which negatively influences the food system in the area is the activity of 'loan-sharks'. High levels of indebtedness, incurred for the purchase of consumer goods, as well as unforeseen family expenses such as funerals, have forced people to make use of micro-loans from loan-sharks, who as security, hold the social grant cards *and* identity documents of the borrowers. On pension payout day, the loan shark hands the social grant card to their owners, while retaining possession of the identity document. By always being in possession of the identity document, the loan shark ensures that the grantee will repay their debt. If any debt remains, the loan shark takes back the social grant card as security to cover the outstanding debt. The small amount of money left in the hands of the grant recipient is not able to cover their expenses, or buy sufficient food, resulting in continual indebtedness to the loan sharks.

In response to my question as to how those community members who, faced with monetary constraints to access enough food survive, some of the co-researchers answered that a common survival mechanism was to ask neighbours who had access to food to share some of their food. The prevalence of this approach highlights the strong community spirit of the area. However, the rest of the co-researchers suggested that theft from fellow community members who grew some of their own food, as well as from adjacent commercial farms, was an increasing trend.

While this analysis of the food system in Mazabekweni paints a very dismal picture, the co-researchers were of the opinion that the situation in their area was better than in other communal areas, because of higher levels of employment, and that some community members at least grew a small portion of their own food.

In order to find the possible causes of the present food system, I asked the co-researchers if the situation that they had just described to me was historically like this, or had it evolved over time. My objective with this question was to get further insight into the dynamic of the local food system, as well as to ascertain if my analysis of the broader picture regarding food security in rural communal areas in South Africa (in section 2.3), I had missed any pertinent points.

Their analysis of the causes revealed broad social, environmental, and economic aspects, which I will now introduce, starting with the social dynamic, which is a critical element of rural community areas.

Social causes

A major change that had taken place over time was the influence of the social grant system, resulting in the reliance on purchased food, rather than each household growing some of their own. In addition, a noticeable deterioration in the general health of the community, which the co-researchers attributed to the increased birth rate in order to qualify for child grants, resulted in people not having the physical strength to cultivate their plots. The death at a young age of many people also reduced the potential labour force to work the household plots.

The result of these social issues meant that there were now many abandoned plots in the community, which I had observed and noted in my research problem statement in section 1.4.1. I questioned why households, both those who grew some of their food, as well as those who did not have plots, did not use these abandoned areas. The emotive debate following this question highlighted the issue of access to land, its use, and the potential to produce some food for the household if land is available.

The co-researchers identified two reasons why this abandoned land was not available for cultivation from a social perspective. Firstly, the households that had traditionally cultivated these plots were reluctant to allow other households to use them because of what the co-researchers described as *mona,* or jealousy. They described the basis of this *mona* as; ‘if I am not able to use it, then I will not allow you to use it either’. Secondly, much of this land was under the control of the landowners, who possibly saw bigger income earning potential in allocating this potentially arable land for building sites, rather than allowing it to be cultivated. The co-researchers identified an element of *mona* on the part of the landowners, in that by demanding exorbitant rentals for the use of this land, they effectively put it out the reach of many poor community members, who did not have historic access to arable land.

However, the group acknowledged that even if community members did have access to this abandoned land, they did not have the necessary knowledge, or resources to use it. There was no input from state agricultural officials, who should have these resources and knowledge available.

Another social issue identified that had changed over the years was the effect of schools on the grazing control of the community’s livestock. In the past, household plots were not fenced, but this had not been a limitation to them growing food, as the young boys of the community were responsible for herding the livestock and keeping them out of the fields. However, with the introduction of compulsory schooling, this was no longer possible, resulting in increased damage to plots from unattended livestock. Rather than expend energy on growing crops only protected by rudimentary fences, community members had stopped planting and resorted to buying food instead.

Economic and environmental causes

The following statement from one of the older women in the Focus Group sums up the environmental and economic aspects of the present food system.

"The land is not fertile any more. In the past, only cattle manure as fertiliser grew good crops. Now if manure is used, the maize only grows waist high, with yellow, sickly plants producing small cobs. People use chemical fertiliser and tractors now but the results are the same, soil erosion and poor crops" (FGD March 2013).

Mazabekweni households now use conventional agricultural practices, including tractors, ploughs, chemical fertiliser, and monoculture maize on their plots, and because of the low yields, are only getting marginal relief from the need to buy food. In addition, the soil is subject to increased levels of erosion. The continuous financial drain for the purchasing of expensive agricultural inputs, coupled with the prospect of livestock destroying their efforts, is instrumental in many of them stopping cultivation. Rather than risk limited financial resources to grow their own food, households have resorted to buying food.

This description of the Mazabekweni food system highlights its complexity, as well as the perilous state of the areas food security, almost solely dependant on the availability of household monetary resources. Having set a benchmark against which we could measure the agroecological cropping system, we proceeded with its assessment.

5.2.3 Assessment of the agroecological cropping system

My first research question (section 1.4.2) relates to the assessment of the agroecological cropping system by the study households. The methodology that I used for this assessment was for the co-researchers to describe all the steps in the cropping process, their correct order, as well as the reasons why each particular step was necessary, and its benefits to the agroecosystem. My reasoning with this methodology was to ascertain if they had understood the principles of the agroecological cropping system. Without any prompting on my part, the group explained each step confidently, listing the reasons and benefits, which they discussed in detail, as well as the order of each step, indicating to me that they understood the principles.

In the following two sections, I will present the ecological and socio-economic assessment of the cropping system by the co-researchers, as well as observations I made during the study. However, because we are dealing with a system, a rigid separation of the comments and observations into ecological and socio-economic dimensions is not possible. For instance, comments concerning the plot fences may well be more of a social nature, than strictly ecological. Nevertheless, I have included them in the ecology assessment, because the presence of a fence around the plot contributes to the ecology of the cropping system, for example, by controlling the grazing of the crop residue by animals, the fence ensures a vegetative soil cover for the following crop. Similarly, aspects that I cover in the socio-economic assessment may also have ecological implications.

5.2.3.1 The assessment of the cropping system: ecological dimension

"My neighbours have commented, that when it gets hot and dry, our crops are green and continue growing, unlike their crops in ploughed fields, whose leaves shrivel up, and they stop growing" (FGD March 2013).

This comment encapsulates the ecological dimension of the cropping system, because it results from the interaction of all its components, producing a noticeable visual difference over the short time of the study.

In a similar vein, this comment sums up the potential of the cropping system to restore the degraded agroecosystem we started with. "When we started with this system, the soil was very hard, with pushing the fork in very difficult, but over the time the soil has got so much softer and easier to work, and now the fork work is very easy. Even the hoeing out of weeds is easier now with the soft soil." A later comment by the same participant demonstrates the interconnectedness of the system. " I said just now that the soil was softer, but that does not mean that the soil erosion is more, in fact even after a very heavy rain, the water just soaks in, and my soil stays where it is and not in the stream" (FGD March 2013).

My observations of the system substantiate all these comments. Firstly, by breaking the compaction layer with the fork, we eliminated a major restriction to the penetration of crop roots, caused by previous inappropriate practices, as well as facilitating the infiltration of rainwater, both of which account for the lack of moisture stress. In addition, the application of lime, coupled with the retention of the weed and crop residue on the surface, has changed the texture of the soil surface over the short duration of the research. Another aspect that has shown a quick change is the elimination of the compaction layer over the whole area of the plots. Because there is no fixed starting-point from which to mark the planting pits, they move to a different location with each crop cycle. Consequently, even after only three crop cycles, because we are not getting any soil re-compaction, pushing the fork in to its full depth is now very easy. This change in soil condition will lighten the workload of any future pit preparation, which the co-researchers identified as the most difficult aspect of the cropping system.

The co–researchers answered my question on the success or not of the cropping system, as well as the reasons for their answer, by comparing it to the conventional methods used in the community to plant plots. The unanimous answer of the group was that their efforts had consistently yielded an abundance of a variety of food, which was excellent in comparison to the monocrop maize crops normally grown in the community.

These are some of the comments from the co-researchers to describe the success of the cropping system:

"We don't have to pay a tractor owner, and then wait for his tractor to plough; we just get on with the job in our own time, and our crops grow better than those in a ploughed field anyway" (FGD March 2013).

"Because of the mixed crops which are not all planted at the same time, our workload is split, we can finish hoeing weeds in the mielies before we need to plant the beans" (FGD March 2013).

"We have a fenced plot now, which means we can start planting when we want, and not have to wait for everyone to tether their goats, and we don't have to harvest before the goats are let loose in May" (FGD March 2013).

"With a fenced plot, the neighbours goats and cattle can't eat our crops and destroy our efforts; we don't worry about that anymore" (FGD March 2013).

"Sweet potatoes are a wonderful crop to grow, because we don't have to buy seed like planting potatoes, they don't get disease like potatoes, and when we eat them they make you very full" (FGD March 2013).

"*We have learnt with the sweet potatoes, they need to be replanted with runners on a new area every year, and not just grow from the tubers left in the ground from last year. The replanted ones are much better quality and not 'glassy' like those that grow from the old tuber"* (FGD March 2013).

"Our chickens have increased in number because of the extra food that we have grown, as well as having a safe place to scratch during the day" (FGD March 2013).

Two issues, namely the cost of a tractor to plough, and the fences, mentioned in these comments, need further elaboration. I will first discuss the role of a tractor in highlighting the cost effectiveness of the fork and pit method used in our research.

