VALUE OF PARTICIPATIVE RESEARCH FOR AGRICULTURAL DEVELOPMENT:

A decade of sustainable amadumbe production using integrated soil fertility strategies in Umbumbulu KwaZulu-Natal

By

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I, Thembisile Charity Mapumulo, declare that:

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Signed: Thembisile Charity Mapumulo [redacted] Date October 2023

Doctoral candidate

"As the candidate's supervisor I agree to the submission of this thesis."

Signed: Prof. JM Green [redacted] Date 11 Dec 2023

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Abstract

Sustainable agriculture provides an attractive alternative in areas where environmental and economic stresses have considerably reduced the cropping of staple crops over the last ten years in the rural smallholder agricultural space. The question arises, then, of how to build resilience with limited locally available resources in commercialising homestead agriculture in a traditional/organic production system whilst maintaining productive soils.

This research uses mixed methodology spanning a decade to explore the potential of stakeholder cooperation with research and development in pursuit of resilient commercial farming as a rural livelihood strategy. An action learning process of participatory engagement validated a unique social engagement in communal space towards agricultural development and continuous sustainable production through visiting and involving five villages in Umbumbulu, namely Ezigeni, Ogagwini, kwaMahleka, Nungwana and kaRwayi (villages E, O, M, N and R). Within this, strengthening market involvement relying on locally available resources was implemented to adapt traditional farming practices that enable sustainable livelihoods through soil biological approaches.

Researcher-managed on-farm experimentation was carried out in all five villages over three years, from 2006 to 2009. These experiments were embedded in participatory field work engaging at various levels that included individual homesteads, collective community level with farmer-field-school, as well as collaboratively with Ezemvelo Farmers Organization (EFO) to enhance the local agronomic practice of taro production in Umbumbulu South of KwaZulu-Natal. A decade later, both the explanatory and embedded designs were used as part of the mixed methods to explore quantitative results further and understand the communication process through which farmers share information to achieve a mutual understanding of the technology without researchers or research project support.

As a result of the experimental trials, emergent best practice solutions were adaptable to the way of life in the community for market-oriented agriculture. Including legumes and mixed cropping systems as part of ecological technology intervention together with locally available organic amendments were likely to result in positive benefits for soil nutrition and crop productivity, thus building resilience and sustainability. Practical best practices whose variability defined a sustainable production system for the successful commercialisation of homestead agriculture were identified. The overall research impact was positively noted by the

continued capacity of the soil to sustain productivity through high yields and maintained soil health and quality.

Survey results revealed that village E showed a systemic integrity by displaying the wisdom of strong leadership, incremental technological integration and learning for sustainability. This highlighted the impact of an intervention prioritising the importance of local resources (knowledge and assets) in developing best technological practices, as well as the value of communalism and social cohesion for the survival of local agronomic norms and traditions while maintaining the productive capacity of soil resources.

The impacts of research stand a good chance of being sustained when a diverse spectrum of agricultural stakeholders, including community gatekeepers, extension and advisory services, researchers, and farmers, are initially engaged as participants to create harmony and ensure a wide range of data collection on R&D, innovations, socio-economic challenges, and changes associated towards sustainable agriculture to discourage a *silo* mentality amongst stakeholders.

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ABBREVIATIONS & ACRONYMS

ARC	Agricultural Research Council
ARD	Agricultural Research for Development
Al	Aluminium
ANOVA	Analysis of Variance
AM	Arbuscular Mycorrhizal
C	Carbon
DARD	Department of Agriculture and Rural Development
DAFF	Department of Agriculture, Forestry and Fisheries
EDX	Energy Dispersive X-ray Microanalysis
EFO	Ezemvelo Farmers Organization
ESEM	Environmental Scanning Electron Microscope
FFS	Farmer Field School
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
JRC	Joint Research Centre
LER	Land Equivalent Ratio
LSD	Least Significant Difference
N	Nitrogen
NO^{-3}	Nitrate
NH^{4+}	Ammonium
NGO	Non-Government Organizations
P	Phosphorus
PAR	Participatory Action Research
PLA	Participatory Learning and Action Research
RCBD	Randomized Complete Block Design
R&D	Research and Development
RDP	Reconstruction Development Project
SANPAD	South African Netherlands Partnership for Alternative Development
SC	Social cohesion
SLF	Sustainable Livelihoods Framework
SSA	Sub-Saharan Africa
UKZN	University of KwaZulu-Natal

CHAPTER ONE: INTRODUCTION

Understanding, protecting, and improving soil health are critical for managing the earth's natural assets since they are fundamentally linked to land productivity and environmental sustainability. The concept of soil health became popular in the 1990's (Doran and Parkin, 1994), emerging from soil quality which was initially met with considerable criticism (Sojka, 1999). More recently, policymakers have embraced the concept, which is exemplified by the distribution of soil health cards given to 100 million farmers in India (Rumpel *et al.*, 2018) and major organisations commencing soil health programs to manage their supply chain in a more sustainable manner (Freidberg, 2020). The inclusion of carbon sequestration in the soil as the main approach by the United Nations Framework Convention on Climate Change (UNFCCC) process to withdraw atmospheric carbon dioxide enhanced the political urgency to implement suitable soil health practices on a global scale (Chabbi *et al.*, 2017). Post the year 2010, there was a rapid adoption of soil health concept that are partly rooted in the flexibility and the ability of different stakeholders to use it in their own ways.

Ladyman et al., (2013) explained that soil is a complex system at the intersection of the atmosphere, lithosphere, hydrosphere and biosphere that is critical to food production and key to sustainability through its support of important societal and ecosystem service. The generosity of soils forms a foundation for human life as it is the most valuable human resource, together with a water supply. Degradation in soil quality and loss of nutrients present within the soil may lead to crop failure and malnutrition, reducing both the quality and quantity of food available to the rapidly growing population. Thus, soil degradation becomes a threat to food security. Hindered by the lack of knowledge and resources together with the recent climate change disasters which have worsened soil conditions, many rural communities are trapped in a vicious land degradation cycle, denying them an opportunity to generate income and overcome the degradation. Degradation in soil quality and loss of nutrients present within the soil may lead to crop failure and malnutrition, reducing the quality and quantity of food available to the rapidly growing population.

Urbanisation is changing how we access our food; populations are becoming more reliant upon markets and supermarket chains, distancing us from production and our impact on the soil (FAO, 2017). When people are disconnected from an issue, they are less likely to care, so there is a need to address this disconnect if change is desired. By having more consumers understand how they connect to the soil and care, they are more likely to lobby for more sustainable

management (McBratney *et al.,* 2017). Developing technologies and delivering them to 'end users' has been ineffective in Africa overall. Despite various government investments, the impact of agricultural research on smallholder farmers has been remarkably limited due to its inappropriateness. Agricultural research produces goods and services for which there is no market. Improving the impact of research is not so much a question of investing in more research but, as Röling (2009) puts it, of developing the farmers' ability to influence it. Since adoption is a voluntary act by farmers, it is their opinions that prevail.

The 68th United Nations (UN) General Assembly declared 2015 the International Year of Soils (IYS). The UN stated that "*soils constitute the foundation for agricultural development, essential ecosystem functions and food security and hence are key to sustaining life on Earth*" (UN General Assembly, 2013).

In this study, the term 'soil fertility' describes the soil's ability to supply plant nutrients. It is also used in a wider sense to cover any soil property that influences plant growth. Nutrient management includes ways to recycle nutrients, replace lost nutrients with external inputs and improve the inherent fertility of soils. For example, it can increase organic matter and the availability of nutrients such as phosphorus (Mabagala and Mng'ong'o, 2022). Methods combining local knowledge, practices and decision-making with scientific approaches (such as participatory technology development) demand research attention to sustain the productive capacity of small-scale farmers' soils. Together, agricultural productivity, food security and livelihoods are impacted by soil fertility and nutrient management. Generally, the low clay and organic matter content of many soils (particularly in Africa) renders this soil inherently infertile. Also, at the national level, soil challenges and potential are over-generalised; meanwhile, their management options are location and situation-specific (Scoones and Toulmin 1999). Key issues include continuous cropping, burning, and overgrazing, leading to loss of organic matter. Thus, soils have a low nutrient status, leaching, and erosion. The type of farming systems also influences management options.

Organic production of taro in a monoculture system, such as that in the study area, increases the demand for external inputs and exerts much pressure on the soil's productive capacity. In a monoculture system, nutrient mining (extracting more nutrients than are returned) is a major factor in impoverishing the soil. The growing demand for organic food and the higher prices it fetches have stimulated an increase in production by these farmers. However, limited quantities of manure used by resource-poor farmers due to scarcity and lack of manure are the primary

cause of low yields experienced in this area (Naramabuye, 2004). Commercialising what homesteads produce also exerts some pressure on each household's production capacity, as most taro is now produced to meet market demands.

Integrated soil fertility management is a biological approach used in this study where locally available amendments and various crops (known legumes and leafy vegetables) are integrated to benefit the soil and the farmer (Stagnari et al., 2017). In many places, labour is generally in short supply, posing a challenge to poor-quality, bulky organic alternatives to mineral fertilisers. Hence, research is needed to investigate labour-saving techniques to overcome this challenge and ease the burden on women who regularly handle these bulky materials.

1.2 MOTIVATION FOR THE STUDY

Previously, standard technology packages failed to help farmers because the top-down manner of delivery was inappropriate, limited creativity, and slowed down problem-solving. Farmers' knowledge and research-based options have been used to help make decisions in this study. Also, as motivation is that soil degradation resulting from decline in soil biological, chemical, and physical quality, thereby reducing the capacity of the soil to support production and environmental functions primarily driven by low application and below optimal management of nutrients, causing nutrient losses (ten Berge et al., 2019). The proposal for this study attempted to establish alternative practices for soil fertility management of an organic production system using biological strategies in commercial (beyond subsistence) homestead farming. Through participation, the researcher engaged farmers in a process of mutual learning where scientific methods and local knowledge (from farmer experiences) of best practices were shared on the organic production of taro and other crops.

The attempt to establish appropriate technologies for organic taro production that responded to market demands motivated the researcher to engage with the community in experiential learning research work aimed at contributing to real-life problems farmers face. In this study, quantitative (field trial measurements) and qualitative (meanings and interpretations of observations and discussions) data were collected, analysed, and interpreted. The *in-situ* field trial is the focus of engagement for all involved (researchers and farmers).

Subsistence farming is mostly practised in Africa, and soil acidity management has received little attention because, in the last century, the focus was mainly on ameliorating commercial productive soils in developed countries (Haynes and Mokolobate, 2001). Land degradation in

the rural areas of KwaZulu-Natal is a serious problem (Hoffman *et al.,* 2001) and contributes to low crop productivity with consequently low and insufficient food supplies. The overall objective of this study was to establish and demonstrate in a participatory way, sustainable organic land use technologies/practices and to improve organic taro crop production. In addition, empowering community members with knowledge and skills to earn viable and profitable livelihoods enhances the researcher's capacity in rural development work by integrating local traditional farming knowledge and practices into the research agenda, benefitting future research work. Regarding the natural resource (soils), the study focused mainly on developing a sustainable strategy for ameliorating chemical degradation, *viz.* acidity and nutrient depletion resulting in poor soil fertility. Basically, this study aims to combine the available technical knowledge of the scientific community with the local technical knowledge of small-scale farmers in addressing the identified major problems of this farming community.

The underlying yield limiting factor in many agricultural areas has been shown to be soil acidity (Frey *et al.,* 1984; Trehan & Wild, 1993; Mokolobate and Haynes, 2003). In acidic soils, aluminium and manganese toxicity are usually major challenges for crop growth and decreased availability of plant nutrients, such as phosphorus and molybdenum, some of which can be leached below the rooting zone (Zhao, 2014). Mara et al., (2019) highlighted the routine use of lime and gypsum in ameliorating soil acidity under intensive agriculture. However, for resource-poor smallholder farmers, the usage of these ameliorants is limited as they are expensive and regularly pose logistic and economic constraints. Haynes and Mokolobate (2001) concluded that many semi-subsistence farmers can use low-cost organic amendments that are available as an alternative.

The adaptation of existing methods, as well as the development of new methods for resource-poor farmers, are critical. The use of kraal manure as the readily available organic material for resource-poor farmers increased soil nutrient status in maise yield (Mokolobate and Haynes, 2003). Residues from grass mulch were shown to have a slow release of nutrients, which suggests that prior application would be best practice to affect the pH positively and benefit the crop during the early stages of growth (Naramabuye, 2004). Of the biological strategies planned in this study, the introduction of a legume in the form of cowpea, regarded as a traditional crop in the area, was implemented. The use of organic amendment (earthworm cast material) and wild mustard (living mulch) as liming materials and to add nutrients, as well as to maintain soil fertility under continuous cropping of *amadumbe* (*Colocasia esculenta*) (L.)

Schott /legume rotations were then planted in the field trial. As a result of retaining and incorporating various organic amendments/mulching materials in the soil, indirect improvement in physical (soil and water) and biological (organic matter) soil conditions is envisaged for soil quality enhancement. This will also help manage the below-ground biodiversity by ensuring that high populations and an abundance of soil-beneficial fauna are important as soil health indicators are present. This is especially important considering that in the decomposition of organic material (amendments), nutrients are recycled by various microbial soil organisms, which in turn will provide a much-needed boost in soil fertility.

1.1 Background

The study took place in Umbumbulu, an area between Durban and Pietermaritzburg. It was selected because of previous interactions with the University of KwaZulu-Natal (UKZN) research team working with farmers to understand factors affecting the commercialisation of homestead farming. The previous research revealed some information gaps that needed attention as farmers clearly stated specific agronomic dynamics of their production system that posed challenges for the productive capacity to meet a growing market demand. Of the various problems stated by farmers, low yield was reported as the main challenge due to poor soil fertility.

Several agronomic studies (Mokolobate and Haynes, 2003; Naramabuye, 2004; Shange, 2004, Phiri, 2005) have been conducted in the area. These studies were descriptive knowledge acquisition using a natural science focus (Leedy and Ormrod, 2005). This research, seeing the amount of data or facts about this farming community, provided an opportunity to learn by filling the information gaps left by previous studies. Since this study is categorised as applied or action research of a participatory nature, it became necessary for the researcher to fully engage in this journey of commercialising homestead production. Over the years, the author worked as the sustainable rural livelihood division researcher and then as a soil health researcher under the Natural Resource and Engineering Institute of the Agricultural Research Council (ARC). Engaging this community was a mutual activity between the researcher's job description and the intended study. The cognitive interest of the researcher in building and enhancing her own capacity for Agricultural Research for Development (ARD) resulted in better resource allocation for the benefit of the study and the organisation. The ARC needed to demonstrate an interest in collaborative (discipline and institution) research with efforts to commercialise small-scale produce. These reasons provided sufficient motive for the researcher to undertake the study and potentially benefit farmers.

At an operational level, this study thus became a joint project between the University of KwaZulu-Natal (UKZN) and the Agricultural Research Council (ARC). It (study) forms part of the participatory action research project funded by the South African Netherlands Partnership for Alternative Development (SANPAD). It views the transformation of homestead agriculture to commercial agriculture through a socio-agronomic dynamic, where local knowledge is used to develop appropriate technologies for soil fertility management and the cultivation of organic crops. Research projects involving smallholder communities are commonly not sustainably adopted or adapted post the research period for various reasons. Thus, it became necessary to assess the sustainability of the capacity built in the EFO community. Hence, the follow-up study was conducted ten (10) years after the initial start of the participative research to identify the sustainability of the process. A period of a decade was optimal to appreciate changes in social behaviour as well as in soil fertility build-up.

1.2 Research Purpose

The study aimed to establish appropriate practices for continuous organic taro production that maintained soil fertility and increased yield. An important aspect of the study was sharing experiences and insights on what was perceived to be best practice (by the farmers based on the market demands) and thus building on it for sustainable production.

1.3 Hypothesis

The study hypothesis is that polyculture has many advantages, but efficient nutrient resource use is major. Taro-cowpea intercropping is beneficial for the yield of both crops, and the addition of earthworm compost (providing readily available nutrients) and the introduction of wild mustard as living mulch will enhance crop performance. Given time, with agronomic best practices implemented continuously, conserve and sustain both the natural resources and livelihoods in a commercially based farming system of homestead produce.

1.4 Study Objectives

These objectives were achieved with the *bi*-lens view of quantitative or experimental trial and qualitative orientation to data collection collected around the following objectives set into different thesis chapters. Quantitative results are not presented in this report but are disseminated through conference papers.

1.4.1 determine the effect (farmer perception) of earthworm cast (vermicompost) and wild mustard living mulch on the yield of taro (*amadumbe*) and cowpea grown in polyculture (intercropping) system *in-situ*

1.4.2 understanding the impact of the research interventions a decade after the research project, determine the effect of formal market loss on commercialisation efforts, i.e., describing determinants of continuity in commercialising homestead agriculture through informal markets

1.4.3 Investigate how the research technologies of adapting traditional agriculture for sustainable commercial purposes impact change in livelihood outcomes through changes in productivity, yields, and food security

1.4.4 To assess the integration of ideas/practices from scientific knowledge with local knowledge-based farming techniques in the formation of appropriate methods

1.5 Method of Engagement (Path to Research)

A field day visit of the combined congress in 2005 exposed the researcher to the area and sparked interest and curiosity about the farming systems and people of Umbumbulu. Based on our visual, auditory, and tactile observations and perceptions, we began the qualitative classification process of people, actions, and responses (Mouton & Stanley,1996). Aspiration for truthful representation propelled the engagement between the researcher and the community to augment the researcher's observations with more reliable and valid measuring instruments. Formal structures in this community existed in the form of a farmer organisation established several years before. Thus, monthly farmer forums were a norm, where the researcher was introduced (by the project leader) to the community. The introduction sparked social interaction to acquire a fair understanding of homestead farming through a process of learning.

Several meetings were held with the community to describe and gradually understand the current production systems. During the first meeting of the following new year (2006), farmers were given exercise books to write in (by the project leader). This was a participatory action research (PAR) tool. Farmers used them to record the challenges faced by their production abilities in commercialising their produce. Two months later the exercise books were returned with a variety of problems facing each homestead. These were translated into English and prompted the UKZN research team to organise a farmer workshop to unpack raised issues.

The farmer workshop (*App i-vii*, 2006) was a platform where major problems with respect to priority enterprises relating to farming in general were identified and prioritised. A detailed definition of these priority problems was generated through analysis and then presented at the workshop. Possible causes (why they exist) were discussed, and possible interactions to solve these problems were recorded. The workshop outcomes were categorised into various disciplines (*App i-vii)* that could intervene and develop solutions together with farmers. A multidisciplinary research team had a post-workshop meeting to clarify and categorise these problems into various disciplines and focuses for their respective studies. Hence, the major soil-related problems were identified as poor soil fertility because of acidity and lack of and/or access to organic fertilisers/amendments and water conservation in soil. Therefore, as the result of the workshop, a diagnostic phase of the study was accomplished through the description, understanding, and analysis of key problems and production systems and possible ideas for solutions by both researcher and farmer together.

Fundamentally, this was the beginning of the research process for all the researchers involved in the new phase of the SANPAD project funding. The farmer workshop results and recommendations from prior research in the area formed the basis for establishing the new research agenda. This resulted in the literature review (agronomic), which helped identify the best practices for intensifying production to address knowledge gaps or uncertainties expressed by farmers and previous researchers.

The technology (practices) and planting materials were then decided upon as they were familiar to the community (farmers decided on the seed material, land, and participants. This decision instilled a sense of ownership of materials and methods through the use of local resources and skills. The introduction of earthworm cast (vermicompost) instead of kraal manure was the only new component in this learning process because the community had the means to adopt or produce this (compost) as an organic amendment and to address the need for manure. The pressure of commercialisation brought about this scarcity. The legume was re-introduced as it was losing its place in local memory and practice to preserve and build on local knowledge. The elements of ownership, experience and reflection affirmed the participatory nature of this study.

Farmers and researchers worked together to plant the trials on farmer-volunteered land using a scientific experimental design. This exercise revealed differences between local practices and what science prescribed in terms of intercropping systems. The process of mutual learning

through sharing by doing had begun for all (researchers and farmers) who are now perceived as united researchers in pursuit of new experiences. During planting, semi-structured interviews were carried out, especially with landowners, individual key informants, and focus group discussions on vermicompost use. Farmers weeded the trials according to local practice and samples and measurements were taken by the researcher at intercrop and main crop harvest. Both qualitative and quantitative data were collected from the farmers and the trial *in situ,* respectively. Samples were taken for analysis, and farmer information synthesised and interpreted.

1.6 Philosophy

The study was based on the philosophy of learning through participation and social interaction, where a research tool in the form of best practices constructed from a literature review and qualitative aspects of farmers' perceptions were used as a theoretical framework. When people are in touch with the wholeness of their existence, that forms a grounding for action research, which will broaden action and deepen research, leading to action research from a systemic perspective. This approach enables people to find effective solutions to everyday problems by constructing meanings that resonate strongly with experiences (Flood, 2010). The unique feature of this study is the participation of those affected by the problem and their potential to be involved in both asking and answering the research questions (Frazer *et al.,* 2003). Sirrine et al., (2008) defined this approach as Participatory Learning and Action Research (PLA). Critical reflection and experiential learning explain the process of PLA by addressing local development challenges. The research agenda was designed to address farmers' interests expressed in the workshop (App A, 2006) in increasing yield to improve soil fertility and moisture retention in an organic system of taro production. The farmers' ownership of the agenda re-affirms the study's participatory nature. The method used in this attempt was a participatory, experiential learning field trial (quantitative) to understand and interpret farmers' perceptions of their best practices used in the crop production cycles. Knowledge was created through reflection, and insights were gained from hearing what farmers were saying.

According to Wellman et al., (2003), the study's exploratory approach had elements of confirmatory aspects considering the field trial design and choice of crops used. Previous research in the area also served as basis for information/knowledge gaps that this study intended to address in this community. Field experiments enabled the researcher to participate with farmers in the learning process and access their local knowledge (for their own capacity

building). Even though the experimental design was scientifically based, it was designed within the community's social, cultural and economic conditions to ensure the participatory nature, transformation and shifting of power for decision-making. The research had control of trial design for planting and harvesting, which enabled a sharing of power, thus allowing the researcher direct learning through the "experience" of the field crop trial and farmers gain skills and regain knowledge, allowing them more flexibility in future decision making.

1.7 Benefits from the Study

The results of this study will add to the agronomic dynamics of constructing a commercialisation model of homestead agriculture. This study is a deliberate output research that fits into the research agenda set by farmers; it is envisaged that it will impact the following:

- Enhanced local economy through sustained market demand
- Better food security and quality of produce for sustainable livelihoods
- Affirm life and diversity of rural communities by having a close match with current and "scientific" practices

Specifically, in those communities of Umbumbulu where the study was implemented, benefits will result in a certain degree of social integration and inclusion that strengthens relationships and creates a sense of solidarity among community members. This commonality is thus viewed as an indication of social cohesion because of the amount of social capital the community had and the combined capacity built. Cloete and Kotze (2009) emphasised that social cohesion benefits stem from the strength of social relations and shared values, sense of belonging (EFO structure), reciprocal loyalty and solidarity, reduction of inequalities and trust among individuals of the community. Long-term prosperity, competitiveness and sustainability are important drivers of social cohesion. The stability of cohesive societies founded over time focuses on economic growth and business development.

1.8 Long-term Research Impact on Community

The primary research entailing experimental trials was initially intended to be carried out over a period of three years in accordance with the SANPAD funding cycle granted at the time. However, due to the reality of the social impact noticed within the Ezemvelo Farmers Organization (EFO) on the preliminary results of the experimental trial, the three-year cycle (2006-2009) was never going to do justice to the hypothesis about polyculture advantages. Also, the level of adoption and adaptation of technologies based on the available local resources to depict real-lived experiences of research results had to be realised. Hence, the need for continuity to observe the change resulting from research impact in the area. Research engagement in this community built and tapped on the inherent assets within EFO farmers to ensure that risk aversion or taking as informed by various constraints was a skill taught to realistically consider suitably best practices based on locally available resources as alternatives to what was currently practised. This was precarious because farming is essentially risky, owing especially to unpredictable factors such as climate and economic change. A longer research engagement period (> 10 years) was necessary to understand the crucial farmer management decision for appropriate extension and development strategies to assist in reducing farmer risks, especially when considering adopting and/or scaling up traditional organic production. Today, many practical lessons learned with the EFO community are practised and implemented in other areas where traditional farming is still a way of life.

In consideration of long-term engagement, implementation required that critical mass capacity building be done gradually and continuously because organic farming is an intense knowledge system. In turn, this will enhance the development of social capital toward practising sustainable agriculture. A collaborative way the participatory trials were implemented led to the belief that as co-creators of knowledge, EFO farmers would gradually adapt their familiar farming techniques to multiple perspectives, leading to new experiences that would shape them and be shaped by agriculture as a way of life. Importantly, though, is that time (seasons) needed to pass for this belief to unfold and be confirmed as true and real. It is natural to anticipate change with time, which also brings about climatic and social risks that may affect various aspects of farming and best practices intended for sustainability. In the research space, uncertainties are equivalent to new research agendas for future enquiries. However, with farmers, these uncertainties are perceived as consequences of time and change that they must live with and adapt to.

1.9 Dissemination of Results

Throughout the study period, the community was informed of the intent and purpose of the study through researcher feedback during monthly farmer forums. The formal dissemination of the study will be the thesis written to complete a PhD degree. The thesis also aims to assist researchers in the natural science discipline in engaging communities and valuing local knowledge. Institutionally, this study will enhance the agricultural research for development capacity for future projects. During the study, at least four papers were presented at local conferences, and a book chapter was accepted for publication. The SANPAD research team intentions of using the study findings are welcomed for dissemination at their discretion.

The thesis is arranged as follows: Chapter 2 unpacks the research philosophy for the whole study in detail. Chapter 3 discusses the importance of local knowledge in an agronomic intervention, presented as a qualitative description. Continuity in commercialising homestead agriculture (a ten-year follow-up study) is discussed in Chapter 4 as a depiction of the envisioned change through sustained commercialisation. Chapter 5 discusses conclusions and recommendations. For additional information on the thesis, data collected and synthesised during the field experiments, additional photography and social change depiction are provided in the appendices section. Also, this thesis did not present the agronomic analysis on quantitative aspects of an intercropping system as an integral strategy for building soil resilience towards sustainable production using integrated soil fertility strategies. Exclusion reasons were that only two of the three planting seasons results were available, and scientifically, three repetitions are considered fair for statistical significance. The study *ethos* was largely on farmer perceptions and experiences of their lived realities. Therefore, inferences of the trial lessons learned from the two seasons became the focus of the study as farmers applied their acquired knowledge from the trial in the continuous market production of *amadumbe* for commercial (beyond subsistence) purposes.

CHAPTER TWO: RESEARCH METHODOLOGY AND PHILOSOPHY

2.1 Introduction

There are three fundamental appraisals that need to be noted regarding rural development approaches. First is the recognition that centrally driven, top-down, autocratic, dictatorial approaches have not been a great success. Second is a re-assessment of the potential and inherent capacity (built-in) within communities to help themselves deal with challenges. Thirdly is the recognition of the sustainability and appropriateness of 'indigenous' skills and expertise in terms of appropriate technology (Tharakan, 2017). Cultural context is locally accepted and largely informed by indigenous knowledge systems that have an incredible amount of sustainable knowledge and technology resource bases. It should be emphasised that in efforts of trying to understand better the dynamics and needs of farmers in rural areas, the government (as informed by research) should realise the great urgency in implementing and strengthening policies leading to empowerment with the use of available human resource (improved livelihoods), promoting rural development and instituting a basis for the ecological utilisation of natural resources.

Noteworthy in this study is the use of old literature, which is deliberate, where the body of work presented responded to literature relevant for that time when the study began in 2006. It is also referenced to emphasise the research participant's responses to the then current available research. It also plays an important role in providing a historical context that depicts a sense of local traditions, culture, and continuity and how the research participants approached their lived reality for livelihood maintenance. In exploring themes of power and resistance based on gender, old literature explicitly shows the sentiment of the time, specifically in rural smallholder farming communities. Booth et al., (2016a) stated that the review of previous studies and the use of old literature situate the relevance of the current study within the UKZN research topic of dynamics of social agronomy in Umbumbulu. The collaborative research agenda for this study was a response to the compilation of several years of research work done in the area (Umbumbulu) by various UKZN students from 2002 (Table 2.1). Existing information gaps resulting from previous studies led to the identification of challenges still faced by farmers then, which demanded that continuity in resolving local production constraints be implemented. Hence, the use of old literature was used to paint a picture of changes and discoveries that occurred in the production of *amadumbe* in Umbumbulu for commercial purposes. Primarily, this approach was to set the context for the title of the study, considering that the nature of agricultural development (soil-based) is slow-paced and thus

requires time for visible progress, especially with the reality of climate change experienced in the past 2 decades (National Science Foundation, 2013). Arguably, others may still re-iterate that there is no fixed timeline for the relevance of old literature in modern times, especially when it has context.

This chapter outlines the research methodologies and processes used to investigate the role of local knowledge in managing agronomic interventions in an organic traditional taro production farming system. This includes facilitating action research among resource-poor farmers for sustainable soil fertility management. The study background, goal, rationale for the research approach, the research approach, methodologies used, and research process are discussed. So, one of the basic tasks of the scientific inquiry in this study was to determine the impact of a polyculture system on taro yield and to understand soil nutrient dynamics better as they affect the fertility of the soil and influence change by improving local practices.

2.2 Background

Farmers of the study area had organised themselves to form a legal entity, The Ezemvelo Farmers Organization (EFO), farmers primarily farming indigenous crops at a household level in a traditional way. Since its establishment (2001), EFO has been marketing traditional crops. Over the years, the need for strong technical support in research and development for the organic production of traditional and indigenous crops had been observed as a way forward for EFO to succeed. In enabling farmer learning, group activities are unquestionable where various information-seeking techniques are used, and agricultural advice from extension officers and researchers is of prime importance. Certainly, visits by an agricultural advisor to individual farms are vastly appreciated and viewed as a powerful and effective communication tool (Baulcombe. 1997). In the pursuit of commercialising homestead crops produced by EFO, a range of multidisciplinary research work has been conducted in the area by the students and researchers of UKZN to benefit the group. Constant changes in legislation, policies, and environmental processes caused by climate change necessitate the specialist support provided by the advisory role in assisting farmers to adapt and transform with change. Converting knowledge to action requires trust in the process of knowledge sharing (Fisher, 2013). Ketterings (2014) noted that the individual trust of farmers and their advisers ensures that farmers are sufficiently confident to adapt and innovate. Trust among farmers within the same group depends on a shared understanding of common objectives to achieve the impact (Aalbers et al., 2013) instead of focusing on holding a competitive edge.

Table 2.1. Relevant Recommendations from Prior Research in Umbumbulu with EFO Farmers

Discovery from knowledge translation	Gaps	Rationale for intervention
Previous studies in the area	Basis for the objectives of the study	Build on recommendations of previous research in the area
Modi, 2003	Baseline investigation of EFO farmer knowledge around indigenous crops and organic farming	In acknowledging local knowledge and interest of farmers in indigenous production systems, an exploration of organic farming to identify competitive indigenous crops and demonstrate their worth in farming should be undertaken.
Naramabuye, 2004	Organic amendments (worm casts) potential to ameliorate acidity and reduce pH. Effect of wild mustard on P level	Cattle kraal manure can ameliorate acid soil infertility by providing nutrients and increasing soil pH and reducing exchangeable and soluble Al. The extent though is still less than what dolomitic lime does in liming efficiency. Addition of grass residues greatly influences soil biochemical and microbial activity progressively over a period of several months, hence prior application of grass residues is advised.
Shange, 2004	Effect of fertiliser on yield of amadumbe	Wetland production yielded better than dryland though dryland were the much-preferred sites due to ease of cultivation. Potential of crop being an organic crop was established as much of it is produced without fertilisation. Effect of fertiliser on yield and soil fertility, plant densities and type of propagule may be investigated
Phiri, 2005	Confirm the hyphal material in the wild mustard (WM) rhizosphere. Also, investigate WM symbiotic mycorrhizal relationship. Based on available funds and preliminary results of confirmed fungal hyphae	Wild mustard can grow all year round (highly recommended for autumn and spring production) to serve as a leafy vegetable for food security. Winter was mainly recommended for seed production of wild mustard. Intercropping offered a greater economic advantage than sole crops only *i.t.o* output value. Polyculture improved the yield of green bean pods.
Mare, 2006	Effect of site (temp) on agronomic performance	A significant amount of traditional knowledge about taro existed, but there is no evidence of knowledge about agronomic aspects of the crop. Four main types of landraces exist in the area. Temperature was found to be an important factor on agronomic performance. Also, confirmed nutritional content of taro as affected by temperature. Site differences were also observed as they had an effect on nutritional value
Ndlovu, 2007	Evaluate farmer dependency on external support	Sustainability issues were of great concern in community gardens and dependency on external support is great. Community networks and platforms for sharing knowledge are strengthened within community gardens engagements
Modi, 2009	Nutritional value of leafy wild vegetables was identified. Hence, inclusion of wild mustard in an intercropping system	Nutritional contribution of wild indigenous vegetables were significant in terms of the traditional socio-economic system. Preparation methods have significant effect on nutrient content. Modified foods have much more nutritional value than traditional and modern foods.
Buthelezi, 2010	Soil fertility management strategy	Established that farmers have deeper understanding of their land and environment based on indigenous knowledge. The soil classification based on use and potential as practised by farmers was also established as its informed choice of crop and field according to the 'expected' general weather conditions.

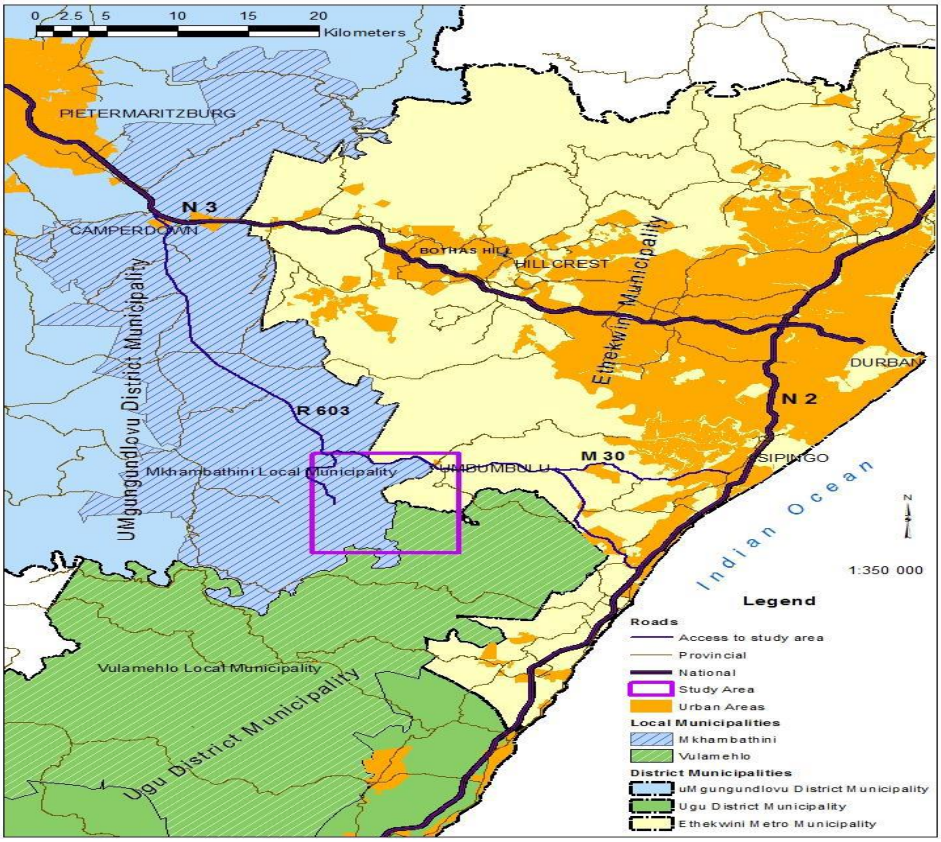
The foundation for this study was embedded in a larger compound (UKZN) research project with an agenda attempting to respond to local farmer needs. This study forms a sequel to previous studies, aiming to integrate locally based agronomic technologies with science-based farming practices to understand the role of local/indigenous knowledge in agriculture. For the 2006-2009 funding cycle, a multidisciplinary team of (UKZN) researchers came together to investigate the various aspects of commercialising homestead production.

Umugulsum et al., (2024) noted that this kind of complexity is way above conventional design of agricultural research and extension government systems. New market entries and forces, combined with demographic pressures and economic growth, have generated the need for development that has an interactive approach. Therefore, It became necessary to search for previous research data and access farmers/homesteads in the (EFO) area to understand the farming system practised by organic taro producers. Smith (2006) described this with stakeholder analysis and diagnostic stages using a systems model that also included the action-research cycle's major phases. With the current challenges that farmers experience, previous studies' literature was used to confirm farmers' concerns and bridge the existing information gap. Without this, it would have been harder to offer sufficient justification for the choice of paradigm and methods.

2.3 Site description

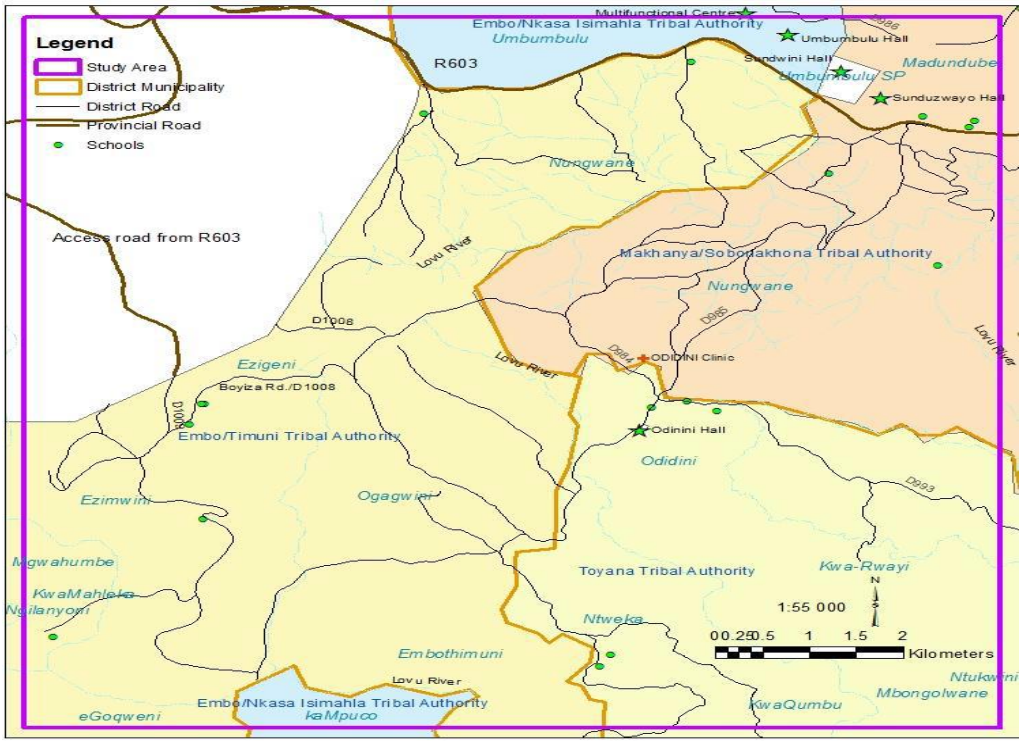
The study area is defined by Latitudes 29°58′30″ and 30°4′45″ South and longitudes 30°36′45″ and 30°43′15″ East; visually south and east from Pietermaritzburg and south and west from the city of Durban. The small town of Umbumbulu marks the closest urban economic hub. It straddles the R603 (Sbu Mkhise Drive) between Camperdown (south and inland, west of Durban) and Isipingo (south of Durban) via the M30.

The area where farmers of the Ezemvelo Farmers Organisation (EFO) live is commonly understood in South Africa as a former homeland area of southern KwaZulu-Natal in Umbumbulu (Map 2.1) under Embo-Thimuni tribal authority (Map 2.2). In understanding rural agricultural livelihoods, it is important to know what local natural resources are available to support and sustain the lives of the people in the area, as well as the knowledge of structures and processes exerting pressure in shaping livelihoods.



Map 2.1. Locality Map of Study Area

The study area is geographically located and described through a livelihood's view of social and agricultural interaction within the context of the environmental system. Except for where otherwise indicated, the information in this chapter synthesises the researcher's subjective observations, participatory experiences, and discussions with informants from field notes recorded between 2006 and July 2019. During this time, the researcher engaged with farmers from all the Ezemvelo Farmers Organisation (EFO) villages. On first impression, Umbumbulu has visual boundaries on the rural landscape. One sees large-scale commercial agriculture (mostly vast, rolling fields of sugar cane) clearly separated from subsistence farming areas, where smaller contoured fields surrounding groups of circular-shaped traditional Zulu homesteads (*rondavels*) form a patchwork effect.