I mentioned in section 3.6.2, that because household C2 had not dug the fence-post holes to erect their fence, they were withdrawn from the research, but still supplied with seed and fertiliser. In November of the 2011/ 2012 cropping-season, they hired a tractor to plough their unfenced plot at a cost of R300 to themselves, and then used the supplied seed and fertiliser to plant maize and beans in rows. In Table 3, I presented the size of the various plots, showing C2 having a 0.1069ha area. The R300 tractor cost therefore translates into R2806 per hectare for the ploughing, which, after enquiring from other households in the community who had hired a tractor to plough their plots, was the going rate. I will discuss this cost further in section 5.2.3.2. The seeds germinated well, but the family could not keep the rampant weeds under control because of the slow growth of the plants. Over the Christmas period, the neighbour's cattle broke the rudimentary fence around the plot, and in two nights, destroyed all the crops. Although they had access to seed and fertiliser for the 2012/2013 season, they did not plant because of disillusionment, and the possibility of having their efforts destroyed again. This confirms the views expressed by the co- researchers in section 5.2.2, of the role of livestock in stopping people cropping, because of the potential damage to their crops.

Returning now to the fencing which was identified by the co-researchers as a critical issue, my observations during the study revealed a number of important differences between the various households, and their use of this asset.

Firstly, due to the positioning of the dwellings of two households in relation to their plot, we fenced them inside the perimeter fence, as opposed to the other households, where the plots and dwellings were separate.

During the FGD, I asked the co-researchers what they had done with the money they had saved by not having to buy food while they had produce from their plots. *"Most of us have started or completed a new building, either a kitchen or a two-room dwelling with the money we have saved having our own food".* Another household head answered, *"I have used the extra money to buy four breeding goats to start a small flock" (FGD March 2013).*

These results confirm the potential of the agroecological approach; even over the short duration of the study, to generate resources that improved the asset base of the co-researchers.

However, the two households whose homesteads were inside the perimeter fence, although adding to their asset base, lost a disproportionate amount of valuable cropping land in exchange, because the new dwellings have a large external yard area, which was previously producing food. In addition, these two households, because of no clear demarcation between field and homestead, did not cultivate all their available land, This was more noticeable in 2012/2013 cropping seasons, where the separate plot households utilized their land right up to the fence line, including the previously uncultivated corners. Figure 8, which shows the corner of C9's plot, confirms this. In the 2011/2102 season, this area was wasteland, and used as the household dumping ground. However, in the 2012/2013 season, the household had cleared all the rubbish and brought the area into cultivation right up to the fence line.

A further distinction between the households was evident in the application of manure to their plots. The three households, without local access to manure, although able to collect it from my dairy cows, did not collect enough, and consequently could not apply it at the one handful per pit rate. Reliance on the low fertiliser application rates only, had a detrimental effect on their crop yields. We confirmed this yield depression in the 2012/2013 season, when heavy rain soaked the cattle kraals, saturating the manure and making it unmanageable, forcing us to use fertiliser applications only on a portion of the plots. These areas yielded lower than the manure/ fertiliser combination. For the forthcoming season, the households have collected and stored their dry animal manure before the rain, noting the lessons from last year of the heavy rains, and wet manure at planting time.

Thirdly, during the study, the reluctance of the co-researchers to utilize any help, outside of their immediate families and group members was noticeable. Because of this, the size of the labour pool available in each group influenced the ability of the households to complete their fieldwork, such as weeding, in good time. However, irrespective of the size of the available labour force, social time constraints and rainfall events played a big part in determining whether the households were able to cope with the workload. In the 2011/2012 season, we experienced long periods between rain events, allowing for good weed control using hoes; however, in the 2012/2013 season, continuous wet weather hampered our weed control efforts. Even if more labour had been available, we would still have had a problem with the weed control because of the excessive rain. Given the labour pool available in each group, my observation was that a 0.33 ha plot is close to the maximum size that one household can cultivate with our fork and pit method, given the myriad of different time constraints. I base this on the need to control weeds in the critical early stages of the crop growth using hoes. However, given good ongoing weed control, the weed seed-bank should reduce, because we are not bringing new weed seeds to the surface, as is the case with ploughing, making weed control easier. A future option to expedite weed control could be the use of Basagran herbicide, registered for use on maize and beans. While this may seem like a solution, the extra management and skill required with this technology, as well as the cost, possible environmental damage and human safety issues, dictate that we consider this option very carefully before embarking on it, if at all.

In section 1.3.1, I made the point that socio-economic, rather than technical issues may be responsible for the situation in Mazabekweni I described in my problem statement in section 1.4.1. While the technical and ecological aspects are vital components of the success of the cropping system, the analysis by the co- researchers revealed that socio-economic issues played a critical role, which I will now detail.

5.2.3.2 The assessment of the cropping system: socio-economic dimension

"I have got a spaza shop and some cattle, so I am not interested in growing crops, but what is wonderful about the cropping system is that the women are able to do it all"(comment from a neighbouring Mazabekweni resident 2013). And, *"The neighbours walk past when we are working in our field, and comment that us women are doing all the work ourselves, and they are right, we can do it all ourselves"(FGD March 2013)*. These two comments highlight the pivotal role that the women in the research groups have played over the course of the study. The women co-researchers acknowledged that apart from the knowledge that they have gained by taking part in the research, they had grown in confidence and self-esteem, by being able to provide food for their households.

"When I come home from school, it's easy; I take the fork and dig some sweet potatoes from the field, cook them and am full. I also eat them before going to school in the morning. I could never do that before we started growing our own food" (FGD March 2013). This comment from a high school pupil in B group shows how the cropping system has transformed the lives of the study households. The co-researchers attributed this transformation to the cropping system, because of the availability of adequate amounts of a variety of foodstuffs, which they did not have to purchase. *"Our children have grown well and are healthier now, especially from the orange sweet potatoes and beans, and we have a stock of food in our kitchens" (FGD March 2013).*

"In my child's school lunch box I just put some pieces of cooked sweet potatoes and a bottle of juice, she's happy and comes home full from school, even if the school lunch is not available"(*FGD March 2013).*

The strategy that the households have employed is to use the homegrown food as a supplement to their purchased food, especially the maize meal, enabling them to reduce the amount of purchased food. The younger members of the study households found the milled maize too fibrous and unpalatable if cooked alone, but when mixed with the fine bought meal, it was very tasty and edible. Significantly, they reported that they felt fuller, for a longer time, with the inclusion of the higher fibre meal.

Another change resulting from the availability of homegrown food was the introduction of some traditional food dishes and drinks into the household diets. These include *isigwaqane*, which is made by first cooking a small portion of beans in water until they are nearly ready, then adding a measure of maize meal normally cooked to make the starch staple *phutu,* into the beans and water, allowing them to cook together. The use of the high fibre maize meal in this dish enhances the taste, as well as making it more filling. The high fibre maize meal is also more suitable than the fine bought meal, for making the fermented drink *amahewu* because of the superior taste. Previously this drink was not popular with the younger household members, but now with the milled maize, they are drinking it. *Isjingi,* also reappeared in some of the households. This is made by first boiling pumpkins, and when nearly cooked, adding enough maize meal to produce a dish with the texture of very stiff porridge. The households substituted butternuts for the pumpkin, when preparing this dish. The availability of butternut leaves, picked from plants that have developed fruit, added another traditional dish *isgwamba* to household menus. This dish, normally made from the young leaves of African vegetables such as *amaranth*, is prepared by first boiling the leaves until soft, then as with *isjingi*, adding maize meal to produce a very stiff porridge.

The agronomic practices we used on the plots affected the cooking quality of the dry beans. I added a dressing of Sodium Molybdate to the bean seed we planted in January 2011, because of the problem with molybdenum deficiency in the crops of the pilot project. When we harvested these beans, the households commented on how quickly they cooked, as well as on their superior taste and softness. We therefore decided to retain some of this crop for seed to plant in spring 2011; however, at replanting; we did not treat it with Sodium Molybdate. Because we never had enough of this saved seed, I bought additional seed of the same variety, which I treated with Sodium Molybdate. This treated seed, when harvested, had the same cooking qualities as the original crop. However, the produce from the saved, untreated seed, apart from having a lower yield, was so hard that even after cooking for a long time, never got soft and edible. These observations, made by the co-researchers, confirmed the benefit of seed treat with Sodium Molybdate.

The variability of the cooking quality of the dry beans demonstrated the need of seed treatment with Sodium Molybdate. However, an over-application of Sodium Molybdate is toxic in the soil. This is the reason why applying the recommended rate of 50g per hectare to the seed, which translates as 60kg of bean seed per hectare, or in the case of maize, 25kg of seed per hectare (see Table 8), is the safest method to ensure the correct amount per hectare is used. In the event of a household saving its own seed, applying the correct dose to the small amount of seed necessary to plant a single plot would be very difficult. A possible solution to this dilemma is for the group or groups to pool their seed for treatment, a step that would also enhance genetic diversity.

"I knew nothing about planting seeds, but now I can do it, but more importantly, my young daughters have also learnt something they will never forget" (FGD March 2013).

My observations during the study showed the willingness of even the youngest household member to assist with the fieldwork. In the FGD, I commented on this observation and asked why everyone, including the young schoolboys, were so eager to help. The co-researchers attributed this to the group structure, which they identified as a very important element of the research.

"The group idea is a very good, because not only do we work together well, but we also share our produce. We have also donated butternuts and beans to our neighbours" (FGD March 2013).

The mutual assistance and support provided by the group members, proved very important, particularly for the younger household members. The co-researchers agreed that the younger household members, particularly the boys who would not normally do fieldwork, received protection from potential ridicule by their peers, because there were always a number of people working in the field. However, a more important role of the group was that of shared decision-making, such as when to plant. For example, the development of the planting procedure came about because of discussions and decisions within the group structure. Flowing from this shared decision-making was the building of shared knowledge between households, rather than in a single household. The co-researchers agreed that the ideal size of a group was three households, because anything bigger would be difficult to coordinate. However, B group, and the two households in C group, have decided to join forces and form a combined group for the 2013/2014 season. The outcome of this move will require further observation.

Figure 25: Group activity: threshing the bean harvest

Source: D Strachan; (own photograph)

However, my observation of the group dynamics revealed a difference between the three groups, which influenced the effectiveness of each particular group. Two groups worked particularly well together, with members always assisting each other in the field, while in the third group, I would often only find the individual household members in their field. My conclusion was that in the groups that worked well together, each had a 'matriarch', which in the one group was an older woman, and the other, a young woman. While they were not the 'boss', they were always at the centre of any decision-making and consultation, performing a role of 'consensus driver'. A possible reason for the third group not working as well was that from my observations, the group members did not socialize together, as was the case with the other two groups. The 'matriarchs' in these groups, who were not the original women I had approached to select a group, are the people who are the centre of their social circle. In hindsight, this should have been one of the selection criterions when group leaders chose their groups. Figure 25 shows the members, both old and young, of one of the groups that worked well together. The socializing of this group was both at the adult level, as well as amongst the children. The photo depicts the threshing of the bean harvest, performed after pulling up and collecting the dry plants from the field. Following threshing, winnowing the beans on a windy day removes any chaff.

A further role of the group structure emerged when I asked the question as to how the households would continue working their fields when I was no longer supplying the inputs, such as the fertiliser, as part of the research. The future financing of these inputs by the co-researchers, rather than an outside entity, be it state or private, is a crucial consideration for the sustainability of the cropping system. The failure of many agricultural development projects in South Africa is because a mechanism for the provision of the ongoing finance is seldom considered or implemented, leading to a culture of continuous handouts (Khoza 2013).

"We will form a 'stokvel' amongst our group as a savings mechanism to buy the necessary inputs, as well as save our own seed to replant" (FGD, March 2013). In order to get a perspective on the feasibility of this option, and its potential financial implications, we need to look at a variable cost budget for planting maize, beans, and butternuts with the methods we used.

I will present this budget on a per hectare basis, because of the variable plot sizes. In Table 8, I have listed the seeding and fertiliser rates per hectare, as well as a cost per hectare, based on their cost at the local agricultural co-op., situated in Ixopo. I have added a transport cost, using community-based vehicles that area residents use to bring their purchased foodstuffs from Ixopo.

Table 8: Variable cost budget maize, beans, and butternuts R/ha (prices June 2013)

Maize	**R/ha**	**Beans**	**R/ha**	**Butternuts**	**R/ha**
Seed 25kg/ha @ R 18/kg		Seed 60kg/ha @ R 71.66/kg	R4300	Seed 2kg/ha @R600/kg	R 1200
Planting fertiliser 100 kg/ha	R580		R 580		R 580
Greensulf 100 kg/ha	R480		R 480		R 480
Molybdate 50g/ha Sodium	R 20		R 20		R 20
Total	R1530		R5380		R2280

However, because each household planted the mix of crops on their plots in different proportions, I have made certain assumptions in order to simulate a 'typical hectare' poly-crop. Most of the plots have approximately 15 percent planted to sweet potatoes, and therefore not available for cropping. Of the balance, about half grow maize, while the rest split equally between beans and butternuts.

Using the assumptions, and the variable costs from Table 7, Table 9 shows the crop areas and cost structure of a typical one-hectare poly-crop plot.

Table 9: Variable cost structure of a typical one hectare, poly-crop plot (Rand)

	ha	Seed	Fertiliser	Total costs
Sweet potatoes	0.150 ha	----0	------0	----0
Maize	0.425 ha	R 191.25	R 459.00	R 650.25
Beans	0.212 ha	R 911.60	R 228.96	R 1140.56
Butternuts	0.212 ha	R 25.40	R 228.96	R 483.96
Totals	1.0 ha	R 1357.25	R 916.92	R 2274.17

The initiation of a *stokvel*, as suggested by the co-researchers, seen in the light of the cost structure presented in Table 9, needs further clarification. A *stokvel* works on the principle of a group of people each contributing an affordable monthly amount into a joint savings, which is then distributed or used at a later agreed date. However, in our case, the households would need to tailor their monthly contribution to provide the lump sum for the required inputs. Flowing from this are two options, namely to save a smaller amount per month, over the year, or a larger sum over six months from harvesting the crops in the autumn, to planting in the spring. A further consideration is the possibility of saving seed from the previous harvest for replanting, or buying new seed.

Using data from Table 9, Table 10 shows the rand/ month/ hectare, with all the different scenarios, required to provide a lump sum able to purchase the inputs as listed in Table 7.

Table 10: Stokvel saving required to purchase inputs (Rand/month/hectare)

Purchasing and finance options	*Stokvel* over 6 months	*Stokvel* over 12 months
Inputs (including purchased seed)	R379.02	R189.51
Inputs (using saved seed)	R152.82	R 76.41

Table 10 shows the significant saving that the households can make from saving their own seed. From the table we can also calculate the amount that each household would have to save to purchase their inputs. For example, household B8, with a 0.332ha plot would need to save R50.73 (for example; 0.332ha x R152.82) over six months or R25.36 over 12 months, if they saved their own seed. I presented these figures to each household for comment, all of whom considered the monthly amount needed to finance the six-month option, with saved seed, within their financial capabilities.

We can also use this typical one-hectare poly crop variable cost budget to place some perspective on the R300 that household C2 spent to plough their 0.1069 ha plot, which I raised in section 5.2.3.1. Table 9 shows that they would have spent R243.09 (for example; 0.1069ha x R2274.17), if they had purchased all the inputs. A household with the same sized ploughed plot, would have spent a similar amount on inputs had they accurately marked the planting pits with the rope. However, by using the fork method for tillage, instead of the tractor plough, they would have saved the R300. My observations in the community suggest that a major cause of the poor crops is that these tractor costs leave no spare cash to purchase the essential inputs of seed and fertiliser.

Apart from the monthly amount set aside for the purchase of inputs, the *stokvel* saving would also have to provide for the repair and maintenance costs of the plot fence. The life of the fence is dependant on how often a veld fire burns under it. From experience, a well-constructed fence should last at least twelve years or 144 months, before needing major repairs, assuming that the households did prevent damage by fire, by clearing of a firebreak under the fence each winter. Using data from Table 3 and Table 5, we can calculate an approximate monthly fence depreciation figure for each plot[15]. For example household B7, with a 287 metre fence, would need to save an additional R36 per month (for example; 1÷144 x R18.10 per metre x 287 metre), to cover the depreciation. The co-researchers considered that because of the importance of the fence, they would rather save a smaller amount each month from their normal cash flow to cover this fence depreciation, and then save the larger amount for inputs, when they had homegrown food to eat.

In Table 11, I quantify the ‘income’ potential of the cropping system, as well as the post-research ‘cash flow’ implications of the *stokvel* option, for both purchase of inputs and fences’ maintenance costs, on the household finances. I have only included three households in the analysis, namely B7 and B8 combined with C9. These two households share a common plot fence (see Table 3) and plan to operate in a combined group for the 2013/2014 season. In the table, for the sake of clarity, I have also combined their produce. I have assumed the value of the maize and beans to be the ruling retail price the household would pay if they purchased them (‘opportunity income’). The volumes of the maize and beans are from the stocks that the households reported after the 2012/2013 harvest. I have not included any ‘income’ from the butternuts and sweet potatoes, because of difficulties estimating their yield, although the input costs associated with these crops are included in the monthly *stokvel*. Regarding the *stokvel* cost, I have assumed that the households planted their plots according to the areas of a typical poly-crop hectare shown in Table 9, as well as using the 12 month, (with seed saving), option from Table 10.

[15] See Table 11

Table 11: 'Cash flow' considerations of post-research *stokvel* savings[16]

Household	B7	B8 and C9
Area	0.336 ha	0.4643 ha
Fence length	287 m	293m
Initial capital cost		
Basic infrastructure	R7907	R8292
First crop input costs	R 764	R1055
Total initial capital costs	R8671	R9347
'Income'		
Maize @ R 6/kg	(110kg) R 660	(395kg) R 2370
Beans @ R20/kg	(120kg) R2400	(100kg) R2000
'Total Income'	R3060	R4370
'Total income' per month	R 255	R 364
'Costs'		
Fence maintenance cost/month	R36	R37
Input cost stokvel per month (12months; saved seed)	R25	R35
'Total *stokvel* cost' per month	R61	R72
'Net benefit' (Income–Costs) **per month**	R194	R292
'Pay back period' (months) (Initial capital cost ÷ 'net benefit per month')	**44.5 months**	**32 months**

Table 11 illustrates the potential of the cropping system to contribute positively to the household finances, as well as the affordability of the *stokve*l financing method. If we add the contribution of the sweet potatoes and butternuts to these calculations, the outcome is even more positive. For example, the sweet potatoes shown in Figure 15 are from a small portion of the sweet potato patch in plot B7.