Map 2.2. Map of Study Area

As in many rural areas of South Africa, housing is a mixture of traditional (mud and grass) and modern brick clusters along the main access roads to secure access to infrastructure and services. The study area is mainly agrarian and traditional homesteads with their associated cultivations, fallow fields and grazing lands remain dispersed over the rolling hills (Pictures 2.1 a&b).

Picture 2.1 a & b. Umbumbulu Traditional Farming Homestead (12/12/2007 & 18/05/2018)

2.4 Goal of the Study

Conclusions reached by Adey (2007) were that cultural factors coupled with socio-economic significantly influence soil fertility management regimes at the household level. Also, the knowledge and skills of farmers make a significant contribution to food security in a household. The study aimed to gradually improve and manage soil fertility to sustain economic yields in an organic production system for sustainable taro production whilst understanding local (household and field) farming practices and ongoing decision-making processes. Three sub-problems emanate thereof as follows:

i Due to the commercialisation of homestead produce and the scarcity of manures, how can the new challenge on production capacity be resolved to ensure optimal yield?

ii How can action research methodologies and tools be used to integrate local knowledge and scientific knowledge in an agronomic intervention of soil fertility management towards sustainable production?

iii Given time (at least a decade), will the stage of environmental and social sustainability be achieved? Assessing the impact of farmer capacity in maintaining pillars of sustainability

i.e. evaluate the learning process through technology adaptation and continuous best practice implementation.

2.5 Rationale for Research Approach

Sustainable agriculture often requires different types of agricultural knowledge than the one generated by research organisations. Agriculture is constantly changing and locality-specific in its nature; thus, to achieve sustainability, a diverse and adaptive knowledge base utilising both formal and informal knowledge sources is important (Brodt et al., 2011). In addition, Friis-Hansen (2004) highlighted that farmer knowledge is contextual and cannot be separated from the farmer in the way that they manage their farms, and thus it is impossible *a priori* to describe what makes relevant technology for farmers. Hence, farmer knowledge should be established and modified on the spot collectively by researchers, extension, and farmers as, by its very nature, it is local, complex, and diverse (Brodt et al., 2011). Solutions, therefore, must emerge locally and by farmers themselves. Farmers are system thinkers (Schiere et al., 2004; Sicart, 2021), as they need to think of today's priorities and tomorrow's sustainability. It is important to be mindful of local situations when providing technological solutions, as they very much

depend on local circumstances. The top-down technology transfer paradigm previously employed by extension personnel had become inappropriate in the current context of changing agricultural development to achieve food security (Mtshali, 2002). Ingram and Morris (2007) contended that researchers are best suited to institute mutual relations with farmers as a result of frequent interactions when they implement on-farm trials through meetings and questionnaires on local knowledge that often build long-term relationships as determined by the duration of their studies in the area. Generally, researchers are specifically seen as an unbiased, reliable and dependable source of advice (Eldon, 1988) instead of influencing farmers to undertake new initiatives or conform with government guidelines, as extension officers do. Farmers' values and interests coincide and are best supported by researchers who regard practical farming decisions and expectations. Central to agricultural advisors' relationship and engagement with farmers should be mutual understanding and recognition as co-producers of knowledge generation (Sumane et al., 2018). It is also crucial that researchers already possess in-depth knowledge of farming practices, which places them in an advantageous position to understand farmer's situational context. The mutual nature of the relationship enriches the advisor through knowledge and experience gained in engaging farmers who are decision-makers and risk-takers in agricultural production.; De Felice et al., (2022) agreed that these personal interactions are key to knowledge gained when experiences are shared as it is the best method of communicating sustainable practices knowledge.

Pound (2008) interpreted these experiences as applying the sustainable livelihood analysis framework to show that the complicated nature of resource access reinforces the perception that the design of interventions needs to be part of a process of learning, reflection, and, of course, action. Hagmann et al., (1999) highlighted that practical field work is best achieved through joint learning as it builds farmers' management and problem-solving capacity. With this paradigm shift, farmers are acknowledged as innovators and improved practices providers, not just technology adopters or rejecters (Chambers 1993). Various studies have revealed the capability of farmers to innovate and advance their solutions to problems, thus becoming part of the innovation system instead of just recipients (QUNO 2015). Solutions developed under such situations require a new and more farmer-oriented approach to problem-solving and decision-making. In searching for and implementing new solutions, the social and technical elements become key, and farmers better understand this context (Friis-Hansen 2004). Hence, the awareness efforts (pumpkin fair) and farmer workshop (platform for farmers to vocalise

their needs) held to understand the local situation and set the research agenda were some of the tools/methods used as part of the approach utilised in this study.

Stringer et al., (2020) refer to the EFO type of farmers as needing interventions to increase access to appropriate technology and training, infrastructure, and credit. Explaining that these will mitigate environmental externalities and exposure to market fluctuations and risks. It became clear that a broader paradigm shift should be underway toward greater empowerment of local people, local-level 'bottom-up' planning and low-external input agriculture. Macadam (2000) called the new paradigm 'learning paradigm' following the emerging appreciation of the need to enhance extension clients' capacity to make informed and critical decisions, with an emphasis on empowerment. In the social practice of agricultural production Sulaiman and Hall (2002) consider farmers, researchers and extension professionals to be social actors in the new paradigm instead of regarding agriculture as a technical income-generating activity. With the recognition that farmer's knowledge is contextual and that farmers can be a source of innovations, farmer experimentation has come to play a central role in participatory extension and learning (Hagmann et al., 1999; Sulaiman and Hall 2002; Percy 2005). The role of higher-order experiences, reflection, and dialogue have become relevant in the experiential learning space of development and extension. Percy (2005) emphasised that in helping farmers evaluate their situations, development practitioners should focus on facilitating processes that assist farmers in identifying solutions collectively through experiential learning.

2.6 Combining Multiple Methodologies

Social science literature has a distinct tradition that promotes the use of multiple research methods (e.g., Baskerville and Pries-Heje, 1999; Dick, 2006; Jick, 1979; Mingers, 2000; Yoong and Pauleen, 2004, Wastell, 2001). According to Allen et al., (2000), the term 'action research' can be regarded as an umbrella term that includes several traditions of theory and practice, which was the focus of this study. It is broad enough to include, for instance, soft systems methodology (Checkland, 1989, 1994) and Guba and Lincoln's (1989) fourth-generation evaluation (or participatory monitoring and evaluation). Other terms, including participatory research, action learning, participatory inquiry, collaborative inquiry, action inquiry and cooperative inquiry, are also used in the literature (Smith, 2006). Action research could therefore be defined as a family of research methodologies which pursue action (or change) and research (or understanding) at the same time (Dick, 1997).

Given the nature of action research, the methodological design in this study could not be fully detailed in advance and then rigorously and inflexibly implemented. However, the research design has emerged because of interaction with farmers, meaning it developed progressively and was influenced by the progressive analyses made (Allen, 2000). Smith (2006) noted that one typically initiates such an inquiry with an unstructured problem and that this unstructured problem is developed during the inquiry. Under the action research umbrella, this study used elements of Farmer Field Schools (FFS) at least as the initial strategy. Duveskog (2006) noted that discovery-based exercises are the basis for learning in the FFS. FAO (2016) described FFS as places or institutions encouraging local innovation for sustainable agriculture and building farmer capacity for improved decision-making. This approach as an extension tool is, by its very nature, participatory and based on farmers' choice of discovery methods for production. These field schools are a platform for farmers and trainers to deliberate on observations, apply previous experiences and present new information from outside the community. The outcomes of the gatherings are decisions on what management action to pursue. Thus, as an extension methodology, FFS is a dynamic process organised and practised by farmers to transform their observations to create a more scientific understanding of the crop/livestock agroecosystem. Field schools are an educational approach that enables farmers to make decisions suitable to the actual field situation based on their understanding of agroecological systems and processes. Thus, a field school is a process and not a goal (van den Berg, 2021) intended to create an environment conducive to group learning by using field exercises, critical analysis, and group discussions carried out at regular intervals during an entire production cycle (FAO 2016).

The wide-ranging objectives of FFS are to bring farmers together and collectively collaborate towards an inquiry with the aim of initiating community action in solving local social problems. Also, it will reduce the period to get research results from actual research to adoption in farmers' fields by involving farmer's experimentation early in the technology development process. Increase the proficiency of farmers to make informed decisions on what works best for them based on their own observations of experimental plots in their field schools and explain their reasoning. Regardless of how good researchers and extension officers are, recommendations should be tailored and adapted to local context, for which local expertise and involvement is required that only farmers can supply (Khisa, 2004). The training methodology is based on learning by doing, through discovery and comparison, and a non-hierarchical relationship between the learners and trainers working together in the field (Figure 2.1)**.** The major principles within the FFS process are the production of a healthy crop, to monitor fields

regularly, conserve natural enemies of crop pests and for farmers to know the ecology and become experts in their own fields (Khisa, 2004).

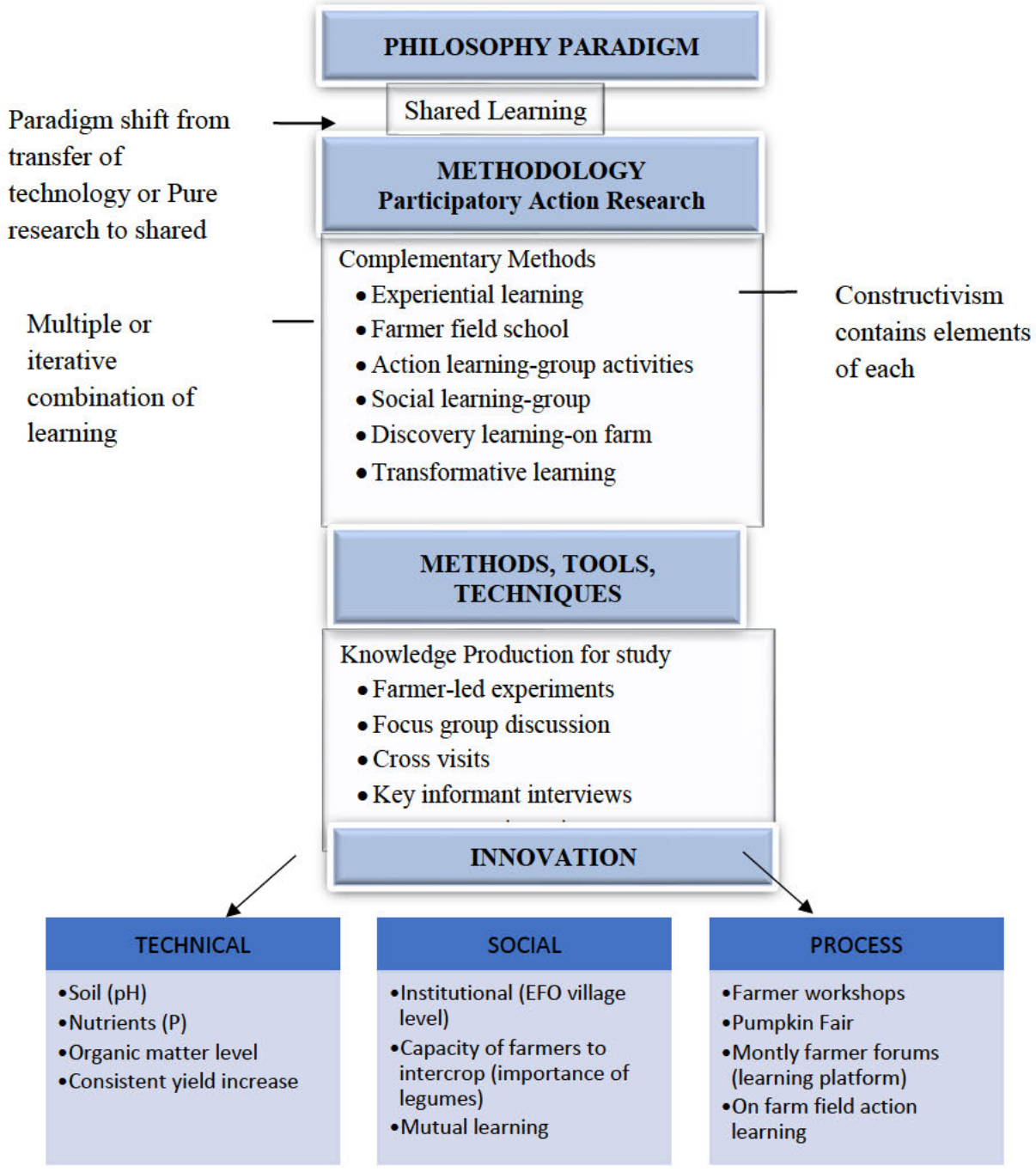


Figure 2.1 Methodological Framework of Original Study at Umbumbulu

Adult education first popularises experiential learning to celebrate and authenticate people's own experiences in their knowledge development (Maestro, 2024). This concept builds on the initial learning theories of Dewey, Lewin and Piaget, which Kolb drew upon to develop a simplified and harmonised learning model. This is commonly referred to as Kolb's learning cycle (Fig 2.2), described as 'experiential learning' based on experience's central role in the learning process (Kolb 1984). The learning links theory and practice through a four-stage cycle; immediate concrete experience (1) is the basis for observation and reflection (2). These observations are assimilated into a theory (3) from which new implications for actions can be deduced (4) (Atherton, 2011). Each learning cycle leads to a new concrete experience, which forms the start of a new learning cycle, thereby increasing the level of complexity and forming a spiral cycle. According to Atherton (2011), the cycle represents two major cognitive growth and learning dimensions: concrete/abstract and active/reflective.

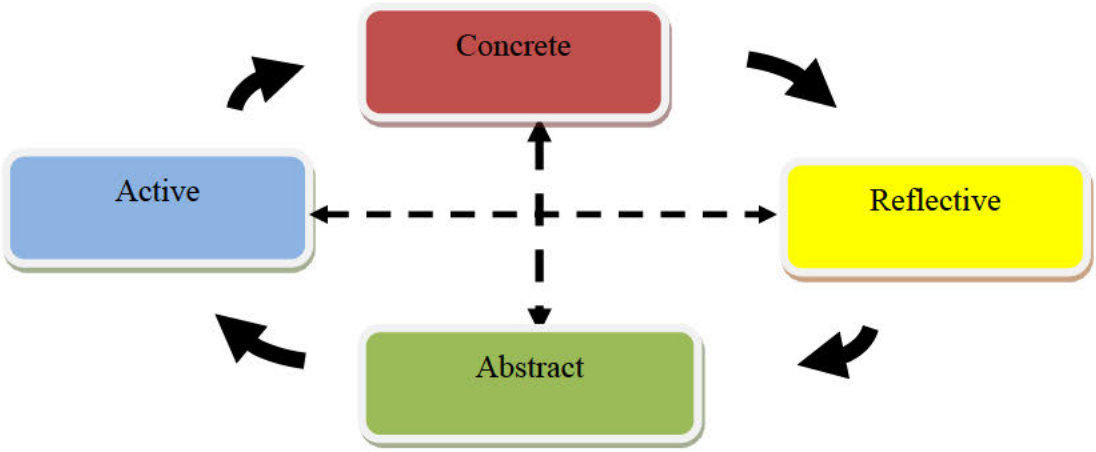


Figure 2.2. Kolb's Learning Cycles (After Atherton, 2011)

In making use of actual real-life situations, the trial, group sessions, practical exercises all facilitated experiential learning as opposed to simulated experiences. All these exercises apply Kolb's learning cycle (Kolb 1984) in the way that farmers use concrete observations to reflect on experiences and, from there, conceptualise the learning points on which actions are defined. However, Fenwick (2001) argues that concrete experience is key in experiential learning, though experience does not have to be real-life experience. In FFS, concrete experiences through actual hands-on activities form the basis of learning. Experience alone does not teach; learning only happens when there is reflective thinking and processing of experiences by the learner (Fenwick 2001). Reflection is usually seen as how experience is turned into learning

(Boud, Keogh et al., 1958 quoted by Duveskog, 2006) and is an integral stage in Kolb's experiential learning cycle, as described above. It facilitates people to make sense of their experiences. The FFS provides a space for people to reflect actively.

Action learning brings experiential learning a step further with its focus on actions as an outcome of the learning process. Action learning operates at a practical or rational level of discourse and is based on the notion that people learn best when working on real-life problems in daily work (Raelin 1997; Dash 1999). The process involves group problem-solving through group sharing, discussion, challenging assumptions, and raising questions with the basic philosophy of learning from each other in a group or organisation rather than being instructed from outside (Dash 1999), thereby encouraging a feeling of 'self-help'. Action research alternates action and critical reflection, or as described by Kemmis and McTaggart, (1988) and Stringer, (2007), using a plan, act, observe and reflect cycle. Theory and practice are integrated (Dick, 2001). Dick (2003) explained that during critical reflection, theory emerges in the form of an understanding of what happened, and how. According to Dick (2003), all action research shares a commitment to both theory development and actual change. The aim [of action research] is to achieve change while developing theoretical understanding. Beilin and Boxelaar (2001) stated that within the emerging participatory approach to agricultural extension, many social researchers adopt an action research approach. Furthermore, action researchers have highlighted the need for social research to be focused on developing practical outcomes. This approach is a reverse response to traditional academic research that emphasises theory development.

According to Baskerville and Wood-Harper (1996), action research is a fine theory discovery method. Dick (2006) stated that action research theorising is associated with reflection. While reflecting on what happened, the action researcher forms assumptions about what occurred and why and then tests these assumptions by acting on them. Stringer (1999), as quoted by Dick (2006), for example, explicitly equates such assumptions with theory. For the most part, no process is given for doing this. One acts and reflects on the action. From the reflection, theory emerges. Beilin and Boxelaar (2001) also argued that this reflexivity is theory-building. They view it as important because 'it builds theory and informs practice'.

Röling (1997) stated that constructivism is increasingly accepted as a description of the way we acquire knowledge, including the way natural scientists develop 'facts'. Guba (1990) stated that, unlike scientific methodologies, constructivist methodologies claim no special status for

a particular way of investigation and rather than impose a general set of methodological principles on all forms of experience, the constructivist will adapt both design and method for investigation to the nature of the phenomenon at hand. Hence, one can be tempted to think that the approach used in this study was constructivist in nature. However, it cannot be ruled out as most of the methods used constitute an element of constructivism. As Hamilton (1995) said, the basis of constructivism assumes that the researcher and the researched object are linked as they interact. The 'findings' are literally created as the investigation and learning process proceeds. Participatory approaches which involve people in constructing their own reality (possibly with the aid of models) and agreeing on their reasons for collective action, promise to be much more powerful. As Guba (1990) put it, to appreciate what is specifically human in mutual experience, the knower must partake in the known. Constructivist methodology sees this participation as obligatory to the acts of discovery and understanding. Without such participation, there can be no truly constructivist or interpretive inquiry."

This form of research strategy is usually described as "one of convergent methodology, multi-methodology, convergent validation or triangulation" (Jick, 1979). Triangulation is broadly defined by Denzin (1978; as quoted by Jick, 1979) as "the combination of methodologies in the study of the same phenomenon". The main intention of combining methodologies is "to add rigour and reliability to the theory development process" (Dick, 2006). According to Jick (1979), the effectiveness of triangulation (combination) rests on the premise that the weaknesses in a single method will be compensated by the counter-balancing strengths of another. It is thus presumed that multiple and independent measures do not share the same weaknesses or potential for bias (Rohner, 1977; as quoted by Jick, 1979). In that respect, the combination [of methodologies] can be very effective. The theory and the theory-building process are made evident and, therefore, more open to challenge. The apparent rigour of the research is enhanced in the eyes of some critics (Dick, 2006).

Raelin (1997) argues that facilitation of action learning and action research requires different and sometimes contradictory skills. In action learning, the facilitator's role is more passive. It resembles that of a mirror to merely reflect conditions so that members can learn for themselves and from each other and make the learner centre of the experience. Action research facilitators, on the other hand, will often need to be more active and probe deeper. Probing deeper into understanding the sustainability pillars of EFO as a community is discussed in the last chapter of this thesis.

To get a feeling of how successful the 2006-2009 research was, it was of concern to determine how sustainable the learning became over a period (10 years). The SANPAD Participatory Project (2006-2009) provided opportunities for participatory knowledge creation and actor learning in a movement towards commercialization of traditional agriculture. In this study, the commercialization of homestead agriculture, specifically *amadumbe* (EFO main crop), was understood as having access to the formal market. It was worth noting that the original study (2006-2009) was meant to provide answers to low yields experienced by EFO farmers due to a lack of access to manure. This challenge was identified as a critical issue towards commercializing homestead produce in an organic traditional farming system. In keeping with local organic practices and farming norms, the study investigated biological strategies towards *amadumbe* yield improvement. Guided by the funding cycle, the study was limited by the funding time frames. Farmer engagement by the author, however, continued beyond the funding cycle to monitor progress on the use of adapted practices in field operations by farmers. In 2010, the SANPAD Project officially ended, and in 2011, the EFO lost the formal organic market. Gradually, many EFO members left the organization and stopped paying their membership fees. The formal monthly forum meetings became informal, with only a few held in a year with dwindling attendance. There were farmer engagements through informal visits to EFO homesteads and occasional attendance at monthly forum meetings by the researcher to hear about the progress made after the project exit. Over the years, through visits to the study site, it was devastating to observe the EFO's disintegration of various institutional structures that were previously efficient in their functionality. The challenges of not having a formal market led many farmers to reduce the size of their production areas. Different EFO villages displayed different behaviours, with 4 out of 5 villages showing signs of being unsustainable. Only Ezigeni village showed consistent sustainability in its production, marketing, and social cohesion patterns. This village showed the evidence of what was initially hypothesised, that in time, agronomic best practices conserve and sustain the productive capacity of the soil resource as well as livelihoods.

Human learning is highly embedded in social interaction, as we acquire new information and form new conceptual representations largely in social contexts. A significant component of human learning lies in the ability to act on and interact with the surrounding environment. Premised on this foundation and the fact that the researcher was already interacting with the farmers in her capacity as an employee for a research council, the mixed method research design became necessary to take advantage of all engagements in the learning process.

Therefore, leading the research design of mixed methods that combined quantitative and qualitative research methods in a single study to gain a more comprehensive understanding (Halcomb and Hickman, 2015) of research interventions in homestead farming. It is common knowledge that each method has its own limitations and shortcomings. Thus, mixed methods were expected to balance quantitative and qualitative research limitations, create robust descriptions and interpretations of data, make quantitative results more understandable, and increase the broad applicability of qualitative results from small samples. The interest in mixed methods research has been enhanced by the growing acceptance of qualitative and social science research, the formation of interdisciplinary research teams, and multilevel approaches to study complex problems (Wasti et al., 2022). Amongst the multiple methods used, the study approach commenced with an in-situ experimental trial in which *amadumbe* were planted in an intercropping system.

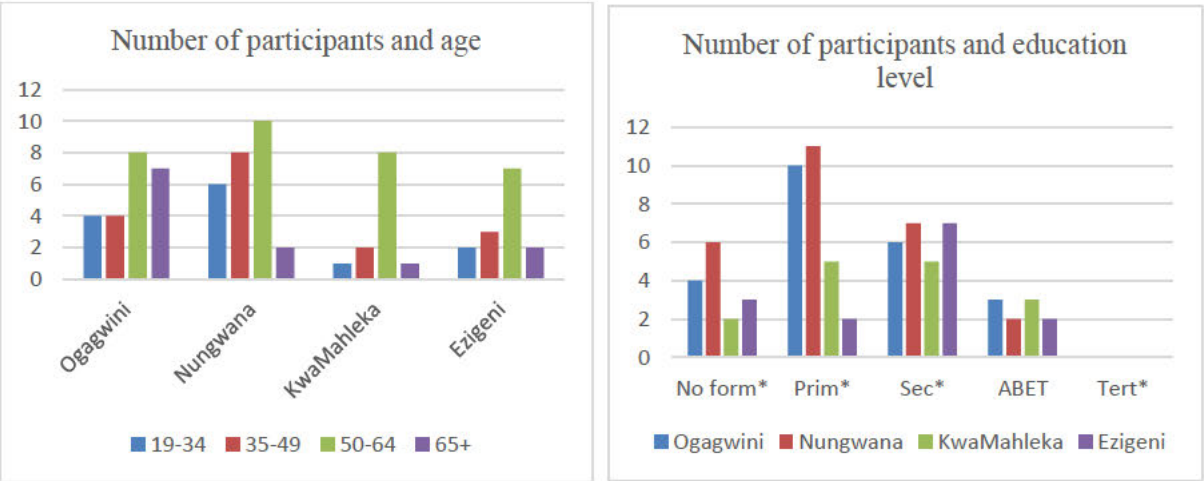
Overall, mixed methods provided multiple perspectives to enhance and enrich the meaning of phenomena research interventions in homestead farming. The rationale behind the use of mixed methods was primarily the expansion of a 3-year quantitative study and the complementarity of methods to achieve a holistic view (Pawson, 2013). The aspect of development as part of the rationale was the use of the implications of the experimental trial to construct the basis for assessing the impact and value of research interventions in livelihoods. Philosophically, a quantitative study (experimental trial) was conducted from a deductive point of view based on a probability interpretation of reality. This belief emphasizes that there is an objective world in which research and discovery are possible (Creswell and Creswell, 2018). On the other hand, qualitative research allowed investigation from an inductive perspective based on interpretive principles. Petty et al., (2012) state that this paradigm acknowledges the possibility of multiple perspectives on reality, knowledge is not value-free, and that subjectivity is a necessary element of investigation. This approach is centered on the interplay of beliefs and actions that are cyclical (Morgan, 2014). Grounded on pragmatism, mixed methods research design employs what works using diverse approaches, prioritizing the importance of the research problem and question and valuing objective and subjective knowledge (Morgan, 2007).

At the beginning of 2018, the study undertook expansion and development as part of the research design philosophy to assess research intervention impact as well as document change. The rationale was to evaluate the implications of experimental trials and construct the foundation to report lessons learned over a decade. The use of the participatory action research approach as a systematic inquiry tool ensured that research participants are members of

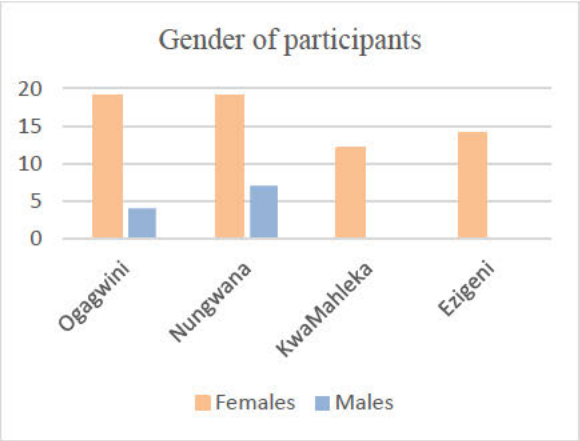
community being studied (EFO) making them co-researchers with their lived experiences considered formative to the research process. This kind of enquiry prioritizes reflection and bridges the gap between theory and practice, focusing on solving specific problems, improving practice, and helping to make decisions (Cohen et al., 2017).

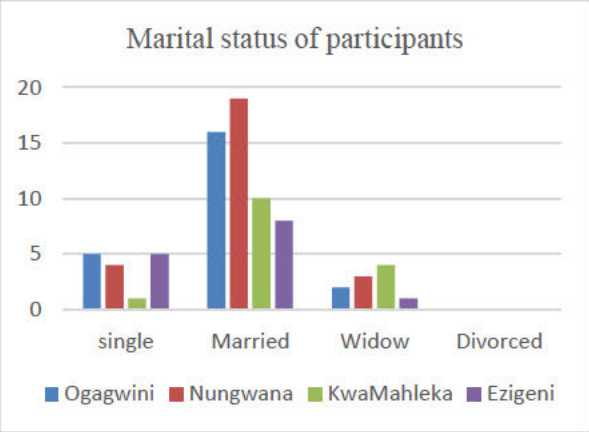
2.7 Sampling and Composition of Participants

From its establishment in 2001, EFO had a membership growth of 54 in 2003 to about 280 in 2009 farmers in Embo's five villages (villages O, E, M, N and R) in Umbumbulu. In 2018, membership dropped to <90 in four of the five villages. Village R was not part of the return study because most arable land had been converted to government housing under the Reconstruction and Development Program (RDP), and many households were no longer planting amadumbe. For the four villages, a key informant in each section was the one who organised all the other farmers. As a result, a total of 78 farmers were available for engagement in the respective villages (*App A & B*). All farmers who participated in the return study were considered to give reliable information pertaining to the study since they have been EFO members since 2006. It was noted that the composition of participants and EFO in general is dominated by adults (>35 years) in all villages (Graph 2.1). As expected in many rural smallholder settings, women are in large numbers as they dominate farmer groups and, in this study, comprise 86% relative to the 14% representing men. In their dominance, women are generally married, and there is no culture of divorce in this community, as none were reported to have occurred (Graph 2.2b).



Graph 2.1. EFO Age and Educational Representation Across Villages





Graph 2.2. EFO Gender Distribution and Marital Status Within Villages

2.8 Data collection and analysis

In this mixed method study, integration refers to the use of results from one data collection to guide or build another data collection as a strategy to implement specific activities. Particularly, the research trial was developed using findings from the initial EFO workshop (2006), which was qualitative data previously gathered to provide the hypotheses or identify constructs or language used by study participants (Jafer et al., 2021). In collecting data, several visits were made to all villages, including a few formal group discussions per village. Data collected from all engagements with EFO farmers were qualitative and quantitative (App C & D). Observations of objects were a quick and efficient method of gaining preliminary knowledge or preliminary assessment of field state or condition (Walliman 2011). The very first primary data collected was during the 2006 farmer workshop (Fig 2.1) and it formed the basis for the research agenda. Secondary data was sourced from previous studies in the area.

Semi-structured face-to-face in-depth interviews were used to obtain further clarity through probing open-ended type questions with key informants and typical EFO farmers in their own spaces at home (picture 2.2) and in the field where taro is planted.

Picture 2.2. Key Informants Face-to-face Interviews with Open-ended Type of Questions

The researcher used Participatory Learning and Action Research approaches explained by critical reflection and experiential learning. Tools such as workshop (open questions in a meeting) experimental trial results, focus group discussion, semi-structured, open-ended questions and interview guides, surveys, questionnaires, in-depth interviews, and field observations (Fig 2.3) were employed to understand individual experiences, participant involvement in interventions and committee members as village facilitators. A survey questionnaire was used with participants of a focus group of EFO members to concentrate on the detail of intercropping as a specific theme of their production system. This method was found to be flexible, cheap, and quick to administer to larger groups (up to 16 farmers) in different villages and lasted up to 2 hours for a group. In these focus group discussions, questionnaires were personally used by the researcher for better results (van Niekerk 2002) as well as to ensure that farmers could be assisted to overcome difficulties with the questions, influenced and reminded to ensure a high response rate. The open-ended questions allowed farmers the freedom to express their opinions and qualify their responses (Walliman 2011). The authenticity of the accounts was cross-checked with other farmers to attain a higher degree of validity and reliability. Jafer et al., (2021) explained this as triangulation, where various methods are used to collect information on the same issue so that the strength of one method could overcome deficiencies of another method. The use of secondary data from various sources, such as documents and statistics, to support views or arguments (Scott, 2006) constitutes a document research method. It should be noted that secondary sources of data and information can be published or unpublished and can be historical or contemporary (Laws et

al., 2003). The triangulation of data and information can be achieved if secondary data is used in conjunction with other types of data.

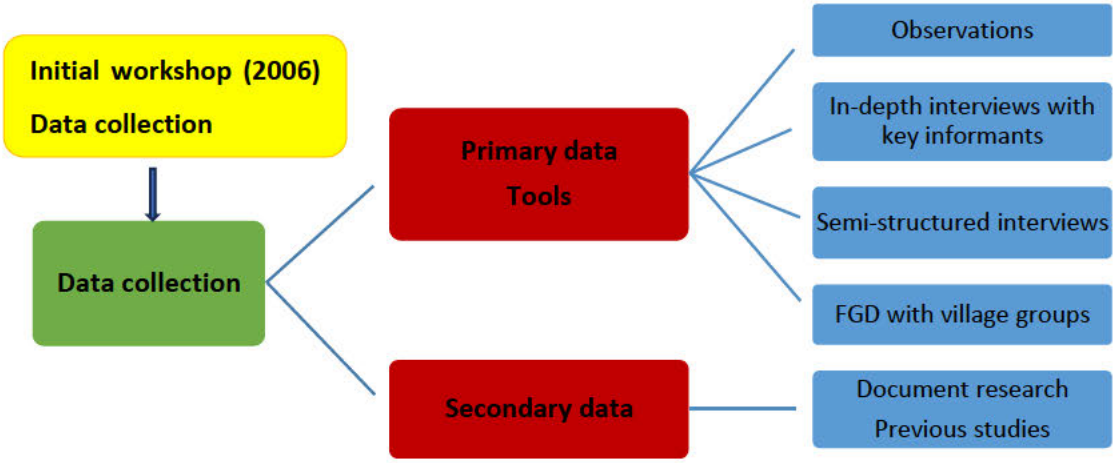


Figure 2.3. Integration process strategy in collecting data for the Return Study (*App C, E &F*)

For the four EFO villages, a total of three field trips per group were made between May and October 2018. Responses were categorised according to similarities; then, a theme was developed from all similar responses. From these themes, relationships and associations were identified to make sense of these relationships. In analysing content, a process of selecting categories of data was the starting point. Sentences (content) with similar meanings were grouped together to form a category that was accurate, exhaustive, mutually exclusive, and clearly defined (de Vos 1998).

CHAPTER THREE: THE IMPORTANCE OF LOCAL KNOWLEDGE IN AN AGRONOMIC INTERVENTION: A QUALITATIVE DESCRIPTION

3.1 Introduction

It is unquestionable that local knowledge systems as a resource are critical and valuable in the management of many ecosystems, including drylands. Rapid changes to biophysical and socio-economic environments are causing the loss or erosion of local or traditional management approaches previously used. Primarily these changes are driven by urbanisation and globalisation processes, which outrun evolutionary adaptive capacity. In dryland (rain-fed) land-use systems, local agricultural knowledge is focussed on the environmental protection, use and optimisation of soil moisture and soil organic matter (IIRR, 2002). The recycling of agricultural residues in various ways has always been an age-old practice to manage soil fertility, which ensured that nutritional shortages in the soil are avoided. Shang et al., (2014) explained that reduced yields are a result of declined productivity is a major constraint due to low soil fertility. Also, dryland farming has become uneconomical because of the rising cost of external production inputs. Efficient use of locally available biophysical and human resources provides a basic solution. Reduction of external inputs and regeneration of local resources thus becomes key (Schreefel et al., 2020). Local knowledge ensures that farming uses soil conservation as the entry point to regenerate and contribute to multiple provisioning and supporting services, with the objective to enhance not only the environmental but also the social and economic dimensions of sustainable food production. Additionally, ecosystem resilience can be achieved through careful management of biodiversity nurtured to interface with hydrological and nutrient cycling to provide food security and risk minimisation.

Research and development support for diversified, innovative systems have been neglected in recent decades due to the focus on agricultural productivity, specialisation, and markets, disregarding externalities and adaptive management strategies (Koohafkan and Boerma, 2006). Pressures are constraining farmer innovation and leading to the implementation of unsustainable practices, overexploitation of resources and declining productivity, as well as agricultural specialisation and adoption of exotic domesticated species. Loss of biodiversity and ecosystem degradation leads to consequential loss of human livelihoods. Society is generally at risk of losing knowledge systems and cultures that ensure healthy, resilient environments and the associated biodiversity. Primarily, it is because farmers believe it is irrelevant to dwell upon the limits of applicability of local knowledge systems versus scientific knowledge.

Working for a research organization for more than a decade, the researcher has seen technologies designed for smallholder farmers for implementation in all areas without consideration of local circumstances or ease of adoption. This mistaken assumption has resulted in best practice technologies not being adopted by end users because their respective immediate environment was not factored in during the design. This study has thus identified a lack of an effective research approach for tackling complex problems of adapting available technology to highly diverse conditions of smallholder farmers. This has led to the non-adoption of scientifically approved technologies. Urgently and interesting is how to develop approaches that effectively integrate the comparative strengths of both types of knowledge systems. Therefore, in trying to highlight the importance of local knowledge, this chapter lays a foundation in implementing field trials integrating science with local knowledge. The chapter seeks to acknowledge local knowledge as the basis for scientific intervention. It also sets out to find answers to three specific questions:

i. What comprises local or traditional knowledge in the context of organic amadumbe production in the Umbumbulu area?

ii. How can the theory of scientific knowledge be merged with local traditional knowledge to strengthen sustainable agricultural practices and farmers' knowledge systems?

iii. What are the principles (intervention steps) for an approach to safeguard traditional management systems for the sustainable use of drylands?

3.2 Review of Literature

3.2.1 Definition of Local Knowledge

Dynamic and changing, local knowledge is the knowledge developed over time by people in a given community and continues to develop. It is based on experience, often tried over centuries of use, modified to the local culture and environment, and rooted in community practices, institutions, relationships and rituals. Local knowledge is usually held by communities or individuals. Warburton and Martin (1999) defined local knowledge **a**s a gathering of facts and relates to the entire system of concepts, beliefs, and insights that people hold about the world around them. How people observe and measure their surroundings, as well as solve problems and validate new information (Crevello, 2004). It includes the processes whereby knowledge is created, stored, applied and transmitted to others. The notion of traditional knowledge is perceived as static and not interactive with other knowledge systems, as though rural folks are separated from the rest of the world. Rural people are associated with indigenous knowledge

systems, which is limiting for policies, projects and programmes seeking to work with farmers in general. Moreover, ethnic and political connotations with backwardness are related to the phrase indigenous in some countries (Warburton and Martin, 1999).

Confined to tribal groups local knowledge, not to the original inhabitants of an area as well. It is not even confined to rural people. Instead, all communities, regardless of their location, possess local knowledge. The term local knowledge seems least biased in terms of its contents or origin. Holding a larger body of knowledge systems includes those classified as traditional and indigenous. Knowledge systems are always changing, people adapt to changes in their environment absorb and assimilate ideas from a variety of sources (Warburton and Martin, 1999). However, knowledge and access to knowledge are not evenly distributed throughout communities. People have diverse intentions, interests, perceptions, beliefs and access to information and resources. Linked to access and control over power, knowledge is created and transmitted through interactions within specific social and agro-ecological contexts. Diverse social status can affect perceptions, access to knowledge and, crucially, the importance and reliability attached to what someone knows (FAO, 2005). Frequently ignored is the knowledge possessed by the rural poor, specifically women.

Prakash (2001) states that "Traditional knowledge systems are frameworks for continuing creativity and innovation in most fields of technology, ranging from traditional medicinal plants and agricultural practices to music". As the source of survival strategies, traditional knowledge systems rest on the social capital being key. Rooted in tradition, traditional knowledge is also contemporary knowledge, defined by its inherently dynamic nature. It is constantly evolving as individual and community responses to the challenges posed by their environment. Adedipe *et al.,* (2004) concurs with the previous explanations in saying that indigenous knowledge is a critical and substantial aspect of the culture and technology of any society. It is sometimes referred to as folk knowledge or traditional knowledge, among others. Indigenous knowledge is the systematic body of knowledge acquired by local people through the accumulation of experiences, informal experiments and the development of an intimate understanding of the environment of a given culture. Although indigenous knowledge has, for a long time, been frowned upon by Western oriented scientists, the positive role which the application of Indigenous Knowledge Systems (IKS) can play in engendering sustainable development in developing countries has been gradually realized. Modern approaches to agricultural development will continue to fail unless they take into consideration a society's indigenous skills and knowledge systems (Rajasekaran, 1993).

Larson (1998) discovered the value that indigenous communities place on an indigenous knowledge system (IKS). Expressing that both the Tonga and Kalanga people of Zimbabwe valued IKS as a knowledge base for determining food production and labour division between gender and age groups, as well as as part of community survival. The study recommended that IKS should complement rather than compete with Western knowledge systems in the implementation of projects. The lesson for development agencies should be to investigate first what indigenous people know and have, then develop and improve upon indigenous technologies. In cases where people are establishing their historical ties to land and territory, like in the case of many indigenous peoples, when rights to natural resources and benefit sharing mechanisms must be put in place, or for when cultural groups are going through a collective process of strengthening their cultural identities, the concept of traditional knowledge is one of the key tools.

However, for the practical management of ecosystems and for the problems those farmers face in providing for their livelihoods, the distinction is often immaterial and, in many cases, counterproductive, particularly in cases where changes outrun the adaptive capacity of traditional knowledge systems and when there is no viable alternative. What counts for a farmer is that the technology or management intervention offers a good solution from his or her point of view, which is, almost by definition, the whole interdisciplinary context that the actor operates in. Whether a solution is traditional or scientific is irrelevant for the farmer. The point is that it works. Additionally, in practice, it is very difficult to establish where one system begins and the other ends. Over history, all knowledge systems have incorporated elements of other knowledge systems, transformed them and given them new meaning. Thus, giving special considerations to attributes of indigenous knowledge built into the traditional practices to have sound technological base for future improvements needed for overcoming the often-unpredicted food crisis prevalent in sub-Saharan Africa (Ogbonna, 2019). A successfully adopted technology can quickly become part of the local knowledge system. In the locality, it will acquire new meaning and application and will most certainly be adapted.