Coming back to our efforts at growing vegetables as part of the cropping system, my thoughts can only find one word to describe it, namely frustration. Having perfected a means to grow a variety of seedlings on a regular basis, and implementing a rotation design that provided a simultaneous supply of leaf, root and legume

[16] Table 11 is compiled from data in Tables 6, 9, and 10

vegetables, as well as incorporating a green manure break crop, our efforts ended up being destroyed by chickens. While the vegetables were available, not only did the two households growing them appreciate their inclusion in the household diets on a regular basis, but they also donated the surplus to their fellow group members. Despite the destruction caused by the chickens, their role as pest control agents, and as contributors to the household diets and food security, proves they have an important place in the cropping system. One could argue that the grain they are being fed should rather be eaten by the household, however, much of what they are eating are non-edible, discoloured maize pips which have been sorted before milling. For these reasons, the chicken, bird and hail proof structure to exclude the chickens from the vegetable patch, as well as a pen to confine them during the planting of the cover crop, appear to be essential components of the cropping system. Both these interventions however, require further research and refinement.

The importance of manure to the success of the cropping system dictates that cattle, as with chickens, are an essential part of the cropping system. During the research, we did not specifically include the management of the small household cattle herds in our study, other than to collect the manure from the kraals where they sleep every night. Because of the stock theft in the area, kraaling of the animals at night is essential. However, despite kraaling at night, one of the households lost a cow and her calf to stock thieves during the study. A feature in Mazabekweni, as with other rural communal areas, is the indiscriminate burning of the community *veld* grazing every winter, causing all the cattle in the area to experience severe feed shortages. However, because of the fenced plots, the study households were able to provide their animals with crop residue grazing after harvest, going some way to alleviate the feed shortage. Following the 2012/2013 harvest, the households without cattle also allowed neighbours cattle to graze residues on their plots, in exchange for manure for the 2013/2014 season.

A problem that some of the households, particularly the younger single mothers, experienced following the 2013/2014 harvest, was that older male livestock owners, who did not grow any crops, put their goats and cattle into the fenced plots to graze the crop residue. By doing this, they provided both feed for their livestock, as well as a secure area to prevent them from straying. However, because of the moral support the groups provided to these young females, they were able to persuade the goat owners to make other arrangements to feed and control their animals. A source of animal manure that we did not utilize during the study is that of the chickens, because they do not sleep in a confined area like the cattle. However, the construction of a chicken confinement pen in the future will provide a safe place for them to sleep at night, making the collection of their droppings possible.

My final question at the March 2013 FGD concerned the co-researchers and their neighbours. My interest was two-fold, firstly to ascertain if any intimidation by the community had taken place, and secondly, how could their neighbours reap the benefits of the cropping system as they had? While they assured me that no verbal intimidation had taken place, my concern was the increased ‘intimidation’ by theft that was apparent in the 2012/2013 season. In two seasons, the plots had become ‘utopias’ surrounded by a hungry community and as with our farm (section 3.3), a recipe for increased theft and external pressure in the future. Only by expanding the cropping system to more households and creating additional 'utopias', will the problem of pilfering be resolved and the potential benefits from the research be able to transform the social conditions in the community.

The co-researchers agreed that the best way to involve the whole community was to expand the system to more households, with the ensuing debate revolving around the mechanism to achieve this. Because they had already indicated the vital role played by the fence, I asked them to assume that the fencing infrastructure and initial inputs were already in place. However, a heated debate ensured around which neighbours would be involved in the expansion. The essence of the debate was that some households, who were definitely not interested in cropping, had indicated that they would like a fence that enclosed their whole yard, similar to the two households in our study. The consensus was that to give them a fence would merely divert scarce financial resources away from more deserving households, and not improve the food security of the area. However, they were unable to offer a practical solution as to how to choose the new households.

Nevertheless, despite the unresolved issue of who would get a fence, the co-researchers were adamant that the duplication of the group structure with any expansion was essential. In addition, they indicated that the best way for other households to learn the methods and techniques, was for the co-researchers to mentor them through farmer-to-farmer extension, confident that they would be able to pass on the knowledge and experience.

My solution to the dilemma as to who would get a fence, building on the willingness of the co-researchers to mentor new households, would be to use the same method that we used to select the household sample for the research. With each co-researcher selecting three new households, who they knew would be interested in planting crops, to start a fresh group. They would mentor them for two cropping seasons, while still participating in their original group. Using this selection method, we could potentially have 30 households, assuming a small attrition rate. If after two cropping seasons, we used the same selection and mentoring procedure, 120 households could possibly be involved, and after two more cropping seasons more than 450. If we assume the same demographics as I have presented in Table 1, then 1208 children and 1266 adults in these 450 households would benefit from the expansion of the cropping system. A prerequisite for this system to work would be the establishment of a local supply co-op., to which all the participating households would belong, that would break down big bags of seed and fertiliser into packages suitable for use on small plots. The group members would buy these pre-packs, using their *stokvel* savings for finance. This co-op. would also operate the hammermill, milling maize for a fee, as is happening now, with community members bringing their limited grain stocks for processing.

Figure 26: Farmer-to-farmer extension in the bean field

Source: K.Tenza

Figure 26, shows one of the co-researchers, standing in her bean field, explaining to a group of visiting women farmers the methods she used to grow the crop.

Table 12 gives some indication of the amounts of money, excluding labour costs for fence construction, required for the fencing material and the initial seed capital, to expand the cropping system to 450 households over five years. I have drawn on data from Table 6, assuming an average plot size of 0.2112ha, as in our research plots, and from Table 9, with the costs inflated at 7.5 percent per annum, to compile Table 12.

Table 12: Capital budget for expansion of the cropping system over five years

	Year 1 24 households @ 0.2112 ha each	**Year 3** 120 households @ 0.2112ha each	**Year 5** 450 households @ 0.2112 ha each
Infrastructure costs R/ha	R 24 608	R27 069	R31 129
Input costs R/ha	R 2 274	R 2 501	R2 876
Total costs R/ha	R26 882	R29 670	R34 000
Total hectares	5 ha	25 ha	95 ha
Total Costs	R134 410	R741 750	R3 230 000
Total costs per household	R5 600	R6 181	R7 177

In terms of household cash flow, the initial capital cost, which includes the basic infrastructure and input costs for the first crop, would be provided by the outside funder (the state or NGO). At the first harvest (June), the households would start contributing the total *stokvel* amount for six months (November). This saving would finance the purchase of the inputs for the second crop. Following this, the household would then continue saving the same amount each month. At the time of planting the third, and each subsequent crop, the saving would provide the finance for inputs, and the balance would build the fence maintenance portion. The risk associated with this approach is the possibility of a first season crop failure, which would hamper the household's ability to contribute to the initial *stokvel* savings. However, a crop failure in a subsequent season would not present a problem, because funds diverted from the fence portion, could provide finance for inputs.

In section 5.4, I will discuss the cost of this proposal in comparison to some other interventions aimed at improving rural household food security, while in Chapter 6 I will present the rationale to provide the finance for the erection of the fencing infrastructure and initial 'seed capital'.

My discussions in the thesis so far have concentrated on the cropping system per se, and its potential role in improving the food security, of not only the co-researcher households, but also other households in similar rural communal areas. However, returning to the alarming realities of the study area, which I highlighted in Table 1 (section 1.2.2), the cropping system could have a much wider role than the mere improvement of rural household food security. The data from Table 1, and section 1.2.2, exposes three pertinent issues, namely the imbalance between the numbers of primary and high school children, secondly, the massive levels of unemployment and thirdly, the predominance of females, both as household heads and in absolute numbers. I brought these issues to the attention of the co-researchers, discussing the implications at length. I will now present the outcome of these discussions.

The reasons for the imbalance in child numbers could be debated from many angles, not least that it is a manifestation of the increased levels of poverty in the area from around 2000/2001, which would be the age of the oldest child in primary school. However, the co-researchers all seemed to be of the following opinion; *"Its simple, that's when the child grant system really got going and we could breed children and the state would pay for them".* A further aspect is the urban migration of mothers who have left their children at home in rural areas with family members. We could classify these primary school children as the 'rural child grant generation'.

The decrease in numbers of pre-school children is a bit more difficult to explain. However, from my discussions over the duration of the study with the co-researchers, as well as other community members, there is a realisation that the amounts of money available from the child grant system are in fact very small, and unable to provide for the welfare of a child. My feeling is that this insight, given the predominance of single mothers in the community, could have led to a rational decision by individuals, to take measures to stop the birth of children. While perhaps not the only reason for the decrease in the birth rate, indications are there has been a behavioural change amongst the area's females, an observation my co-researchers agreed with. Interestingly, throughout the study, in many group and individual discussions, I cannot recall one instance where we ever discussed HIV or Aids directly, or as the reason for young people dying and the increased number of funerals.

However, the reality is that the huge numbers of primary school children are in the near future moving into the high school system, which, with only one high school in Mazabekweni, already accommodating 800 learners, is unlikely to cope. The ratio of primary to high school children in the study valley indicates the urgent need for the building and equipping of a second high school for Mazabekweni, something that is not in the pipeline. The 'rural child grant generation' in Mazabekweni therefore face a bleak future as far as high school education and the learning of new skills are concerned.

The extension of the cropping system throughout the area is therefore imperative, so that this rural youth can at least learn life-skills to produce their own food. The co-researchers agreed that this is particularly important for the females, so that when they have their own children, they will be in the position to provide them with food. This learning is also relevant to the adult females in the community, more than 50 percent who are unemployed, particularly as daily they must provide food for their children.

The question of whether the male youth and unemployed adult males would participate and benefit from the extension of the cropping system is perhaps more difficult to answer. However, my observation of the male youth and male pensioner in the study, and their involvement in the fieldwork, shows that with the group structure, they were more than willing to participate, in spite of the traditional paradigm that males do not take part in fieldwork. A sense of achievement and pride was the reason they gave for their enthusiastic participation. My feeling is that given the opportunity, the community's males will embrace the concept of the cropping system, because of this sense of achievement and pride.

The high levels of unemployment, as well as the lack of employment opportunities, are not likely to change over the short or medium term, because of depressed local and global economic conditions. However, the unemployed adults in the community could be very easily 'employed,' should the cropping system be extended to more households. If the cropping system can do for the other households in Mazabekweni what it has done for the study households, then not only will the food security be on a more sustainable level, but the social dynamic of the area will be radically transformed.

5.2.3.3 Summary of the qualitative assessment of the cropping system

Social factors

- females able to do all the work, including the pit preparation
- building up household self esteem
- children's growth and health improved
- better nutrition and diet because of variety of food
- able to donate food to neighbours
- group structure
- shared decision-making
- share food
- share knowledge
- help each other with field-work
- education, agricultural and other, of children/adults
- ideal group size
- moral support from group membership

Agroecological cropping

- fencing vital
- do work in own time because of fence
- provides adequate amounts of a variety of food
- crop rotations improve soil
- spreads the workload
- provides monetary resources for other uses: buildings, livestock purchases
- no crop moisture stress compared with conventional cropping methods
- home-grown food stock to eat over a long period
- no soil erosion
- easy weeding with soft soil
- quick germination of seeds and fast growth of plants
- no need for tractor to plough therefore no tractor costs

- sweet potatoes, easy and cheap to grow, as well as very nutritious foodstuff
- provides food, as well as safe habitat for chickens

Difficulties experienced during the research process

- time pressures
- initial heavy work with fork
- theft
- chickens
- neighbours cattle and goats grazing crop residue in plots

Strategies for continuing post research

- maintain group structure
- group *stokvel* to fund purchases
- save seed

Possibilities to expand system to more households

- initial infrastructure provision essential
- fence vital
- groups
- farmer-to-farmer extension
- share knowledge,
- *stokvels* to purchase ongoing inputs

5.3 The quantitative assessment of the cropping system

The collection of data on the household diets started in the beginning of March 2011 and ran until the end of June 2012, a total of 66 weeks. We did not collect any information for two weeks over the Christmas period of 2011, because of the possible changes in household diets over this period, which could have influenced the results. Households normally eat more meat and dishes made from cake flour over the Christmas period. The initial 18 weeks of data collection, which yielded benchmark data on the regular household diets, covered the period before the harvesting of the first bean crop in May 2011. Following this was a period when the households added the homegrown beans to their diets, the duration of which varied by the amount of beans that each had access to, as well as the number of days in the week that they ate beans. After the beans were finished, a short period followed where the households returned to their historic diets, before the next harvest of beans, sweet potatoes, green mielies, and butternuts/pumpkins in the autumn of 2012. We then collected data for a further period, during which these additional crops supplemented the household diets.

I stopped collecting the data at the end of June 2012, because I sensed a measure of fatigue on the part of the co-researchers to continue filling in this data week in and week out. For the purposes of the quantitative assessment of the cropping system, we had enough data, covering the normal diets, the period with the availability of beans, followed by the time with the availability of the additional crops. At the time we stopped, the households still had access to homegrown food, which they continued to eat, again for varying periods.

The data collection of the household diets yielded more than 500 individual household diet sheets, each of which required careful checking before entering them into the excel spreadsheet. This spreadsheet is able to calculate the weekly FCS, as well as the percentage contribution that homegrown food makes to the particular weeks FCS. In addition, by entering the individual food item that makes up the food group into the spreadsheet, an analysis of the consumption of this particular food item is possible, both purchased or home-grown. For example, bread, maize, rice, and sweet potatoes are all in the main staple food group. The ability to record each of them separately, gives a good indication of the dietary diversity within the main staple group, as well as their grouping into either purchased or homegrown.

Checking and recording all this information into the spreadsheet proved to be a time consuming process. Because the writing up of this thesis coincided with a very busy period on the farm, I found that I was unable to find the time to enter each household's data into the spreadsheet. However, in my preliminary perusal of the data, I noticed that the households that had access to an old age pension of one of its members, compared to those that did not have this additional source of income, seemed to eat more chicken in their diets. Because of the pressing time limitations that faced me, I decided to enter the data of a household in each of these categories, as examples of the effect of the cropping system on the household diets, rather than the whole data set. I chose A4 as an old age pensioner household, and B8 as one without. Apart from the difference of the pension income, these households have very similar income profiles, with both the household heads employed as farm workers, while A4 has three child grant children, as opposed to two in household B8 (Table 2). The child grant of R290/month/child, and the old age pension of R1200, guarantees a social grant payment of R 2070/month for household A4, and R580/month for household B8.

In section 3.7.1, I presented the theoretical basis as well as the application of the FCS in household diet evaluation. The WFP considers a diet with an FCS of less than 21 to be poor, with the range from 21 up to 35, a moderate diet, and over 35 to be adequate. My analysis of the two study households, showed diets with a FCS of 30 and upwards in the pre-bean harvest benchmark period, indicating adequate levels of household nutrition, with a regular inclusion of chicken pieces in their diets (Tables 13 & 15). However, if we look at Table 7, the high weighting accorded to animal proteins and dairy consumption stands out, with only a small inclusion level of these foods having a significant effect on the composite FCS number. While both the household's FCS are adequate, I used the spreadsheet to hypothetically reduce or exclude the chicken from their diets, resulting in the FCS levels dropping to the low 20's. This indicates the vital contribution that the access to monetary resources has on the adequacy of both these household diets, before the period of inclusion of homegrown food from the cropping system.

I will firstly discuss the diet of household A4, which includes an old age pensioner, followed by household B8, which does not. In the discussion, I will look at the trends in the FCS, using averages for each different period in the study. More importantly, I will discuss the trend of the percentage that homegrown food comprises of the FCS, as an indication of the effect of the cropping system on the household diets.

Table 13, which reflects the FCS of household A4 over the four time-periods of data measurement, shows a consistent high score over the study period. This was as the result of the consumption of chicken pieces, with this food source accounting for up to 20 points in some weeks, illustrating the effect of the high loading for animal protein in the FCS model. For the period prior to the availability of the beans (period 1), the average FCS was 45.7 which then increased to 52.4 for the 13 weeks that beans were on hand (period 2; see Table 15). The reasons for this jump was that the family both increased their frequency of bean consumption, some weeks up to five days a week, as well as adding extra days of chicken consumption. During this period, homegrown food contributed an average of 31 percent of the increased FCS, which reflects the extra bean consumption.

However, during the second period of home grown food availability (period 4), the average FCS remained at 50, while the percentage contribution of homegrown food to the FCS, jumped to 40 percent. The availability of homegrown sweet potatoes as a staple starch source during this second period, coupled with high bean consumption accounted for this increased percentage contribution.

In contrast, Table 14, which shows the analysis of household B8's diet, reflects a different scenario to that of household A4, brought about by the lower income from the social grant system. Table 15 shows that their average FCS, including their benchmark first period diet, was lower throughout the study period. In addition, the percentage contribution that homegrown food made to their FCS was lower in the period 3. However, in period 4, although household B8's average FCS was appreciably lower than A4's, the percentage contribution from homegrown food is similar.

The strategy that household B8 followed was to eat the beans at a slower rate, over 19 weeks in period 2, compared to the 13 weeks of A4. The inclusion of this lesser amount of extra beans in their diets never the less increased their FCS compared to the first period, but because they ate them at a reduced rate compared to A4, the percentage contribution to the FCS was lower. However, the FCS increase to 43.1(see Table 14) is solely attributable to the inclusion of beans in their diets, because they kept their chicken days per week at the same number, compared to the first period. This illustrates that a relatively small inclusion of a high nutrient value homegrown food, can make a substantial contribution to the quality of a household diet.

In the autumn 2012 period, again A4 ate their beans more days a week, as well as increasing their chicken consumption appreciably, reflecting in the higher FCS compared to B8. The FCS of B8 in this period however shows no improvement to that of the pre-bean harvest first period, but they were able to provide for almost 40 percent of this FCS from homegrown food (see Table 14).

Table 13: Food Consumption Score (FCS) diet analysis: Household A4

Period 1 **Normal diet** (March 2011 - 15 May 2011)			**Period 2** **Normal diet plus homegrown beans** (16 May 2011 -15 August 2011)			**Period 3** **Normal diet** (16 August 2011 -15 December 2011)			**Period 4** **Normal diet plus additional homegrown food** (January 2012 -June 2012)		
Week	**FCS**	**% FCS from home grown food**	**Week**	**FCS**	**% FCS from home grown food**	**Week**	**FCS**	**% FCS from home grown food**	**Week**	**FCS**	**% FCS from home grown food**
1	53		**19**	44	32	**32**	33		**47**	42	7
2	46		**20**	48	31	**33**	42		**48**	52	40
3	51		**21**	45	37	**34**	35		**49**	51	47
4	49		**22**	40	45	**35**	45		**50**	62	43
5	51		**23**	55	42	**36**	45		**51**	62	37
6	49		**24**	53	38	**37**	38		**52**	48	35
7	53		**25**	58	36	**38**	49		**53**	57	39
8	51		**26**	66	27	**39**	48		**54**	55	36
9	38		**27**	56	27	**40**	43		**55**	58	47
10	45		**28**	48	25	**41**	50		**56**	43	51
11	47		**29**	62	24	**42**	39		**57**	58	36
12	41		**30**	57	21	**43**	34		**58**	40	32
13	45		**31**	50	18	**44**	42		**59**	47	43
14	52					**45**	49		**60**	40	43
15	31					**46**	41		**61**	55	36
16	47								**62**	47	39
17	36								**63**	49	53
18	39								**64**	48	48
									65	43	48
									66	42	41
Av[17]	**45.7**	**0**		**52.4**	**31**		**42.2**	**0**		**50.0**	**40.0**

They did this by including a wider variety of homegrown foods, in addition to the beans, such as sweet potatoes, butternuts, and vegetables on a more regular basis. They sourced the vegetables, included in small amounts

[17] Average

almost every day for most of the winter period, from one of the experimental vegetable patches, which was on their plot. Again, this shows the positive contribution that a small amount of a micro nutrient dense food, such as vegetables, can make to a household diet. In addition, while maintaining the FCS at the pre-harvest level, the inclusion of the range of homegrown produce in their diets made a substantial contribution to the household financial position.