Over the years, the non-adoption of technologies and the inefficiencies of various rural development service providers' participation demonstrated that traditional knowledge was more likely to be beneficial to local economic growth if it were maintained within the community itself rather than promoted by detached organizations. Ultimately, educating each new generation in the community on its traditional knowledge can optimize the potential for this knowledge to contribute to development solutions. Several studies (Schulz et al., 2014;

Creissen et al., 2021; Verburg et al., 2022) pointed out that from the viewpoint of a farmer, a new technology is said to be sustainable if it passes the acid tests of:

(a) technical feasibility within the current/ potential absorptive capacity of the farmer

(b) being relatively less risk-prone

(c) economically profitable

(d) socially acceptable

(e) environmentally friendly

An ideal technology for farmers would naturally be one that, from their standpoint, combines all these virtues to the greatest extent possible. The weight given by farmers to these characteristics would vary according to their resource endowment, social conditions and family priorities. Hence, no single technology would be perfectly suitable and acceptable to every farmer, even within a region or a locality. However, it can be safely concluded that nearly ideal "new" technologies are likely to be those which are a refinement of the technologies already being followed by or familiar to the farm-household and for which additional preconditions of adoption (input supply, marketing, and others) are assured (Bonke and Musshoff, 2022). Development of such technologies requires learning from farmers, analysing the reasons for their present practices, building upon their local knowledge, finding their constraints, cooperating with them, fostering their innovative potential, and carefully assessing their absorptive capacity (Cafaro and Cavallo, 2019).

Previously, Waters-Bayer and Bayer (2009) noted a tendency to regard IK as something traditional and static rather than to see IK 'on the move': how it is changing, how resource users are trying to adapt to change, and how they are innovating. However, the value of Indigenous Knowledge (IK) is now widely acknowledged in scientific circles, and studies of IK have led to a better understanding of local practices in agriculture and natural resource management. Scientists have generally overlooked changes brought about by local experimentation and innovation. Local innovation is the process through which individuals or groups discover or develop new and better ways of managing available resources to suit their conditions. The local innovations (the outcomes) of this process may be technical or socio-institutional. Innovation reflects the dynamics of creating and applying new knowledge. It includes modifying or adapting existing knowledge, be it endogenous or externally conceived. Local innovations are new to a particular locality, and encompass both endogenous (home-

grown) initiatives and local adaptations of exogenous ideas, i.e. of 'interventions' introduced from outside. Local innovations include practices that new outsiders coming into the area might initially regard as 'traditional'. However, an examination of agricultural history reveals that they have been developed in recent decades, sometimes only a few years ago. Local innovation through informal experimentation has always taken place worldwide, but only in the last decade has increased attention been given to identifying and documenting the innovation processes and the innovations with a view to enhancing farmer-led multi-stakeholder innovation processes (Sanginga *et al.*, 2009). The anchor of the African Renaissance as moral renewal through positive African values is the revitalization of the economies, preservation of the ecosystem, reconciliation, social cohesion, and nation-building (Teffo, 2019).

Dialla (1994) remarked that the knowledge reflected in traditional conservation practices is the product of life-long experience in managing natural resources and that these practices should be supplemented and improved rather than replaced by modern technology. Regardless of the degree to which modernity and modernism are embraced, people would continue to prefer and use certain knowledge which belongs to them in time and space, as they deem them suitable for purposes (Kolawole, 2001). Culture lag exists when changes in non-material culture (ideas and social arrangement) and always lag material culture (technology and invention). Changes in attitudes, values, beliefs and social organization, which invariably cannot match up with the rate of change in technology and inventions, encourage sluggish responses to the use of foreign technology and inventions. Adams et al., (2021) said cultural lag can be found in the introduction of improved technologies in agriculture and the institutional adjustment needed to popularize the adoption of the technologies.

3.2.2 Farmer's Knowledge about Crops

In South Africa, many rural communities do not consume adequate amounts of traditional vegetables to meet their daily requirement of vitamins, minerals, and proteins. Even what is consumed has a large proportion of these nutrients destroyed or lost during preparation and cooking. Modi (2005) found that in rural KwaZulu Natal, people still largely use traditional food (68% of 1200 respondents). His study revealed that preparation methods have a significant effect on the mineral content of traditional, modern, and modified foods. The study further explained that since the major source of sodium in food is table salt, it was deduced that traditional food preparations involved higher levels of table salt compared with modern and modified food preparation. In conclusion, the study reported that modified foods had higher nutrient contents than traditional and modern foods (Modi, 2005). Hence, the promotion of

modified recipes that contain nutritious traditional ingredients to raise awareness and nutritional benefits, especially for the youth (who are less interested in any indigenous/traditional aspect of rural lifestyle), was recommended. Some examples of such modifications are substituting conventional vegetables with wild vegetables (*amaranthus* and wild mustard), using *amadumbe* as pizza toppings and wild edible vegetables when baking various cakes are to be encouraged.

The commercialization of agriculture has displaced many indigenous crops that used to ensure a balanced rural diet. The homestead gardens that are meant to have traditional vegetables in the rural setting are characterized by intercropping systems of a variety of exotic vegetables (Maseko et al., 2018). In many developing countries where these gardens predominate, the contribution of traditional vegetable gardening as a food production strategy has been overlooked by policymakers and extension staff in favour of exotic vegetables, which are mainly produced for commercial purposes (Mathaba, 2017). Unfortunately, resource-poor households do not benefit from the remarkable increase in the commercial production of exotic vegetables due to the costly inputs of agricultural chemicals needed for their successful production. Traditional vegetables play a major role in achieving food security, especially in rural areas where there are lower incomes and larger families. They could provide households with alternative sources of micronutrients high antioxidant activity; therefore health and nutrition of the household will be improved (Sithole et al., 2011). Therefore, it was extremely important for this study to ensure the re-introduction of traditional vegetables (wild mustard and cowpea leaves) and their production strategies to directly enable the poorest of the poor to produce taro (amadumbe) and traditional vegetables.

3.2.3 Analysis of Information to Inform Experimental Protocol

Qualitative information gathered in this study was used to inform the planning and learning of the crop trial protocol and to increase the insight of the research participants (researcher and farmers). Information from Field Notes (FN13/03/2009) were used to reflect on and as the researcher's record of what activities and decisions were happening in the environment around the crop trial. The information from the intercropping questionnaire was tabulated and can be seen in *Appendix* ii at the end of this thesis. This information is reflected on in the discussion section.

3.2.4 The Plan: Field Trial Protocol

On-farm trials were planted in Umbumbulu and on-station at the University farm (Ukulinga) for the duration of the study. In the previous chapter, Table 2.1 summarizes the objectives and recommendations of prior research in the study area. The intervention outlined in Table 3.1 explains the use of an intercropping system held over two planting seasons, integrating a scientific investigation with a participatory engagement. The participatory strategy for each phase arose from the discussion and lessons learned from previous interactions. Prior research in Umbumbulu had shown that wild mustard has hyphal material in the rhizosphere with the potential of mycorrhizal relationship for phosphorous addition to the soil and that further research was needed on soil fertility and knowledge about soil management practices. During the workshop in 2006, farmers raised the issue that the commercialisation of taro had led to challenges with access and sufficient quantities of manure to sustain production. They were also interested in looking for alternatives. Advantages associated with the intercropping system are well documented (Odurukwe et al., 1996; Muoneke and Asiegbu, 1997; Kantor, 1999 and Ibeawuchi et al., 2007) as an appropriate soil management system adaptable and flexible enough to address crop and fertility issues in homestead agriculture.

For these reasons, the intervention was designed as an intercropping trial. The first season focussed on awareness and inclusion of a wide group of farmers, placing trials across all six EFO wards. Each trial in this phase used the farmers' preferred choice of amadumbe cultivar, intercropped with wild mustard, which was locally known and cowpea that were re-introduced. Cowpea is grown in various regions of KwaZulu-Natal. However, in this community it has lost its place in the cropping patterns due to the preferred use of dry beans. Earthworm casts, or vermicompost were introduced to assess its potential as an alternative for manure. In the second season, a commercial organic fertilizer replaced the vermicompost as a source of manure, and the number of trial sites was reduced to work with farmers interested in experimentation with fertility management. In the third year, researchers used follow-up visits and discussions to understand how farmers were using their new knowledge.

Table 3.1. Using experiential field trial to blend local knowledge with science for an agronomic intervention.

Discovery process with farmers	Direction for interventions arising from discovery process	Rationale for intervention	Plan for intervention
Farmers research agenda (Participatory Workshop Results, Caister 2006) - Declining soil fertility - Low levels of soil moisture - Quantity of manure under pressure (market production) - Increasing demand for manure - Efforts to weed - Interest in other crops	Addresses fundamental concerns Aim is to achieve optimum use of resources and integrate farmer knowledge with alternatives for sustainable growth in amadumbe production.	Utilizes research recommendations from prior local research (Table 4.4) - Re-introduction of indigenous crops (Modi 2003) - Alternative green leafy veggie (wild mustard) (Phiri, 2005) - Nutrient deficiencies, use of organic amendments and soil fertility (Naramabuye, 2004) Recommendations from other research • Use of legume (cow pea) for more efficient nitrogen fixation in intercropping systems (Smith et al., 2004)	Season 1 Intercropping trial: Evaluate impact of earthworm casts on taro intercropped with cowpeas and wild mustard. Total of 6 sites to distribute knowledge to all areas of EFO's reach, as well as agronomic performance as affected by site i.e. site differences
Own data (questionnaire, survey and observations) Intercropping questionnaire (*App*?) and Soil survey data (*App*?) - farmers are familiar with intercropping but very wide range of use and details; lots of information (management practices) discussed during weeding events; effort to plant and manage the crop	Sharing of local knowledge Participatory (farmers and researchers) approach emphasises working with individuals and homesteads	Build on local knowledge This study wanted to demonstrate efficient use of resources *i.t.o.* - - land (space), light, nutrients, and water - - cost of inputs and labour - Create an opportunity for skills development.	Season 2 Polyculture trial: Evaluate organic manure and investigate mycorrhizae. Also, assess biological soil fertility management strategy for yield improvement
Observation of farmers' production choices following the intervention and drawing conclusions Understanding of Local impact of exposure to: Crop rotation, Animal manures, Tillage/ resting (fallow), Buffers, Natural/organic pesticides, Soil types, use and management	Exploring lessons learned and understanding influence of intervention		Season 3 Evaluate aspects of trials adopted and adapted knowledge sharing platform and dependency to external support. Farmer researcher learning improves confidence and understanding of organic farming.

3.3 Planting Materials

Taro is mainly a KwaZulu-Natal coast and hinterland traditional crop (Modi, 2004), hence the Zulu name *amadumbe*. The crop is also cultivated in the subtropical and tropical parts of Mpumalanga and Limpopo provinces. Taro is an important staple crop in the subtropical coastal areas of South Africa, starting at Bizana district in the Eastern Cape and the rest of coastal KwaZulu-Natal. Shange (2004) reported that most taro production in South Africa is consumed as subsistence food on farms. A small proportion finds its way to the market and mainly by Umbumbulu farmers (Modi, 2004). Locally used taro [*Colocasia esculenta* (L.) Schott] planting material was donated by farmers in the form of corms for all trials for the duration of the study. Various local landraces of taro are available and planted for different reasons. *Dumbe-dumbe* and *Mgingqeni* were cited as the top two best types for income generation and cultural activities (Mare, 2006). Hence, these were the two landraces used in this study for both on-farm and on-station trials. Cowpea [*Vigna unguiculata* (L.) Walp] cultivar PAN 311 was purchased from a local seed company, Panaar. Wild mustard seeds [*Brassica juncea* (L.) Czern. & Coss] collected from crop fields at Msinga, near Tugela Ferry, KwaZulu Natal, were tested in a previous study by Phiri (2005). This study (also done at Umbumbulu) showed that wild mustard intercrop offered greater economic advantage than growing a sole crop, especially during autumn and spring. As part of planted treatments: Wild mustard was planted as living mulch between taro crop rows at 50% planting density of the crop-stand. Vermicompost earthworm cast of (*Eisenia fetida*) from Wizzard worms farm in Rietvlei, Mooi River, KwaZulu-Natal were applied at 2.5kg/m^2.

3.4 Results and Discussions

3.4.1 Crops and Planting in Umbumbulu

Table 3.2 shows evidence of field husbandry of a taro crop based on local knowledge and how it evolved because of learning process during research crop trials planted in farmers' fields with farmers and managed by farmers over the duration (2006-2009) of the study. Participatory assessments revealed that farmers' management activities were not specifically strict in terms of time (when they were performed) since the activities are dependent on resources available to execute activities.

Table 3.2. Evidence of attitudes and behavioural change (experiential learning) synthesized from various farmer engagements [informal individual and group discussions by the researcher with farmers; (FN27/02/2009; 13/03/2009; 17/04/2009)

Local practice	**Method of doing**	**Fertilizer addition**	**Adaptation/Integration**
Intercropping of maize and pumpkins	Random, no specific row for each crop	Broadcasting of kraal manure and placement of different seeds together	Maize intercropped with beans systematically in rows *Amadumbe* intercropped with beans in formal rows & harvested before first weeding thus no interference of the two crops
Systemic planting of *amadumbe* in rows following land preparation and furrow opening	Large spacing both intra(within) and inter (between)	Planting hole placement of two handfuls	Less spacing to discourage weeds, high plant population and correct (small & medium) sizes required by market (recent market dynamics *i.t.o.* type of produce required)
Rotation without legume common e.g. *amadumbe* – maize – sweet potato	Below ground crop followed by above ground	Limited quantities poor quality manure used	Use of legume in an intercropping and rotation system. Livestock farmers plant cowpeas on fallow fields to ensure winter grazing
Deliberate monoculture	Each crop in separate field	Limited and spread out thinly amongst all fields	Double all inputs (energy, labour, manure, costs). Limited manure not managed effectively by concentrating in few fields and building the soil health
Beans legume of less strength *i.t.o* soil fertility improvement (N-fixation) relative to cowpea	Planted last following *amadumbe*	Very poor/less broadcast	Beans intercropped with maize. Timing for bean harvest becomes critical to ensure better yields. Theory of legume importance understood (root nodule demo)
Wild spinach "*imfino*", pumpkin leaves	Manually collected around the homestead (certain times of year)	Indigenous plants not fertilized	Plant spinach and wild mustard (leaves) together in the same field as mustard interferes with weeding of amadumbe.

It should be noted, however, that the sequence of crop management activities is adhered to regardless of accurate timing. For example, the sequence is such that land is identified for a specific crop and prepared accordingly. In the case of taro, this happens between July and

August, and it depends on available money for tractor rental for ploughing or draught power and labour. Consistent to what Mare (2006) discovered is that planting time ranges from July until October and, for some farmers, till late November. Weeding would follow from November to February and sometimes March. Generally, two weeding events (Table 3.3) are performed except when it is a high rainfall season, where weeding is done manually three times using hand hoes. The first crop of taro is generally ready at about seven to eight months until ten months after planting.

Plant spacing was not an issue for farmers as many have no land constraints and have been using large spacing (inter and intra row) based on the belief that taro needed more space to be 'free" to yield more and bigger tubers. However, spacing is gradually being decreased because of understanding the benefit of weed discouragement by small spacing. Also, this reduces resources (time, energy and money) invested in the weeding process since it cannot be cut short. Observations in the third season revealed that farmers were beginning to appreciate resource use because of available limited quantities of kraal manure caused by commercialization pressure on production. Contrary to their beliefs about monoculture practice some farmers were now starting to intercrop as part of mitigating limited resources.

To enhance the soil benefit of an intercropping system, a different legume (cowpea) instead of dry beans was introduced both as an intercrop and a rotation crop. Also, as part of new behaviour by farmers, leafy vegetables (spinach and wild mustard) were planted in home gardens to supplement food especially during winter months. During fieldwork, researchers noted as part of the results that some farmers actively innovated using the local resources at their disposal in attempts to improve their crop production. Often, these innovations were used to compensate for the lack of modern agricultural inputs, such as fertilisers and pesticides.

Table 3.3. Summary of current understanding of weeding process and purpose (FN19/10/2007 with farmers in Umbumbulu)

Science of process (How it's done)		**Local/Indigenous knowledge & practice**		
	Planting	**1st weeding**	**2nd & 3rd weeding**	**Final weeding**
Clearing	All growing plant material	Remove weeds and scoop soil to encourage mother plant and growth	Remove second crop (if multi cropping), scoop to encourage side growth	Remove any newly growing shoots and weeds to focus energy onto maturing side growth.
Tools	Pre-ploughing followed by trenching with hoes	Hoe	Hoe	By hand only to prevent damage and disturbance to maturing rhizomes.
Feeding	Only at planting Manure (1-2 handfuls) deposited per planting hole under or over corm			
Mulching	Under or over rhizome, Surface	Weeds piled up in the inter-row	Weeds piled up in the inter-row	Weeds piled up in the inter-row
Decision making	Available resources for land preparation then planting (labour, rain, timing Spacing: 2 rulers/ 60cm or two feet length	Height of plant: two distinct leaves visible	Height of plant: Wilting of beans	Spotting of leaves
Technology	1 ½ hoe head depth	Hand	Hand	Hand
Alternative strategies: timing, multi cropping, care of planting material	Some farmers leave rhizomes to shoot in *situ*. Others dig a hole and bury until next planting.			
Preparation of planting material	Some farmers plump up by burying in a soil pit and add water.			
Storage of planting material	Dig a hole and bury until next planting.			

Examples of local innovations by farmers in Ogagwini and Hwayi villages that attempted to improve seed vigour of taro were dried rhizomes placed in dug holes and covered with soil (Table 3.4). The hole is then watered and kept moist for about 2 weeks. When plumped up, the rhizomes are then ready for planting. Through observations, farmers confirmed that planting material treated in this manner resulted in relatively fast and good emergence. The other example is based on the knowledge of various wild plants (still available in nearby forests) that helped farmers mix their own organic pest repellent concoctions. Many farmers who have used this mixture concurred with the claims and the mixture's ability to repel several pests.

Table 3.4. Seed storage for good vigour

Planting decision	**Farmer process**
Alternative strategies: timing, multi cropping, care of planting material	Some farmers leave rhizomes to shoot *in-situ*.
Preparation of planting material	Some farmers plump up by burying in a soil pit and add water.
Storage of planting material	Dig a hole and bury until next planting.

In Umbumbulu, it is a norm/ local practice that the planting material is stored in *situ*; hence, most fields are rested in winter until next planting season. Many farmers explained that this is the best way to store the rhizomes as they are safe from any potential harm (environmental and human). Through a process of experimentation, farmers found that dry beans (*Phaseolus vulgarus*) can be intercropped with taro without any interference of the intercrop on the main crop (taro). When the wilting of leaves begins, the whole dry bean plant must be uprooted from the ground and laid on the house roof for further drying off. Then, the taro plant will have sufficient space to grow more rhizomes as the field is weeded.

Farmers are beginning to understand the pest and disease threat to the expected yield due to potential crop loss in the light of commercialisation. Mare (2006) reported that 12% of respondents (in Umbumbulu) stated downy mildew as a problem and 16% cited warthog as a pest in taro fields. Whilst Shange (2004) said millipedes were the most frequently cited pests of taro also in Umbumbulu. One way to overcome the pest problem is intercropping, which is a common practice in many parts of Africa. As a strategy for integrated pest management, crops like onion and wild garlic, which are among the crops planted by some of the interviewed

farmers, are known to have characteristic insecticidal properties of pungent smells that repel insects (Jacques *et al.*,1999).

Commercial agriculture has a great reliance on synthetic insecticides, even though most farmers criticized their use. For many farmers, the continuous use of these chemicals may be due to a lack of reliable alternatives. As a consequence of limited resources, small scale or homestead agriculture ethos of being organic relies on indigenous knowledge-based techniques for pest management. The use of indigenous methods of pest control is the only viable option available to these farmers. Interestingly though, quite many farmers are aware of these techniques, but currently neglect them. Odeyemi *et al.,* (2006) reported that the knowledge of the application of these indigenous methods was being eroded, especially among the young farmers. In the study area, the specific indigenous knowledge about wild plants used for pesticidal mixtures are held by very few male farmers, hence the limited use by the greater proportion of female farmers of the community.

Local farmers in the study area have, over the years of taro (amadumbe) production, developed a great depth of knowledge of taro landraces available locally and their varied use. Mare (2006) discovered that a total of four main groups of landraces existed, known and named by farmers. These are in the order of their relative importance: *Dumbe-dumbe, Mgingqeni, Pitshi,* and *Dumbe-lomfula.* These are cultivated for the following reasons: consumption, cultural events, market, green vegetables (leaves), plant protection (chase away moles), medicinal use and ornamental purposes (Mare, 2006).

3.4.2 Farmers' Knowledge about soils

According to Sillitoe (1998), indigenous soil classification disregards soil formation processes (genesis) but considers factors that influence land evaluation, such as topography, vegetation, and microclimate. Hence, this classification is based on physical and perceptual dimensions (Ettema, 1994; Talawar and Rhoades, 1998).

Cervantes-Gutiérrez *et al.,* (2005) simplified this further by saying that local people use their knowledge to classify soils according to appearance, visual characteristics, and productivity. Umbumbulu farmers recognized six main types of soils (Table 3.5), with each category having some variations according to its potential use. Consistent with the results found by Sandor and Furbee (1996) and Talawar and Rhoades (1998), soil morphological attributes that were key to the farmer's classification were soil texture and colour as they were said to relate to potential

fertility and water retention. Ettema (1994) thus concluded that local soil classification is mainly concerned with land productivity, as soil suitability is derived from the soil's name.

Shrestha *et al. (2004) noted that the increasing value of indigenous soil knowledge in agricultural sustainability has resulted in the documentation of farmers'* knowledge with regard to how they perceive and classify their soils. Hence, this indigenous soil knowledge forms a benchmark for communication between farmers, soil scientists, development and extension workers compared to formal scientific classifications (Niemeijer and Mazzucato, 2003).

Low rainfall regions exhibit reduced yields as well as lower soil productivity. Soil fertility never used to be a major constraint due to the age-old practices of recycling agricultural residues in several ways. However, in these days of inorganic fertilizers and quick returns, the problem of soil management and its related constraints are surfacing. Zurayk *et al.,* (2001) explains that indigenous knowledge on land evaluation plays a vital role in decision making on land use and management, as it enables farmers to match their production systems to soil types by providing basic information on soils.

Using indigenous knowledge, farmers have managed to develop sustainable land use management practices to improve subsistence farming. Farmers perceive soil fertility as a function of the current and previous management regimes. This, according to Greenland *et al.,* (1994), cited by Talawar and Rhoades (1998), explains why soil fertility is not a primary factor in local evaluation of soils. Farmers treat soil fertility as a dynamic characteristic of soil, which they improve by maximizing crop diversity. Sillitoe (1998) further explains that farmers also take advantage of climatic and soil variations to enhance soil productivity and increase yields. Agronomic indicators of soil fertility include organic matter content, microbial activity, soil air and water balance (which is related to soil depth, texture, and structure), and the availability of the most important nutrients (Finck, 1995; Lal, 2000). The main sources of plant-available phosphorus, which are generally the limiting nutrients in acid soils (Haynes and Mokolobate, 2001), are from the weathering of soil minerals, the mineralisation of soil organic matter, fertiliser applications and organic inputs.

Farmers use soil colour and crop performance in terms of yield and vegetation as some indicators of soil fertility (see Table 3.6). While indigenous knowledge springs from local resources local people and is used for solving local problems, can with refinement and adaptation, become global knowledge. Farmers readily accept simple techniques displaying

sound logic when it fits into their routine and if they are cost effective (Middleton, 2007). The indigenous practice of cattle shed bedding with groundnut shells becomes global knowledge when locally available residues are involved. The principle in this documented practice can be adopted not only by the groundnut- growing regions, but also by the areas where other crops grow i.e., any crop residues which are not useful as cattle feed can be tried for bedding the cattle for recycling, depending upon the quantity of material available (Maruthi and Srinivas 2006). In Umbumbulu, farmers use weeds instead of groundnut shells. Some farmers even go further into bagging the manure and immersing the bag in a drum of water to create liquid fertilizer to use when fertigating their vegetable gardens by hand (FN19/10/2007).

Table 3.5. Local soil classification based on productivity used by farmers at Umbumbulu (FN 23/07/2008: also Buthelezi, 2010)

Use	**Productivity Level**	**Colour**	**Texture/ Structure**	**Local indigenous name**	**Scientific name (soil form & family[1])**
Arable	High	Black (OM[2])	Loamy	*Idudusi*	Oakleaf 1210
Arable	High	Black	Loamy sand	*Ugadenzima*	Bloemdal 2200
Arable	Moderate	Red	Clayey	*Isibovu*	Hutton 2200
Pots	Low	Dark grey	Clayey	*Udongwe*	Katspruit 1000
Plaster	Low	Light grey	Clayey	*Umgogodi*	Kroonstad 1000 (possibly)
Arable	Moderate	Red	Sandy	*Ugedle*	Hutton 1100
Unused	Low	Greyish black	Crumb-y with stones	*Ugedlane*	Glenrosa 1110
Building	Low	Black or red	Gravelly	*Umgubane*	Glenrosa 1000
Arable	Low	Black	Clayey (soft)	*Isdaka/isduli*	Katspruit 1000

Through a process of experimentation, farmers found that reworking organic plant matter into the soil after harvest improved the nutrient content of the soil, demonstrated by the fact that vegetable crops planted in soil in which organic matter had been reworked had a higher yield than the same crops planted in soil in which no organic matter had been reworked (FN12/09/2008). Some strategies sourced from indigenous knowledge systems by farmers normally used to build soil fertility levels are crop rotations, animal (kraal) manures, and random intercropping mainly limited to maize and pumpkins. Many farmers believe that for

rotation, the crop sequence should be above ground crop (maize or beans) followed by the below ground crop (taro) to ensure balance on nutrient loss by crop removal. The only exception to this rotation rule being groundnuts, since normally no fertilizer is added to the crop, its residual soil advantage is far less than expected. Hence, poor (less optimal) fields are used for the crop. Both intercropping and rotation assist in replacing nutrients removed from the soil during harvest, hence establish a balanced nutrient cycling mechanism to prevent fertility depletion and increasing the sustainability of production systems (Grant *et al.*, 2002). These cropping systems prevent competition and have high microbial populations, which results in high mineralization of organic material (Haynes, 1984; Crevello, 2004).

3.4.3 Traditional Agriculture

Although the agricultural sector is not the mainstay of the economy in this area, farmers still rely largely on traditional farming methods. There is a sense in which each farm is its own farming system; no two farms are ever exactly alike. Complexity is a feature within the farm, intercropping is common in many systems. Because of the large number of treatments implied, intercropping is notoriously difficult to research. What is needed is to provide farmers with options from which they can choose. In the final analysis, it is the farmers themselves who decide what technologies they will adopt; they carry out the final stage of adaptive research. Traditional agriculture has always displayed random multi cropping, rotation and fallowing with the use of organic waste. Shange (2004) reported that 91% of respondents in her Umbumbulu study practised crop rotation. Mare (2006) further reported that in monocultural taro production, farmers cited corm rot as a type of taro disease. Crop rotation was also believed to control millipedes.

Farmers treat organic material as the primary source of soil fertility because they can access it as crop residues, domestic (kraal) manure (Hoffmann *et al.*, 2001), and use it as mulch (Barrios and Trejo, 2003; Niemeijer and Mazzucato, 2003). These practices minimize soil disturbance and are beneficial to environmental issues such as land degradation, climate change effects and water quality (Dumanski *et al.*, 2006). Farmers appreciate the holistic nature and interaction of factors affecting soil fertility, such as nutrient status, soil structure, moisture content, and soil fauna and flora (Fairhead and Scoones, 2005). These practices supply plant nutrients while improving other soil physical properties (Le Doanh and Taun, 2004). Together with crop rotation, intercropping has long been practised by farmers in this area as a way of managing nutrient balances in the soil. Companion plants commonly planted together are maize and pumpkins, of which pumpkin leaves are used fresh as a leafy vegetable. Leafy greens are

traditionally not planted but collected from around a manure pile and in the wild at certain times of the year (rainy season). Only recently, a deliberate attempt to plant spinach has been practised in homestead gardens to provide some kind of edible vegetable, especially during the winter season.

Cropping patterns and planting dates are, to a certain extent, determined by the availability of fencing materials to keep off stray animals but generally begin immediately after land preparation between July and August for most farmers. Plant production in the area mainly focuses on field crops (taro, sweet potato, maize, beans, groundnuts) because of the minimal damage caused by stray animals despite some pockets of crop losses from wild animals such as warthog that still exist in the area. Several factors determine the planting date as it varies per homestead, and these are means (money for tractor plough or actual labour) of ploughing, availability of manure, planting material (seed) and first rain. A combination of these factors will then determine when and how much land will be planted that season. Modi (2003) discovered that farmers in Umbumbulu and Umsinga district municipalities regarded taro as an indigenous crop because of the role it plays in their culture and the length of time it has been associated as a staple. Hence, taro is the main crop in this area, and it receives priority with regard to scarce input resources (manure, labour, and money). Late planting is believed to perform badly in terms of yield; hence, it is avoided by many farmers at all costs. Shange (2004) confirmed that early planting will make efficient use of local climatic conditions (based on long term averages) for the benefit of optimal resource use. Recently, the area was hit by intense rainstorms during the first critical months of growth, and those farmers who had planted early benefited from good crop stands and avoided complete crop loss experienced by late planters through erosion by water. During planting, women follow behind the plough. The plough determines the distance between rows usually greater than 60 cm and less than 1 m. Taro corms are planted approximately two feet length apart (follow behind the plough and drop a corm into the furrow). The method of using two feet is also confirmed by Shange (2004). More than 80% of farmers in Umbumbulu practice organic farming (Modi, 2003) and the reasons mentioned are the lack of resources, food safety and better crop performance. Manure is dropped individually on *amadumbe* and maize but scattered for beans. A minimum of one handful of manure is placed on top of the rhizome. If you have enough, you will use two handfuls.

Planting of one field must be completed in one day to ensure uniform growth and ease of crop management with regard to weeding. The shoots are weeded and heaped for the first time when

they have produced two distinct leaves (Table 3.3). Farmers are critically aware of the importance of keeping taro field weed free until tuber initiation. The second weeding occurs much later, and some leaves are also cut off and dug into the soil, which is heaped further up the plants. The reason for trimming leaves is to encourage the food to go to the tubers and not to maintain the leaves. Generally, taro is weeded twice unless there is too much rain, which means three weeding events will occur. It takes a minimum of nine months to harvest a taro crop in this area, and withering of the petiole is an indication of maturity. All farmers harvest taro by using hand hoes. Farmers only harvest the required quantities (for selling and consumption), and the rest is left in the field. They remain in the ground for most of the winter season until the field is ready to be ploughed again for the successive crop. Farmers believe this is the best way to store the harvest to keep it fresh and safe from any potential damage. Shange (2004) showed that most (77%) of the farmers kept taro for 1 to 3 months in the ground as they mentioned that it will go rotten if kept for longer periods.

Groundnuts can grow on any soil (or rather deficient soils) hence, farmers never bother with using manure. The seeds are just dropped while following the plough as it opens the furrow. Good soil is never wasted on groundnuts if poorer quality soil is available. The amount of rain, proper weeding, sufficient manure, and good quality planting material will determine the expected yield.

Together with exposure to commercialization, the pursuit of economic development has changed subsistence production farming systems to a mixture of both commercial and subsistence production techniques, thus proceeding to monocultural production to the detriment of soil health. In addition, since land pressure is not an issue for many farmers in Umbumbulu. monoculture has become the norm for every crop (except pumpkins) (FN27/02/09; 17/04/09). However, this is not the case for the kwaRhwayi village, which has seen a lot of development (government houses, water and electricity infrastructure development) in the recent past. Household members that have left for urban areas are seen returning, hence putting a lot of pressure on agricultural land use. Farmers in this area practice intercropping as a coping strategy to ensure their varied production. Since taro is believed to 'need' more space to aerate the plant to produce more tubers, it is mostly monocropped. Shange (2004) found a small proportion of farmers who were intercropping taro mainly with beans. Many considered intercropping as a practice of those with less land. Over the years' farmers have observed the detrimental effects of monoculture on the successive taro crop; hence, they

have resorted to both rotation and intercropping to a lesser extent (FN27/02/09; 13/03/09; 17/04/09).

Buthelezi (2010) found that farmers in the study area had a deep understanding of their land and environment based on indigenous knowledge. The study continued to state that farmers have built up a vast store of indigenous knowledge that has been used for many generations. Hence, it is important to encourage the use of indigenous knowledge, especially in small-scale farming where farmers cannot meet the expense of a purely scientific technological approach.

3.4.4 Local Classification System

Table 3.5 details the local classification for soils in Umbumbulu based on the high degree of agreement amongst the village groupings of EFO farmers. The six village groups of farmers consistently divided the soils into four major soil classes: hard/heavy clay soils (locally known as *isibovu/ubumba*), sandy soils (*ugedle/isihlabathi*), gravel with stone (*ugedlane*) and soft clay (*udongwe*). The hard/heavy clay soils were further divided by perceived fertility, the dark black clay soils being considered more fertile than the red clays. A fifth type of soil, loamy texture (*idudusi/othambile*) was identified by a characteristic black colour and high in organic matter. Farmers' opinions were diverse in that whether *isdaka* or *isduli* were the same soil (a notion observed on both during the survey and approximately two-thirds of farmers interviewed) did not describe *isdaka* as a separate soil type, whereas all groups described the other five soil types as distinctly different. This summary gives a conceptual framework. The division is primarily soil texture-based and has three (clay, sand & gravel) exclusive classes. There are two secondary divisions in one of these classes (clay) based on fertility, being characterised primarily by colour difference. Herein two exclusive classes (red & black) are determined. The other secondary division based on colour is on the soft clay class, where there are black and grey colours. Thus, there are a total of five distinct classes of soil (*isibovu, ugedle, ugedlane, udongwe, idudusi*) and a floating class defined by clay's consistency (*isdaka*) that can occur on any of the other two soft clay soils.

The relative fertility of the different soil types was perceived by the farmers in terms of crop production. In a year with adequate and evenly distributed rainfall (a 'good' rain year), the groups consistently reported heavy soils (*isibovu*) as more fertile than the sandy (*ugedle*) soils. Fertility was related both to intrinsic soil properties and critically the amount of rainfall in a given year. Few groups ranked the fertility of soft clay (*isdaka*) but of those that did, half ranked it equal in fertility to *isibovu* and half ranked it lower. In years when rainfall was low

or poorly distributed (temporally or spatially) (a 'bad' rain year), loamy soils (*idudusi*) were reported to have the highest fertility position while loamy sand (*ugadenzima*) and sandy (*ugedle*) were equally low; notably, consistent with the finding by Buthelezi (2010) *idudusi* retained its relatively high position in the rankings in these years (Table 3.5). Sandy soils were believed to be unproductive in a 'bad rain year'. It is clear from the fertility rankings that soil fertility is not perceived as an intrinsic property of the soil but rather as an interaction between a combination of soil characteristics (encompassing nutrient content and texture) and rainfall.

Soil organisms are other local indicators used by farmers to improve soil quality. The presence of soil macrofauna, particularly earthworms created an expectation of high yield as worms are known to be beneficial for soil fertility. The decomposition of organic matter in earthworms' guts and casts, indirectly mediated by an intensification of microbial activity, leads to a mineralization and release of nutrients that become available for plants and microbes. Earthworms consistently increase nitrogen turnover (van Groenigen *et al.,* 2019) and release large amounts of mineral nitrogen ammonium and nitrate (Wu *et al.,* 2017). Fresh casts of *Pontoscolex corethrurus* have a five-fold higher ammonium content compared to non-ingested soil (Lavelle *et al.,* 1992). Similarly, high phosphorus levels in (fresh) casts were found to have more available phosphorus (P) than in the bulk soil (Ros *et al.,* 2017); however this effect strongly differs among species and habitats.

Like Ettema (1994), EFO farmers tended to classify soils in connection with land productivity (FN10/02/08).

"…in Ogagwini you can plant year after year with little or no manure. The soils are extremely fertile. In Ezigeni, you must use kraal manure"

"We know that soil is fertile and suitable for planting if there is vigorous growth of grass. If uqadolo (black jack: Bidens Pilosa spp) is growing, we know the soil is very fertile and amadumbe will do well."

"We prefer to grow our crops in wet soil… we get better yields from red soil than black soil" (unable to explain why)

3.4.5 Manure Measurements

There are three main themes running through the intercropping interviews. The most obvious is that plants have differing requirements for manure. Manure is seen as providing food for the specific plant. Amounts used are based on perceived plant requirements. Table 3.6 shows how much is used learned by experience, noting most people use the same amount for the different crops if there is plenty available. There is a perception of a minimum amount of manure

required for each crop. Manure availability determines the types of crops to be planted. When the minimum amount is not available some plants are not considered for planting in that season.

Table 3.6. Typologies of Manure Use

	Spacing of seed	Placement of manure	Amount per rhizome/seed
Amadumbe	1 to 2[1] boot lengths apart.	On top[2]	2-3 handfuls
Beans	Step & drop broadcast	Overlapping broadcasts	Ranges: 1-3 generous handfuls per broadcast
Mustard	not planted, treated as wild veggie '*imfino*'		

Scientists have the advantage of being precise in measuring soil fertility using agronomic indicators. However, through a process of experimentation, farmers have found that reworking organic plant matter into the soil after harvest, improved the nutrient content of the soil (FN12/09/2008). This is demonstrated by the fact that vegetable crops planted in soil in which organic matter had been reworked had higher yield than the same crops planted in soil that had no reworked organic matter.

3.4.6 Intercropping is a Function of Resource Scarcity

Mostly, the perceptions about intercropping are expressed in terms of plant yields and labour required rather than impact on soil. Intercropping is perceived as a strategy for when land and labour are limited. There are a wide variety of beliefs and experiences with intercropping, some of which contradict each other. For example, pumpkins and maize do or do not impact each other. Also, knowledge is generally passed down from parent to child rather than in farmer-to-farmer transmission (FN22/11/2006). However, when a woman joins (by marriage) the husband's family, her farming knowledge may or may not be included. For example, in our interviewees, Z. Mkhize (Ogagwini area) had been told by his wife not to intercrop amadumbe and beans as it would impact the yield of the amadumbe. He tried it anyway and proved her correct. S. Wanda (Msholozi area) was about to try the same experiment. From other conversations with farmers, we learned that although many of the wives had brought the knowledge of cowpea production and use from their families, they did not grow them because their husbands did not eat them (FN10/01/2008). In particular, the Umbumbulu clans had been

[1] Mr Mkhize uses a plough to scarify the first weeding which may be the reason he gives more space.
[2] Mr Mkhize made the distinction that if soil was wet, he put the manure underneath the rhizome.

told by the 'Sangoma' many years earlier that they were not to eat "*imbumba*" cowpeas as it would make them 'forgetful'. As a result, the use and knowledge had died out (FN22/11/06).

3.4.7 Monocropping Provides Optimal Resource Use

Mono-cropping in beneficial rotations is perceived as offering the most effective use of land in combination with other resources. Mono-cropping impacts soil fertility negatively or positively depending on the system's management practice. Farmers consider rotating an above ground crop with a below ground crop is the general basic understanding to be the best practice. There is a general understanding that this maintains soil fertility as the different crops draw different nutrients from the soil to sustain plant growth with differing fruiting zones (under and above ground). The knowledge about types and use of legumes is limited; hence, the coincidental use is dictated by household needs between beans and groundnuts (FN13/03/2009).

Mono-cropping also has other advantages for efficient weeding (Table 3.7), grazing space, and planting material preservation *in-situ*. Taro are not intercropped because of the importance of weeding and piling-up soil creating space for rhizomes to mature. On the other hand, the rain (available moisture), the effort it takes to plant and weed as well as the awareness of soil fertility decline in the face of increasing demand for manure and problems with pests (Caister, 2006) suggest that new patterns need to be identified if yield is to be sustained or increased for commercial purposes.

Table 3.7. Typologies of Intercropping (FN12/09/2008)

Main crop	Companion	Justification	Adaptations
Amadumbe	Mono cropped in rotation with above ground crop i.e. beans	• Amadumbe need space to develop • Hilling (weeding) conflicts with other crops	
Maize	Beans/cowpeas	Retains soil fertility- "*field can be used over and over again*"	Maize planted further apart than when mono-cropped to prevent canopy effect on intercrop
Maize	Pumpkins	• Maize disadvantaged (sharing of limited nutrients) • No impacts on each other	Pumpkins planted in holes (not furrows) body length apart with individual supply of manure

Picture 3.1. Typical Subsistence Land Use Around Homestead

3.4.8 Building on Local Knowledge

During fieldwork, researchers observed that some farmers actively innovated using local resources at their disposal in attempts to improve their crop production. Frequently, these innovations were used to compensate for the lack of external agricultural inputs, such as fertilizers and pesticides. Examples of local innovations which attempt to improve seed vigour of taro are that the dried rhizomes are placed in the dug hole and covered with soil. The hole is then watered and kept moist for about two weeks. When plumped-up, the rhizomes are then ready for planting. Farmers confirmed that, based on observations, planting material treated in this manner results in a relatively fast and good emergence (FN12/09/2008). The other example is based on the knowledge of various wild plants (still available in nearby forests) that helped farmers in mixing their own concoctions of organic pest repellent. Many farmers who have used this mixture concur to claims and ability to repel several pests (FN26/06/2006).

In Umbumbulu, it is some sort of norm that the planting material is stored in *situ*; hence, most fields are rested in winter until the next planting season. Many farmers explain this practice as the best way to store the rhizomes as they are safe from any potential (environmental or human) harm. Through the process of experimentation, farmers found that beans (*Phaseolus vulgarus*)

can be intercropped with taro without any interference of the intercrop on the main crop (taro). This was realised when the wilting of leaves begins, the whole bean plant must be uprooted from the ground and laid on the house roof for further drying off. Taro plant will then have sufficient space to grow more rhizomes as the field is weeded.

When the farmers decided to transform traditional farming technologies into certified organic farming practices, they were presented with concepts which they could recognise. These include management practices that restore, enhance and maintain ecological harmony and the use of minimal off-farm inputs as well as intercropping and rotation manuring to ameliorate the soil fertility and resting fields. Farmers were aware of soil fertility if not actually soil biological activity. They recognised that although highly skilled in the use and management of available resources, there are knowledge, additional skills and practices that need to be learned to fully understand sustainable agriculture that produces excess quantities for commercial purposes. There was also a growing awareness that the demands of commercial production were contributing to pressure for production at the cost of good management practices.

A fuller understanding shared by all farmers in the system is required to deal with interrupting pest cycles, build soil fertility, optimise resources, and develop confidence in innovation and experimenting. Farmers also expressed that they knew what to do but did not always understand why. For example, Mr Z. Mkhize (Ogagwini village) knows not to plant amadumbe for three consecutive years in the same field because yields will decrease. Although he knows that toxicity builds up with repeated potato crops, he does not 'know' what the causal factor is for the amadumbe. From the cropping interviews, it was also noted that farmers who had means of mechanized tools or implements and draft power for land preparation had more flexibility in decision making about land management.

In response to the farmers' awareness of poor soil fertility being a limitation to sustainable production of both food and excess for the market, soil fertility capacity building needed to be addressed. The need for knowledge was strongest in understanding the why's of soil fertility. These include answers to what impacts the rhizosphere and how nutrients, microorganisms and plant roots work together as a system invisible to the eye. Farmers understood companion planting, crop rotations and spacing, and hence they were already practising a system of friendly land management. This advantage platform enabled the Field Trials to incorporate these best practices while focusing on rearranging resources for improved yields and soil

management. The re-introduction of cowpea as a forage intercrop and high-quality nitrogen fixer, as well as wild mustard, was intended to expand the perception of possibilities and encourage attitudes and behaviours of innovation that were consistent with sustainable agriculture principles.

Improved crop productivity was achieved through technical and socio-institutional innovation by EFO farmers relying on the use of available local resources. This achievement reveals how scientists and technical advisors in research and development organisations can harness the dynamics of local knowledge by identifying local innovations, exploring together with users (farmers) the rationale behind and explaining in scientific terms why they work. A great example that argues for an approach to research that allows farmers to be creative and that strengthens their abilities to continue to adapt to changing conditions. The role of researchers in showing how farmers could create solutions that challenge official policy and then joining forces with farmers to bring about policy change to accommodate and inspire local innovation is emphasized. It thus presents an 'intervention' that could improve organic crop productivity: promoting an approach of recognising local innovation and engaging in participatory research with local people who are developing their own ways to make the most of scarce/limited resources. Noteworthy is that resource poor farmers have been innovating since time immemorial to adapt to changing conditions and grasping opportunities. Mitigating increasing water scarcity and other farming resources harnessing productivity in an organic system all require improving local innovation processes, including both endogenous development and local adaptation of exogenous interventions.

Waters-Bayer and Bayer (2009) concluded that the resilience of the local actors to change is strengthened by engagements in participatory innovation processes. Also, it emphasizes the importance of these engagements in identifying local innovations as an entry point to collaboration in more vibrant local innovation systems rather than transferring technologies or designing standardised interventions in productivity. The promotion of an approach that involves recognising local innovation and engaging in participatory research and development with local people developing their own ways to use natural resources more productively for farming enhances productivity. In harnessing local human and social capital, bottom-up approaches are necessary to sustain the rural livelihoods of the resource-poor as well as ensure sustainable management of natural capital. Both natural resource management research and extension should shift emphasis from prescriptive research technical solutions to a trans-disciplinary joint understanding of resource-poor farmers' soil management practices and

capacities. More effective and acceptable integrated hybrid innovations are a result of improved farmer practices and capacities through the participatory integration of scientific knowledge and modern technologies.

One part of farmers' strategy for managing soil fertility is represented by the local ethno-pedagogy framework. This strategy drew upon varied ecological knowledge to make complex and dynamic management decisions. Local perceptions of the environment, including biophysical, economic and social variability, heavily influence soil fertility management, was shown by this study. Noting the local approach to incorporating measurements of crop yield, integrated complex soil–water relations and allowing inter-annual rainfall variability. Each household responded to these influences according to its capabilities, constraints and, opportunities and ability to mediate access to resources. Results revealed that resource poor farmers' ability to adapt to the effects of climate variability is influenced by many factors, which include socio-economic characteristics of a household such as household size, age, gender, education level and marital status of the household head (Opiyo et al., 2015). Eriksen et al., (2011) noted that these factors vary between individuals and within communities, countries, and regions.

Further studies to discover, develop and maximise the benefits of indigenous knowledge, particularly important where labour and capital are constraining influences, are urgently required. It is acknowledged that despite the local capabilities, many of the constraints on the use of technologies to improve soil fertility management, such as the scarcity of inputs, labour, land, capital, and, to some extent, knowledge, can only be overcome by intervention at the policy level such as the state land returned to a previous owner. Specifically, better access to credit and economic rewards for farmers before investment in soil fertility matches local aspirations and knowledge is important.

Prediction of the use of soil fertility management strategies has a bearing on socio-economic factors of individual homesteads, including the gender of the household head. Therefore, socioeconomic factors can play a role in policy making to strengthen resource-poor farmers' adaptation of soil fertility management strategies to cope with climate variability. These factors can be utilized to build a more interdisciplinary approach to developing agriculture in rural areas by researchers, regional planners and policy makers. Rural development endeavours should aim at integrating local knowledge by involving farmers in determining the most suitable adaptation plans and 'farmers ability to take up these strategies. This is because

household types are highly heterogeneous, with some households having better capacity for using different strategies to adapt to innovations based on climate variability locally. Therefore, adaptation plans need to be tailored to farmers with different biophysical and socio-economic circumstances.

Generally, research funders, researchers, and civil society grapple with how research can best meet pressing social, environmental and technological challenges. A 1999 United Nations Educational, Scientific and Cultural Organization (UNESCO) report stated that: '*it must be recognized that the relationship between scientific research, education, technological innovation and practical benefits is much more diverse and complex today than in the past, and frequently involves many players other than researchers. The progress of science cannot be justified purely in terms of search for knowledge. In addition, it must be defended through its relevance and effectiveness in addressing the needs and expectations of our society'* (UNESCO, 1999). In response, researchers were cautioned that collaboration and integration across traditional research boundaries necessitates intellectual cross-fertilization, learning and exploitation of significant synergies between approaches.

Overall, the study demonstrated a combination of different knowledge sources and information types on how to merge the theory of scientific knowledge to local knowledge in the formation of new adapted practices. Thus showing the importance of first considering what is locally known within the community before seeking technological solutions outside the community. This consideration underpins the principles necessary for an approach that yields sustainable management of rain-fed agricultural systems. Implications for research and development process herein are such that it is inadequate to only document existing local knowledge, but equally important is to understand how knowledge adapts, develops, and changes over time. The ten-year research impact evaluation study detailed in Chapter four of this study highlights these changes and demonstrates farmer confidence in their progressive pursuit of commercializing homestead produce in a sustainable manner.

CHAPTER FOUR: RESEARCH IMPACT IN COMMERCIALISING TRADITIONAL HOMESTEAD PRODUCTION OF AMADUMBE: A TEN-YEAR FOLLOW-UP STUDY

4.1 Introduction

Together with climate change effects, environmental impacts resulting from degradative agricultural practices common in many smallholder farming systems can be mitigated by the adoption of sustainable agricultural innovations (Foguesatto et al., 2020). D'Amato et al., (2020) highlighted that lately, the growing realization of the urgency to adopt more sustainable practices in the smallholder agricultural sector is driven by the desire to assess their positive environmental effects. Farming systems that stand out as effective include agroecology, regenerative agriculture, precision farming and organic farming (Sachet et al., 2021). This study places a spotlight on organic farming, which is referred locally as traditional farming, as an option to ensure sustainable homestead production of taro for commercialization purposes. Thus, research interventions supporting traditional farming should bring forth innovative solutions to tackle challenges faced by farmers safeguard the environment while ensuring continuous sustainable production. Considering that achievement of rural development and poverty reduction goals can be possible when smallholder agriculture is advanced. By embracing these farming modalities, farmers can promote ecological resilience, conserve natural resources, and respond to the pressing need for sustainable agricultural systems. Organic/traditional farming, specifically is widely regarded as the most sustainable and responsive method in the primary sector (Ferreira et al., 2022). Lee and Yun (2015) emphasize that organic farming adoption of natural techniques and the exclusion of pesticides and chemical fertilizers, thereby promoting soil health and preserving biodiversity (Chiriacò et al., 2017).

KwaZulu-Natal has the highest number of agricultural households, at 536 226 of the 2.3 million noted for South Africa (Stats SA 2016). Illustrated by the increased yearly budgetary allocation by the Department of Agriculture, Forestry and Fisheries the support toward smallholders' development is apparent (DAFF 2020). The commitment by the South African government was to expand the number of smallholder producers selling their produce from 200 000 to 250 000 by 2014, and to 500 000 smallholders towards 2020 and onwards (Aliber and Hall 2012). About 2 million smallholder farmers farm on marginal areas and at a limited scale. Smallholder farming activities are characterized by limited production inputs, low yield, lack of mechanization and lack of financing solutions, amongst other factors. The South African government has used value addition as a policy to correct some of the historical imbalances in

the agricultural sector. In trying to integrate small-scale farmers into the agricultural economy as well as boost their productivity plans and policies made include the agricultural policy action plan 2015-2019 (Masenda and Masiya, 2022). Therefore, agricultural developmental efforts targeting rural communities and small-scale farmers should be implemented with high impact potential to succeed so that the winning formulae can be repeated and distributed in other localities.

The South Africa Netherlands Partnership for Alternative Development (SANPAD) Participatory Project was the result of a long-term building of relationships between researchers at the University of KwaZulu-Natal (UKZN) and farmers who were members of the Ezemvelo Farmers Organisation (EFO). The first interventions (2001 to 2003) in Umbumbulu through the Public Understanding of Science and Technology (PUSET Project) focussed on the transfer of technology initiated by Professor Rijkenberg and Professor Modi, both from the University of KwaZulu Natal (UKZN). The strategy was to engage with society to increase awareness of the importance of science and technology in the environment in which we live. The second phase in the relationship initiated a farmer-researcher approach to investigate the organic production of traditional crops (Table 4.1). The third phase of this relationship, the SANPAD Participatory Project 05/32 (2006-2009), initiated a farmer-researcher partnership for research to support the farmers' growing involvement in commercial farming (see EFO timeline over a decade *App G*). The aim was to address commercialising challenges and understand how market relations changed the way farmers grew their crops and whether this transformation affected social relationships between and within homesteads and villages that constituted the EFO. This phase was a 2nd SANPAD fund and viewed the transformation of homestead agriculture to commercial agriculture through changing social paradigm and agronomic dynamics. The SANPAD Project of commercialising homestead[3] agriculture was the third phase of compound research by the UKZN students to develop a model for the successful marketing of traditional produce. As a compound study of the agronomy social dynamics during commercialising homestead agriculture, the various aspects of commercialising *amadumbe*[4] were separated into individual research projects, which led to multidisciplinary

[3] Homestead refers to a place where a person and/or family cultivates the land and tries to become self-sufficient. As a way of life EFO farmers strived to live off of the land by growing and raising what they eat (including livestock and poultry). Hence the agricultural production efforts around homesteads are usually a quarter or more of a hectare up to four hectares.

[4] *Amadumbe* is the isiZulu word for taro root or rhizome of *Colocasia esculenta* a starchy staple eaten throughout rural KZN.

collaborations within the agricultural faculty over time. Of the primary stakeholders involved, UKZN research team leader was interested in designing effective economic models for appropriate small-scale commercial farming. The formal market (Woolworths) was interested in selling high-quality produce at the best price. The organic inspectors were interested in following the rules for organic certification.

Table 4.1. Outcomes of Relationship Between UKZN and the EFO farmers. Adapted from Caister (2012)

Phase of Relationship	**Outcomes**
First SANPAD funded project farmer-researcher relationship 2003-2005	By 2003, EFO membership had increased to 54 farmers Organic certification of EFO subsistence farmers, Woolworths' Food Market gains its first supply of organically certified traditional vegetables Identification of some vegetables suitable for cultivation and marketing (wild mustard, *amadumbe*, landrace potatoes) Increasingly respectful relationship between Prof Modi and the EFO, Prof Modi elected as gatekeeper
Second SANPAD funded project participatory action research 2006-2009	Researchers were interested in both action and research. Researchers and community members participated in the change process, and research took place when the researchers reflected on the change process that occurred. The change process itself was important in generating new knowledge and placed the research within a specific living context.

Crop trials were focused on the soil's reliability (potential), their relationship to the crops and yield improvement. Aspects of strengthening the household were about livelihoods, strategies and ways in which agriculture and people in households were related through the commercialisation of homestead agriculture. Overall, the research team's intentions were to do research over a specified period to look at all the opportunities that farmers had at their disposal to find a new way of thinking and new strategies about using available local resources to make livelihoods sustainable. Our purpose as the compound research team was to eventually

convince all these different perspectives (people who had their different areas of interest) to compromise and agree on what was needed to sustain and encourage agricultural-based livelihoods within the Ezemvelo Farmers Organisation (EFO). In this context, we understood the need for diverse strategies by farmers to support agriculture-related livelihoods and were very interested in all their farming aspects. The research focus was embedded in the way of life in this Umbumbulu community since the planting of *amadumbe* using traditional methods mainly for subsistence was done by almost all households at various scales using only local production resources. In principle, traditional methods used in this area were similar to organic farming, with tillage aspects oriented towards soil conservation. Considering the high rural unemployment levels, implementing a research project to commercialise locally available produce to generate an income and sustain livelihoods was felt to be appropriate. Umbumbulu is climatically suited to sustain crop production because of its varied high annual rainfall of 800-1400mm and mean annual temperature of 17.9 °C (Smith, 2006). This climatic advantage is of particular significance in rural agricultural systems that are mainly rain fed due to historical lack of agricultural infrastructure and investment. The success of prior project phases in the area, especially concerning the environmental sustainability and conservation of natural resources, were therefore ascribed to this environmental advantage.

Historically, the primary mode of knowledge transfer had always been oral communication combined with modelled practice from generation to generation. Generally, most traditional phenomena have been shaped by social, technical, and ecological responses for ensuring food security and social cohesion within the socio-agronomic landscape. Traditional farming as a way of life has, however, been threatened by decades of a shift from the integrated social, political, and economic focus of a focused agrarian economy to the multiple livelihood strategies designed to survive in a cash-based society because of economic and political power struggles. Together, traditional strategies such as keeping livestock, the disruption caused by recent climate change and especially the lure of young people to higher, more reliable incomes and the loss of arable land contributed to disturbing traditional farming livelihoods. Perceived job opportunities in the urban regions and decreasing food production in rural areas result in youth migration from rural areas, searching for better livelihoods (DALRRD, 2019).

Rural development is almost always conducted in environments where resources are restricted, management is critical, and issues are often challenged. Scientific research generally delights in this uncertainty as a new direction for knowledge production, whereas the rural dwellers live with consequences. Hence, research institutions gear their mandates and programmes towards

socially robust development processes if outcomes are sustainably achieved. In the current market-driven economy, the opportunity was presented for social learning processes to link technology (including indigenous knowledge), service networks and markets in innovative ways. The outcomes of social learning led to solutions that overcame typical agri-food related constraints. Technological improvements and agricultural research are crucial for increasing agricultural productivity and safeguarding food security, leading to poverty reduction and employment opportunities and ensuring sustainability within the development context. Effland et al., (2022) concurred that growth in agricultural productivity has been driven by improved seeds, new farm technologies, and agronomic practices. Improved household income, creation of labour opportunities for the poor, reduced food prices, environmental sustainability were amongst the benefits of livelihood properties resulting from agricultural technological changes.

The removal of input subsidy, the high cost of moving fertilisers from source to the farm, inadequate supplies of organic and inorganic fertilisers, and untimely availability and low quality of fertilisers are all dynamics that influence soil fertility. Additionally, factors that contribute to soil fertility challenges include the poor cultural practices employed, deteriorating agronomic capacity and weak agricultural extension services. Guto et al., (2011) further added that low yields, food insecurity, and perennial starvation were caused by continuous cropping and inappropriate farming practices, these that have had massive negative environmental outcomes characterised by declining soil fertility, erosion and degradation of vast expanses of arable land. In many rural areas, where subsistence and smallholder farming are a way of life, these problems can be particularly intense. Predominantly, Umbumbulu, like many other rural communities, consists of mostly subsistence and smallholder farmers who still rely on simple traditional technologies and tools, mainly hand-held hoes, minimal use of animal traction and limited tractor access. Recent land scarcity resulted from increased pressure from residential land competing for arable land needs. Poor agricultural management strategies and unsupportive agricultural policies worsen the problem. Despite the negative agricultural impacts on loss of productivity, food security, environmental degradation and loss of social capital because of poor health, to date, Ezemvelo Farmers Organisation community has traditionally produced *amadumbe* with limited input resources for decades as a way of life and thus annually decreasing yields reported by the farmers are a true reflection of the extent of unintended nutrient mining done by the perpetual mono-cropping of these tubers with limited input supplies. This formed the basis for the evaluation of this research a decade later to assess the sustainability of adapted traditional systems used in this area,

Agricultural development interventions and research are known to positively influence livelihoods of smallholder farmers. Hence, agricultural sustainability in this study was viewed as the primary objective within the context of overall productivity, thus implying that agricultural success would depend on exploiting natural and man-made resources using human skills and labour. The consequences of this exploitation were expected to be products in the form of food for sustenance and their excess produce for the market. Traditional, sustainable agriculture is based on optimising nutrient flows through the recycling of biomass, improving soil conditions and minimising resource losses (Altieri 2005). Accordingly, this system manages agricultural systems for improved and sustained productivity, increased food security while preserving and enhancing the resource base and the environment in general. Desirable livelihood outcomes of sustainable agricultural practices are increases in food security, household income and general welfare especially good for the groups of smallholder farmers. Experiences with sustainable and conservation agriculture in South Africa have shown that livelihood changes in economic and socio-institutional conditions of the actors involved are accelerated when adoption of productivity-enhancing technologies grows (Swanepoel et al., 2017).

Research engagement with the Umbumbulu community intended to adapt local traditional agricultural practices towards sustainable agriculture through soil fertility enhancement by using diverse crop species, alternative organic soil amendments and soil cover through non-removal of residues that protect the soil from erosion and suppress weeds with leftover residues during land preparation (adding to soil's physical resilience and gradual nutrient status build-up). Also, to adapt farming systems through crop rotation where the below-ground crop is followed by above ground planting, which helps weed control and boosts soil fertility. The main advantage of adapting traditional agriculture for sustainability is the technology's ability to address a broad set of farming constraints particularly common among smallholder farmers in vulnerable communities. In this regard, the constraints in question include continuous hybrid seed requirement, depleted nutrient base, lack of sufficient access to equipment with varied implements for land preparation, sowing, weeding and harvesting. Answers to farming issues are the technologies to address expressed needs obtained through participatory methods using a facilitation model instead of technology transfer (Duvel, 2001). Hence, this qualitative study looked at the impact of socio-agronomic intervention through integrated soil fertility management and farmers' use of best practices in the context of EFO values, opinions and behaviour towards sustainable growing of amadumbe crop for a high-value market. EFO

farmers were central from the beginning to the end, where their local farming system and knowledge of amadumbe production were recognised as assets honouring their existing livelihood strategy. As a result, the research project through this chapter seeks to:

i. Investigate how the research technologies of adapting traditional agriculture for sustainable commercial purposes impacted or changed livelihood outcomes through changes in productivity, yields and food security.

ii. Identify sustainability aspects of how the research intervention affected farmers production of amadumbe post the research project.

iii. Assess the effect of formal market loss on commercialisation efforts, i.e. understanding the determinants of continuity in commercialising homestead agriculture through informal markets.

iv. Identify social and agronomic factors that positively supported continuity after the funded project ended.

The rest of the chapter is arranged as follows: Section 4.2 identifies the purpose for the return study, Section 4.3 discusses the underlying framework, followed by Section 4.4, that presents results and discussions.

4.2 Purpose for the ten-year assessment

4.2.1 Assessment of Research intervention

As part of the compound research study, the original study (funded 3yr: 2006-2009 project) was meant to address the challenge of low yields experienced by EFO farmers due to a lack of access to manure. During the community workshop (2006), the challenge was identified as a critical issue affecting the commercialisation effort of homestead produce in an organic traditional farming system. based on the workshop sentiments, soil fertility was highlighted as a subject for investigation. In keeping with local practices and farming norms, the study focused on investigating soil biological fertility strategies that would improve *amadumbe* yield. Three planting seasons were implemented within 2006 and 2009 when project funds ended. Farmer engagement continued to monitor the use of adapted practices in field operations by farmers. In 2010, the SANPAD Project officially ended, and in 2011, the EFO lost the formal Woolworths market. Gradually, many EFO members left the organisation and stopped paying their membership fees. Formal monthly forum meetings became informal, with only a few held in a year with dwindling attendance. There were farmer engagements through informal visits

to EFO homesteads, occasional attendance of the monthly forum meetings by the researcher to hear of the post-project progress. Over the years, through visits to the study site, it was devastating to observe the EFO's disintegration of various institutional structures that were previously efficient in their functionality. Difficulties of not having a formal market led many farmers reduce the size of their production areas. Different EFO villages displayed different behaviours, with 4 out of 5 villages showing signs of being unsustainable. Only village E displayed consistency in their production, informal marketing and social cohesion.

At the beginning of 2018, the researcher identified the need for the 'return study' to document what went wrong through a formal collection of qualitative data to assess the impact of research interventions brought by the SANPAD Project for more than a decade in the area. In the quest to find evidence to what was happening in the EFO community, the 'return study' became a systematic inquiry tool into a set of related events that aimed to explain the phenomenon of interest in social setting for the researcher to understand (Nieuwenhuis 2007). The challenge expressed by EFO farmers over many years post project and departure of research team leader as facilitator, and gatekeeper was that the organisation could not operate until he returned. In agreement, the EFO committee and members concluded that they could not identify anyone good enough to resurrect the organisation (EFO) without the gatekeeper. Prospects of ever getting a formal market, specifically Woolworths, died until the return of the gatekeeper, whom they believe will one-day return in their lifetime to rebuild the organisation. Despite these challenges, village E continued to use all the best practices recommended by the research interventions, whilst in other villages, a few pockets estimated at 15-20% of the same behaviour were observed. The SANPAD Participatory Project (2006-2009) provided opportunities for participatory knowledge creation and actor learning in a movement towards commercialisation of traditional agriculture. In this study, the commercialisation of homestead agriculture, specifically *amadumbe* being the main EFO crop, was understood as having access to the Woolworths market. Over a period of a decade, the focus of the 'return' element of the study was to assess the impact of having a research intervention (through the SANPAD project) on the production systems of commercialising homestead agriculture.

4.2.2 An Emergent Research Topic

An emergent research topic was an outcome of the participatory research workshop facilitated by UKZN researchers with EFO farmers in Umbumbulu. Caister (2006) originally described the workshop that revealed information that led to a shared (farmer-researcher) agenda for transformation and development of researchable questions proposed for the SANPAD

Participatory Project. During the three months prior to the workshop held on 25 March 2006, farmers had recorded (written) questions about the problems they were experiencing in the conversion of traditional farming priorities from subsistence to commercial priorities. Noteworthy, is that the workshop formed a premise for many studies' this one included. Researchers and farmers explored questions raised to ensure a mutual understanding of the nature and rationality behind the questions. It was then agreed who (amongst the research team members) would be responsible for addressing individual problems. Researchers took these comprehensions away to reflect on and extract researchable problems within the natural learning process anticipated in the participatory agenda for transformation. Farmers had already made categorical their intentions for commercialisation in the constitution of the EFO organisation. In this document, farmers stated a deliberate intent to move beyond what they already knew and transform traditional agriculture into a practice of market-oriented sustainable agriculture.

Potential researchable problems were discussed by student supervisors, identifying individual research projects across a variety of disciplines that addressed farmers' concerns. A further priority in these discussions was to ensure that current research activity would contribute to the accumulation of knowledge being produced through the collaborative accumulation of prior research (2001 - 2005) and then followed by later research (SANPAD Project 2006 - 2009). Through a comprehensive reflection on the farmers' agendas, research consultants and students designed multiple individual research projects for students. These would also contribute to the farmers' knowledge requirements. The ten-year follow-up study involved EFO members who were smallholder farmers in village O (50%), village E (35%), village N (10%), village M (4%) and village R (1%) communities of Umbumbulu in the province of KwaZulu-Natal as the units of analysis. This study sought to identify the sustainability aspects of how the research intervention affected farmers' amadumbe production after the research project was complete.

4.2.3 An Emergent Research Question

The research question is also emergent from the workshop held on 25 March 2006, and the project information was presented previously in an account by Caister, as stated above. This study presents research enquiries envisioned in the consultations between EFO and research supervisors as a way of understanding the agronomic dynamics of the three-year (2006 - 2009) partnership. The research question emerging as the focus for this enquiry was: what are the biological strategies required towards sustainable *amadumbe* production in commercialising traditional agriculture? As decided by the EFO farmers, the role of this study was to contribute

to exploring alternative organic soil amendments to ensure improved soil fertility status for improved yield in the production of *amadumbe*. In understanding the challenge of limited and no access to manure by farmers when no other forms of soil fertility booster were available since the farming system for *amadumbe* in this area was primarily monoculture, the researcher needed to incorporate multiple strategies to providing improved soil fertility amendment for enhanced yield. Strategies involved the following components as sustainable practices to improve yield:

i. system change from monoculture to polyculture and/or intercropping

ii. use of other edible legume intercrop instead of dry beans

iii. introduction of vermiculture for the use of vermicompost

iv. incorporation of mutual benefit crop (wild mustard) with residual nutrient gain to soil.

The study's underlying theme for investigation became which type of farming system would result in a successful and sustainable production for continued commercialization. The sustainability measure of a farming system whether it is used for commercial or subsistence reasons, depends on the productivity of the soil and is enhanced by the practices employed that consider the critical issue of time scale. *Amadumbe* have a nine-month crop cycle, which suggests that three years of the SANPAD Project partnership with EFO was too short a time to determine any long-term indicators of sustainability in the production system. Yield improvement was, however observed in the 3rd year funded cycle of the project. The realization of the need for the 'return' study to evaluate signs (as perceived by farmers) of sustainability over a period of a decade that had gone past since the research intervention. A ten-year lapse was unintentionally allowed to pass so that the initial study of adapting local traditional agriculture could be assessed and the return study of research impact could report on the impact post the intervention. In assessing the impact of the research intervention and soil biological strategies gleaned through a livelihood survey summarized in the section below, the study thus presumed the necessity to examine farmers' perceptions on the different technological adaptations for the promotion of sustainable production leading to better livelihoods.

4.2.4 Study Assumptions

i. The study assumed that EFO farmers had access to unlimited organic manure sources to sustain the commercial endeavours of organically producing *amadumbe* as the main crop and other organically grown field crops (sweet potatoes, potatoes, pumpkins)

ii. Local crop rotation system (above ground followed by below ground fruiting types of crops) was adequate to ensure sufficient nutrient replenishment for the main crop of amadumbe without compromising the yield.

iii. Traditional farming system as a livelihood strategy had positive ecological benefits to the productive capacity of the soil.

iv. Advantage of the research agenda being set by farmers would ensure better adoption/adaptation levels of the best practices recommended for sustainable production (intercropping, use of legumes, use of vermicompost as an alternative).

v. Over a decade of research interventions and enhanced capacity built amongst farmers would result in social cohesion unity and strengthen internal institutional arrangements of EFO for sustainable united management in administration and productivity once the intervention period was completed and research team would exit the area.

4.2.5 Study Limits

The study was presented with a variety of limits to its execution:

i. The study inquiry was about changes (as seen by farmers) brought about by the biological soil fertility management practices resulting in the productive capacity of soils and yield improvement of *amadumbe* to sustain commercial aspects over time (10 years).

ii. The study was presented with limited research funds to focus on quantitative agronomic assessments over several years to depict statistically significant impact.

iii. The study relied on information provided by farmers and not any other sources, farmer perceptions of their lived reality following experiential learning and various research team engagements after a decade (10yrs)

iv. The study evaluated soil health status/soil quality (productivity) brought about by research interventions based on farmers' perceptions and impact on livelihoods over

the years, not the amount of money made in selling the produce but the ability of soils to produce high yields consistently.

4.3 Approach and Livelihoods Framework

In considering the full picture of people's livelihoods, it is important to note that agricultural research and technologies may not play a central role. Understanding the full picture can, however help develop technologies that better fit in with the complex livelihood strategies, especially of the rural poor like Umbumbulu community. The livelihoods approach seeks to gain an accurate and realistic understanding of people's strengths (assets or capital endowments) and how they endeavour to convert these into positive livelihood outcomes because it is concerned with people. A guide for research and intervention is provided by the livelihood framework (Carney et al., 1999). The framework particularly serves the purpose of linking the previous research work (SANPAD Project phases 1& 2) and capabilities with what people are proficient in doing, what they are looking for, and how they recognise their needs, especially post the intervention (when the research project ended). As a form of livelihoods analysis, the framework looks at more aspects of people's lives, analysing causes of poverty (low yields and reduced production/loss of formal markets), access to resources and livelihoods diversity, considering that *amadumbe* production is their primary livelihood strategy. Poor or not, the framework recognises people as actors with assets and capabilities who act in pursuit of their own livelihood goals envisioned to be dynamic recognising changes due to both external variations and the results of people's own actions, activities, and relationship between relevant factors at micro, intermediate, and macro levels (UNDP 2017).

The way livelihoods benefit from available resources through engaging in certain activities in an environment governed by some existing rules and institutions (EFO) is clearly explained by the sustainable livelihoods framework (SLF). In livelihood strategies, owned assets are used to transform people's lives. In implementing livelihood strategies such as crop production and livestock rearing, necessary for the realisation of desired livelihood outcomes, assets owned are key. Types of assets owned and envisaged livelihood outcomes have an indirect but positive relationship (Ibrahim et al., 2017). This study embraces the definition of a livelihood as comprising "capabilities, assets and activities required to make a living and to cope with and recover from shocks and stresses" (Kasim et al., 2017). Lim and Mansur (2015) advocated that access to physical assets enhances the income and wellbeing of households and individuals; as such, it has impacts on livelihood outcomes. Thus, this study submits that physical assets correlate positively and significantly with livelihood outcomes. Difficult issues of rural

development are described by the framework on how they could be approached and successfully addressed, showing the significance of resources and transformation structures in attaining welfare goals (Start and Johnson 2004).

The sustainable livelihoods framework illustrated in Figure 4.1, adapted from Chambers and Conway (1992), shows the link between farmers' assets (represented by different forms of capital), transformation structures, livelihood strategies, and livelihood outcomes. Precisely, the framework shows how, by availing households' opportunities/potential for livelihood strategies through the promotion of agricultural technology, research interventions impact livelihood outcomes. It shows the indirect association between livelihood outcomes and households' assets and the role of transformation structures and livelihood strategies. Assets include natural (land and its resources), financial (savings, membership fees, own contributions, and project funds), physical (infrastructure such as roads), social (EFO/social networks), and human forms of capital (skills and education levels). In improving livelihoods, assets are used as building blocks, influencing household capacity to withstand challenges of shocks encountered.

Households make decisions in response to available asset endowments for the adaptation of technology they perceive to generate positive social and economic outcomes. The existing policy environment, together with broad political and economic structures, considers livelihood context. Possibly, these policies and economic structures influence livelihood asset holdings, strategies undertaken, activities of development agencies and resultant livelihood outcomes. As exemplified in Figure 4.1, the system is defined by forward and backward linkages in response to changes in fields and farmer specific variables captured through livelihood assets and observed livelihood results. A particular "package" of field and farmer exact factors or livelihood assets is associated with each outcome, although each factor may be linked to various other outcomes. Traditional organic production is a mechanism through which farmers, given their socioeconomic and field characteristics, transform livelihoods. Farmers adapt their traditional organic production to increase land productivity to ultimately improve livelihoods through the commercialisation of homestead produce, even though income generated by smallholder farms is seldom adequate to ensure a meaningful livelihood generation (Homann-Kee Tui et al., 2015). Socioeconomic, farm specific features and expected positive benefits from traditional organic production affect farmers' decisions about technology adoption/adaptation. The actual and perceived impact of traditional organic production on livelihoods was noted to vary with the geographical location of the farm. Biophysical and

institutional constraints, together with socioeconomic factors that favour specific practices, were shown by the varied results in the EFO villages.

Generally, farmers are diverse and face dynamic local political and economic environments that determine adaptation trajectories, taking care of consequent constraints and opportunities for traditional organic production. Noteworthy still is that even using best-practice farming methods, small farms are often not financially viable (Harris, 2019), with land users also relying on other sources of income, particularly where fragmentation reduces the effective arable land. Farmers with less than 2Ha of land are unlikely to become prosperous, no matter how productive they are (Harris, 2019), and meaningful poverty reduction will generally not be achieved from increasing crop productivity alone (Wichern et al., 2017). As the perception's paradigm suggests, farmer behaviours are shaped by the view that commercialisation influences livelihoods directly and positively (Uaiene et al., 2009). These attitudes are driven by farmer specific factors such as age, gender, household size, level of education, and marital status, all of which are indirectly linked to perceptions about livelihood outcomes and intervening technologies.

In its approach, the project hopes to influence the Department of Agriculture and Rural Development (DARD) policy environment towards supporting traditional organic production as part of rural development through varied platforms addressing food security and poverty alleviation goals.

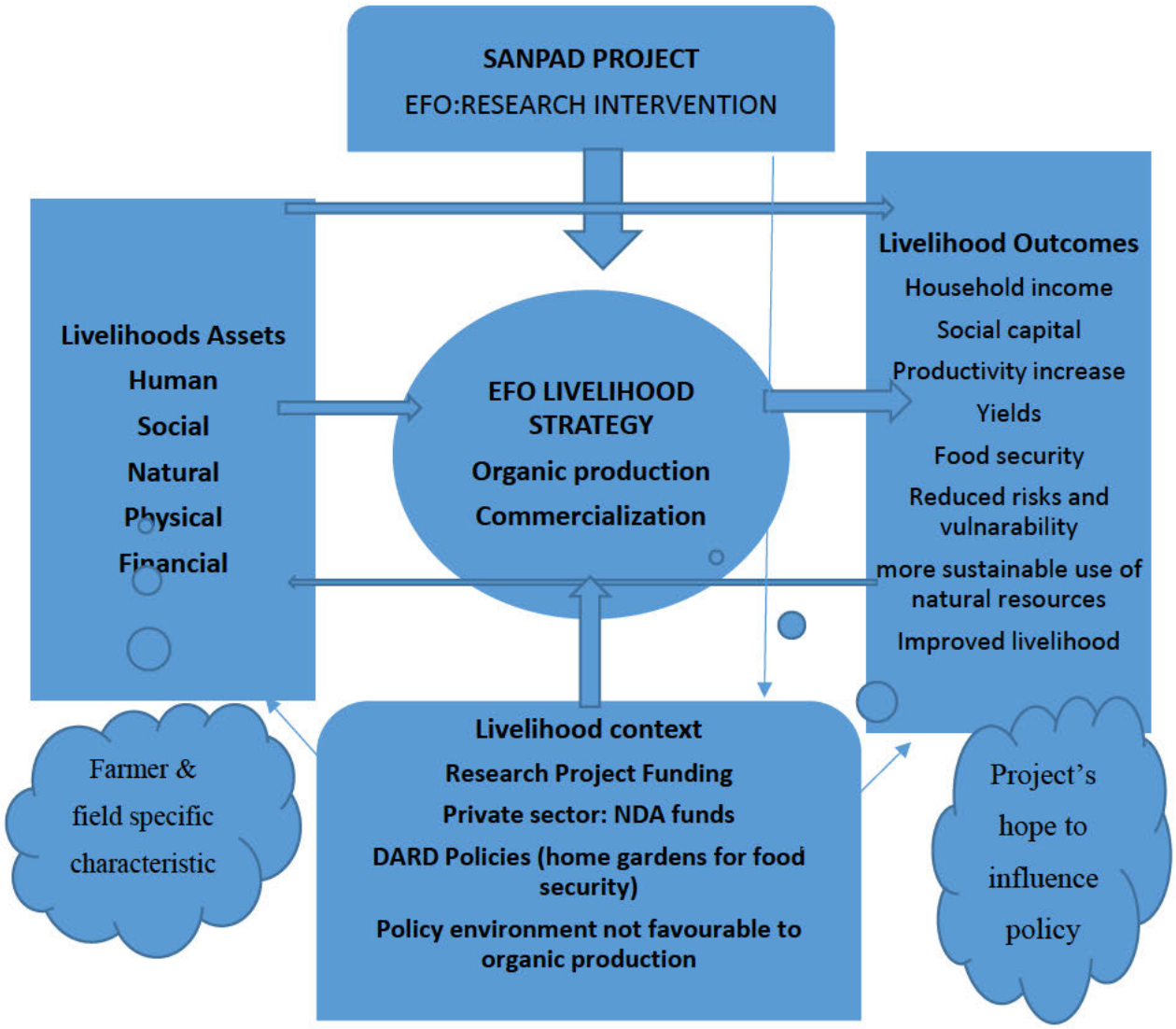


Figure 2.1. Link Between EFO Commercialization and Livelihood Outcomes (Source: Author's own adaptation of Sustainable Livelihood Framework; UNDP, 2017)

4.4 Results and discussions

4.4.1 Overall Sustainability

Research results from fellow UKZN research cohort have looked at various sustainability aspects, and some of the views may have been officially reported in different studies looking at EFO holistically. This study is reporting on the socio-agronomical influences of sustainability. Graphically depicted (in Fig 4.2) are the components of sustainable agriculture specific to the EFO community. These components outlined the space in which farmers and the UKZN research team operated so that EFO farmers could be successful at genuinely engaging in sustainable agriculture and ensuring that research interventions were successful in supporting them.