Table 14: Food Consumption Score (FCS) diet analysis; Household B8

Period 1 Normal diet			**Period 2 Normal diet plus homegrown beans**			**Period 3 Normal diet**			**Period 4 Normal diet plus additional homegrown food**		
Week	**FCS**	**% FCS from home grown food**	**Week**	**FCS**	**% FCS from home grown food**	**Week**	**FCS**	**% FCS from home grown food**	**Week**	**FCS**	**% FCS from home grown food**
1	31		**18**	48	13	**37**	47		**42**	41	20
2	38		**19**	36	8	**38**	39		**43**	42	50
3	42		**20**	43	7	**39**	43		**44**	45	51
4	48		**21**	36	14	**40**	38		**45**	39	39
5	43		**22**	54	22	**41**	35		**46**	38	39
6	49		**23**	44	27				**47**	41	25
7	35		**24**	37	16				**48**	36	19
8	41		**25**	48	31				**49**	36	36
9	38		**26**	51	12				**50**	35	20
10	38		**27**	41	7				**51**	38	34
11	38		**28**	39	23				**52**	43	23
12	37		**29**	46	26				**53**	37	38
13	37		**30**	39	23				**54**	39	49
14	29		**31**	47	13				**55**	33	58
15	39		**32**	43	21				**56**	46	34
16	35		**33**	48	19				**57**	35	49
17	42		**34**	38	24				**58**	35	54
			35	39	23				**59**	32	38
			36	42	22				**60**	40	55
									61	44	45
Av[18]	**38.8**			**43.1**	**18.5**		**40.4**	**0**		**38.7**	**38.8**

[18] Average

Table 15: A4 and B 8 household diets: a comparison

Period 1 Normal diet			**Period 2 Normal diet plus homegrown beans**		**Period 3 Normal diet**		**Period 4 Normal diet plus additional homegrown food**	
Plot	**Average FCS**	**Average % FCS from home-grown food**	**Average FCS**	**Average % FCS from home-grown food**	**Average FCS**	**Average % FCS from home-grown food**	**Average FCS**	**Average % FCS from home-grown food**
A4	45.7	0	52.4	31	42.2	0	50.0	40.0
B8	38.8	0	43.1	18.5	40.4	0	38.7	38.8

While we do not have quantitative figures for the 2012/2013 season, indications are that we would possibly approach a contribution of over 50 percent from homegrown food to the FCS. I base this on the fact that in the 2011/2012 season, none of the households kept any maize for home consumption, because of the unavailability of a hammermill, utilizing it as green mielies and as chicken food instead. However, they have now kept most of the harvest as grain to mill, which will contribute substantially to their diet as a homegrown main staple. In addition, there are larger volumes of sweet potatoes and beans available, which will also make a positive contribution.

Following the 2012/2013 harvest, the study households have varying amounts of beans and maize stored, which they are including into their diets. The households measured this produce volumetrically, after which I converted it to kilograms (i.e.0.86 kg per litre). While it is difficult to quantify how long these stocks will last, household B8 estimates that their 57 kg of beans will last another seven months, until the next harvest in autumn 2014, and their 210 kg maize until perhaps January or February 2014. Household C9, with 43 kg of beans and 185 kg of maize stored, expects the same consumption patterns. The sweet potatoes, because they remain in the ground, are even more difficult to estimate, suffice to say that the households seem to have them on their menus for most of the year.

The contribution of these stored grains to the financial well being of the households is also substantial. Again using household B8 as an example, the beans at the retail price of R20/kg are worth R1140, while the maize adds a further R1260. Quantifying the financial benefits, such as possible reduced health care costs, resulting from the increased household FCS resulting from the inclusion of these grains, is more difficult, but nevertheless relevant.

This quantitative analysis shows both an increase in FCS, as well as a substantial contribution of the homegrown food to this increased FCS. This confirms the positive qualitative assessment of the cropping system, which the co-researchers gave in the FGD, and its effect on their household diets. The households have therefore complied with the conditions set out by Barrett (2010) and Vink (2012) necessary to improve their food security. The implementation of the agroecological cropping system has given the households simultaneous *access* to an affordable means of improving the *availability* of a *stable supply* of homegrown food, which the households have *utilized* to improve their diets and food security

5.4 Other interventions to alleviate rural household food security: a comparison

This research has focused on a different approach to those tried in the past to improve rural household food security in KwaZulu-Natal. The results from our research show, amongst other social and ecological benefits, that the study households have experienced a positive impact to their food security. In addition, Table 11 shows that the approach achieves a relatively short 'payback period' on the initial capital funding, and that it is self-sustaining in terms of future finance. However, its continued success depends on the expansion of the agroecological cropping system to more households. The capital financial implications of this expansion, costing R5 600 per household for the initial 24 households, rising to R7 177 (inflation adjusted) for 450 households in year five, is presented in Table 12. How do these capital figures compare to other recent attempts to improve rural household food security in KwaZulu-Natal?

5.4.1 Empowerment for Food Security Programme

The Empowerment for Food Security Programme (EFSP), a joint initiative between the Flanders and Kwa Zulu-Natal governments, focused on four district municipalities in the province, two of which are in the south of the province, identified on grounds of high unemployment rates, HIV prevalence and poverty levels. The programme ran from 2006 to 2011, with total funding of R93.5 million; R60 million from the Flanders Government and the balance provided by the KwaZulu-Natal provincial government. Allocations to capital investments and operational expenses accounted for 86 percent of the budget, with personal costs making up the balance. The implementing agency was the provincial Department of Agriculture (KZN DAE) (KwaZulu-Natal DAE 2005).

The interventions included the establishment of community gardens, homestead gardens and broiler chicken projects for 700 households, involved in 38 EFSP projects, which included 85 community gardens. The investment represents R133 571 per beneficiary household (KwaZulu-Natal DAE 2008).

One of the conditions of the aid was for an evaluation of the outcome (KwaZulu-Natal DAE 2005). The evaluation methodology involved interviewing 390 randomly selected beneficiary households, during July and August 2010. The evaluation covered household demographics, food security indicators, household food consumption and expenses, crop and animal production and the participant's views on the individual programs of the EFSP (D'Haese, Vink, Nkunzimana, Van Damme, Van Rooyen, Remaut, Staelens & D'Haese 2013).

The evaluation concluded that while the sample households perceived the programme to be successful, more than 50 percent were still severely food insecure, and “Furthermore, project involvement has actually led to the cultivation of a new type of crop for only 35% of the respondents. This means that most beneficiaries must already have been involved in crop production and project involvement has not really increased their production or income” (D'Haese et al.2013:18).

The evaluators concluded:

> A clear impact of the projects on food security could not be established when comparing new entrants with established participants. Yet some improvement was shown in terms of diet diversity. Hence, the EFSP demonstrates slow improvement in the diet but no clear improvement of food security levels could be established (yet) (D'Haese et al.2013:20).

5.4.2 Sisonke District Municipality farmers’ market

An example of the amounts of money that the state is prepared to invest in commercialising small-scale farmers is the Sisonke district municipality farmers’ market outside Ixopo, erected in 2000, at a cost of more than R17 million which, inflated at 7.5 percent per annum, would be in the region of R21 million today. The municipality correctly identified the need to improve food security in the district as a priority, and acting on advice, built the market to provide small-scale farmers with a venue to sell their produce. However, to date the market has not operated for two reasons. Firstly, the small-scale farmers who are supposed to use it find it more lucrative to sell directly to hawkers who retail the vegetables, mainly cabbage, on the streets in Ixopo, as well as to individuals awarded tenders for the school feeding schemes. Secondly, the market, sited two kilometres away from the main shopping area of Ixopo, would not draw customers because of its location. Ironically, the municipality, in an effort to generate produce for the market, has given most of the identified small-scale farmers in the district, who number no more than 30, handouts of seed, fertiliser and crop chemicals as working capital, which they have since used to supply the hawkers and school feeding scheme tender holders with vegetables. Facing political pressure to get the market functional, the municipality is now considering making it obligatory for school feeding scheme tender holders to buy their vegetable requirements at the market, which to date, still does not have any farmer suppliers (Khoza 2013; Miya 2013).