The five pillars were adapted from previous work done by Khwidzili (2012) presented as:

1 Maintaining and increasing biological (organic/traditional) productivity;

2 Decreasing the level of risk to ensure greater security;

3 Protecting the quality of natural resources (soils, water and veld);

4 Ensuring agricultural production was economically viable (commercialisation); and

5 Ensuring agricultural production was socially acceptable (strengthening social cohesion).

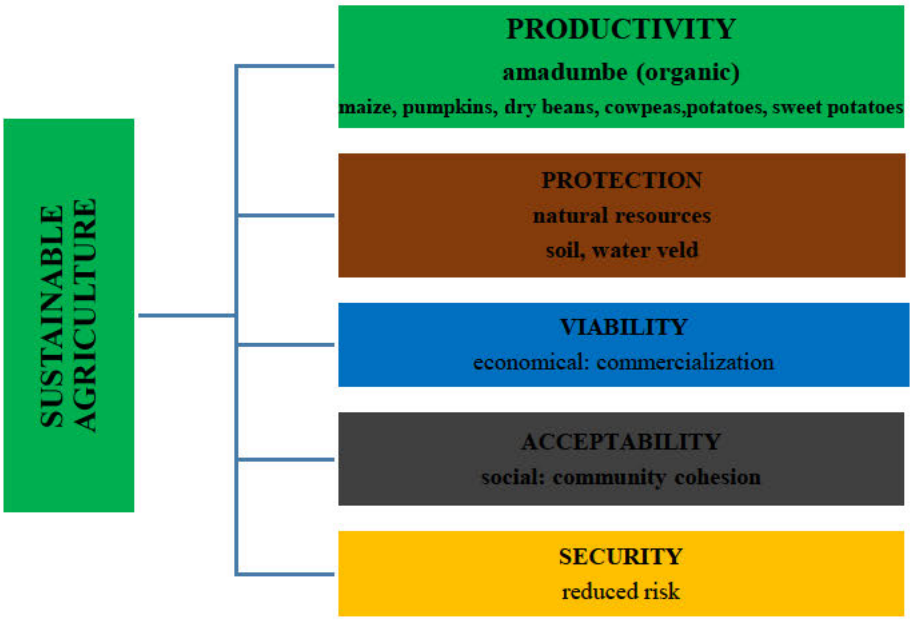


Figure 4.2. Five Pillars of Sustainable Agriculture (Adapted from Khwidzili, 2012)

village E presented a good opportunity to discuss these pillars, where relevant principles for each pillar was demonstrated through examples of their practical application to illustrate the point. Relative to other villages, village E's unique circumstances are based on their consistency in practising sustainable farming and assistance in developing appropriate responses to show sustainable practices in the continuous production of amadumbe. These pillars will be addressed in an integrated fashion, not as an individual aspect to be addressed in isolation. Environmentally, land scarcity is causing food scarcity for the ever-increasing population. In the context of the EFO community, where traditional agriculture is a way of life, it can be said that their goals and understanding of the long-term impact of their activities on the environment and, consequently, other species trends toward sustainable agriculture (Francis 1990). Importantly, to be noted is that sustainability is a direction rather than a destination. Hence, as stated in the study, assumptions that EFO will continue to remain sustainable in their farming style. village E farmers understood clearly what was being sustained, for whom and for how long to afford future generations' agricultural livelihood opportunities. Sustainability was entrenched in the study's resulting technologies that reflected a combination of traditional (*amadumbe* monoculture) and modern techniques (row intercropping, use of cowpea, vermicompost and wild mustard). Central to sustainable agriculture is the necessity of taking a long-term view in ensuring the supply of products to future generations, the necessity to maintain and enhance soil fertility, veld condition, water quality, supply and generic resources on which agriculture depends. Sustainable agriculture delivers on these critical elements through a variety of technology options, as seen in the implementation of both phases of the SANPAD project at village E.

4.4.2 Biological Productivity: Improvements to Soil Health and Quality

Increased biological productivity of the soil is considered the first pillar of sustainable agriculture and needs to be maintained. The ability of soil to promote microbial activities is defined as biological productivity. The continuous application of large quantities (village E) of cattle manure as part of traditional organic farming ensured that microbial populations were enhanced. The high organic matter content build-up is key to the biological productivity of soils at village E because of these best practices, including minimum soil disturbance, which led to reduced mineralisation. In this village, farmers understood that their soils' productivity forms the foundation that sustains consistently high yields to keep the commercial viability and maintain livelihoods. In managing biological productivity, other pillars of sustainability are simultaneously considered, such as economic viability, social acceptance, and reduced

production danger. Protecting the quality of natural resources is directly connected to the biological productivity pillar toward attaining sustainable agriculture that works within the confines of nature, not against them. The implication being, that matching land uses to the constraints of the local environment as well as planning production to not exceed biological potentials with no use of synthetic fertilisers and pesticides. Traditional agricultural systems are, in their nature, a premise for sustainability (Franco, 2021).

Soil is the fundamental capital asset as it is the most important part of any agricultural system. When in poor health, it cannot sustain productive agriculture. In rural areas, many agricultural systems are under threat because soils have been damaged (due to bad management practices, including overgrazing), eroded, or simply ignored during the process of agricultural intensification programs by the government and various non-governmental stakeholders. Soil fertility is the primary factor affecting agricultural sustainability and is known to be a function of current and previous management regimes. Amongst indicators farmers use, crop production factors are considered the most reliable indicators of differences in soil fertility. These crop factors include primarily crop yield and crop appearance during the establishment stage. Yield forms a benchmark for soil quality assessment in the indigenous approach (Ayodele et al., 2024). Even so, crop production indicators used by farmers (yield and crop appearance) may not always be a true reflection of soil quality since high yield can be a result of favourable weather and improved seed. In taking advantage of the climatic conditions and the results from the ARC cultivar trial outcomes (2013-2017) that identified the best local cultivar for use at village E and the good rainy seasons (2015/16 onwards) post the 2014/15 drought year farmers maximised productivity and increased yield (FN020618: App IV). Farmers, from village E in particular, treat soil fertility as a dynamic character of soil which they improve through maximising crop diversity by using rotations and intercropping and large amounts of manures in boosting nutrient levels. Djama et al., (2023) explained that soil colour provides a good measure of inherent soil fertility. Together, the dark soil colour and the presence of earthworms are recognised as indicators of soil quality beneficial to fertility. Farmers understand the positive linear relationship between manure addition and dark soil colour. Thus, the strong belief that the continuous addition of large quantities of manure will enhance both these indicators for long-term productivity and maintenance of high yields. In turn, soil organic carbon reserves also get established in the build-up of a resilient soil system.

Contrary to unmanaged perennial ecosystems, annual agricultural ecosystems like the EFO *amadumbe* system regularly exhaust soil carbon (C) and release more reactive nitrogen (N)

into the water and atmosphere. Yet, we depend on these ecosystems for livelihoods and food security, as they represent the largest stock of soil carbon that can be directly managed to mitigate climate change (Kallenbach et al., 2019). How, then, do we resolve this dichotomy to create a win-win scenario whereby agroecosystems remain productive while contributing to climate change mitigation? To address this grand challenge, agroecosystem soil biology should increasingly be managed to regulate soil C and nutrient cycling better (Wallenstein, 2017). Many approaches, like the soil biology strategies used in the EFO project, focussed on soil C rejuvenation through increased residue returns and biomass production (legume intercropping) and decreasing C losses *via* reduced disturbance (minimum-till).

In this traditional organic agricultural system, the net return of soil C and its storage was attained through the adaptation of a wide variety of physical and biological soil conservation measures, use of legumes and intercropping, incorporation of phosphate-releasing plants into rotations, use of composts, cattle manures, vermicompost and maintenance of minimal soil disturbance during tillage. The use of vermicompost is known to enhance microbial life in the soil as the high populations of microbes (including earthworms) are active and continue with nutrient cycling within the vermicast. The use of legumes (cowpeas) that attract nitrogen fixing bacteria naturally living in soils enhances the root zone with a community of microbial life. This project framework focused on connections between best management practices and microbial traits to allow us to describe better, envisage and manage the relationships among critical soil services, the microbes that drive them, and the environment under which they manifest in the long run toward sustained soil health and quality. It is thus suggested that the combination of various types of manure (cattle and vermicompost) to improve soil C sequestration, effectively engineer rhizosphere microbiota and increase nutrient efficiency farmers needed to understand the long-term effects of fundamental soil microbial processes of the dominant microbes within the community created in this specific agroecosystem. Schimel et al., (2007) also found that a diversity of inputs represented a wide range of C and nutrient availability that may have facilitated a balance between individual and community-level C use efficiency optimisation, thus indicating a productive system. In promoting species with different life histories to coexist, practices such as diversifying crop rotations or mixing legume crop biomass with *amadumbe* residues could be used to provide feedstock resources.

4.4.3 Impacts on Rural Livelihoods

With specific reference to village E, results revealed that sustainable agricultural improvements produce positive effects on people's livelihoods with regard to social capital. Village

membership increased and was demonstrated by the collective management of natural resources and stronger social bonds, thus resulting in new norms. The perceived sustainability by non-members lured them into wanting to be united with the original members for better connectedness to external institutions, bringing about the change at the local (village) level. These improvements in human capital led to increased self-esteem in a formerly marginalised group and increased the status of women with more local capacity to experiment and solve local problems. This situation resulted in improved nutrition, especially from more food during dry seasons and reversed rural migration whilst creating additional local (village) employment opportunities.

The process of adjustment in sustainable agriculture projects is a vital part of social learning. The notion that a simple diffusion explains the conventional model of understanding technology adoption as if by osmosis no longer holds. The alternative is not simple either, as it comprises building farmers' capacity and communities to learn about the complex ecological and biophysical complexity in their fields and farms so they can act in different ways (Caister, 2012). When the process of learning is socially rooted, it provokes changes in behaviour and can bring forth a new world to those engaged. The practical evidence seen at village E shows that social learning resulted in greater innovation with an increased likelihood that social processes producing these technologies are likely to continue. This is noted in the history of the EFO, where a research relationship provided an excellent platform on which various kinds of initiatives, including new indigenous crops and conventional irrigation schemes (rainwater harvesting and supplementary irrigation), were slowly and carefully introduced.

To date, these initiatives are still in use and beneficial. At village E, farmers exhibited a reflection of the way values, attitudes and goals are shared within a group, thus showing success in building relationships in the development process, including culture. As their way of life has gradually progressed over a decade of continuous learning as village E farmers stayed true to their beliefs and expressions noted in their constitution: "W*e wish to cooperate with the Department of Agriculture at all levels and any other institution or persons in sustainable, productive, stable and equitable agriculture to commercialise our produce in a manner that improves our economic development without compromising our cultural integrity*" (taken from the EFO constitution, 2001). In their understanding of the impact of research intervention as a driver for social change and material gains, village E farmers understood that momentum was generated to attract various funding possibilities. Acceptance of the ARC *amadumbe* cultivar trial when the EFO rejected the request showed their progressive nature in aspects of

environmental sustainability for economic development through their strength in social cohesion and maintained relationships. The villagers were aware that results from this cooperation would present them with new potential market opportunities, especially because their level of confidence in good quality products would be heightened by the trial outcomes of the best cultivar in their area. A lesson long learned during the UKZN SANPAD Project team that all research results are built into action and used to sustain, advance and enhance the overall production system.

Farmers at village E made a conscious effort to elect lead farmers who facilitated the establishment of the village's human and social capital formation with the understanding that yield improvements and production income do not translate to social capital formation. This was done through encouragement and facilitation of the formation of village-based farmer organisation. village E has strong and committed leadership and has responded flexibly to the changing EFO set-up/break-up that happened (post 2010) and managed to keep their village intact. There has been a move from original male-led leadership in the EFO generally to female-led leadership who were more skilled and patient in engaging in the process of change and village independence. This move has seen more households being able to earn a good livelihood strategy to the point of sending their children to tertiary institutions of learning with success. After leaving the employ of Farmwise Packhouse in 2010, Mr Mkhize (1st EFO chairperson 2001-2004) has been the support system for the village as the individual who played the key role in linking the village with external markets based on his history and experience (see Fig 4.3). The relationship has been built on trust between the village representatives of lead individuals and the new market at the Toyota Plant in Isiphingo. Flexible and responsive collaboration with a supportive market agent (at Toyota) and a wide range of opportunities within have steadily increased sales momentum. The Toyota plant at Isiphingo is believed to have more than 500 employees per shift who prefer having produce delivered to their security gate. Twice a week, produce delivery is expected as individual orders are placed with fortnightly (every 2 weeks) payments. This system is efficiently coordinated by village E's leading individuals, who then distribute monies accordingly in the village every 2 weeks to all the respective homesteads who have supplied the produce. Farmers at village E do not have access to additional land outside their village to expand their area of production. Hence, to continue supplying their market consistently, they must rely on the Mkhize clan relatives in other villages like village O to supplement their overall tonnage and extend the amadumbe

market season (Mar – Jul) based on family relations and trust, a mutual financial benefit is thus accomplished.

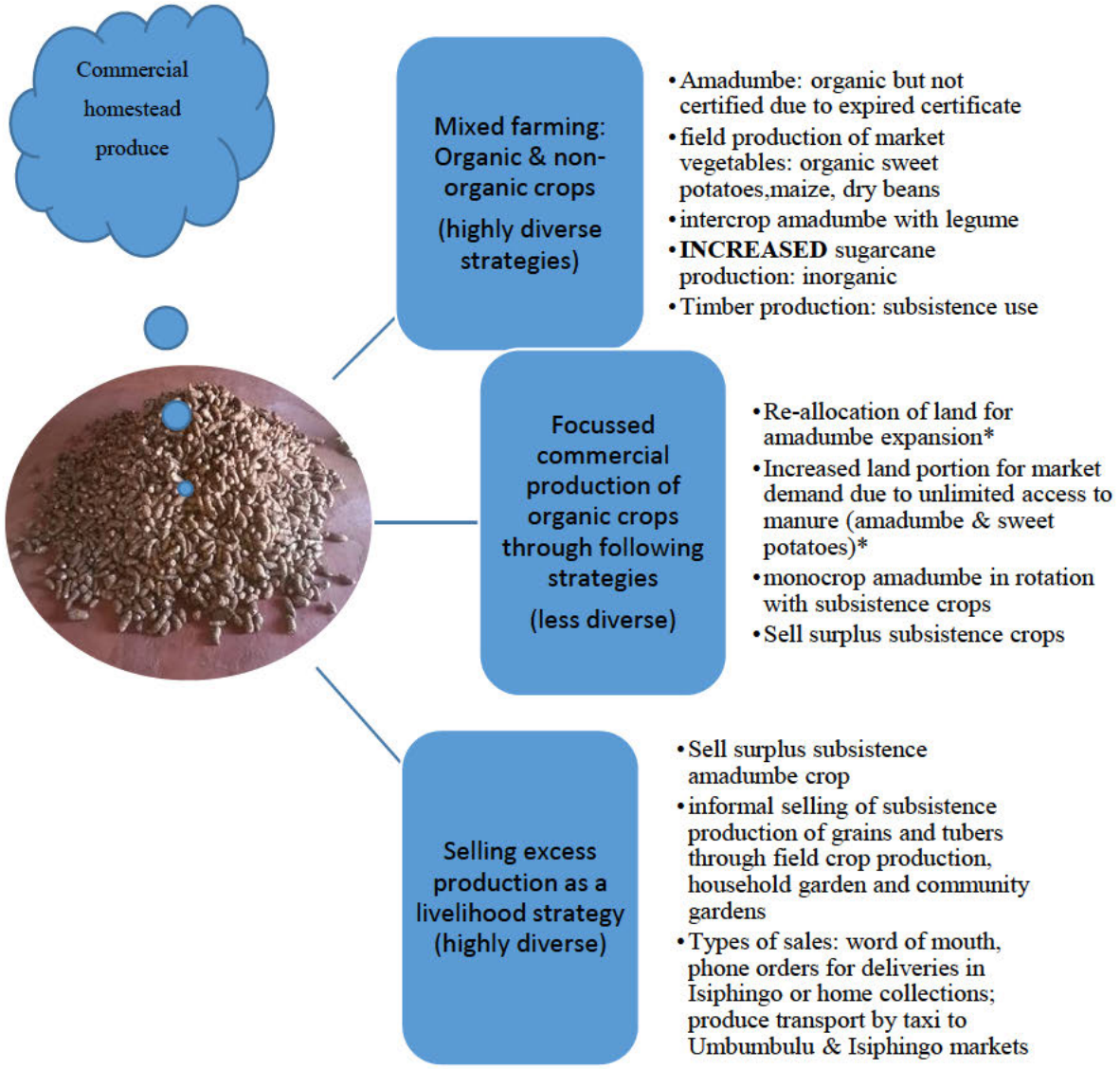


Figure 4.3. System Adaptation for Commercial Production Compiled from Observations and Discussions 2011-2019 at village E

Human capital appears in the framework for sustainable livelihoods as an asset that affects livelihoods. Aside from its inherent value, human capital is required to leverage all other forms of capital. Whilst not sufficient as a stand-alone resource, it is vital for the achievement of positive results in any dimension regarding livelihoods. Subsequently, human capital is a multifaceted concept comprising a range of human attributes that are difficult to quantify. Also, its stock value cannot be determined alone by existing knowledge and experience. It should include an assessment of an individual's..ability to learn new knowledge and skills according

to their future development needs clearly demonstrated by the Ezigeni women over the years post the research intervention (Table 4.2).

The livelihoods framework is human-centred and involves a broader appreciation of the process, including governance of natural resources and local practices, such as land access and distribution, veld management norms and similar. Thus, because the village E group is primarily women, they cannot access additional land despite their great need to increase production, as guided by market trends. Similarly, with the physical capital, women alone in a rural setting do not have much influence on the development and enhancement of this capital.

The other four groups (EFO villages) showed that research interventions did not enhance individual human capital development as many farmers have today gone against all the capacity and training done by the research intervention. Observed as evidence, was their decision to sell prime organic land for a small income brought in by the cane plantations that use inorganic chemicals (FN130718: App IV). This may also be a result of the old age of many members, thus causing them to easily backslide without much care for the future because of the lack of interest shown by their immediate young descendants in agricultural livelihoods. Many members believed that all four capitals (human, social, natural & physical) cannot be further developed to gain a livelihood without the market facilitator. Their decision to disaggregate the organisation by getting rid of the committee and destroying their institutional arrangements are clear indicators that without commercialisation, not much can be achieved in the absence of their gatekeeper.

Despite the opportunity for financial gains brought by commercialisation, many believe the effort (pursuing informal markets and using public transport) is too much to do on their own for not much return as they cannot get back the premium market they had during the days of having a market facilitator. Whilst at village E, all capital assets are viewed and treated as equals because of their understanding that these assets are inter-related. Located at village O, EFO headquarters (packhouse) owned by a certain family caused many to view those premises as a personal asset to that family as depicted by the score of 1 on both the natural and physical assets (Table 4.2). Internal conflicts resulting from the collapse of institutional arrangements made the village E farmers feel unwelcome at the packhouse, hence the establishment of a secondary EFO at village E. To realise the significance that each stakeholder group attributes to each capital, they were asked to assign a value to each from 1-3 (the greater the value, the greater the importance).

Table 4.2. Depiction of unity in women of village E in view of Livelihood Assets

Capital	**Research Intervention**		**EFO Institution**		**Commercialisation**	
	village E	Others*	village E	Others*	village E	Others*
Human	3	**1**	3	1	3	**1**
Social	3	3	2	3	3	**1**
Natural	3	3	**1**	3	3	**1**
Physical	3	2	**1**	3	3	**1**
Financial	3	2	3	2	3	2

Others*: Primary EFO members with all villages together, excluding Ezigeni

4.4.4 Socio-agronomic pillars of sustainable continuity

4.4.4.1 Impact of age and level of education on sustainability

The distribution of the farmers by their level of education was generally low across all villages. Detailed in Chapter 2 (Graph 2.1) results show numbers of participants that have no formal education are 4; 6; 2 and 3 for villages O, N, M and E respectively. Also, none of the farmers had tertiary education. This placed a large proportion of participant farmers within the primary and secondary school level as shown by 10; 11; 5, and 2 for primary and 6; 7; 5 and 7 for secondary schooling for villages O, N, M and E respectively. These results clarify why most members of the EFO executive committee are from village E because of the greater proportion of women with secondary school education. In agreement with small numbers representing the youth, dominating older folks did not have an opportunity to study further because of various factors in the South African political context as shown by the lower levels of formal education. This dominance has an influence on several decisions taken by the group in moving forward towards future engagements with other external stakeholders for sustainable development of their continued commercialisation of traditional homestead organic production. The issue of age dominance was revealed by the responses on their opinion of the group (EFO) before and after the UKZN research team engagement (Table 4.3). Dominant older members felt that without the leadership of UKZN (gatekeeper), the organisation would suffer a slow death of internal differences due to conflicts. This was seen from the collapse of institutional arrangements where the first committee members had to resign because of differences of

opinion with regard to leadership and development goals of the group without the leadership guidance of the UKZN research team coordinator. The older members found it difficult to continue with the organisation (EFO) when the SANPAD/UKZN research funds were exhausted. The engagements were reduced and eventually the project ended after several years. The fear of the unknown was apparent in their view of a bleak future where the sustainability of EFO was not expected, especially by the older farmers. As a result of their dominance in numbers (older proportion) the whole EFO structure was compromised. Younger members were outvoted and side-lined when, unfortunately, they had the capacity and skills to lead the group with better administrative and good institutional arrangement skills into a sustainable future. These differences because of age gap contributed to the break-up of EFO into primary and secondary cooperative entities. The relatively younger, better educated members of EFO were more progressive, hopeful (even without the UKZN leadership) and better able to engage external stakeholders for their future betterment as they utilise the leadership capacity built by the UKZN research team.

Dhillon and Moncur (2023) also agreed that lower levels of literacy and lack of competence in the administration led to farmers not using existing information for their development. The secondary EFO cooperative, based primarily on younger and better educated members at village E, is more successful and has benefited from new external stakeholders. They currently boast a stable market and have increased their production areas (through new membership within the village) to meet their new market demand. At village E, a clear display of strengthened (age-related) group dynamics is seen in their combined use of local resources (land, labour, planting material) whilst preserving biodiversity. village E's strength is seen through the unity of the village (added new pieces of land) planted with *amadumbe* and sweet potatoes. Younger members are now part of the group, and their additional land is dedicated to the traditional organic planting of tubers. Planting material is shared amongst themselves (within the village) for quality assurance of the produce. Labour is also shared where weeding is done together for all fields. Marketing of bulked harvest is done by the dedicated members who collect and deliver produce to the newly acquired markets in Durban and Isipingo. Skills and capacity gained during the research engagement are now utilised to build a more sustainable and successful village.

Table 4.3. Differences/Changes in EFO Over a Period of a Decade[#]

EFO characteristic	2006 -2010	2011-2019
Institutional arrangement	United group: active committee strong social bonds within EFO community	Disaggregated: in-active committee, no direction, cannot read and understand records/books, extremely poor admin. Hidden records as anyone can learn important information about EFO
Gate keeper (research team)	Present and actively involved	Absent no activity
Organic certificate	Paid for and valid	Expired no funds to re-apply
Markets	Formal and active (all members)	Informal members
Field sizes (amadumbe)	1 – 2.5Ha and increasing	<1Ha and decreasing
Membership	>200 and increasing	<100 and decreasing
Future perception	Sustainable and growing	Hopeless and dying
Crop yields	Gradually increasing	Relatively very low[1]
Generation gap	Equal proportions of young and old	Older members dominate[2]
Executive committee	Representative of all group demographics	**Dominated by older members** with no leadership skills[3]
External stakeholder engagements	Open to a variety of engagements that brought development and growth to EFO	Opposed to any stakeholder opportunity which is detrimental to the growth. Obligation to seek EFO consent for participation from gatekeeper "we belong to Prof only". Some stakeholders have been deterred by this attitude of the EFO
Beliefs	Gate keeper will always be with us and help us grow. Always listens and takes his advice. Only trustworthy	Will await the return of the gatekeeper and in the interim, no one is good enough to help us. Any arising opportunity is thus rejected. Without Prof anyone wants to 'rob' or cheat us of something or the other.

EFO characteristic	2006 -2010	2011-2019
	person to work with into the future	
Monthly forums Management of EFO assets: tractor, bakkie, PC, camera, general admin and income generation	Constantly every 1st Monday of the month with formal agenda and meeting protocol observed with >70% attendance All assets properly managed with good record keeping. Income growth and transparent management of funds Efficient display of good institutional management	Random once every 3 to 4 months with no agenda and no formal protocol observed with less than 30% attendance. Sometimes the forum is just about how much did the tractor make and how much will be spent on repairs, then meeting is adjourned. Currently there are sparse records of a few items, with tracker removal from the bakkie, unwarranted activities observed by many but cannot be questioned as members are threatened by those holding the specific asset. Trust is completely lost within the organisation
Fears	Generally, no fears were noted except for the ability to satisfy market needs (quantities)	EFO belongs to Ogagwini village and specifically to the family that owns the land where the packhouse/hall is situated. Any EFO asset enquiry upsets others. Live with perception that access to formal markets lost for good or at least until the gatekeeper returns. The absence of gatekeeper implies no progressive farming until he returns and resurrect the organisation. Don't trust genuine efforts by any external stakeholders to bring development.

[#] Data presented excludes village E which is detailed in the next table as the best village *i.t.o* sustainability

[1]Low yields: result of decreased planting areas (no formal markets) low soil's productivity (high fallow hectarage)

[2]EFO segregation did not attract new and younger members to join

[3]Current chairperson not a farmer but a reverend/pastor, entire committee have had no leadership capacity training

4.4.4.2 Impact on Production Practices

In honour of existing livelihood strategies and acknowledgement of the farming system, previous research (2006 -2009) had followed the use of traditional agriculture as part of local knowledge. To improve the management of locally available production resources in the journey of commoditising *amadumbe,* new knowledge acquisition in dealing with organic market demands permitted the learning. Farmers learned through experiential work, plant spacing and manure quantities that will achieve the expected market sizes or value of the produce. Over the years, the loss of organic certificate (expired validity) led to reduction of land area that was planted with *amadumbe* in fear of uncertain informal markets. Apart from village E, all other EFO villages have farmers that have decreased the production areas over the years due to the lack of formal market (*App I & J*). Considering that village O is known as the base or centre of EFO, it is a great loss that half of the membership in this village have reduced their production land for *amadumbe*. Many farmers reported a land reduction of between 40 – 60% with the smallest areas at village M where members now grow *amadumbe* on 0.2 – 0.25Ha portions of land. Land use for sugarcane production has however increased which is rather unfortunate because cane production requirements are highly dependent on inorganic fertilisers. In keeping with organic principles and sharing of same beliefs, attitudes and goals around agricultural productivity, farmers reported that a 6m contour is used as a border between cane fields and *amadumbe* land to manage the inevitable possibility of underground chemical seepage. This practice is accommodated by all new cane growers and those who are expanding their cane lands since access to land is now a constraint, large proportions of previously *amadumbe*/organic lands are now lost.

4.4.4.3 Land Use and Cropping System

Mixed cropping that includes livestock has been gradually diminishing over the last decade because of changes in land-use (*App I & J).* Village N, for example is undergoing quick urbanisation with residential land use increasing. This trend is placing pressure on both arable and grazing land, leaving farmers limiting production areas, which lead to an intercropping adaptation practice increasing to mitigate land pressure using mixed cropping style. Loss of formal markets led to changing livelihood strategies and reshaping of cropping patterns. Results revealed that many home gardens (village N) are converted to create additional land for mixed cropping (amadumbe, legumes intercropping and maise, sweet potatoes rotations). All villages except village E have experienced a decreasing amount of livestock in the herds

due to stock theft and lack of grazing land, amongst other reasons. The loss of livestock consequently results in limited access to manure which impacts yields negatively. As pointed out by Loeper et al., (2018), historically, smallholder farmers have not had the opportunity to produce high-value crops due to limited input resources. This is especially critical for EFO farmers since access to manure is key to their traditional organic production and continuing commercialisation goals.

village E, on the other hand has maintained their livestock numbers, with a slight increase in herds as they expanded their production areas because of stable markets. Also, the element of unity in the village is indicated by the positive results of less to no stock theft relative to other villages where this challenge is increasing (village N). In their adapting, village E farmers needed to attend to concerns associated with intensified production and recognise factors that shape market acceptability without any reliance on external resources (loans, organic fertilisers, and planting material). This can be viewed as a clear advantage of incremental integration driven by market stability. As expected, over a period of 10 years, many valuable lessons were learned through the process. However, due to the scope limitations of the study, only production related impacts are reported, including the adapted practice of legume (cowpeas and dry beans) incorporation in their standard *amadumbe* production routine. It is noted that in their understanding of sustainability within a development context, practices that require less effort on their part and are beneficial to their needs were easily incorporated and thus integrated as part of best practices. Also, for some villages, though it was noted on a smaller scale at villages N and O, the chosen legume intercrops were part of their protein source for household consumption as well as adding an alternative to the normally consumed dry beans except for village E where cowpeas specifically are used for soil fertility augmentation.

4.4.4.4 Production Motives

Jouzi et al., (2017) found that lower yields common in traditional systems, issues with soil nutrient management, certification, market restrictions, and small-holder teaching and research requirements are among the key challenges of food production systems. In this study, challenges and constraints related to production resources, together with institutional arrangements expired organic certificate, led to the loss of formal market. Despite this, it was observed that a good proportion of farmers are still eagerly producing *amadumbe* for subsistence purposes. Fortunately, the foundation laid by previous research work (UKZN team) with farmers built on local abilities rather than replaced them, assisted farmers in believing in

what they are doing. This work ensured that traditional agriculture was modified rather than replaced with technologies that displaced local ways of production and a way of life (social relationships). This learning method was clearly displayed by village N farmers in their ability to attract many new farmers to join EFO through their social engagements of farmer-to-farmer knowledge sharing experiences in producing *amadumbe*. This village showed that *amadumbe* production is still a mainstay activity during these times of competitive land use with a need for rising residential use (FN170818).

The good stable past (with the market facilitator) had taught farmers that markets and economic climate fluctuate with good and bad seasons; hence their motives are still primarily based on the knowledge that *amadumbe* is their way of life and the crop will always be required by the community as it forms part of the staple foods. Villages O and N sell most of their produce through informal methods, whilst in village M, the few remaining farmers produce for subsistence mainly because of the ageing members in this village who are not economically active. Village E found and established two steady (constant) markets that pay organic rates despite the absence of a valid organic certificate. The EFO, in general has a good reputation for high-quality organic *amadumbe* in many market circles in KwaZulu-Natal. This has been an advantage adopted by village E farmers in their progressive outlook of sustainable commercialising of their produce. Large profit margins allowed farmers in this village to send their children to tertiary institutions of learning, with four university (UKZN) graduates and four information technology (IT) students benefiting from *amadumbe* profits made in this village. Caister (2012) concluded that technology shifts from something to be applied to something leveraged for networking and organising where the capacity to co-operate in a way that opens the possibility of social change is a way of interacting that preserves and creates new forms of social cohesion for sustainable growth. A true reflection of how values, attitudes and goals are shared for united development. Village E exhibits unity in progressive continuity that they have demonstrated over the years of qualitative assessment of the project.

Acknowledging the differences between villages in their way of thinking about production motives was observed when the EFO structure was dismantled. Farmers' responses are rational, considering the complexities faced by individual homesteads in the pursuit of market production. Challenges with the cost of transportation and price of inputs have risen hindering agricultural development in rural areas where they are experiencing poverty (Mpandeli et al., 2014). Village M's example of group numbers decreasing with less land area planted and planting mainly for subsistence demonstrates the reality of varied decisions in view of the lost

EFO stability and group security as far as markets were concerned. Whilst village E has a qualified motive for *amadumbe* production as they are the only ones participating in the cultivar evaluation trial of 4 years by the Agricultural Research Council vegetable institute. Trial results showed that local cultivars outperformed other cultivars from KwaZulu-Natal and some African countries, thus boosting village E's newfound confidence in dealing with new markets on their own terms.

4.4.4.5 Rural Livelihood Intervention Through Experiential Learning

In design, the compound SANPAD project study had a variety of sub-research projects that looked at the dynamics of commercialising homestead agriculture. The overall focus was narrow and on the commercialisation of agricultural commodity production. In assessing the impact of an intervention, the original compound study was not holistic in its design as it only focussed on agriculture, when, in fact, rural livelihoods are complex and do not only rely on agricultural livelihood for sustenance. Considering agricultural and non-agricultural elements, the capacity of government and private sectors and market conditions at all formal and informal levels is paramount for overall sustainability. It was believed that with the capacity built within the participants, especially members of the committee, institutional sustainability would be maintained post the research project intervention. Sadly, with the absence of external support, EFO members on their own failed to manage internal disputes to the point of institutional collapse and organisational destruction. Looking at village level, village E displayed positive results of research designed to be adaptive and participatory, as indicated by the strong social bonds that benefit all other sustainability assets.

Noteworthy is that the involvement of the private sector in implementation is essential to promote appropriate and sustainable mechanisms for the different elements of the production system and in rural livelihood systems. This requires a range of partners working together instead of establishing parallel structures. The middle level is key to service delivery in coordination mechanisms of bringing together public and private sector stakeholders. Unfortunately, in the compound study, not much effort was placed into engaging the private sector in a significant way, as it was believed that the presence of extension officers would assume the role of bringing public and private operators together to support the EFO post research intervention. Environmental sustainability, however, was particularly the foundation on which the various research studies were rooted, as all of them were of an agricultural nature, and the technologies investigated together with the participants addressed this pillar. As was

expected a decade later, environmental sustainability still showed a solid and positive result indicated by the productive capacity of soils and high yields. Contrary to many rural interventions that usually show environmental degradation post the intervention because beneficiaries neglect or dis-adopt/adapt best practices for various personal reasons. A more sustainable agriculture system increases the asset base and leads to rural livelihood expansions where people are better off, have more food, are better organised, have access to external services and power structures, and have more choices in their lives. In the context of EFO, holistic sustainability was observed during project phase one (2006-2009), as post the research team *era* (project phase two), a gradual emergence of critical trade-offs and contradictions was seen. The strength and stability of institutional arrangements through the committee was challenged by members to the point of collapse and destruction, thus compromising critical functioning of the organisation. This was seen by the expiry of the EFO's organic certificate, which guaranteed their market, in this regard, the committee was found wanting as it had been disbanded by the very members of the organisation who would benefit.

With the emergence of unsustainable *ad hoc* administration of the organisation, EFO ended its good run with winners (village E 35%) and losers (with specific reference to village M 5%), whilst other villages (O and N 60%) were in-between with a few winners on a small scale and many losers. What was of note about the winners was that they valued agriculture as the century-old engagement with the local environment to maintain household nutritional health, community security and identity, as well as entry to commercialisation. With this background and all the lessons learned during the research engagement period, this community was able to continue environmentally and economically to sustain their agricultural livelihoods for more than a decade with full confidence in the future.

Visser and Wangu (2021) pointed out that women are key to household food security, yet they play these roles in the face of enormous social, cultural, and economic constraints. Also, the gender aspect is still not adequately addressed and integrated into discussions of achieving adequate food supplies. Generally, female farmers in many regions have myriad constraints, including less access to land, livestock, agricultural inputs, credit, education, extension, and other services than do men, due to social norms (FAO 2011b). Recognition of the importance of gender equality and women's empowerment in improving food systems has been increasing recently (Njuki et al., 2021; GAIN, 2019; CARE, 2021). However, the lack of a strong gender lens in efforts that seek to improve local food systems despite the widespread agreement on the importance of gender equality in food systems still exist. Having shown their capability,

women in village E aspire to additional land and better access to credit (for a tractor since it is their major constraint) to expand their efforts and transition from smallholder into the commercial sector of agriculture. These women are counted among the few smallholder farmers who have flourished on their own land (post research team assistance) because of their hard work and ability to seek assistance and profit from it. To the eyes of researchers (UKZN team), they are a credit to local agriculture with the imagined change maintained. Unfortunately, there are not enough of them as at the other end of the pendulum, other EFO villages have converted the highly invested soils from organic to inorganic cane production. Many of these members who have converted to cane have a limited understanding of the financials involved within the cane cycle system. This situation is disheartening because, with *amadumbe* production, farmers were taught through years of capacity building the worth of their work and produce so that they could see the value of farming in terms of profit as well as negotiate their price for profit making when dealing with informal markets.

It is disappointing that a big proportion (*approx.* >40%) of EFO farmers have forgotten all that foundation of training and demonstration through workshops to teach them about these basic principles of being a farmer towards commercialising your produce. It is unfortunate that the gatekeeper cannot exist within this community indefinitely for the majority of EFO (65%) to continue practising sustainable agriculture, pursuing commercialisation of homestead produce. However, *hopes and prayers remain that the gatekeeper will return and restart EFO (Pers comm, 2019).* To date, several external stakeholders have made efforts to engage the EFO. These have been subtly rejected because many EFO farmers still believe that without the gatekeeper who introduced them to a good market and unified them, nothing can ever be done (by anyone) to advance EFO into the future. Many still believe that only the full-time return of the gatekeeper will resurrect the organisation, which is very sad because the reality of their expectations can never be realised as we all know that realities of life do not work/present similar times and opportunities again and again. Most sustainable agriculture projects and initiatives like the SANPAD Project based within communities reported noteworthy increases in household food production as yield improvements, and some as increases in cropping intensity or diversity of produce.

Practical evidence seen at village E after a decade shows that sustainable agriculture can be realised when premised upon the following considerations:

i. appropriate technology adapted by farmers' experimentation (use of legumes in rotation and as an intercrop)

ii. a social learning and participatory approach between the project (research team) and farmers (researcher trial and farmer fields)

iii. good linkages between project/initiative and external agencies, together with the existence of working partnerships between agencies; (linkages with ARC cultivar trial and informal markets)

iv. presence of social capital at a local level (groups that possess technical capacity and strengthened relations)

Village E is a good example of what constitutes commercializing homestead production. However, those in places of influence need to play a pivotal role in advancing subsistence farming in general. Since it is noted that the best way to enhance access to food is through subsistence and smallholder farmers' food production since the access is direct, and this will also reduce food prices. In spite of this, only 10% of the food for SA households is sourced from subsistence production (Baiphethi and Jacobs, 2009).

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Background and Conclusion

A group of farmers using traditional farming practices established an entity called Ezemvelo Farmers Organisation (EFO) in 2002 in Umbumbulu, KwaZulu-Natal. Like all traditional farming, Umbumbulu farming is shaped by social cohesion within the community and the environment to ensure food security and livelihoods. Communicated orally, sharing of knowledge and practice was demonstrated from one generation to the next, this created shared local knowledge of the area. EFO members expressed that they wished to find an answer to successfully commercialising produce in a manner that improved economic development without compromising their cultural integrity. Consistent low yields over the years of monoculture led to the understanding by farmers that the increased demands on local resources for maintaining production has sparked an interest in becoming part of the knowledge finding solution themselves. The partnership formed with UKZN, and food retailer (Woolworths) placed EFO on the path of market-oriented production of their homestead produce with the aim of encouraging farming as a continued way of life. Together with the mediating role of a facilitator and obtaining the organic certification for traditional farming were both strategic to the accomplishment of research for development of market required produce. The niche marketing opportunity for organic produce was the primary aspiration towards continued livelihood of traditional vegetable production.

In a participatory effort to prompt farmers towards joint development of the research agenda, a farmer workshop was proposed and executed in March 2006. Farmers contributed written problems and concerns arising from the continuous monoculture production of *amadumbe* and consistent low yields. These concerns were deliberated over by researchers, categorized into discipline-based research areas, and taken back to farmers through a feedback workshop for clarification, confirmation and prioritisation in terms of how to respond, who would respond, and which issues were priority. Research students' involvement through various studies and trials with farmers was thus legitimized by these workshops. In the middle of year 2006 student individual studies settled into systemic rhythms of seasonal production, harvesting, engaging stakeholders, and dealing with qualitative and quantitative data gathering.

Research engagement in Umbumbulu built and tapped on the inherent assets within EFO to ensure that risk aversion or taking, as informed by various constraints was a skill taught to realistically consider various alternatives. This was critical because farming is essentially risky,

owing especially to unpredictable factors such as climate and economic change. Understanding the crucial EFO management decision for appropriate extension and development strategies to assist in reducing farmer risks, especially when considering adapting and/or scaling up traditional *amadumbe* production, a longer research engagement period (>10yrs) was necessary. Today many practical lessons learned with EFO community are practised and implemented in other areas where traditional farming is still a way of life. The low numbers of new membership in three of the five EFO villages concludes that traditional organic farming systems require intense knowledge for successful implementation and the need for critical mass capacity building locally. Future attention needs to be paid to developing social capital within rural communities and between external agencies to ensure sustainable agriculture is well distributed to larger numbers of farmers and communities. Project participants became sufficiently confident to leave their narrow disciplinary traditions (or familiar farming strategies) and co-created knowledge from multiple perspectives and experienced how people shape and are shaped by agriculture as a 'way of life'. However, these changes were only sustained over a short period of time after the end of research project in four villages.

As a participant researcher, the role of evaluating biological soil fertility technologies adapted with farmers practices became a primary focus. The three-year funded research cycle period where biological technologies were collaboratively implemented and needed post impact assessment. True reflection of the impact required that relative time (≥10yrs) is afforded the EFO farming systems (social and natural) to adapt and respond to technology applications. This assessment a decade later became the secondary research role to present a fuller picture of the impact of biological strategies implemented and how over the years they have been adapted for continued application. Articulation of these impacts subsequently took two years (2019-2021) of reflection, crystallization and learning the language needed to communicate the resultant impact in an academic environment. This impact assessment work has been submitted for publication as a book chapter under agricultural policy for rural resource management in furtherance of accountability to the farmers' request that their commercialising experience inform decision makers in understanding how traditional agriculture could contribute to building sustainable rural economies.

5.2 Linkages to the Study Objectives

Study objectives included identification of social and agronomic factors that positively supported continuity of technologies post the funded project. It was also important to recognise sustainability aspects that had an impact because of research intervention. Study aims also

looked at how the adaptation of research technologies into traditional agriculture affected sustainable commercialization and livelihood outcomes through changes in productivity, yields and food security. Assess how the loss of a formal market affected commercialization efforts.

Primarily, research intervention intended to improve plant available nutrient, maintain productive soils, result in higher yields with an overall soil health benefit. Specifically, this study's intervention was a crop trial of taro (*amadumbe*) and cowpea grown in a polyculture system with wild mustard as a living mulch and using vermicompost. Nitrogen fertilization was effectively achieved with vermicompost as both soil and plants concentrations it increased (Lu et al., 2011).

Therefore, improving available plant nutrient status and maintaining productive soils resulted in higher yields with an overall soil health benefit. Plant available nutrients liberated from the organic matter by the earthworms in their composting action improved crop nutrition as well as played a role in stimulating indigenous soil biota. The result of biologically stimulated soil through biofertilizers (mycorrhizal fungi), agricultural wastes and organic wastes mitigated Aluminium toxicity in plants to acidic soils thus allowing plant roots easy access to nutrients (Rahman et al., 2018).

It is concluded that the taro production system by EFO farmers showed sustainability indicators especially because of the best practices including organic nutrient cycling and minimal soil disturbance practised. Taro (*amadumbe*) intercropping with wild mustard and cowpea showed considerable improvement in growth and yield of taro than in monoculture as indicated by the higher land equivalent ratio (LER) values, showing the efficiency of land use by intercropping.

Monitoring and evaluating recycled nutrients in assessing soil fertility under continuous cropping of *amadumbe* (*Colocasia esculenta*) (*L*.) *Schott*, cowpea (*Vigna unguiculata* (*L*.) *Walp*) and wild mustard (*Brassica juncea* (*L*.) *Czern*. & *Coss*) polyculture results revealed that nutrient mining challenges observed in these soils prior to the experiment were gradually reversed and soil fertility improved with time. The use of biological practices was intended to kick start the build-up of the soil's resilience to external shocks and climate change whilst maintaining productivity and improving taro yield, every consecutive harvest in years to come because taro productions in this area are primarily a way of life.

In the assessment of scientific knowledge with local knowledge-based farming techniques, the integration process yielded an adapted system of best practices that is based on locally available

resources for the sustainable production of taro crop. Specific elements of the trial including plant spacing, quantities of manure use and the use of a legume as an intercrop have been incorporated into the local farming techniques to form an adapted system.

A combination of different knowledge sources and information types on how to merge the theory of scientific knowledge to local knowledge in the formation of new adapted practices was demonstrated by the study. Thus, showing the importance of first considering what is locally known within the community before seeking technological solutions outside the community. This consideration underpins the principles necessary for an approach that yielded sustainable management of a rain-fed agricultural system. Research and development process inferences herein are such that it is inadequate to only document prevailing local knowledge but equally essential to recognize how knowledge adapts, develops and changes over time. The ten-year research impact evaluation study detailed in Chapter four of this study highlights these changes and demonstrates farmer confidence in their progressive pursuit of commercialising homestead produce in a sustainable manner. The impact of formal market loss on commercialisation efforts of the EFO was shown by the low numbers of new membership in three of the five villages thus revealed as describing determinants of continuity. This observation over time concluded that traditional organic farming system requires intense knowledge for successful implementation, hence, the need for critical local system building. Supposition being that to reach larger numbers of farmers and communities, attention needs to be afforded towards social capital development within rural societies and between external agencies for sustainable agriculture.

5.3 Value of Participative Research for Agricultural Development

In agricultural sciences research, a hypothesis is typically formulated on theoretical foundations that are tested (experimented) through research enquiry activity. Hands-on learning, knowledge and meaning are built through peoples' facilitated understandings. Thus, suggesting that scientific knowledge can be a mental construct proposed by the researcher to explain experienced reality. Through the agronomic experiment of intercropping *amadumbe* with cowpea and wild mustard planted as living mulch, the researcher was not only committed to being a facilitator, but also a learner with farmers through shared experiences.

A useful strategy for facilitating managerial independence and addressing technical and organisational problems in the transformation of homestead farming to small-scale commercial agriculture was that participatory practice allowed decision making in the field with EFO

farmers. The significance of being participatory was that primary stakeholders had a voice in the processes that unfolded over time. Both individual and collective farmers' voices came from within the community whilst some were external. The agendas that informed participation was both participatory and catalysed by specific personalities. Collective agendas together with subsequent crop trials, adaptive production technology and improved *amadumbe* cultivars, provided a centre for interaction around which decisions were made and the tolerance for and inclusion offered to UKZN students (such as me) to enter, observe, explore, and work alongside the community in establishing a conceptual model for commercialized social agronomy. Overall, this participative engagement in the research process was of great value to all involved in agricultural development of practical solutions for *amadumbe* production in the smallholder resource poor sector.

5.4 Recommendations

5.4.1 Research impact on the community

The way the EFO community of farmers interpreted the nature of the process by which they adapted their social agronomy towards production and beyond subsistence proposed recommendations to decision-makers about rural development priorities.

In general, many smallholder subsistence farmers in remote and rural areas contribute to the national food basket, thus rendering them very important in attaining food security. The EFO experience thus qualifies as an example highlighted to inform agricultural policy in rural resource management for poverty alleviation and local economic development. In understanding how the EFO experience contributed towards local economic development within rural south of KwaZulu-Natal, it is important to re-think how we perceive or understand the concept of 'commercial' agriculture. Recommendations proposed by this study focus on supporting the preferred practical livelihoods as the outcome of the decision-making of agricultural policy and delivery processes of agrarian services in integrating agriculture and local culture as a 'way of life' within commercially significant traditional food chains in the agricultural sector. One of the recommendations from this study is that all stakeholders, including agricultural practitioners, farmers, and markets, approach their engagement with a focus on rural development and resource management using mutual dialogue and working together. Over the years, village E farmers showed behavioural and attitude changes from the typical EFO member that positively impacted better networking and organization. This mindset shift resulted in the co-creation of new socio-agricultural norms in this village, specifically new

informal market linkages that advance commercialization continuity despite the loss of the formal Woolworths market.

Observations and assessments revealed that points of influence arose from the set goals, power structures, rules and local culture that define the local system. Noteworthy was that these influence points were not intuitive *nor* easy to find as they were an integrative adaptation of the local norms post the research engagement. Over the years, formal and informal relationship between village E farmers and research (ARC and UKZN) assisted in legitimising norms and behaviours in the village that led to a new mindset and revealed power shifts which acted as catalysts for the changes seen. Strategies towards innovation-specific relevant solutions were established by gradually allowing sufficient time (≥10yrs) for farmers' mindsets and power relations to transform. Village E achievement of legitimate leadership was attained within the community because these members (leadership) were initially EFO executive members leading all EFO villages for more than five years. Natural resistance between internal and external cultures is conquered by nurtured social cohesion efforts achieved through legitimate leadership. Therefore, it was automatic that together village E community and external stakeholders validated the leadership. The research experience affirmed that the research agenda was first positioned with farmers, who were the ones to live with the consequences of it eventually. Both accountability and credibility formed the foundation for the realization of future dealings between stakeholders.

The research experience acknowledged that the sustainability observed at village E was encouraged when the interdependent relationship between community and external stakeholders benefitted through innovating and by adapting traditional agriculture with scientific agronomic theory to the system rather than replacing it. The new discovery reflected ways of combining resources and capabilities in relationships that were already available and easily accessible to the farmers. The communication of this research was difficult, posing confusion about whether the focus was on agronomic (soil improvement) intervention and/or social development because of the commercialization of produce. The difficulty was also on how to present the data in a meaningful way for agricultural science. This was resolved by combining both the natural resources and social aspects of the community within the agricultural perspective. Articulating the impact of research for agricultural livelihoods, therefore making a significant contribution towards participative research for agricultural development in managing rural resources. This research was able to comfortably explain the soil's resilience for sustainable productivity based on the social capital (and its built-in capacity)

available in the example of village E outcomes. Noteworthy is that the resilience is specified/experienced by the end user (farmer) and not the researcher's opinion. The presence of social capital at a local level was shown by most group members who possessed technical capacity, which strengthened relations. An example in this village is, that the first (2001-2005) and the latter (2006-2010) EFO committee members came from this village and have received all types of training offered during the research engagement. Many of the youth of earlier EFO years (2001-2010) were capacitated during the UKZN research team period, are now currently EFO leaders today, and specifically come from this village. Thus, indicating social capital with innovative ideas ensuring research results are continuously being adapted for sustainable production as exemplified by the soils.

5.4.2 Recommendations to Decision Makers

The Department of Agriculture, Forestry and Fisheries (DAFF, 2016) announced that the South African agriculture sector is constrained by challenges of ensuring zero hunger, food security, sustainable production on highly degraded land, and a frequently changing climate that makes it difficult for farmers to produce at a sustainable optimum level, thus reducing food production. Noteworthy is that most smallholder or subsistence farmers are typically located in areas characterized by marginal soils with limited productivity. Coupled with climate change effects such as increased occurrence of drought, flooding, and excessively high temperatures, the degradation of the communal farmers' soils has further increased the stresses of crop production, resulting in the continued decrease of yields, thus threatening the food security.

This study was an effort responding to the research push seen of late among the smallholder sector towards the promotion of ecological farming techniques that promote soil organic matter build-up. The realization of focusing on feeding both the soil as well as the crop for productivity to increase is growing among smallholder farmers. The EFO experience results showed that village E managed to demonstrate the fact that despite being underprivileged with limited resources and known to be part of the smallholder sector that primarily produces for subsistence, they were able to improve and contribute to their socio-economic challenges of food insecurity, poverty, and unemployment. Hence, the lesson is that in pursuit of sustainable agriculture, it is paramount to include an integrated farming system with efficient soil, water, crop, and pest management practices that are environmentally friendly and cost-effective.

Together, poor training at the tertiary level and diminishing capacity in appropriate government extension services are some of the technical factors negatively affecting better adoption and

adaptation of best practices for sustainable productivity. Unfortunate, though, is that the absence of an extension officer (Eo) in the growth process of EFO is a historical challenge since, as a result of their formal training, Eo's had limited expertise and competencies in organic farming, especially indigenous crops. In a more formal request through the chairperson of EFO (2001-2004), a reversal of roles was suggested whereby EFO members provide exposure in traditional and organic farming to extension officers and Departmental staff since it was known that farmers already knew a lot more about this system than the officials. This noble gesture was viewed like a subtle offence by Agricultural staff, which resulted in the distance created between these two entities that lasted for more than 2 decades. This long-term situation yielded negative results as the role of extension officers, which was anticipated to be of critical importance in the sustainability of EFO post research, was not fulfilled. Extension officers should provide a constant advisory and support service to farming groups.

It is expected that when all projects reach their exit phase, extension officers would take over, playing the role of support structure for all the systems created/established during the research project and continue to encourage farmers in using the technologies. Whilst authorities in government should develop an enabling policy environment that will advance sustainable agricultural technologies like traditional organic farming infrastructural investments toward the improvement of market access and communication channels. Therefore, practical evidence seen at village E after a decade shows that sustainable agriculture can be achieved and maintained when founded upon appropriate technology adapted by farmers' experimentation; social learning and participatory approach between the research team and farmers; good linkages between project/initiative and external agencies, together with the existence of working partnerships between agencies including government departments and strengthened social capital at a local level. Despite village E representing just one out of five villages showing sustainable development over the years, their success is noteworthy as the example to highlight and promote for repetition of best practices elsewhere in the future.

Study results revealed that from farmers who participated in the research engagement, two thirds did not adopt/adapt best practices recommended by the experimental trials. Such initiatives die when the researchers or research institutions run out of funds for awareness campaigns, training, and continuous adapting. This situation, therefore, suggests that an intervention was a once-off engagement during the funded period. Hence, institutionally, it is important that continuity is maintained by local agricultural practitioners servicing the area to ensure that trust deficit challenges are not experienced and that best practices are encouraged

and adapted based on locally available resources of that specific period and locality. Also, the general lack of funding for conservation-based research and development in agriculture regarding capacity building through training more people, and the lack of government subsidies for procurement of appropriate machinery is a challenge for upscaling where more farmers are attracted to implement and/or adapt best practices.

This work provided a collaborative framework required to develop impact-driven activities needed to inform evidence-based policies on the sustainable use of rural resources. In a small localized manner, Sustainable Development Goals (SDGs), including SDG 5, were addressed in an attempt made by this study through agricultural research and development to contribute towards gender equality and women's empowerment, specifically at the village E. Recognizing that rural areas continue to be the reserves for the world's poor. Public support for preserving the 'homestead farmer' through the improvement in the technical levels of production access to resources and services becomes necessary. The challenge is to enable the choice of excess production for economic gain within the dynamics of generational life cycles.

5.5 Impact of the Gatekeeper

Ezemvelo Farmers Organization (EFO) conclusive leadership choice through the election of a gatekeeper (regarded as the interface with external institutions and processes) was key in that there would be a particular personality influencing decision-making. This role also emphasised the importance of dialogue/inclusive discussion, representation of household, community, researcher's perspectives, and external interests. Even the inclusion and acceptance of student researchers was also built on trust and confidence in the gatekeeper. This relationship of trust with the gatekeeper worked excellently over the years and mutually benefited farmers, students and other external stakeholders involved. However, the unintended consequence of this strong relationship was seen seven years later when the gatekeeper was no longer available to lead the organization. Parallel to what Adams and Jumpah (2021) found their study's results also showed that regional location, educational level, age, and Farmer Based Organization (FBO) membership were the main determinants of technology adoption among smallholder farmers' progress. The point in case here is that in standing on its own, the EFO executive committee revealed the inevitable cracks depicted by issues of internal trust, leading to the collapse of the leadership structure. Institutional arrangements within EFO gradually crumbled down as the old committee (active during the gatekeeper's *era*) was expelled, and the newly elected committee lacked administrative and leadership skills. Elected based on their educational level, age and physical abilities, the old committee (gatekeeper's *era*) was capacitated and geared to

lead the organization in the succession of several decades ahead. The distinctive feature between the old and the new committee members was the age difference; the old members were in their mid-life age range (45- 60 years), and the new members were mostly elderly (65^{+} years.). This age issue contributed immensely to EFO breakdown into primary and secondary factions and forming a new sub-group. The elderly members are not easily changed in their beliefs and ways of doing things. Hence, in the absence of the gatekeeper, many elderly members felt that no one (even within EFO) was sufficiently trustworthy to lead the organization despite the good leadership shown by the old committee that reigned during the research team's presence under the guidance of the gatekeeper.

From this observation, it is concluded that in rural settings where elderly folks still hold positions of power and influence, external actors with known and proven good conduct have a better chance of being trusted in local leadership roles than younger local people in the area. This is, however, an unfortunate situation of missed opportunities to groom and mentor younger local people into leadership roles towards agricultural development. Many (elderly folks) are still hoping that the gatekeeper will return to assume his role and rebuild the fallen organization. It can also be seen that despite laying strong foundations of people-centred engagements, achieving sustainability, a dynamic process, can never be fully realized as people change together with their behaviour influenced by various factors over time. Four of the five villages have fallen into this unfortunate predicament of believing that the EFO can never regain its good old days of enjoying success and agricultural prosperity without the gatekeeper. village E, however, has thrived and demonstrated immeasurable growth utilizing the inherent local assets and the capacity built in them during the research intervention. The intended outcomes of research meeting society over uncertainties (markets, social cohesion, use of local assets and resources) for sustainable growth and improved livelihoods have been accomplished at village E. This conclusion suggests that sustainable livelihoods are realized in this village not as an endpoint but as a dynamic process, considering that continuous successful production of *amadumbe* is the mainstay or primary livelihood strategy.

5.6 Summary

The diverse spectrum of agricultural stakeholders should be engaged as participants to create harmony and ensure a wide range of data collection on Research and Development (R&D), innovations, socio-economic challenges, and changes associated with best practices to discourage *silo* mentality within stakeholders. Climate change and rainfall patterns are primarily the reasons why it is critical to build the soil's resilience when rainstorms and periods

of drought occur, and healthy soils will be able to buffer the adverse effects caused by these natural hazards. The province is made up of vastly opposite climatic conditions, resulting in different terrains and soil types; thus, the response provided by best practices may require varied time frames for the impact to be seen.

The notion of considering soil as a resource has now - or mixed cropping with the inclusion of legumes and any other preferred intercrop. The diverse organic amendments locally available in an area are likely to result in positive benefits for soil nutrition and crop productivity in an effort of ‘feeding the soil to feed the crop’ principle. Socio-economic studies also need to be embarked on to appreciate the drivers behind technological non-adoption among smallholder farmers.

Technologies that are friendly to smallholders in rural settings emphasize the use of local resources, increase the adoption of organic and/or biological soil fertility management practices, and present an opportunity for a positive future of homestead and subsistence agriculture.

Noteworthy is that in recent decades, sustainability-related issues highly influence consumers' food choices. Thus, demand for produce/food whose production has a minimal impact on the environment is growing rapidly, along with the spread of sustainability-related information about food. Consumers assign a credence attribute to produce that carries an idea of sustainability based on the extent to which they understand the idea of sustainability (Palmieri and Perito, 2020). Therefore, the consumer's perception of quality and choices is thus influenced by the incorporated value in sustainability-related brands (Franco and Cicatiello, 2018).

Smallholder farming can provide numerous direct and indirect environmental, social, cultural, and economic benefits, job security, and self-sufficiency worldwide by improving crop diversity, even though they face several challenges that include lower income, lack of technology, poor access to information, market and certification barriers, and labour shortages (Jouzi et al., 2017). Commercial agriculture has seen a lot of technological advancements in the last few decades. The substantial transformation seen in village E, led by advancement because of many years of research interventions, is believed to be a strong foundation for continuous sustainable livelihoods.

REFERENCES

Aalbers, R., Dolfsma, W., Koppius, O. 2013. Rich Ties and Innovative Knowledge Transfer within a Firm. *Br. J. Manag* 25, 833-848.

Adams & Jumpah, *Cogent Economics & Finance* (2021), 9: 2006905 **https://doi.org/10.1080/23322039.2021.2006905**

Adams, A., Jumpah, E.T. and Shafiullah, M. 2021. Agricultural technologies adoption and smallholder farmers' welfare: Evidence from Northern Ghana. *Cogent Economics & Finance*, *9*(1). https://doi.org/10.1080/23322039.2021.2006905

Adedipe, N.O., Okuneye, P.A., Ayinde, I.A. 2004. The relevance of local and indigenous knowledge for Nigerian agriculture. In International Conference on Bridging Scales and Epistemologies: Linking Local Knowledge with Global Science in Multi-Scale Assessments, Alexandria, Egypt (pp. 16-19).

Adey, P. 2007. 'May I have your attention': airport geographies of spectatorship, position, and (im) mobility. Environment and Planning D: *Society and Space*, 25(3), pp.515-536.

Agrawal, O.P. 2004. A general formulation and solution scheme for fractional optimal control problems. Nonlinear Dynamics, 38(1), pp.323-337.

Allen, T.D., Herst, D.E., Bruck, C.S. Sutton, M. 2000. Consequences associated with work-to-family conflict: a review and agenda for future research. *Journal of occupational health psychology*, 5(2), p.278.

Aliber M., Hall, R. 2012. Support for Smallholder Farmers in South Africa: Challenges of Scale and Strategy. *Development Southern Africa*. 29. 10.1080/0376835X.2012.715441.

Altieri, M.A. 2005. Introduction. *Bulletin of Science, Technology & Society*. 25(4):287-288. doi:10.1177/0270467605278366

Alvi, M. 2016. A Manual for Selecting Sampling Techniques in Research Online at https://mpra.ub.uni-muenchen.de/70218/ MPRA Paper No. 70218

Andersson, C.I.M., Kiria, C.G., Qaim, M., Rao, E.J.O. 2013. Following up on smallholder farmers and supermarkets. *Glob Food Discuss Pap*. 23:1-29.

Angell, S.M., Baulcombe, D.C. 1997. Consistent gene silencing in transgenic plants expressing a replicating potato virus X RNA. *The EMBO Journal*, 16(12), pp.3675-3684.

Atherton, D.P. 2011. An introduction to nonlinearity in control systems. Bookboon.

https://books.google.co.za/books?id=0LIfogERg7EC&lpg=PA10&ots=oZOcwBzlTn&dq=Atherton%2C%20D.P.%2C%202011&lr&pg=PA11#v=onepage&q=Atherton,%20D.P.,%202011&f=false

Baiphethi, M.N., Jacobs, P.T. 2009. The contribution of subsistence farming to food security in South Africa. *Agrekon*, 48 (4): 459-482.

Barrios, E., Trejo, M.T. 2003. Implications of local knowledge for integrated soil management in Latin America. *Geoderma*. 111: 217-231. 10.1016/S0016-7061(02)00265-3.

Baskerville, R.L., Wood-Harper, A.T. 1996. A critical perspective on action research as a method for information systems research. *Journal of information Technology*, 11(3), pp.235-246.

Baskerville, R., Pries-Heje, J. 1999. Grounded action research: a method for understanding IT in practice. Accounting, Management, and Information Technologies, 9(1), pp.1-23.

Baveye, P.C., Baveye, J., Gowdy, J. 2016. Soil "ecosystem" services and natural capital: Critical appraisal of research on uncertain ground. *Front Environ Sci.* 4:41

Beilin, R., Boxelaar, L. 2001, October. Rethinking action research: Theory and extension practice. In Australian Pacific Extension Network 2001 International Conference Proceedings.

Biggs, J. 1998. Learning from the Confucian heritage: so size doesn't matter? *International Journal of Educational Research*, 29(8), pp.723-738.

Booth, A., Sutton, A., Papaioannou, D. 2016a. *Systemic approaches to a successful literature review* (2nd ed.). Los Angeles, CA: Sage
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9582830/#B7

Breure, A.M., Lijzen, J.P.A., Maring, L. 2018. Soil and land management in a circular economy, Science of The Total Environment, 624: 1125-1130, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2017.12.137

Brodt, S., Six, J., Feenstra, G., Ingels, C., Campbell, D. 2011. Sustainable Agriculture. *Nature Education Knowledge* 3(10):1

Buffett, H. 2012. In Support of Conservation Agriculture for Smallholder Farmers. www.thehowardgbuffettfoundation.org

Buthelezi, N. 2010. The use of scientific and indigenous knowledge in agricultural land evaluation and soil fertility studies of Ezigeni and Ogagwini villages in KwaZulu-Natal. Dissertation (MSc), University of KwaZulu-Natal.

Caister, K. 2006. Report of the Feedback on Research Questions Workshop, 25 March 2006. *SANPAD Student and Research Consultant Report Back.* University of KwaZulu-Natal. Available from author. caister@ukzn.ac.za.

Caister, M. 2011. *MAPS.* Compiled from the following data bases: Shape Files from the GIS Section of Durban University of Technology November 2010; Durban (eThekwini) Municipality [www.citymaps.gov.za]; the Municipal Demarcation board data base [www.demarcation.org.za]; and the Cadastral database of the Office of the Surveyor General: KwaZulu-Natal, Pietermaritzburg.

Caister, K. 2012. Moving beyond subsistence: systemic integrity in Commercializing homestead agriculture, with the Ezemvelo Farmers Organization, KwaZulu-Natal. Doctor of philosophy dissertation PhD, University of KwaZulu-Natal.

CAMP, K.G.T. 1995. Cedara Report N/A/95/32. Pietermaritzburg: KwaZulu-Natal Department of Agriculture and Environmental Affairs.

Cawley, A., Heanue, K., Hilliard, R., O'Donoghue, C., Sheehan, M. 2023. How Knowledge Transfer Impact Happens at the Farm Level: Insights from Advisers and Farmers in the Irish Agricultural Sector. *Sustainability 15*, 3226. https://doi.org/10.3390/su15043226

Chabbi, A., Lehmann, J., Ciais, P., Loescher, H.W., Cotrufo, M.F., Don, A., San-Clements, M., Schipper, L., Six, J., Smith, P., Rumpel, C. 2017. Aligning agriculture and climate policy. Nature Climate Change, Nature, 7(5), pp 307-309. DOI: 10.1038/nclimate3286

Chambers, R., Conway, G. 1992. 'Sustainable Rural Livelihoods: Practical Concepts for the 21st Century.' Institute of Development Studies, University of Sussex: Sussex.

Chambers, R., 1993. Challenging the professions: frontiers for rural development. Intermediate Technology Publications.

Checkland, P.B. 1989. Soft systems methodology. *Human systems management*, 8(4), pp.273-289.

Checkland, P. 1994. Systems theory and management thinking. American Behavioural Scientist, 38(1), pp.75-91.

Chianu, J., Chianu, J., Mairura. 2012. Mineral fertilizers in the farming systems of sub-Saharan

Africa. A review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA 32 (2) 545-566 https://doi.org/10.1007/s13593-011-0050-0 hal-00930525

Cloete, P., Kotze, F. 2009. 'Concept paper on social cohesion/inclusion in local integrated development plans', Commissioned by Department of Social Development, Republic of South Africa, final draft.

Cohen, L., Manion, L., Morrison, K. 2017. *Research methods in education* (8th ed). Routledge.

Creswell, J., Creswell, J. 2018. Research Design: *Qualitative, Quantitative, and Mixed Methods Approaches*. 5th ed. SAGE Publications.

Crevello, S. 2004. Dayak land use systems and indigenous knowledge. Journal of Human Ecology, 16(1), pp.69-73.

DAFF. 2020. National Policy on Comprehensive Producer Development Support. Department of Agriculture, Forestry and Fisheries, Pretoria

DAFF. 2012. Maize market value chain. Department of Agriculture, Forestry and Fisheries,

https://www.dalrrd.gov.za/phocadownloadpap/Agricultural_Marketing_Commodity_Profiles/Maize%20Market%20Value%20Chain%20Profile%202012.pdf

DALRRD. 2019. Department of Agriculture Land Reform and Rural Development: Trends in the agricultural sector 2019. Accessed from https://www.dalrrd.gov.za

Dalton, D.C., Knight, T.W., Johnson, D.L. 1980. Lamb survival in sheep breeds on New Zealand hill country. New Zealand journal of agricultural research, 23(2), pp.167-173.

Dash, J.G. 1999. History of the search for continuous melting. Reviews of Modern Physics, 71(5), p.1737.

De Felice, S., Hamilton, A.F., Ponari, M., Vigliocco, G. 2022. Learning from others is good, with others is better: the role of social interaction in human acquisition of new knowledge. Phil. Trans. R. Soc. B 378: 20210357. https://doi.org/10.1098/rstb.2021.0357

Defoer, T. 2002. Learning about methodology development for integrated soil fertility management. Agricultural Systems, 73(1), pp.57-81.

De Vos, A.S. 1998. Research at Grass Roots: A Primer for the Caring Professions. Van Schaik Publishers, Pretoria.

Dhillon, R., Moncur, Q. 2023. Small-Scale Farming: A Review of Challenges and Potential Opportunities Offered by Technological Advancements. *Sustainability 15* 15478. https://doi.org/10.3390/su152115478

Dialla, B.E. 1994. The adoption of soil conservation practices in Burkina Faso‹ indigenous Knowledge and Development Monitor 2:1 10-12.

Dick, R.P. 1997. Soil Enzyme Activities as Integrative Indicators of Soil Health. In: Pankhurst, C.E., Doube, B.M. and Gupta, V.V.S.R., Eds., Biological Indicators of Soil Health, CAB International, Wallingford, 121-157.

Dick, W.C. 2001. Genetic rescue of remnant tropical trees by an alien pollinator. Proceedings of the Royal Society of London. Series B: Biological Sciences, 268(1483), pp.2391-2396.

Dick, J.E. 2003. Breast cancer stem cells revealed. Proceedings of the National Academy of Sciences, 100(7), pp.3547-3549.

Dick, B. 2006. Action research literature 2004-2006: Themes and trends. Action research, 4(4), pp.439-458.

Di Stefano, L., Marchionni, M. Mattoccia, S. 2004. A fast area-based stereo matching algorithm. Image and vision computing, 22(12), pp.983-1005.

Doran, J.W., Parkin, T.B. 1994. Defining and assessing soil quality. *Defining Soil Quality for a Sustainable Environment* 1: 21

Doss, C.R. 2006. Analyzing technology adoption using microstudies: limitations, challenges, and opportunities for improvement. Agricultural Economics. https://doi.org/10.1111/j.1574-0864.2006.00119.

Dube, L.T., Jury, M.R. 2003. Structure and precursors of the 1992/93 drought in KwaZulu-Natal, South Africa from NCEP reanalysis data. *Water South Africa* 29, pp.201-208.

Dumanski, J., Peiretti, R., Benites, J.R., McGarry, D., Pieri, C. 2006. The paradigm of conservation agriculture. Proceedings of world association of soil and water conservation, 1(2006), pp.58-64.

Duvel, G.H. 2001.some realities of extension management in South Africa. *S. Afr. J. Agric. Ext*. V30.

Duveskog, D. 2006. Theoretical perspectives of the learning process in Farmer Field Schools, with reference to East African experiences. Unpublished manuscript. Working paper. Uppsala: Swedish University of Agricultural Sciences. Available at http://www. share4dev. info/kb/documents/3581.

Effland, A., Saavoss, M., Capehart, T., McBride, W.D., Boline, A. 2022. Innovations in Seed and Farming Technologies Drive Productivity Gains and Costs on Corn Farms https://www.ers.usda.gov › amber-waves › april › innova

Eldon, J. 1988. Agricultural change, conservation, and the role of advisors. Ecosystem 9 (4): 14 -20 https://www.cabidigitallibrary.org/doi/full/10.5555/19891864257

Eriksen, S., Aldunce, P., Bahinipati, C.S., Martins, R.D.A., Molefe, J.I., Nhemachena, C., O'brien, K., Olorunfemi, F., Park, J., Sygna, L., Ulsrud, K. 2011. When not every response to climate change is a good one: Identifying principles for sustainable adaptation. Climate and development, 3(1), pp.7-20.

Ettema, C.H. 1994. Indigenous soil classifications. What are their structures and functions and how do they compare with scientific soil classifications? Institute of Ecology, University of Georgia, Athens.

Fairhead, J., Scoones, I. 2005. Local knowledge and the social shaping of soil investments: critical perspectives on the assessment of soil degradation in Africa. Land use policy, 22(1), pp.33-41.

FAO. 1999. The Strategic Framework for FAO 2000–2015. Rome: Food and Agriculture Organization of the United Nations (FAO).

FAO. 2005. FAO Web site on Gender, Agrobiodiversity and Local Knowledge: www.fao.org/sd/links.

FAO. 2011. Save and Grow. A Policymakers' Guide to the Sustainable Intensification of Smallholder Crop Production. Rome: FAO. 98. www.fao.org/ag/save-and-grow/.

FAO. 2011. Socio-economic analysis of conservation agriculture in Southern Africa, NETWORK PAPER 02. Johannesburg: Regional Emergency Office for Southern Africa.

FAO. 2016. Farmer Field School Guidance Document: Planning for Quality Programmes. Rome: Food and Agriculture Organization.

Food and Agriculture Organization Rome. 2017. The future of food and agriculture–Trends and challenges. Rome: Food and Agriculture Organization

Fearne, A.P. 1990. Communications in agriculture: results of a farmer survey. *Journal of Agricultural Economics*, 41(3), pp.371-380.

Fenwick, T.J. 2001. Experiential Learning: A Theoretical Critique from Five Perspectives. Information Series No. 385.

Field, D.J., Morgan, C.L.S., McBratney, A.B. 2017. Global Soil Security, Springer, New York pp. 3-14

Finck, A. 1995. From the fertilization of crops to the management of plant nutrients in crop rotations and farming systems: an overview. FAO Fertilizer and Plant Nutrition Bulletin (FAO).

Fink, A. 1995. How to measure survey reliability and validity (Vol 7). Thousand Oaks, CA: Sage Publications.

Fisher, R.A. 2013. The role of social capital and trust in transforming information into usable knowledge. *J. Rural Stud*. 31, 13–22.

Flood, R.L. 2010. The Relationship of 'Systems Thinking' to Action Research. *Syst Pract Action Res* 23:269–284 DOI 10.1007/s11213-010-9169-1

Foy, C.D. 1992. Soil chemical factors limiting plant root growth. In Limitations to plant root growth (pp. 97-149). Springer, New York, NY.

Francis, A.C. 1990. Sustainable Agriculture: Myth and Realities. *Journal for Sustainable Agriculture*, Vol. 1(1). The Haworth Press. University of Nebraska, Lincoln.

Francis, C.A., King, J.A. 1998. Cropping systems based on farm derived renewable resources. *Agricultural systems* 27:67-75.

Franco, S., Cicatiello, C. 2018. The role of food marketing in increasing awareness of food security and sustainability: Food sustainability branding. Encycl. *Food Secur. Sustain*. 27–31.

Frazer, K.A., Elnitski, L., Church, D.M., Dubchak, I. and Hardison, R.C. 2003. Cross-species sequence comparisons: a review of methods and available resources. Genome Research, 13(1), pp.1-12.

Freidberg, S. 2020. Assembled but unrehearsed: corporate food power and the 'dance' of supply chain sustainability. *J Peasant Stud* 47:383–400

Frey, R.W., Pemberton, S.G., Saunders, T.D. 1990. Ichnofacies and bathymetry: a passive relationship. Journal of Paleontology, 64(1), pp.155-158.

Friis-Hansen, E. 2004. Concepts and experiences with demand driven advisory services: review of recent literature with examples from Tanzania (No. 2004: 7). DIIS Working paper.

Gabre-Madhin, E., Johnston, B. 2002. Accelerating Africa's Structural Transformation: Lessons from Asia. In *Perspectives on Agricultural Transformation: A View from Africa*. Edited by: Jayne TS, Isaac M, Gem A-K. Nova Science, New York; 2002.

Garforth, C., Angell, B., Archer, J., Green, K. 2003. Improving farmers' access to advice on land management: lessons from case studies in developed countries. Agricultural Research and Extension Network Paper, 125. https://agrifoodecon.springeropen.com/articles/10.1186/s40100-014-0012-3

Gee, J.P. 1990. Social linguistics and literacies: ideology in discourses. *Critical Perspectives on Literacy and Education*, London: Falmer Press.

George, T. 2024. *What Is Action Research? | Definition & Examples.* https://www.scribbr.com/methodology/action-research

Grant, C.A., Peterson, G.A., Campbell, C.A. 2002. Nutrient considerations for diversified cropping systems in the northern Great Plains. *Agronomy Journal*, 94(2), pp.186-198.

Gruver, J.B., Weil, R. 2007. Farmer perceptions of soil quality and their relationship to management-sensitive soil parameters. *Renewable Agriculture and Food Systems.* 22: 271 - 281. 10.1017/S1742170507001834.

Guba, E.G., 1990. The paradigm dialogue. In Alternative Paradigms Conference, Mar, 1989, Indiana U, School of Education, San Francisco, CA, US. Sage Publications, Inc.

Guba, E.G., Lincoln, Y.S. 1989. Fourth generation evaluation. Sage.

Guto, S.N., Pypers, P., Vanlauwe, B., de Ridder, N., Giller, K.E. 2011. Tillage and vegetative barrier effects on soil conservation and short-term economic benefits in the Central Kenya highlands. Field Crops Research, 122(2), pp.85-94.

Haig, B.D. 1995. Grounded theory as scientific method. Philosophy of education, 28(1), pp.1-11.

Hagmann, J., Chuma, E., Murwira, K., Connolly, M. 1999. Putting process into practice: operationalizing participatory extension. London, UK: Overseas Development Institute.

Halcomb, E., Hickman, L. 2015. Mixed methods research. *Nurs Stand*. 29:41-7.

https://doi.org/10.7748/ns.29.32.41.e8858

Hamilton, J.T. 1995. Pollution as news: Media and stock market reactions to the toxics release inventory data. Journal of environmental economics and management, 28(1), pp.98-113.

Hassanein, N., Kloppenburg Jr, J.R. 1995. Where the grass grows again: knowledge exchange in the sustainable agriculture movement 1. Rural Sociology, 60(4), pp.721-740.

Haynes, R.J. 1984. Lime and phosphate in the soil-plant system. Advances in agronomy, 37, pp.249-315.

Haynes, R.J., Mokolobate, M.S. 2001. Amelioration of Al toxicity and P deficiency in acid soils by additions of organic residues: a critical review of the phenomenon and the mechanisms involved. Nutrient cycling in agroecosystems, 59(1), pp.47-63.

Helyer, R. 2015. Learning through reflection: The critical role of reflection in work-based learning (WBL). Journal of Work-Applied Management, 7(1), 15-27. Retrieved from https://doi.org/10.1108/JWAM-10-2015-003

Hoffman, H.G., Patterson, D.R., Carrougher, G.J., Sharar, S.R. 2001. Effectiveness of virtual reality–based pain control with multiple treatments. *The Clinical journal of pain*, 17(3), pp.229-235.

Ibeawuchi, I.I., Dialoke, S.A., Ogbede, K.O., Ihejirika, G.O., Nwokeji, E.M., Chigbundu, I.N., Adikuru, N.C., Oyibo, P.O. 2007. Influence of yam/cassava based intercropping systems with legumes in weed suppression and disease/pest incidence reduction. *Journal of American Science*, 3(1), pp.49-59.

Ibrahim, A., Hassan, K., Kamaruddin, R., Anuar, A. 2017. Examining the Livelihood Assets and Sustainable Livelihoods among the Vulnerability Groups in Malaysia. *Indian-Pacific Journal of Accounting and Finance.* 1. 52-63. 10.52962/ipjaf.2017.1.3.17.

IIRR. 1996. Manual on Indigenous knowledge: Recording and using indigenous knowledge. A manual for development practitioners and field workers. International Institute of Rural Reconstruction. The Philippines.

Ingram, J., Morris, C. 2007. The knowledge challenge within the transition towards sustainable soil management: an analysis of agricultural advisors in England. Land Use Policy, 24(1), pp.100-117.

Institute of Education Sciences & National Science Foundation. 2013. *Common guidelines for education research and development*. Retrieved May 20, 2022, www.nsf.gov/pubs/2013/nsf13126/nsf13126

International Institute of Rural Reconstruction IIRR. 2002. Managing Dryland Resources – An extension manual for Eastern and Southern Africa. International Institute of Rural Reconstruction, Nairobi, Kenya.

Jacques, P.F., Selhub, J., Bostom, A.G., Wilson, P.W. and Rosenberg, I.H. 1999. The effect of folic acid fortification on plasma folate and total homocysteine concentrations. *New England Journal of Medicine*, 340(19), pp.1449-1454.

Jafer, M., Crutzen, R., Ibrahim, A., Moafa, I., Zaylaee, H., Ajeely, M., van den Borne, B., Zanza, A., Testarelli, L., Patil, S. 2021. Using the Exploratory Sequential Mixed Methods Design to Investigate Dental Patients' Perceptions and Needs Concerning Oral Cancer Information, Examination, Prevention and Behavior. *Int. J. Environ. Res. Public Health*, *18*, 7562. https://doi.org/10.3390/ijerph18147562

Jibowo, G. 1992. Essentials of Rural Sociology Abeokuta. Ogun State: Gbemi Sodipo Press

Jick, T.D. 1979. Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly*, 24(4), pp.602-611.

Jogulu, U.D., Pansiri, J. 2011. Mixed methods: A research design for management doctoral dissertations. *Management Research Review*. 34(6).

Jouzi, Z., Azadi, H., Taheri, F., Zarafshani, K., Gebrehiwot, K., Van Passel, S., Lebailly, P. 2017. Organic farming and small-scale farmers: Main opportunities and challenges. *Ecol. Econ*. 132, 144–154.

Kallenbach, C.M., Wallenstein, M.D., Schipanksi, M.E., Grandy A.S. 2019. Managing agroecosystems for soil microbial carbon use efficiency: Ecological unknowns, potential outcomes, and a path forward. *Frontiers in Microbiology* V10. https://www.frontiersin.org/article/10.3389/fmicb.2019.01146

Kantor, S. 1999. Comparing yields with land equivalent ratio (LER). Renton, WA: Washington State University Agriculture and Natural Resource Fact Sheet, 532(4).

Karlen, D.L., Andrews, S.S., Doran, J.W. 2001. Soil quality: Current concepts and applications.

Keith, A.M., Schmidt, O., McMahon, B.J. 2016. Soil stewardship as a nexus between Ecosystem Services and One Health. *Ecosyst Services* 17:40–42

Kemmis, S., McTaggart, R. 1988. The Action Research Reader (3rd ed). Geelong: Australia: Deakin University Press.

Kerem- Saysel, A., Barlas, Y., Yenigun, O. 2002. Environmental sustainability in an agricultural development project: a system dynamics approach. *Journal of Environmental Management* V64: (3): 247-260. https://doi.org/10.1006/jema.2001.0488.

Ketterings, Q.M. 2014. Extension and knowledge transfer: Adaptive management approaches for timely impact. *J. Agric. Sci*. 152, 57–64.

Khisa, G. 2004. Farmers field school methodology: Training of trainers' manual. FAO, Rome.

Khwidzhili, R.H. 2012. The willingness of Ehlanzeni Further Education and Training students (Mthimba campus) to participate in agricultural projects after completing their studies. Masters dissertation. Centre for Sustainable Agriculture. University of Free State, Bloemfontein, RSA.

Kolawole, O.D. 2001. Local knowledge utilisation and sustainable rural development in the 21st century.

Kolb, D.A., Boyatzis, R.E., Mainemelis, C. 2014. Experiential learning theory: Previous research and new directions. In Perspectives on thinking, learning, and cognitive styles (pp. 227-248). Routledge.

Koohafkan, P., Cultural, C., Boerma, D. 2006. Conservation and sustainable management of Globally Important Ingenious Agricultural Heritage Systems (GIAHS).