The KwaZulu-Natal provincial DOA, aside from the Sisonke district municipality, is also providing financial assistance in the drive to commercialise small-scale farmers. Specifically in the Mazabekweni area, they provided two small-scale farmers with four vegetable tunnels three years ago, in order for them to grow ‘out of season’ produce, such as winter tomatoes. Strangely, neither of the two farmers had ever requested help in the form of a tunnel, and again to date, these highly technical infrastructures have produced no crop. The reasons for this is that in the case of the first two tunnels, the initial tomato plants supplied with the installation to the farmer, all died of disease, because no on-going extension was provided for this sophisticated method of crop production. In the case of the second farmer, the tunnels stand abandoned, because of the failure to include a water supply into the installation, without which the hydroponic irrigation system required for production is unable to operate. A water supply was also not included in the first installation, but because the tunnels are next to a stream, the farmer was able to connect a pipe himself and provide the necessary water. However, nobody tested the quality of the stream water, which because of pollution, contributed to the demise of the hydroponicaly irrigated crop (Miya 2013).

This drive to commercialise small–scale agriculture by the DOA, as alluded to by Drimie and Ruysenaar (2010), goes beyond the provision of financial resources to the farmers, finding its way into the thinking of the rural population. To illustrate this point, in an incident related to our research, the local tribal chief and his councillors in Mazabekweni invited me to attend a meeting with them in July 2013. They had noted that the crops on the research plots were very good in comparison to those normally grown in the community, and asked if I would help them with their fields. They requested assistance to grow cabbages, for sale to the school feeding scheme contractors, as well as grow maize to sell to commercial farmers for stock feed, and because they had access to bigger blocks of land, in excess of one ha, they would need a tractor to plough. My reply was to ask why the community's children were eating at school, and what the price was of a 50kg bag of maize meal. At R300/bag, translating to R6 000/ton, I explained that the going rate commercial farmers were paying now for maize was R2200/ton in the field. As for the children, they answered that it was government policy. Upon re-asking the question, and after some thought and deliberation, they concurred that it was because the children came from home hungry. These examples highlight the futility of directing all the emphasis on the commercialization of small–scale farmers, at the expense of household food security. Ironically, a recent DOA programme directed at household food security, namely 'One home, one garden'; had failed because the vegetable seedlings supplied to households as part of the initiative, were eaten by livestock, primarily goats, because they were planted in unfenced plots (Khoza 2013).

One could argue in defence of the DOA, that to date, the relative success of the commercial agriculture model must serve as the blue print for their efforts to improve food security in rural communal areas. However, continued handouts of inputs from the state, in an effort to achieve the commercialisation of the small-scale communal farming sector, should indicate the need for another approach. While I am not suggesting that the support for small-scale farmers be stopped, the potential of the agroecological approach to alleviate the broader social issues in rural areas, by focusing at the household level and the 'entire food system', which we have done in this research, merits its consideration and implementation by state and NGO development agencies.

5.5 Summary

The chapter covers the results of the research, with a qualitative, as well as a quantitative assessment of the cropping system, and its effect on the study households' food security. Using FGD, the co-researchers evaluated the food system in Mazabekweni. Financial analysis showed that the agroecological approach had a short ‘payback period’ of the initial capital infrastructure costs. In addition, the ongoing finance of post research inputs by the co-researchers is possible, using a group *stokvel*. The chapter also details a method to expand the cropping system to more rural communal households.

The quantitative assessment of the study households’ diets using a modification of the FCS, shows that the inclusion of home grown food into the household diets accounts for 40 percent of an increased FCS, compared to the normal household diets.

Chapter 6
Conclusions and recommendations

6.1 Introduction

This chapter consists of three sections, firstly, the conclusions from the research, including references to the research questions, secondly, recommendations necessary to take the results of this research forward, and thirdly, an isiZulu translation of the agroecological 'fork and pit' method we have used in the research.

6.2 Conclusions

6.2.1 Food security

In section 1.4.2, I presented my research questions, the second of which relates to the influence of the homegrown food crops on the food security of the study households. In order to answer the research question, I measured the food security status of the households before the homegrown food crops became part of their diets, as well as after their inclusion in the household diets. In order to overcome the difficulties of measuring food security (section 2.3.2); I made use of both qualitative and quantitative methods in the research. In the FGD (section 5.2.3.2), the co-researchers recognized the positive contribution that this homegrown food had made to their household diets and health of their children. Further, the FCS analysis of two of the study households (section 5.3), showed that the introduction of the homegrown foods had improved the household FCS, as well as contributing 40 percent of this score. Both the qualitative and quantitative evaluations therefore showed that the homegrown food crops had made a positive contribution to the food security status of the study households. In addition, apart from improving the household diets, the co-researchers were able to improve their asset base with the extra monetary resources they had available from their reduced purchases of food.

6.2.2 Agroecological cropping system

At the start of the research, the study households had access to abandoned, and degraded household garden plots. By providing a basic infrastructure in the form of a fence and hand tools, we were able to transform these plots into valuable household assets over the short duration of the research, by implementing the agroecological cropping system. My commercial agriculture knowledge of agroecological techniques, as well as principles gleaned from the literature, served as a starting point to design the cropping system. Using PAR, all the subsequent design changes involved the co-researchers. In addition, they contributed to the design by introducing refinements, such as the planting procedure, covered in section 4.2.2, and depicted in Figure 13.

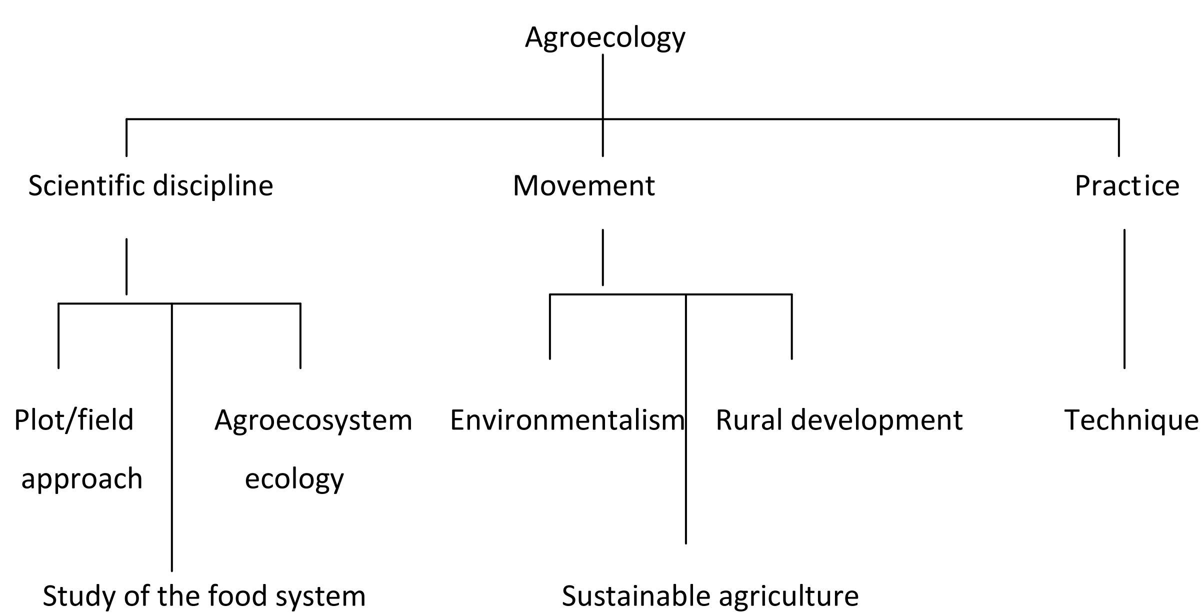
The implementation of the cropping system, including the preparation of the planting pits, proved to be within the physical capabilities of the mainly female co-researchers. In addition, the contribution of the household groups, recognizing the social dimension of agroecology, assisted with both the workload in the fields, as well as with decision making regarding the implementation of the cropping system. The adequate amounts of a diverse range of food crops that the households grew on their plots, using the agroecological methods, proved the viability of the cropping system from an ecological perspective.

The FGD, as well as ongoing dialogue within the research environment, enabled the co-researchers to assess the cropping system. In their qualitative assessment of the cropping system, the co-researchers noted an improvement in the condition of the soil, over the duration of the study, indicating the positive benefits of the agroecological methods we instituted, on the plot agroecosystem. In addition, observations that they made during the research, such as the effect of Sodium Molybdate seed treatment on the cooking quality of the beans, showed that they were actively involved in this assessment of the cropping system on their diets.

During the study, certain of our agroecological interventions, such as the planting of the winter oats cover crop and the extension of vegetable production to all the study households were not successful. However, these unsuccessful outcomes, seen in the light of their causes, namely the damage by the increased number of chickens, which was a successful outcome of the cropping system, are possibly reversible by introducing adaptations to the cropping system.

Finally, returning to Figure 4, in which I presented the diversity of meanings and emphasis of agroecology, our research included each of the elements in the diagram. These are some of the interventions and outcomes.

Figure 4: Diversity of meanings of agroecology



Scientific discipline:

- **Plot/field approach**

  We experimented with different combinations during the research, such as the combination of manure and fertiliser; seed treatments with or without Sodium Molybdate, and strip cropping versus solid block cropping.

- **Agroecosystem ecology**

  The use of chickens, including those belonging to the study households neighbours, as pest and insect control agents on the plots, as well as the use of animal manure as a soil amendment, incorporated the local agroecosystem ecology into the research.

- **Study of the food system**

  We included numerous socio-economic aspects in the research, which coupled with the ecological emphasis, qualifies our research as a study of the entire food system of Mazabekweni. These comprise:

  Designing the cropping system taking cognisance of the central role of women in rural communal agriculture, and household food provision.

  Recognizing that agroecological practices formed the basis of pre-colonial communal agriculture, and incorporating techniques from that era into our cropping system design.

  Incorporating a group structure amongst the households, which served as a work, decision-making and moral support mechanism, as well as a means to generate and enhance shared knowledge.