Krantz, L. 2001. The Sustainable Livelihood Approach to Poverty Reduction. An Introduction. Executive Summary. pp. 6-21. Swedish International Development Cooperation Agency. Division for Policy and Socio-Economic Analysis.

Ladyman, J., Lambert, J., Wiesner, K. 2013. What is a complex system? *Eur J Phil Sci.*3:33–67

LaFlamme, M., Davies, J. 2007. Developing a Shared model for sustainable aboriginal livelihoods in natural-cultural resource management, CRC–Desert knowledge. http://www.desertknowledgecrc.com.au/research/inlandpublications.html

Lal, R. 2000. Physical management of soils of the tropics: priorities for the 21st century. Soil science, 165(3), pp.191-207.

Lal, R. 2020. Managing soils for resolving the conflict between agriculture and nature: the hard talk *Eur. J. Soil Sci.* 71 (1) pp. 1-9

Larson, C.R. 1998. When is a Nation? *Black Renaissance*, 1(3), p.137.

Laws, S., Marcus, R., Harper, C. 2003. *Research for development: a practical guide*. Thousand Oaks, [Calif.]: SAGE Publications, Ltd.

Lavelle, P., Melendez, G., Pashanasi, B., Schaefer, R.,1992. Nitrogen mineralization and reorganization in casts of the geophagous tropical earthworm *Pontoscolex corethrurus* (*Glossoscolecidae*). *Biology and Fertility of Soils*, 14(1), pp.49-53.

Le Doanh, Q., Tuan, H.D. 2004. Improving indigenous technologies for sustainable land use in northern mountainous areas of Vietnam. *Journal of Mountain Science*, 1(3), pp.270-275.

Leedy, P.D., Ormrod, J.E. 2005. Practical research (Vol. 108). Saddle River, NJ, USA: Pearson Custom.

Leeuwis, C. 2004. Fields of conflict and castles in the air. Some thoughts and observations on the role of communication in public sphere innovation processes. *The Journal of Agricultural Education and Extension*, 10(2), pp.63-76.

Lehmann, J., Bossio, D.A., Kögel-Knabner, I., Rillig, M.C. 2020. The concept and future prospects of soil health. *Nat Rev Earth Environ* 1(10):544-553. doi: 10.1038/s43017-020-0080-8. PMID: 33015639; PMCID: PMC7116140

Loeper, W.J., von Drimie, S. and Blignaut, J. 2018. The Struggles of Smallholder Farmers: A Cause of Modern Agricultural Value Chains in South Africa. *Agricultural Value Chain*. http://dx.doi.org/10.5772/intechopen.75710

Lu, W., Luo, Y., Chang, G. and Sun, X. 2011. Synthesis of functional SiO2-coated graphene oxide nanosheets decorated with Ag nanoparticles for H2O2 and glucose detection. *Biosensors and Bioelectronics*, 26(12), pp.4791-4797.

Maestro. 2024. Malcolm Knowles Five Assumptions of Learners and Why They Matter.

https://maestrolearning.com/blogs/malcolm-knowles-five-assumptions-of-learners-and-why-they-matter/

Mabagala, F.F., Mng'ong'o, M.E. 2022. On the tropical soils: The influence of organic matter (OM) on phosphate bioavailability. *Saudi Journal of Biological Sciences* 29:5, pp 3635-3641

https://doi.org/10.1016/j.sjbs.2022.02.056.

Macadam, R.D. 2000. From pushing production inputs to empowering the community: a case study in the transformation of an extension agency. *Australian Journal of Experimental Agriculture*, 40(4), pp.585-594.

Magingxa, L.L., Alemu, Z.G., van Schalkwyk, H.D. 2009. Factors influencing access to produce markets for smallholder irrigators in South Africa. *Development Southern Africa*. 26(1):47-58. http://www.tandfonline.com/doi/abs/10.1080/03768350802640081

Mara, S., Fontoura, V., Pias, H., Cherubin, M., Moraes, R., Bayer, C., Tiecher, T. 2019. Effect of gypsum rates and lime with different reactivity on soil acidity and crop grain yields in a subtropical Oxisol under no-tillage. *Soil and Tillage Research* 193

Maragelo, K.P. 2008. Traditional agriculture and its meaning in the lives of a farming community: the case of Embo. Unpublished dissertation (MSc), University of KwaZulu-Natal.

Mare, M.R. 2006. Phytotron and field performance of taro (Colocasia esculenta (L) Schott)

landraces from Umbumbulu. Master's thesis. University of KwaZulu-Natal, Pietermaritzburg,

South Africa.

Maruthi, V., Srinivas, K., Reddy, G.S., Reddy, B.S. 2006. Groundnut shells boost crop yields. Appropriate Technology, 33(1), p.13.

Maseko, I., Mabhaudhi, T., Tesfay, S., Araya, H.T., Melake, F., Du Plooy, C.P. 2018. "African Leafy Vegetables: A Review of Status, Production and Utilization in South Africa" *Sustainability* 10:(1) 16. https://doi.org/10.3390/su10010016

Mettrick, H. 1993. Development oriented research in agriculture. No. 630.072/M595.

https://books.google.co.za/books/about/Development_Oriented_Research_in_Agricul.html?id=WTJsAAAACAAJ&redir_esc=y

Miller, F.P., Wali, M.K. 1995. Soils, land use and sustainable agriculture: A review. School of Natural Resources: The Ohio State University, 2021 Coffey Road, Columbus, USA.

Mingers, J. 2000. What is it to be critical? Teaching a critical approach to management undergraduates. *Management Learning*, 31(2), pp.219-237.

Modi, A.T. 2005. The social agronomy of homestead agriculture: A case study of the dynamics of commercialization. *SANPAD Startup Workshop Report.* Pietermaritzburg: University of KwaZulu-Natal.

Mokolobate, M.S., Haynes, R.J. 2003. A glasshouse evaluation of the comparative effects of organic amendments, lime and phosphate on alleviation of Al toxicity and P deficiency in an Oxisol. *The Journal of Agricultural Science*, 140(4), pp.409-417.

Morgan, D.L. 2007. Paradigms lost and pragmatism regained: Methodological implications of combining qualitative and quantitative methods. *Journal of Mixed Methods Research*. 1(1):48-76.

Morgan, D.L. 2014. Pragmatism as a paradigm for social research. *Qualitative Inquiry*. 20(8):1045-1053. doi: 10.1177/1077800413513733

Morgan, K. and Murdoch, J. 2000. Organic vs. conventional agriculture: knowledge, power and innovation in the food chain. *Geoforum*, 31(2), pp.159-173.

Mouton, S.G., Stanley, M.A. 1996. Habit reversal training for trichotillomania: A group approach. *Cognitive and Behavioral Practice*, 3(1), pp.159-182.

Mtshali, S.M. 2002. Household Livelihood Security in Rural KwaZulu-Natal, South Africa. Wageningen University and Research.

Muoneke, C.O., Asiegbu, J.E. 1997. Effect of okra planting density and spatial arrangement in intercrop with maize on the growth and yield of the component species. *Journal of Agronomy and Crop Science,* 179(4), pp.201-207.

Naramabuye, F.X. 2004. Use of organic amendments as ameliorants for soil acidity in laboratory and field experiments (Doctoral dissertation).

Nieuwenhuis, J. 2007. Qualitative research methods and data gathering techniques. In: Maree K. (Ed). *First steps in research*. Van Schaick Publishers, Pretoria.

Odeyemi, O.O., Gbaye, O.A., Akeju, O. 2006, October. Resistance of Callosobruchus maculatus (Fab.) to pirimiphos methyl in three zones in Nigeria. *In 9th International Working Conference on Stored Product Protection* (pp. 15-18).

Odurukwe, S.N., Matthews-Njoku, E.C., Ejiogu-Okereke, N. 2006. Impacts of the women-in-agriculture (WIA) extension programme on women's lives; implications for subsistence agricultural production of women in Imo State, Nigeria. *Livestock Research for Rural Development*, 18(2), pp.47-61.

Opiyo, A.M., Mungai, N.W., Nakhone, L.W., Lagat, J.K. 2015. Production, status and impact of traditional leafy vegetables in household food security: A case study of Bondo District-Siaya County-Kenya. *ARPN J. Agric. Biol. Sci*, 10(9), pp.330-338.

Ortmann, G., Machete, C. 2003. Problems and opportunities in South African agriculture. In Nieuwoudt L, Groenewald J (Eds), The challenge of change: agriculture, land, and the South African economy. Pietermaritzburg: University of Natal Press, pp. 47 – 64.

Palmieri, N., Perito, M.A. 2020. Consumers' willingness to consume sustainable and local wine in Italy. *Ital. J. Food Sci*. 32 (1), 222–233.

Pawson, R. 2013. *The Science of Evaluation: A Realist Manifesto*. Sage; 2013.

Percy, R. 2005. The contribution of transformative learning theory to the practice of participatory research and extension: Theoretical reflections. *Agriculture and Human Values*, 22(2), pp.127-136.

Petty, N.J., Thomson, O.P., Stew, G. 2012. Ready for a paradigm shift? Part 1: Introducing the philosophy of qualitative research. *Manual Therapy* 17(4):267-274.

Phiri, P.S. 2005. A checklist of Zambian vascular plants. https://pdf.usaid.gov/pdf_docs/Pnado386

Poulton, C. 2004. Economic opportunities for the poor. http://www.dfid-agricultureconsultation.nri.org/economic-opportunity.html.

Pound, M. 2008. Zizek: A (very) critical introduction. Wm. B. Eerdmans Publishing.

Prakash, A. 2001. Why do firms adopt 'beyond-compliance' environmental policies? *Business strategy and the environment*, 10(5), pp.286-299.

Pretty, J., Benton, T.G., Bharucha, Z.P., Dicks, L.V., Flora, C.B., Godfray, H.C.J., Goulson, D., Hartley, S., Lampkin, N., Morris, C., Pierzynski, G., Prasad, P.V.V., Reganold, J., Rockström, J., Smith, P., Thorne, P., Wratten, S. 2018. Global assessment of agricultural system redesign for sustainable intensification. *Nat. Sustain* 1 (8): pp. 441-446

Puig de la Bellacasa, M. 2019. Re-animating soils: Transforming human-soil affections through science, culture and community. *The Social Review* 67:391–407

Punch, K. 2005. Introduction to social research: quantitative and qualitative approaches. Thousand Oaks, Calif: SAGE Publications.

Quisumbing, A.R., Smith, L.C. 2007. Intra-household allocation, gender relations and food security in developing countries. https://hdl.handle.net/1813/55670

QUNO. 2015. Small-scale farmer innovation systems. A review of current literature: http://quno.org/resource/2015/10/small-scale-farmer-innovation-systemsreport-first-expert-consultation-26-27-may

Raelin, J.A. 1997. Internal career development in the age of insecurity. In Business Forum (Vol. 22, No. 1, p. 19). California State University, Los Angeles, School of Business and Economics.

Rahman, M.A., Lee, S.H., Ji, H.C., Kabir, A.H., Jones, C.S., Lee, K.W. 2018. Importance of Mineral Nutrition for Mitigating Aluminum Toxicity in Plants on Acidic Soils: Current Status and Opportunities. *Int J Mol Sci*. 19(10):3073. doi: 10.3390/ijms19103073. PMID: 30297682; PMCID: PMC6213855.

Rajasekaran, B. 1993. A framework for incorporating indigenous knowledge systems into agricultural research and extension organizations for sustainable agricultural development in India (Doctoral dissertation, Iowa State University).

Reij, C., Waters-Bayer, A. 2001. Entering research and development in land husbandry through farmer innovation. Farmer innovation in Africa: a source of inspiration for agricultural development, pp.3-22. https://doi.org/10.4324/9781315071886

Rodale, R. 1995. Your farm is worth more than ever. Put your farm's internal resources to work. New Farm Magazine Regenerative Agriculture.

Röling, N. 1997. The soft side of land: socio-economic sustainability of land use systems. *ITC Journal*, 3(4), pp.248-262.

Röling, N. 2009. Pathways for impact: scientists' different perspectives on agricultural innovation. *International Journal of Agricultural Sustainability*, 7(2), pp.83-94.

Ros, M.B., Hiemstra, T., van Groenigen, J.W., Chareesri, A., Koopmans, G.F. 2017. Exploring the pathways of earthworm-induced phosphorus availability. *Geoderma*, 303, pp.99-109.

Rubaihayo, E.B. 2002. Uganda- The contribution of indigenous vegetables to household food security. https://ideas.recec.org/p/wbk/wboper/10794

Rumpel, C., Amiraslani, F., Koutika, L.S., Smith, P., Whitehead, D., Wollenberg, E. 2018. Put more carbon in soils to meet Paris climate pledges. *Nature*, *564*(7734), 32-34. https://doi.org/10.1038/d41586-018-07587-4

Rusoke, D.G., Rubaihayo, P.R. 1994. The influence of some crop protection management practices on yield stability of cowpeas. African Crop Science Journal, 2(1).

Samuel, A.M., Paul, S.S., James, K.A. 2024. Exploring farmer's assessment of soil quality and root yield in cassava-based cropping systems, *Journal of the Saudi Society of Agricultural Sciences*, ISSN 1658-077X, https://doi.org/10.1016/j.jssas.2024.06.003 https://www.sciencedirect.com/science/article/pii/S1658077X2400064X

Sanginga, N., Woomer, P.L. 2009. Integrated Soil Fertility Management in Africa: Principles, Practices and Developmental Process. Nairobi, Kenya: TSBF-CIAT. http://agrilinks.org/sites/default/files/resource/files/integrated_soil_fertility

Scarborough, V., Killough, S., Johnson, D. & Farrington, J. 1997. Farmer-led Extension: Concepts and Practices. London: IT Publications.

Schimel, J.P., Balser, T.C., Wallenstein, M. 2007. Microbial stress-response physiology and its implications for ecosystem function. *Ecology* 86, 1386–1394.

Schreefel, L., Schulte, R.P.O., de Boer, I.J.M., Schrijver, P.A., van Zanten, H.H.E. 2020. Regenerative agriculture – the soil is the base, Global food security 26. 100404, ISSN 2211-9124, https://doi.org/10.1016/j.gfs.2020.100404

Scialabba, N.E. 2007. Organic agriculture and food security. Paper presented at International Conference on Organic Farming and Food Security, 3– 5 May, Food and Agriculture Organization, Rome, Italy.

Scoones, I., Toulmin, C. 1999. Policies for soil fertility management in Africa. Policies for soil fertility management in Africa, International Institute for Environment and Development.

Scott, J. 2006. *Documentary research*. Thousand Oaks, Calif; London: SAGE Publications.

Shang, Q., Ling, N., Feng, X., Yang, X., Wu, P., Zou, J. 2014. Soil fertility and its significance to crop productivity and sustainability in typical agroecosystem: A summary of long-term fertilizer experiments in China. *Plant and Soil* 381: 13-23 DOI:10.1007/s11104-014-2089-6.

Shange, L.P. 2004. Taro [*Colocasia esculenta (L.) Schott*] production by small-scale farmers in KwaZulu-Natal: farmer practices and performance of propagule types under wetland and dryland conditions (Doctoral dissertation).

Sheath, G., Webby, R. 2000. The results and success factors of a farm monitoring and study group approach to collective learning in New Zealand. Cow up a tree Knowing and learning for change in agriculture, Case studies from industrialized countries. Inra. Paris, pp.111-119.

Shrestha, B.M., Sitaula, B.K., Singh, B.R., Bajracharya, R.M. 2004. Soil organic carbon stocks in soil aggregates under different land use systems in Nepal. *Nutrient Cycling In Agroecosystems*, 70(2), pp.201-213.

Sillitoe, P. 1998. The development of indigenous knowledge: a new applied anthropology. *Current Anthropology*, 39(2), pp.223-252.

Silvio, F. 2021. Assessing the environmental sustainability of local agricultural systems: How and why. *Current Research in Environmental Sustainability* Volume 3, 2021, 100028, ISSN 2666-0490, https://doi.org/10.1016/j.crsust.2021.100028. https://www.sciencedirect.com/science/article/pii/S2666049021000049

Sirrine, D., Shennan, C., Snapp, S., Kanyama-Phiri, G., Kamanga, B., Sirrine, J.R. 2010. Improving recommendations resulting from on-farm research: agroforestry, risk, profitability and vulnerability in southern Malawi. *International Journal of Agricultural Sustainability*, 8(4), pp.290-304.

Smith, B. 2006. The farming handbook. Pietermaritzburg: University of KwaZulu-Natal Press.

Mazenda, A., Masiya, T. 2022. South Africa's small-scale farmers still can't find a place in the food value chain. University of Pretoria. The Conversation, Creative Commons license.

Sojka, R.E., Upchurch, D.R. 1999. Reservations regarding the soil quality concept. *Soil Sci Soc Am J*. 63:1039-1054

Stagnari, F., Maggio, A., Galieni, A., Pisante, M. 2017. Multiple benefits of legumes for agriculture sustainability: an overview. *Chemical and Biological Technologies in Agriculture*, 4(1), pp.1-13.

Start, D., Johnson, C. 2004. Livelihood options? The political economy of access opportunity and diversification. Overseas Development Institute (ODI). Working paper 233.

STATS SA. 2016. Census 2016. Statistics South Africa. Pretoria. https://census.statssa.gov.za/#/

Stoorvogel, J.J., Smaling, E.M.A. 1998. Research on soil fertility decline in tropical environments: integration of spatial scales. In Soil and Water Quality at different scales (pp. 151-158). Springer, Dordrecht.

Stringer, E.T. 2007. Action Research. 3rd Edition, SAGE Publications Ltd., London.

Šūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., des Ios Rios, I., Rivera, M., Chebach, T., Ashkenazy, A. 2018. Local and farmers' knowledge matters! How integrating informal and formal knowledge enhances sustainable and resilient agriculture. *Journal of Rural Studies*, 59: 232-241, ISSN 0743-0167 https://doi.org/10.1016/j.jrurstud.2017.01.020 https://www.sciencedirect.com/science/article/pii/S0743016716302194

Stringera, L.C., Fraserb, E.D.G., Harrisc, D., Lyona, F.C., Pereirad, L., Warda, C.F.M., Simeltone, E. 2020. Adaptation and development pathways for different types of farmers. *Environmental Science and Policy* 104: 174-189.

Sunding, D., Zilberman, D. 2000. The Agricultural Innovation Process: Research and Technology Adoption in a Changing Agricultural Sector. https://are.berkeley.edu/~zilber11/innovationchptr.pdf.

Sulaiman, V.R., Hall, A. 2002. Beyond technology dissemination: reinventing agricultural extension. *Outlook on Agriculture*, 31(4), pp.225-233.

Swanepoel, C.M., Swanepoel, L.H., Smith, H.J. 2017. A review of conservation agriculture research in South Africa. *South African Journal of Science 35*: 297–306.

Talawar, S., Rhoades, R.E. 1998. Scientific and local classification and management of soils. *Agriculture and Human Values*, 15(1), pp.3-14.

Tashakkori. A., Teddlie. C. 2010. *SAGE Handbook of Mixed Methods in Social & Behavioral Research*. 2nded. Accessed 2023/01/25. https://methods.sagepub.com/book/sage-handbook-of-mixed-methods-social-behavioral-research-2e

Trochim, W. 2007. The Research Methods Knowledge Base. https://www.researchgate.net/publication/243783609.

Thamaga-Chitja, J.M. 2008. Determining the potential for smallholder organic production among three farming groups through the development of an empirical and participatory decision support tool (Doctoral dissertation).

Tharakan, P.M. 2017. Experiments in favour of a publicly funded and socially responsive higher education system in the state of Kerala: A study in the context of fast changing national preference for private funding. *Higher Education for the Future*, 4(1), pp.82-100.

Thompson, L.M., Troeh, F.R. 1978. *Soils and Soil Fertility*. 4th ed., New York: McGraw-Hill, 1978

Trehan, S.P., Wild, A. 1993. Effects of an organic manure on the transformations of ammonium nitrogen in planted and unplanted soil. *Plant and soil*, 151(2), pp.287-294.

Uaiene, R.N., Arndt C, Masters, W.A. 2009. Determinants of agricultural technology adoption in Mozambique. Discussion paper no. 67E. National Directorate of Studies and Policy Analysis, Ministry of Planning and Development, Republic of Mozambique. http://cebem.org/cmsfiles/publicaciones/Determinants_of_agricultural_technonolgy_adoption_in_Mozambique.pdf.

Ummugulsum, Z., Ayla, E., Murad, C., Nevran, K., Gencay, K., Ipek, T. 2024. A systems approach to understanding the interconnected factors affecting rural development: A case study from Türkiye, *World Development Perspectives*, Volume 34, 100588, ISSN 2452-2929, https://doi.org/10.1016/j.wdp.2024.100588

UNDP, 2017. Strengthening Livelihoods in Environmental Action: Sustainable Livelihoods Approach. A Contribution to Agenda 2030. Discussion Paper. Panama City. Retrieved from http://www.latinamerica.undp.org/content/rblac/en/home/library/poverty/DiscussionpaperAgenda2030.html

UNESCO. 1999. World Culture Report: Culture, Creativity and Markets. France.

Van den Ban, A.W., 1998. Supporting farmers, decision making by agricultural extension. *Journal of Extension Systems*, 14, pp.55-67.

Van den Berg, H., Phillips, S., Poisot, A.S., Dicke, M., Fredrix, M. 2021. Leading issues in the implementation of farmer field schools: a global survey, *The Journal of Agricultural Education and Extension*, 27:3, 341-353, DOI: 10.1080/1389224X.2020.1858891

Van Groenigen, J.W., Van Groenigen, K.J., Koopmans, G.F., Stokkermans, L., Vos, H.M., Lubbers, I.M. 2019. How fertile are earthworm casts? A meta-analysis. *Geoderma*, 338, pp.525-535.

Van Niekerk, A.A. 2002. Moral and social complexities of AIDS in Africa. *The Journal of medicine and philosophy*, 27(2), pp.143-162.

Wallenstein, M.D. 2017. Managing and manipulating the rhizosphere microbiome for plant health: a systems approach. *Rhizosphere* 3: 230–232.

Walliman, N. 2011. Research Methods: The Basics. 10.4324/9780203836071.

Warburton, H., Martin, A. 1999. Local people's knowledge in natural resources research. https://core.ac.uk/download/pdf/42389817.pdf

Wastell, D.G. 2001. Barriers to effective knowledge management: Action research meets grounded theory. *Journal of systems and Information Technology* 5(2), 21-36.

Wasti, S.P., Simkhada, P., van Teijlingen, E.R., Sathian. B., Banerjee. I. 2022. The growing importance of mixed-methods research in health. *Nepal J Epidemiol*. 12(1):1175-1178.

https://pubmed.ncbi.nlm.nih.gov/35528457/

Waters-Bayer, A., Bayer, W. 2009. Enhancing local innovation to improve water productivity in crop–livestock systems. *The Rangeland Journal*, 31(2), pp.231-235.

Waters-Bayer, A., van Veldhuizen, L., Wongtschowski, M., Wettasinha, C., Waters-Bayer, A., Kaaria, S. 2009. Recognizing and enhancing processes of local innovation. Innovation Africa: Enriching farmers' livelihoods. London, Earthscan.

Wellman, C.H., Osterloff, P.L., Mohiuddin, U. 2003. Fragments of the earliest land plants. *Nature*, 425(6955), pp.282-285.

Yoong, P., Pauleen, D. 2004. Generating and analysing data for applied research on emerging technologies: a grounded action learning approach. Information Research, 9(4), pp.9

Zhao, X.Q., Chen, R.F. Shen, R.F. 2014. Coadaptation of Plants to Multiple Stresses in Acidic Soils. *Soil Science* 179: 503-513 DOI: 10.1097/SS.0000000000000086

APPENDIX I-VII: TRANSCRIPTION OF RESULTS SHEETS

Appendix i: Problems related to soil

Problem	Path to solution	Promoter of suggestion	Solution	Definitely can do it	I think I can do it	Can't do it
Infertile : small yields	Need assistance	Problem for everyone	Fertilizer suitable for organic farming	No vote taken		
			Addition of organic matter	No vote taken		
			Make compost for themselves	No vote taken		
Soil too hard too much clay.	Need assistance	Problem for everyone	Top dressing with manure[5]	No vote taken		
An organic top dressing required: Cow manure too slow Chicken suitable[6] LAN not allowed	Need assistance	Problem for everyone	Top dressing with manure	No vote taken		
aMadumbe leaves Burn	Needs Solution	Problem for everyone	New problem, no known solution, began this year	0	0	50
Microorganism in red soil (could be red clay (is'bomvu)	Red clay is a problem for everyone		Add compost	50		?
Erosion from rain storms especially on slopes next to roads and from road drains which flood gardens		Baba Maphumulo	Dig run off trenches around fields	21	21	30
		Baba Maphumulo	Plant Vetiver grass	37	25	45
		Mrs Mkhize	Choosing plants that obstruct water movement	16	30	23
		Miss Sabela	Plant across fields not down slope	50	0	0

[5] See Figure 14 – diagramme of how to produce liquid manure

[6] There are questions about chicken manure – do the white commercial chickens not get fed chemicals and hormones? These are not appropriate for organic farming.

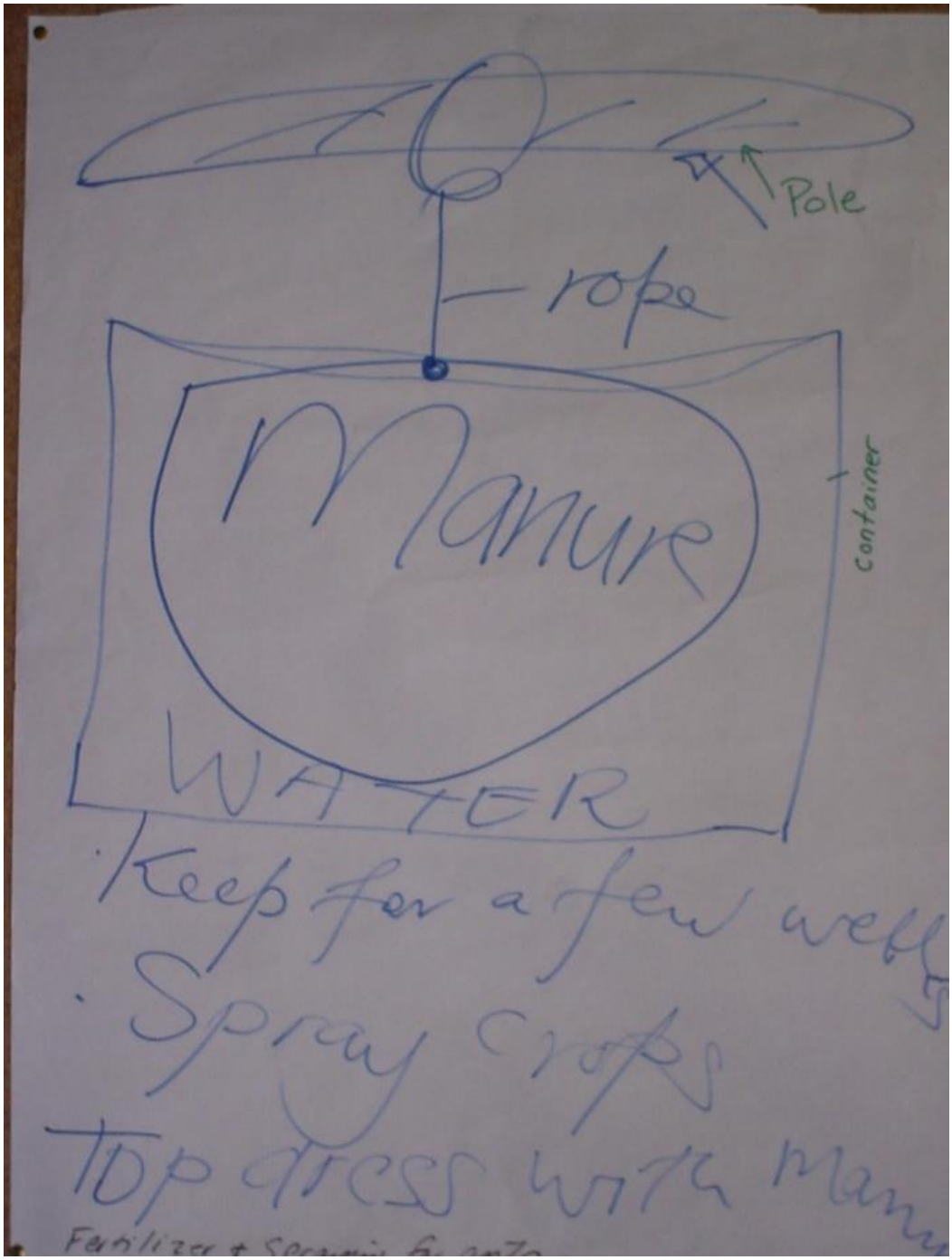


Figure 14: Diagram of how to produce liquid manure

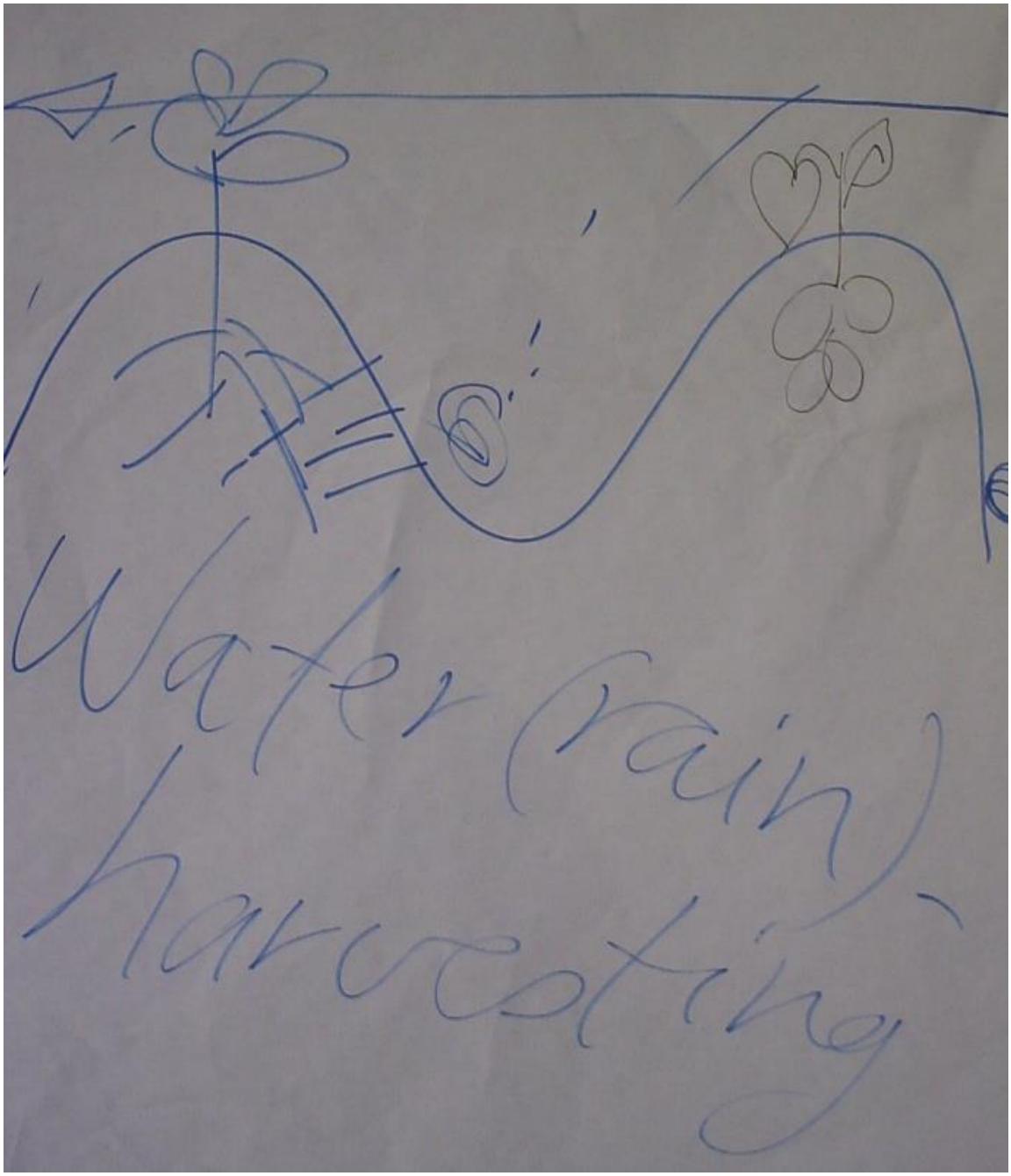


Figure 15: Water harvesting

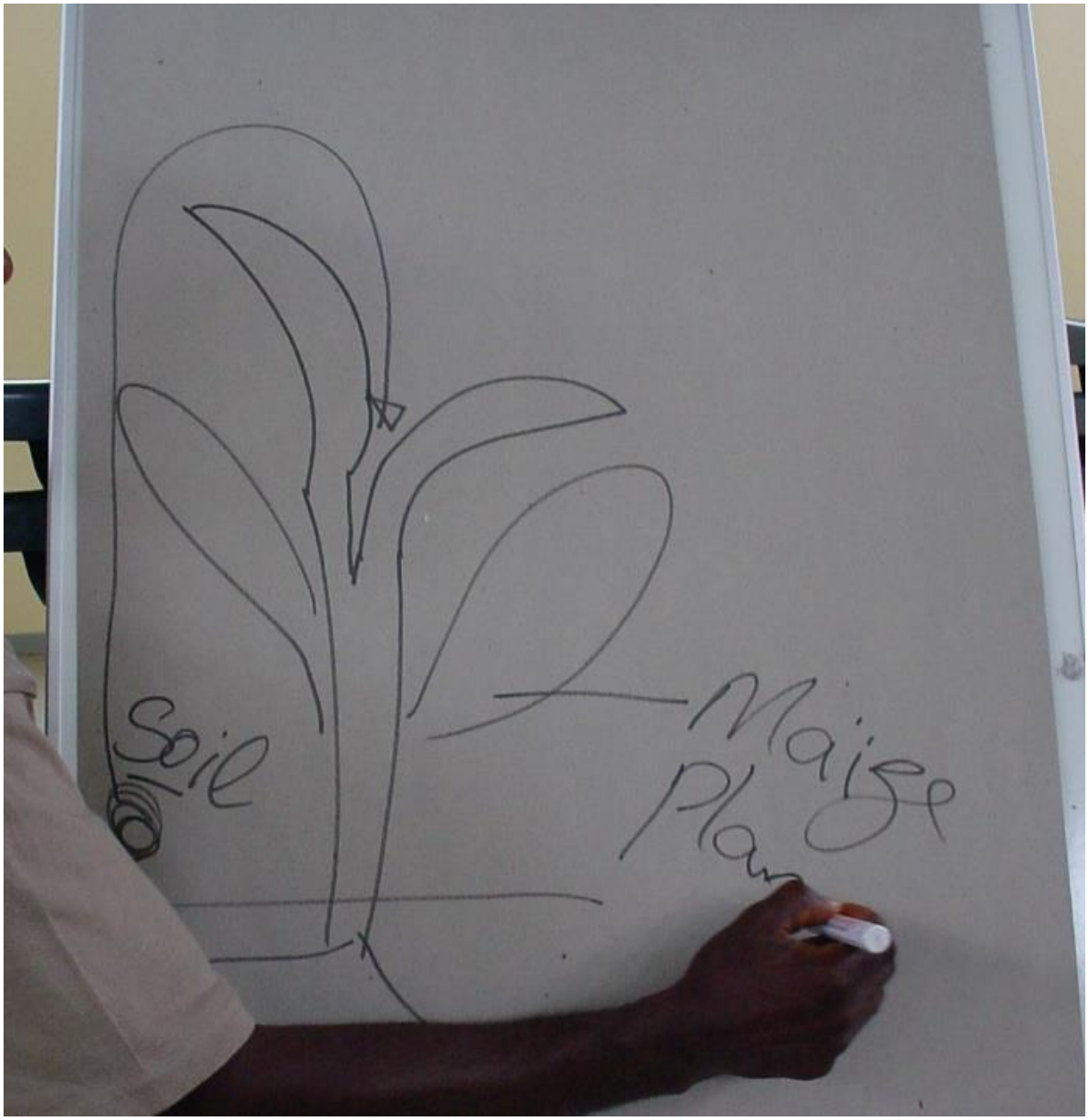


Figure 16: How to sprinkle ash or soil on plant to prevent

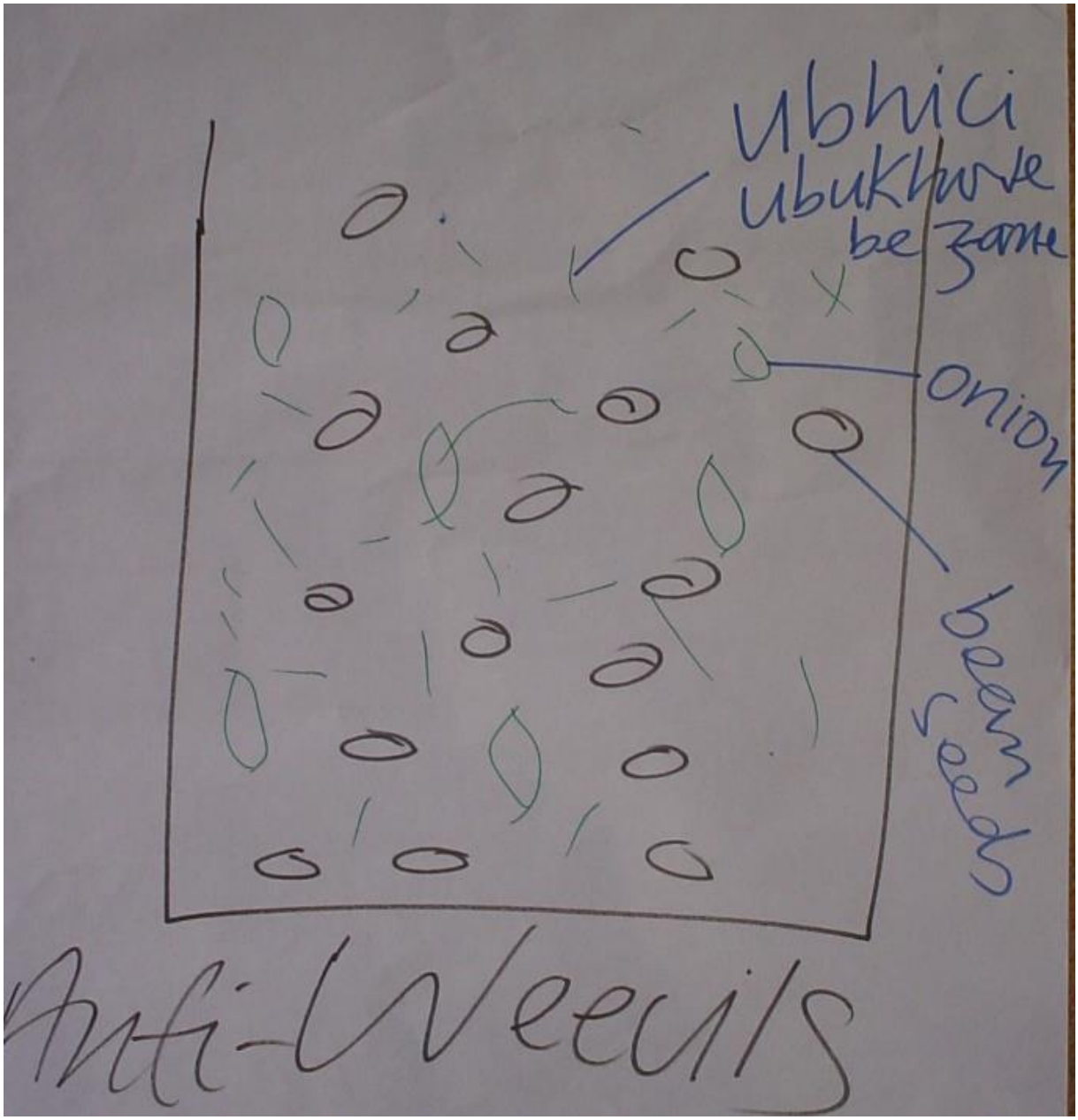


Figure 17: Diagram showing how to mix the *bhici* Stock borer and onion/orange peel in with the stored grains.

Appendix ii: Problems with crops

Problem	Path to solution	Promoter of suggestion	Solution	Definitely can do it	I think I can do it	Can't do it
Water in general and water for irrigation		Mrs Sithole &	Irrigation system	3	25	50
Planting on ridges is okay for small fields but in bigger fields is very labour intensive		Mrs Mkhize	Plant on top of ridge (small fields)[7]	43	5	0
			No solution for large fields			50
Drought		Mrs Sabela	Plant early in season to catch early rains	12	28	37
		Nonhlanhla	Mulching	40	8	28
Weeds: Wild berries. Watergrass biggest problem 'Isonani'[8]		Mrs Mkhize	Cultivation by hand	40	0	37
		Bhege	Indigenous herbicide (has a book on these and will share it)	3	34	50
			Mulching			
Tillage causes weeds		Nonhlanhla	Mulching	43	0	37
		Baba Maphumulo	Cultivate	0	34	50

[7] See Figure 15 Water harvesting.