  We recognized that the social security system, including child grants and old age pensions, is an integral and vital element of the Mazabekweni food system.

  By taking cognisance off, as well as respecting the local customs and social dynamic of the area, for example funerals.

  Designing the system, so that post research, it is within the physical and financial capabilities of the study households.

Movement:

- **Environmentalism**

  Our practise of using the fork to break the compaction layer restored the environmental degradation caused by the use of ploughs, as well as eliminating soil erosion.

- **Rural development**

  By using the cropping system as a means of boosting rural employment, as well as improving household food security with the diverse food crops we grew, this approach could become an important factor in rural development.

- **Sustainable agriculture**

  We adapted our practices to take cognisance of the implications of resource depletion, such as phosphate and oil and natural gas, highlighted by the polycrisis, and ensured that the cropping system is financially sustainable post research by the low use of purchased inputs and the proposed use of *stokvels*. In addition, the agroecological techniques we used, specifically with reference to the soil, are the basis of sustainable agriculture.

Practice:

- **Techniques**

  We used agroecological techniques such as non–inversion of the soil, rotations including legumes, strip cropping, surface mulch retention, incorporation of animals, and seed saving.

6.2.3 The research questions

6.2.3.1 The design, implementation and assessing of the cropping system

In section 6.2.2, I have shown that the study households were able to design, implement, and assess the agroecological cropping system, which answers my first research question as stated in section 1.4.2., namely:

> Can the study households implement and assess a cropping system, designed on agroecological principles, on their garden plots?

6.2.3.2 Household food security

In section 6.2.1, I have covered the positive contribution, both qualitatively and quantitatively, that the food crops grown by the study households on their plots, made to their household food security. This answers my second research question from section 1.4.2., namely:

> Have the food crops they grow and harvest from their household plots, contributed positively to the diets and food security of their households?

6.3 Recommendations

While much of this research remains a ‘work in progress’, with future refinements and improvements possible, the results to date indicate that we have identified and tested an agroecological cropping system, that is making a positive impact on food security of the study households, as well as the ecology of the local agroecosystem. However, in section 5.2.3.2, I intimated that the expansion of the cropping system to more households in the community is imperative for two reasons.

The first one is, to prevent the study household plots being subject to increased pilfering from their hungry neighbours; and the second reason, as a means to provide both ‘employment’ and food security for the communities’ unemployed adults. Coupled with this second reason, is the potential of the cropping system to offer a measure of hope to the ‘rural child grant generation’ to gain life skills to grow their own food. The impending crisis of overcrowding of the local high school system means that their chances of receiving an adequate high school education appear remote. Because of this looming crisis in the education system, they seem destined to join the ranks of the unemployed in increasing numbers, potentially swelling the flow into urban informal settlements in a quest to survive. In addition, the ‘potential’ of further exploitation of the child grants system as a survival mechanism, is a distinct possibility.

In our FGD, we identified a method to extend the coverage of the system to more households, building to 24 at first, then after two years to 120, followed by 450 at the start of year five. Table 12 (section 5.2.3.2) gave some indication of the capital financial implications of the proposal. I mentioned in section 2.3.3, that because of communal tenure, the responsibility is on the state to provide the finance for capital projects of this nature. The R4 106 160 inflation adjusted total cost, invested over five years, may seem excessive, considering that only 450 households would benefit. However, this figure amounting to R7177 per household is small, viewed in the light of what the state and other aid funding agencies are spending in their efforts to commercialise small-scale farmers, as well as improve food security at the household level, highlighted in section 5.4.

What would be the motivation for the state to finance an agroecological approach, directed at the household level?

Firstly, the research has shown that the study households, comprising mostly females, were able to implement the cropping system on their own, gaining self-esteem, as well as acquiring knowledge to pass on to future generations. Though only self-reported at this stage, the potential improvement in their households' health because of the diverse diet and increased food security means that over the long term, the state would have lower health care obligations.

Secondly, the impending crisis in high school education, as well as the existing chronic unemployment levels that the research has exposed, requires a local solution. By extending the system, a local solution to these predicaments is possible. From a macro perspective, spending a relatively small amount in the rural areas could possibly check the accelerated urbanization of this segment of our population, with all its associated financial implications for the state. In addition, the present rural communal population, by utilizing their own financial resources for their housing, reduces the financial obligation of the state, in comparison to their urban counterparts, as far as housing is concerned.

Thirdly, the research has shown that after the initial infrastructure capital investment, the provision of the future financial requirements is possible, with the beneficiary households instituting a *stokvel* savings. Again, this would relieve the state of the providing future development funds for the improvement of rural food security.

However, the biggest obstacle to the extension of this agroecological approach is the present paradigm, that the commercialisation of small-scale agriculture, as well as the use of conventional agricultural practices in projects aimed at the household level, are the only interventions that will improve rural household food security.

In order to influence the status quo in the direction of the agroecological approach, we need to promote this research through three channels:

- by hosting visits on the plots from local and other communities
- engaging the state at municipal and DOA level, through presentations, as well as visits to the plots
- utilizing the media in order to spread the concept more widely

6.4 Future research priorities

6.4.1Extension of this study

The relatively short duration of this research did not allow time to provide definitive answers for aspects of the study. These include the rotation lengths for the vegetable planting schedule, as well as the proposed chicken and bird exclusion structure, associated with the vegetable production. The only way to find these answers is to continue the research, possibly over the next two years. This timeframe includes two winters, which was the time that the damage to the vegetables took place (section 4.2.4).

In addition, the present study has shown the potential of the household chicken flocks to provide a valuable addition to the household diets, as well as of the positive agroecological benefits of the oats/vetch winter cover crop to the cropping system. However, determining some method of restraining the chicken flocks, necessary during the planting and early germination period of the oats cover crop, as well as testing the possible contribution of chicken droppings as a manure source, particularly for those households without access to cattle or goats, was not part of the study. Therefore, finding a method of successfully controlling the chickens will possibly provide a solution to the successful incorporation of the winter cover crop, as well as of the provision of chicken droppings (section 4.2.2).

Another question not answered in this study is the success or not of the vacuum packaging of the beans and maize, and the storage box. These methods need further testing over a longer time- period than that offered in the present study (section 4.2.3).

The incorporation of a *stokvel* as a possible future financing mechanism for both the present study households, as well as an element in the extension of the cropping system to more households, is a critical socio-economic intervention emanating from the present study. While I consider both the financial calculations, and the mechanism of a *stokvel* as an appropriate technique for the future financing of the inputs associated with the cropping system to be sound; both these aspects need testing and refinement over the 2013/2014 cropping season (section 5.2.3.2).

6.4.2The development of an agroecological cropping system for small-scale communal area farmers

The agroecological techniques and results presented in this thesis are relevant at rural communal household level. However, these techniques may not be relevant for small-scale farmers in these areas who have access to fields larger than the 0.3 ha maximum plot size in our research. There is a need therefore to follow on with this research and develop a cropping system for these farmers, conforming to the same agroecological principles, but applicable to their larger scale operations. This should be a natural progression, building on the skills and knowledge learnt during the present study, and thereby encouraging the continuing development of the agroecological approach.

6.5 *'imFOLOKO neFOLO'*

Finally, we have coined an onomatopoeic isiZulu translation for the agroecological 'fork and pit' method, namely *'imFOLOKO neFOLO'*.

Could the results of this research possibly be the start of an agroecological movement, and an answer to the call by Lal (2009) for an 'African solution' to the problems confronting rural household food security and communal agriculture?

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Appendix A

Research time line

September 2009:	Request for help with garden plot from staff member
March 2010:	Community field day on pilot project plot
November 2010:	Research proposal for Masters Research accepted
	Sample selection of study households
	Commenced fencing plots
January 2011:	Fencing complete
	Planted first bean crop
March 2011:	Commenced with household diet data collection
June 2011:	Harvested first bean crop
	Start recording household diets with homegrown bean inclusion
	Application of lime to plots
October 2011:	End of bean inclusion in household diets
	Started planting 2011/ 2012 summer crops
	Started with experiments to determine methods to grow vegetable seedlings
April 2012:	Started harvesting beans and butternuts from 2011/2012 season
	Beginning of inclusion of 2011/2012 seasons crops in household diet
August 2012:	Ended household diet data collection
	Chickens destroyed vegetable patches
October 2012:	Started planting 2012/2013 summer crops
April 2013:	Started harvesting beans and butternuts from 2012/2013 season
March 2013:	FGD
September 2013:	FGD
October 2013:	Thesis submission
	Planned start of 2013/2014 summer crop planting

Appendix B.

isiZulu Diet data collection sheet

(Purchased Foodstuffs)

Name.	Group	Week					
Food group Date	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Impuphu							
Stambu							
Rice							
Amadombolo/uJeqe/ amagwinya							
Isinkwa esimhlope							
Isinkwa esiBrown							
Amakhekhe							
Amazambane							
uBhatata							
uBhontshisi							
Inyama ebomvu							
Inyama yenkuku							
Poloni							
uFish							
Amaqanda							
Imana							
Amaveji Amaqabunga							
Impande							
Bhonsthisi/Peas							
Bhathanathi Amathanga/							
Izithelo							
uBisi/amasi							
uSukela							
Amafutha/ Rama							
iTiye/iKhofi /Knorox/isout/							

(Home grown food stuffs)

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
uMbila						
Amazambane						
uBhatata						
uBhontshisi						
Inyama yenkuku						
Amaqanda						
Amaveji Amaqabunga						
Impande						
uBhontshisi/ peas						
Amathanga/ Bhathanathi						