[8] '*isonani*- witchweed. Gogo told us that some believe that the flying ants which fly after the rains land and grow as a plant.

Problem	Path to solution	Promoter of suggestion	Solution	Definitely can do it	I think I can do it	Can't do it
Planting dates: 1) with respect to rain 2) when to plant veggies that are not familiar for experiments to increase variety of crops.	Need Help		No solution	No vote taken		
Pesticides too slow – don't work – termites always return	Need help	Baba Maphumulo	Khaki weed, ntswanga[9], pepper , Vetiver	No vote taken		
Poor growth/no growth caused by environment, monoculture, seed quality	Need Help	Baba Maphumulo	Top dressing with manure[10]	No vote taken		
Crops wilting: this could be soil, water, disease, any cause – not sure of the cause	Need Help		No solution	No vote taken		
Grey spots on bean leaves caused by grey beetles[11]	Need Help	Baba Maphumulo	Same T_x as for aphids: Teas made from: Menubese, Mhlandlothi, Nukgani, Mnukambiba	29	8	17

[9] *Ntswanga* -
[10] See Figure 14 – diagramme of how to produce liquid manure
[11] *Mkhithana* –

Appendix iii: Problems with Pests

Problem	**Path to solution**	**Promoter of suggestion**	**Solution**	Definitely can do it	I think I can do it	Can't do it
Cutworm - *umswenya*		Baba Maphumulo	Use natural (indigenous) plants: *Intlingo yibombana, umnukambiba, membhesa*	11	28	14
Mole – *imvukuzane*		Khuzaneni	Catch the mole, burn it mix with water and spray on fields (not popular method)	2	40	0
		Mr K Mahphumulo	Take 2l bottles make wings– wind passing through disturbs the moles	11	27	0
		Tholi	Take dried pepper and straw, burn and push down hole	22	26	0
Millipede – *amasongalolo affects potatoes and madumbes*			No solution			
Stalk borer - *isihlava*		Mrs Phawa & Baba Maphumulo	Sprinkle soil[12]	34	4	0
			Or sprinkle ash	28	0	0
Frogs – *amselesele* good because they eat insects, bad because they eat peanuts	8- think frogs are a problem 23 don not think that they are a problem	Khuzanani	Has heard that you can sprinkle salt on frog when in house – hasn't tried it or tested it in fields	0	0	0
Locusts – *intothoviyane*		Mrs Ndelu	Pick them off by hand	2	2	0
			Spray with Khaki weed spray	40	1	0

[12] See Figure 16: How to sprinkle ash or soil to prevent stock borer

Appendix iii: problems with pests continued

Problem	Path to solution	Promoter of suggestion	Solution	Definitely can do it	I think I can do it	Can't do it
Big Ants – *omakoti* attack the maize germ and vegetative parts of seedlings		Mrs T B Nxele	Mix seeds with Jeyes fluid at time of planting	20	8	0
		Mrs Mkhize	Prime the seeds with water as they sprout, then you plant (works for grains)	39	0	0
Black Insects – *ntwala* (aphids) Especially attacking late planted beans		Baba Maphumulo	Spray with teas made from *Membes, Mhlandlothi, Mnukambiba, Nukgani*	29	8	17
Bush pig – *Ingulube yehlathi*	No real solution, farmers are afraid of them	Nonhlanhla	Trap (dig a deep hole) and kill	1	0	31
Birds –*izinyoni, amagwababa*		Miss Mkhize	scarecrow	32	2	0
		Mrs Mkhize & Mrs Phewa	Lay sticks in field, birds think they are snakes	26	0	0
Monkeys – *izinkawu*		Mrs Sabela	Barking dogs (best dog per homestead)	31	0	0
**much discussion occurred on how to catch a monkey!*		Miss Chonco	Trap in large mouse trap and spray with paint	2	0	0
Stray Cattle - *izinkomo*		Baba Maphumulo	Fencing	34	0	0

		Khuzononi	Spray plants with cow dung	3	2	0
In a grazing camp, cows may be stolen easily & whose land would be used?		Miss Chonco	Grazing camp	No vote taken as land belongs to everyone		
Chickens- *izinkukhu*		Nonhlanhla Nxele	Trim beaks and toe nails	27	2	0
		Miss Sabela	Coop chickens	38	0	0
	Need help with new ideas		Feed them enough	1	0	45
Weevils – *imbovane* plants in the field and storage		Mr Mathe	Mix cut onion & *bhici*[13] in with beans	40	14	0
		Miss Ngidi	Mix cut orange peel with *bhici*	40	14	0
Termites		Mrs Sabela	Mix jeyes fluid with water and spray on soil	6	18	1
Porcupine - *Ingungu mbane*						
Beetles - *amabhungezi*		Baba Maphumulo	Same as for aphids			
Rabbits - *unogwaja*		Mrs Mkhize	Drums and noise made with cans chase the rabbits away :solution not really viable as rabbits come at night	1	2	0
		Mrs Mkhize uses dogs to chase the rabbits		No vote taken		
At this point researchers decided to change the methodology and stop voting on solutions as the process was too time consuming. Questions asked were now, can we do it ourselves or do we need outside help.						

[13] bhici is? Lantana = ubukhwebezane

Appendix iv: Other Problems - related to Equipment

Problem	Path to solution	Promoter of suggestion	Solution
Fencing to keep out unattended cattle, people and wild animals: not all have fencing	The community needs assistance	Everyone	Fencing for each homestead but not community gardens
Planting equipment: hand hoes need replacing every year, and are expensive, cheap ones are not good quality	The community needs assistance	Everyone	Need enough of these for everyone: e.g. hand hoes, wheelbarrows
			New types of hand tools invented: eg. Weeding fork
No Tractor: the one available is broken	EFO will resolve		Mr R Dladla from Zakhe Institute will be invited to explain the process of funding for a tractor
Access roads: needed to collect crops for loading 9there are people willing to collect but roads are only foot paths)	EFO will resolve		The transport forum in Camperdown will be approached
Transport Vehicle for harvest produce: ownership is a problem –who will keep it?	EFO will resolve		A larger vehicle would double production

Appendix v: Other Problems - related to access

Problem	Path to solution	Promoter of suggestion	Solution
Sources of organic manure	Need assistance	Problem for everyone	Relationship with commercial farmers to guarantee supply.
			Compost making
Available fertilizer not accessible by everyone	Need assistance	Problem for everyone	Identification of suitable products and suppliers
Financial Assistance because cash required before harvest for seed, labour to weed, plant, and harvest, but payouts come after harvest	Need assistance	Problem for everyone	Training on how to maintain cash flow for the organisation.
		Prof. Modi	Savings clubs
Sourcing markets for harvest –	EFO farmers to experiment		Ascertain ability to produce different crops

Problem	Path to solution	Promoter of suggestion	Solution
Woolworths favours amadumbes, more crops need to be marketed	with different crops		
			Find a market for every crop they can grow
Routine of Extension Officer: does not visit gardens to check organic practice only comes in mornings	EFO		Officer needs training in organics
			Advise her on our needs:
			Involve her by communicating needs

Appendix vi: Ranking of most important problems (by group consensus)

Transport for harvest to markets	1	
Fencing	2	
Tractor	3	"researchable problem – model for community tractor system?
Identifying planting dates for new types of crops as well as predicting rains	4	Researchable problem
Use of indigenous plants for weed control	5	Researchable problem
Madumbe Blight (leaf burn)	6	Researchable problem
Water	7	Researchable problem

Appendix vii: Questions requesting knowledge that may provide opportunities for technology transfer or adaptation of indigenous technology

1. How do we test if we need lime?
2. Soil analysis indicates that we need lime, How do we access lime
3. How do we source markets?
4. What makes crops bitter?
5. How often can I plant a crop in the same area?

6. What can I use for topdressing?
7. How do I plant bananas?
8. Can we check the soil fertility before planning? How do we do this?
9. Who do we call for pest problems that we do not know how to solve?
10. What are drought resistant plants/crops/varieties?
11 Why does tillage produce more weeds?
12. What alternatives to current practice e.g. Jeyes fluid would be more acceptable for organics?

Identification of indigenous plants used as pesticides/herbicides

Zulu name	English common name	Latin name
bichi		
	Khaki weed	
Membes		
Mhlandlothi		
Intlingo yibombana		
Mnukambiba,		
Nukgani,		
Menubese ? membhesa		
ntswanga		
Mhlandlothi,		
Mnukambiba		
	Pepper	
		Vetiver

Appendix A: 08 May Attendance Register

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EFO MONTHLY FORUM MEETING ATTENDANCE RESIGISTER
UHLA LWABAKHONA EMHLANGANWENI WE EFO WANYANGA ZONKE

Indawo: Ogagwini EFO Packhouse
Usuku: 08 May 2018
Isikhathi: 10H00

Igama nesibongo	Inombolo yocingo	Indawo	Sayina
1. T	08	OGAGWINI	
2. M	0	OGAGWINI (Lower)	
3. No	08	Ogagwini - Upper	
4. Zep	07	Ogagwini - U	
5. B	06	Ogagwini - L	
6. S	07	06 Ogagwini - U	
7. K	07	Ogagwini - L	
8. Be	0	Ogagwini - U	
9. Jh	07	Ogagwini - U	
10. M	07	Ogagwini - U	
11. Xo		Ogagwini - U	
12.			
13.			
14.			
15.			
16.			
17.			

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Appendix B: 31 May 2018 EFO Attendance Register: Presentation of the qualitative study return workshop

ARC • LNR
Excellence in Research and Development

EFO MEETING ATTENDANCE RESIGISTER
UHLA LWABAKHONA EMHLANGANWENI WE EFO

Indawo: EFO Packhouse Ogagwini
Usuku: 31 May 2018
Isikhathi: 10H00

Igama nesibongo	Inombolo yocingo	Indawo	Sayina
1.		Ogagwini (u)	
2.		Ogagwini (u)	
3.		Ogagwini (u)	
4.		Ogagwini (L)	
5.			
6.		KWA MAHLEKA OGAGWINI	
7.		ASIME	
8.		ASIME	
9.		ASIME	
10.		Ogagwini	
11.		Mahleka	
12.		Ogagwini	
13.		Ogagwini	
14.		Ogagwini	
15.		kwamahleka	
16.		kwamahleka	
17.		Ogagwini	

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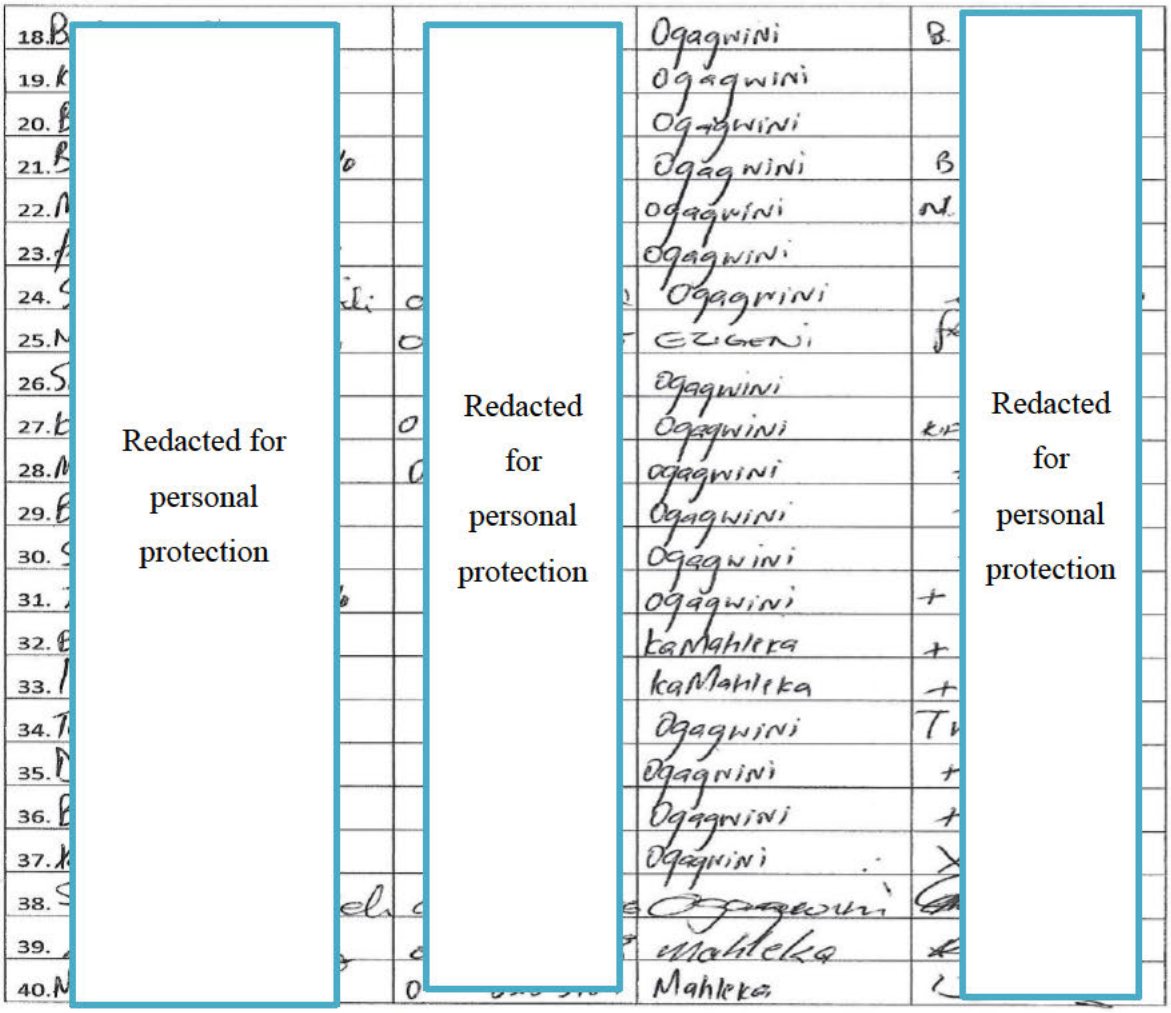
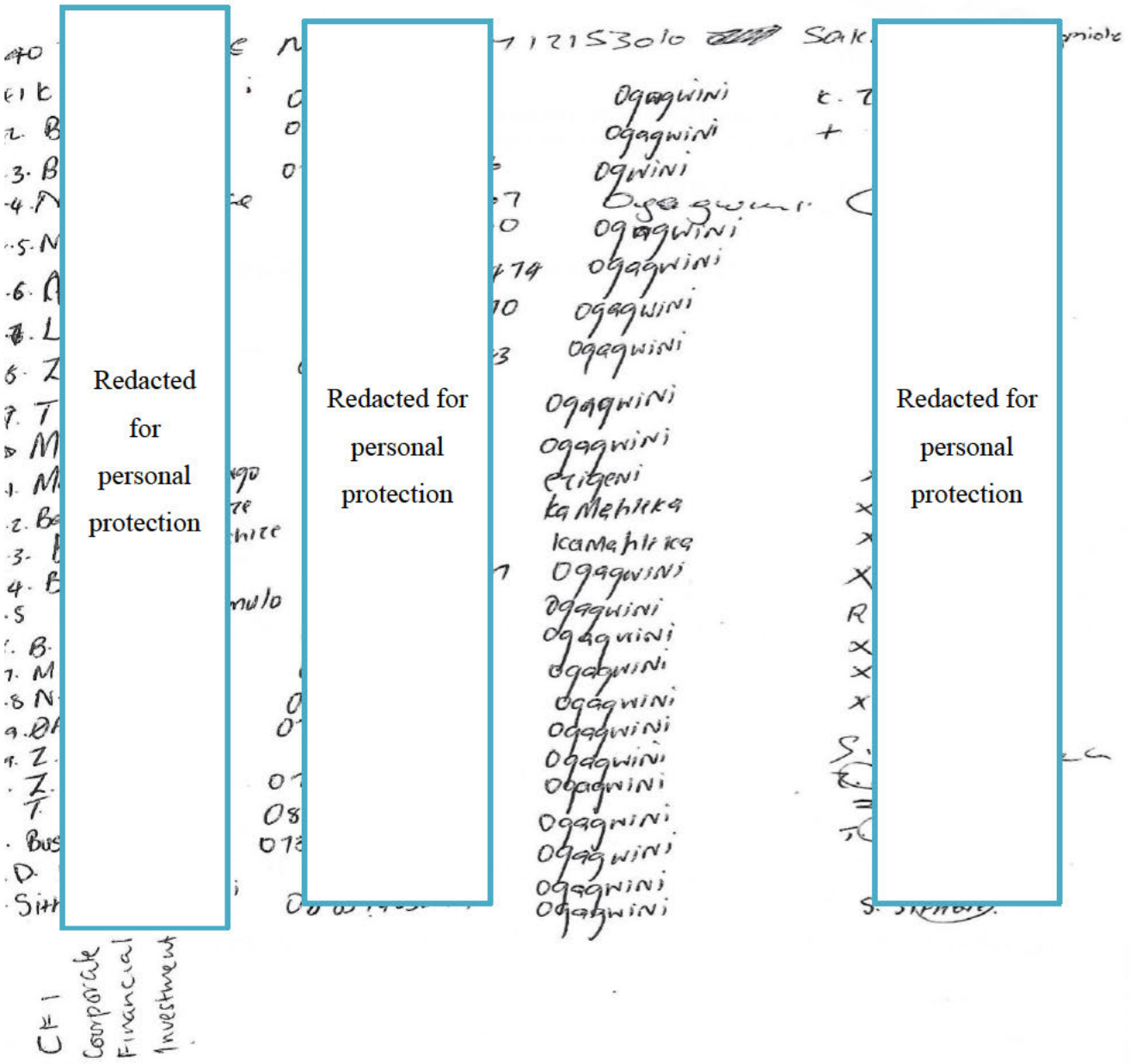
31 May 2018 EFO Attendance Register: Presentation of the qualitative study return workshop (continued)



31 May 2018 EFO Attendance Register: Presentation of the qualitative study return workshop (*continued)*



Appendix C: Researcher -Farmer interactions providing data for this study (2006 - 2009 and 2018 - 2019#)

Category of Interaction	Type of interaction	Instrument for data collection	Data arising from interaction
Monthly Meetings (1st Monday of every month)	Group decision making and reporting	Participant observation	Minutes Field notes Records of decisions
Farm Visits	Household interviews (2006) Selected per village household interviews (2018)	Semi structured interviews with family groups of household systems	Flip chart summaries of household information Field notes
Social visits	Homestead visit, social events (2011 - 2016)	Observations	Background information
Data Collection questionnaires	Field Trial Visits (2006-2009)	Probing conversations	Field notes
	Community Garden interviews (2007)	Semi structured group interviews Probing conversations	Time lines Field notes: *
	Farming System Interviews (2008)	Questionnaire	Field notes:**
	Soil Names and Indigenous knowledge group interview (2010)	Questionnaire Probing conversations	Qualitative Data Field Notes***
	Farming Technology Questionnaires (2009) (2018)	Questionnaire Probing conversations	Qualitative data Field Notes
	Impact of biological strategies intervention a decade later (2019)	Questionnaire Probing conversations	Qualitative data Field Notes

EFO member workshops	Marketing Workshop (18 April 2008)	Breakaway group discussions Group Feed back	Flip chart summaries (translated later into English)
	Reflection workshop (27 Nov 2008) Reflection workshops[#] in the monthly forum meeting (May – Aug 2019)	Breakaway group discussions Group Feed back Individual village group feedback[#]	Flip chart summaries of breakaway group discussions Field note summaries of consensus; discussion

* Researcher assisted with data collection for master's research (Ndlovu, 2007). **Towards an understanding of the relationships between homestead farming and community gardens at the rural areas of Umbumbulu, KwaZulu-Natal**. This provided access to questionnaires on Household information about interviewee's' farming system and data for triangulation.

** Researcher assisted with data collection for master's research (Maragelo, 2008). **Traditional agriculture and its meaning in the lives of a farming community: the case of Embo**). This provided access to questionnaires on Household information about interviewee's' farming system and data for triangulation

*** Researcher assisted with the data collection for master's research (Buthelezi, 2010). **The use of scientific and indigenous knowledge in agricultural land evaluation and soil fertility studies of Ezigeni and Ogagwini villages in KwaZulu-Natal, South Africa**). This provided access to questionnaires on Household information about interviewee's' farming system and data for triangulation

Appendix D: Best vs Worse :COMPARISON BETWEEN THE BEST (village E) AND WORST (village Ma)

ITEM	BEST (village E)	WORST (village M)
Typology	**Age**: 1b; d & e 1 youth; 13 >50yrs **Edu**: 1,2,3,4 & highly skilled 14 females	**Age**: b; c & d 1 youth; 11 =35-64yrs **Edu**: 1,2,3 & 4 12 females
Farm land (sizes)	Increased and intensified	Drastically reduced 2500m^2
Affiliation	Secondary EFO	Primary EFO
Type of cropping	Mixed with livestock Adequate access + use of legumes (dry beans and cowpeas)	Mainly crops with very few livestock No access to manure
Internal capacity	Many members received good training *wrt* managerial, administrative, leadership, conflict resolution, financial skills as they previously occupied important positions within the organization. Group has systems and strategies in place for ease of work and harvest continuity in extending the amadumbe season	Village had no representation in the executive structures of EFO. So, all members of this village are general members of EFO with no specific capacity built within the group. Individual effort in every aspect of production including the small marketed fraction
Socially	Inter-institutional arrangements have always existed as the group long recognized themselves as a village within the EFO organization Maintenance (by group leaders) of complex network of relationships internally (village) and externally (other stakeholders) ensured that social cohesion bonds are continuously strong. Main livelihood strategy with almost all the households in the valley producing. Valley has proper grazing arrangements as	No leader was elected to represent the village; hence no one could facilitate within the group i.e. lack of inter-institutional arrangements to sustain and give direction to the group. Group is cultured into external command and control with no insight to source within a potential leader/s Agric. not a livelihood strategy. Many villagers work in adjacent commercial cane farms as casual labours. Few households still own livestock which is mostly stray and thus planted fields are not protected. Village also has a problem with wild hog damaging crops

ITEM	BEST (village E)	WORST (village M)
	the fields are not fenced, so all livestock is kept in the range lands thus no stray livestock.	
Production motives	Market supply (both formal and informal) as well as walk-ins. Good market networks and socially known to be the hub of produce	Mainly for subsistence with limited informal market sales. Geographic location disadvantages the village *ito* public transport for ease of informal market access
Sustainability	Environmentally: use of legume intercrop and rotation in the farming system ensures sustainability indicated by high yields Socially: village cohesion and strong social bonds ensures good labour force and efficiencies Economically: access to a variety of markets and ability to make profit ensures economic sustainability	None of the sustainability pillars are observed due to lack of social cohesion thus disadvantaging the group to negotiate various production aspects i.e. bulk planting to marketing, transportation, access to markets
Stakeholder engagement	Participated in the ARC cultivar trial (4 – 5yrs) to ensure best yielding cultivar for the market. Open to other attempts by office of the Premier through ASIME entity (NPO)	Part of the bigger group that rejected all developmental endeavors by various stakeholders thus contradicting the expression in EFO constitution
Additional factor	Pack house **quality controller** with market experience and contacts. Good understanding of post-harvest operations. Male figure influence strengthening of female group with great appreciation of the EFO's image/reputation and status used as an advantage to advance progressive sustainable farming **Close field vicinity** for all members, ease and synergy of field work operations. Whole Mkhize valley is occupied by farming homesteads. **Family bonds** as all members belong to the Mkhize clan	Individual household scattered throughout the village. Sole effort in all field operations. Village has a smaller fraction of farmers in general

Appendix E: Focus Group Discussion & impact of Learning

Data from four of the five villages is presented in the table below. Village five (village R) only had one agricultural homestead remaining (with a small garden and a patch of amadumbe) following local infra-structure development for residential use as a result of governmental RDP programme. Hence, for this reason the village was excluded from the study during the qualitative data collection period.

Qualitative observations (meanings and interpretations) of changed behaviour post research engagement

Villages **Observation**	**Village O lower & upper**	**Village N**	**Village M**	**village E lower[S]**
Vermicompost use (perceived by farmers as high maintenance relative to accessing other organic manure sources)	Maintained wormery and used vermicompost during engagement[#] period. In the absence of research team neglect & none feeding led to death of earthworms	Maintained wormery and used vermicompost a few years after engagement[#] before it was flooded	Never used post engagement[#]	Maintained wormery and used vermicompost a few years after engagement[#] before it was flooded
Nutrient cycling impact	Continuous use of organic manures seen with good results in maintaining yield. Still have winter fallows thus not taking advantage of good side of climate change. Not aware of lack of efficiencies in their systems. Mind-set change to changing world is difficult to achieve for many thus affecting their attitude toward farming decisions. Slow but gradual positive impact on nutrient build-up due to limited best practices usage	Appreciate benefits of using various legumes as intercrops and winter crops. Evidence seen in increased yields in their fields. Legume integration benefits attracted many new farmers into taro production. Home gardens have also benefited from this new norm of having legumes. Alleviate shortage of manure due to livestock theft. Use of legumes form sound	No benefits seen, declining agricultural livelihoods. No evidence of continuity. Dying agriculture in the area, loss of fertile soils due to neglect and fields left fallow	Benefits of continuous use of organic manures seen in gradual yield increase over the years. Visually healthy & highly rich soils with OM. Annual organic amendment load to further build-up the soil's capacity and resilience. Legume integration effect minimal but still advantageous. Taking advantage of good phase of climate change

Villages Observation	Village O lower & upper	Village N	Village M	village E lower[S]
		foundation for fertility build-up		
Production norms	Consistent production norms without any research innovations. Need continuous leadership for support to implement learned practices. Generally difficult to accept proven change and thus sticking to old ways of doing thing in all aspects of their farming	General overall change with intercropping practice that was practised in maize with pumpkins. Previously taro was a mono crop and now it is a new norm to intercrop it with beans. Despite the slight reduction in production areas, intercropping has been intensified with winter legumes instead of fallows	Declining to almost none existent in other. The few who are still producing are using the old practices without any of the research innovations learned during the engagement. Production areas educed by more than 70% in those who are still producing	Progressive village with future outlook in every decision taken toward improved productivity. Main focus on taro, sweet potatoes and maize as their main crops with dry beans and cowpeas as intercrops. Diversified continuous sustainable production with firm markets driving continuity. 100% livelihood based on production
Adapted & adopted practices	No adoption seen, still using old prod[n] practices. In the absence of research team farmers reverted back to their ways of farming	Adopted the use of cowpeas as intercrops. Adapted local monocrop production norms of taro prod[n] by integrating legumes in a intercropping	No practices from research have been adopted or adapted	Adapted their practices to including legumes in a rotation and intercropping. Efficient use of organic manures. Maintained cane lands and increased organic lands
Food security	Focus on fields both taro and sugarcane with less emphasis on home gardens. Thus, food security is secured but not sustainable in the	Through field produce and home gardens secured food security	In-secure due to lost agricultural livelihoods	Highly secured and sustainable due to access to markets, high yields, intensified & diversified production

Villages **Observation**	**Village O lower & upper**	**Village N**	**Village M**	**village E lower[S]**
	long run with lack of markets and declining cane industry			
Soil fertility (yields)	Consistent with slight improvement	Highly improved and increasing every season	Not available	Significantly improved and sustained high yields
Social cohesion indicators *(with specific reference to gender, age, field work & resource use)*	Fragmented village: EFO members operating as individual homesteads. Older female members dominating the village and against change and any new leadership, stuck in the past. Able to work in the fields by themselves leading to no growth as there is no continuity in impacting skills to the young. Male members have decreased due to illness and death. Complete or direct opposite of EFO '	Unity of old and new members specifically older folks. More women compared to men and not much youth involved in farming activities. The fewer men in this village provide leadership, harmony and guidance as well as support in resources especially transport (to meetings, to collect inputs). Field work is still an individual household responsibility although unity is seen in the way field activities are done. Evidence of EFO identity value is still strong.	EFO members have reduced due to old age, illness and death. Very few are left and feel forgotten due to distance. Almost collapsed state with none existent social cohesion. The pride of being an EFO member has lost its value and meaning since the common denominator of being amadumbe grower is no longer existing.	United village with dominance of only women equally young and old and a fraction of youth. Combined efforts & assets (labour, manure, planting material. Village has re-identified themselves as the secondary EFO group with strong social bonds demonstrated through unity in working together and sharing resources and markets. A true reflection of technology used for networking and organizing. Their cooperative capacity ensured social change
Livestock	Have sufficient stock for manure use, availability and access is easy. Continuous planting in less hectarage	Experienced high livestock theft, challenged access to available organic manures	No livestock within the few EFO members	Have sufficient stock, easy access and highly productive with increased land area.

Villages Observation	Village O lower & upper	Village N	Village M	village E lower[$]
Research impact*	Being the HQ of EFO, this village has power struggles and research impact is viewed as stability and security. Institutional arrangements drive the use of best practices i.e. EFO leaders promote sustainable NRM. More member converted to cane in this village	Valued by old member who have benefited from engagements and gained more sustainable farming knowledge	Believe that research team should exist indefinitely for their continued farming. About half of members are now deceased	Highly values and perceived to be the foundation for successful farming in a sustainable manner
Learning (overall)	Not fully capacitated especially with leadership skills. Lost some members with capacity, low adoption rates no adaptation of research, still using old production norms of monocropping taro	Capacitated, high adoption and adaptation of research innovations, sustainable	Lost members, currently no capacity not sustainable, diminished interest in EFO matters and livelihood dependency on agricultural production almost none existent	Highly capacitated, exhibit principles of sustainable production and soil health concept of fertility build-up. Overall learning bearing fruits of being consistently highly productive and beyond subsistence. Village is self-sufficient in many production aspects

* Research impact: assessment of scientific knowledge (awareness/facts/practices) integrated with local knowledge (experience) based farming techniques in the formation of appropriate methods (best practices)

[#] engagement is referring to the research engagement the time when researchers were still around in the area executing their various research works

[$]upper Ezigeni has <5 members who form part of upper Ogagwini (and thus included in the Ogagwini groups) due to their proximity *i.t.o* distance

Appendix F: Qualitative observations (meanings and interpretations) of changed behaviour post research engagement

Villages **Observation**	**Village O lower & upper**	**Village N**	**Village M**	**village E lower[$]**
Vermicompost use (Viewed by farmers as high maintenance relative to accessing other organic manure sources)	Maintained wormery and used vermicompost during engagement[#] period. In the absence of research team neglect & none feeding led to death of earthworms	Maintained wormery and used vermicompost a few years after engagement[#] before it was flooded	Never used post engagement[#]	Maintained wormery and used vermicompost a few years after engagement[#] before it was flooded
Nutrient cycling impact	Continuous use of organic manures seen with good results in maintaining yield. Still have winter fallows thus not taking advantage of good side of climate change. Not aware of lack of efficiencies in their systems. Mind-set change to changing world is difficult to achieve for many thus affecting their attitude toward farming decisions. Slow but gradual positive impact on nutrient	Appreciate benefits of using various legumes as intercrops and winter crops. Evidence seen in increased yields in their fields. Legume integration benefits attracted many new farmers into taro production. Home gardens have also benefited from this new norm of having legumes. Alleviate shortage of manure due to livestock theft. Use of legumes form sound foundation for fertility build-up	No benefits seen, declining agricultural livelihoods. No evidence of continuity. Dying agriculture in the area, loss of fertile soils due to neglect and fields left fallow with very small areas planted with very little inputs	Benefits of continuous use of organic manures seen in gradual yield increase over the years. Visually healthy & highly rich soils with OM. Annual organic amendment load to further build-up the soil's capacity and resilience. Legume integration effect minimal but still advantageous. Taking advantage of good phase of climate change

Villages Observation	Village O lower & upper	Village N	Village M	village E lower[$]
	build-up due to limited best practices usage			
Production norms	Consistent production norms without any research innovations. Need continuous leadership for support to implement learned practices. Generally difficult to accept proven change and thus sticking to old ways of doing thing in all aspects of their farming	General overall change with intercropping practice that was practised in maize with pumpkins. Previously taro was a mono crop and now it is a new norm to intercrop it with beans. Despite the slight reduction in production areas, intercropping has been intensified with winter legumes instead of fallows	Declining to almost none existent in other. The few who are still producing are using the old practices without any of the research innovations learned during the engagement. Production areas educed by more than 70% in those who are still producing	Progressive village with future outlook in every decision taken toward improved productivity. Main focus on taro, sweet potatoes and maize as their main crops with dry beans and cowpeas as intercrops. Diversified continuous sustainable production with firm markets driving continuity. 100% livelihood based on production
Adapted & adopted practices	No adoption seen, still using old prod[n] practices. In the absence of research team farmers reverted to their ways of farming	Adopted the use of cowpeas as intercrops. Adapted local monocrop production norms of taro prod[n] by integrating legumes in a intercropping	No practices from research have been adopted or adapted	Adapted their practices to including legumes in a rotation and intercropping. Efficient use of organic manures. Maintained cane lands and increased organic lands
Food security	Focus on fields both taro and sugarcane with less emphasis on home gardens. Thus, food security is	Through field produce and home gardens secured food security	In-secure due to lost agricultural livelihoods	Highly secured and sustainable due to access to markets, high yields,

Villages **Observation**	**Village O lower & upper**	**Village N**	**Village M**	**village E lower[$]**
	secured but not sustainable in the long run with lack of markets and declining cane industry			intensified & diversified production
Soil fertility (yields)	Consistent with slight improvement	Highly improved and increasing every season	Not available	Significantly improved and sustained high yields
Social cohesion indicators *(with specific reference to gender, age, field work & resource use)*	Fragmented village: EFO members operating as individual homesteads. Older female members dominating the village and against change and any new leadership, stuck in the past. Able to work in the fields by themselves leading to no growth as there is no continuity in impacting skills to the young. Male members have decreased due to illness and death. Complete or direct opposite of EFO '	Unity of old and new members specifically older folks. More women compared to men and not much youth involved in farming activities. The fewer men in this village provide leadership, harmony and guidance as well as support in resources especially transport (to meetings, to collect inputs). Field work is still an individual household responsibility although unity is seen in the way field activities are done. Evidence of EFO identity value is still strong.	EFO members have reduced due to old age, illness and death. Very few are left and feel forgotten due to distance. Almost collapsed state with none existent social cohesion. The pride of being an EFO member has lost its value and meaning since the common denominator of being amadumbe grower is no longer existing.	United village with dominance of only women equally old and young and a fraction of youth. Combined efforts & assets (labour, manure, planting material. Village has re-identified themselves as the secondary EFO group with strong social bonds demonstrated through unity in working together and sharing resources and markets. A true reflection of technology used for networking and organizing. Their cooperative capacity ensured social change

Villages **Observation**	**Village O lower & upper**	**Village N**	**Village M**	**village E lower[$]**
Livestock	Have sufficient stock for manure use, availability and access is easy. Continuous planting in less hectarage	Experienced high livestock theft, challenged access to available organic manures	No livestock within the few EFO members	Have sufficient stock, easy access and highly productive with increased land area.
Research impact*	Being the HQ of EFO, this village has power struggles and research impact is viewed as stability and security. Institutional arrangements drive the use of best practices i.e. EFO leaders promote sustainable NRM. More member converted to cane in this village	Valued by old member who have benefited from engagements and gained more sustainable farming knowledge	Believe that research team should exist indefinitely for their continued farming. About half of members are now deceased	Highly values and perceived to be the foundation for successful farming in a sustainable manner
Learning (overall)	Not fully capacitated especially with leadership skills. Lost some members with capacity, low adoption rates no adaptation of research, still using old production norms of monocropping taro	Capacitated, high adoption and adaptation of research innovations, sustainable	Lost members, currently no capacity not sustainable, diminished interest in EFO matters and livelihood dependency on agricultural production almost none existent	Highly capacitated, exhibit principles of sustainable production and soil health concept of fertility build-up. Overall learning bearing fruits of being consistently highly productive and beyond subsistence. Village is self-sufficient in many production aspects

Appendix G: EFO Timeline Over a Decade through the eyes of the researcher

2005
1st visit during
Congress field visit

2006/2007 (EFO rise)
Needs assessment workshop
Researcher assignments
1st experiential learning trials

2007/2008 (EFO market peak)
2nd season of trials

2008/2009 (EFO market decline)
3rd and last season of trials

2010 – 2016 (EFO without research team)
EFO disintegrating slowly into village factions' occasional attendance of monthly forums

drive through to observe general production patterns. Data collection with key informants

social household visits for observations and note taking evaluations of cropping field

assist a few homesteads with marketing of produce

ARC amadumbe cultivar trial at Ezigeni group only

new membership at village level (Ezigeni)

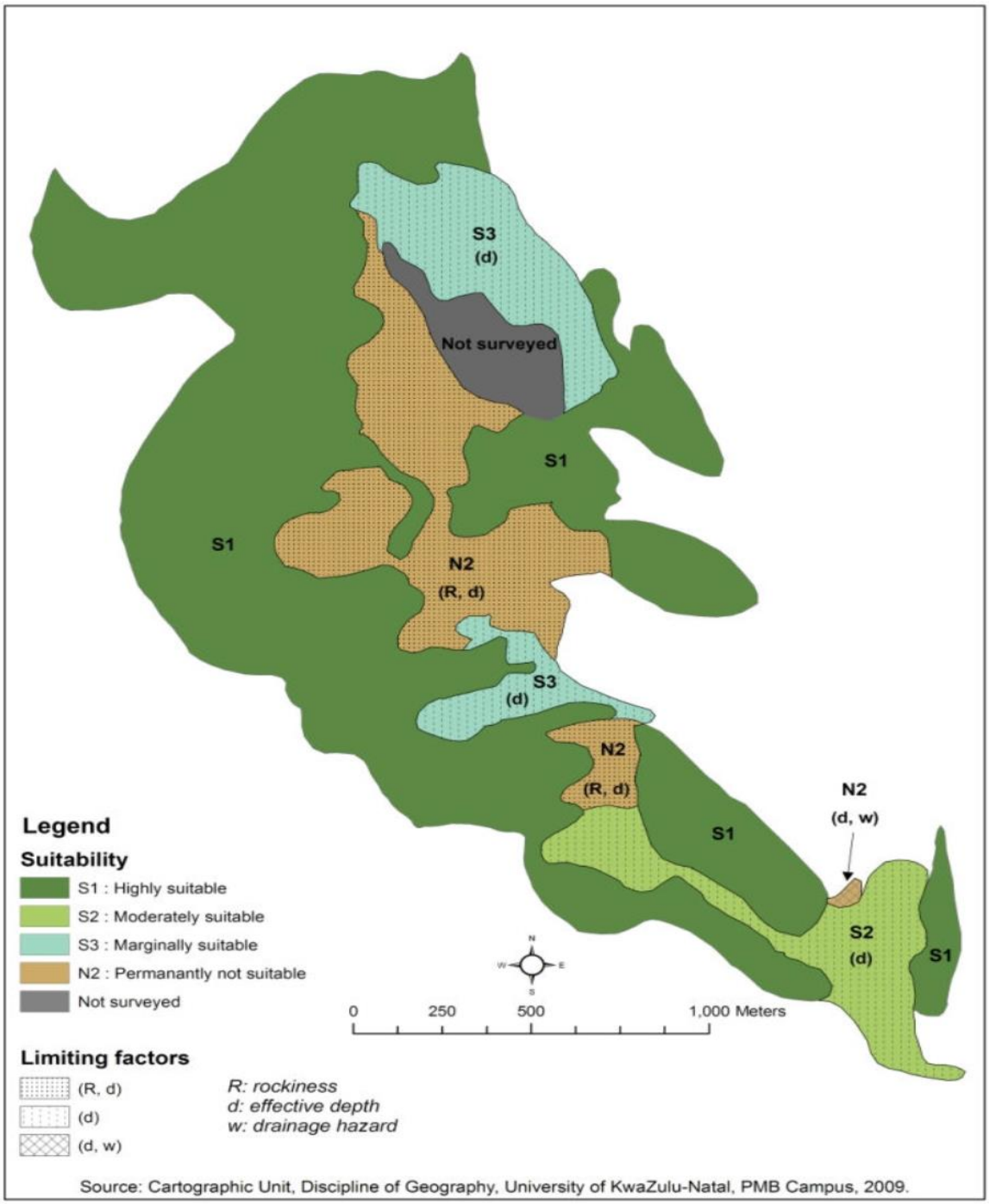
qualitative data collection

2018-2019 (Disbanded EFO unity attempts)
full time return to the area to monitor and evaluate
progress, livelihoods, general farming and social interaction
Attendance of monthly forum meeting and
Qualitative data collection through FGD, interviews and questionnaires

2020: (EFO restoration efforts)
The return of Prof Modi
the resurrection attempt of EFO
Occasional EFO visits and frequent Ezigeni visits
Market linkages with UMGIBE (sold all Ezigeni produce): COVID19 *era*

The next decade…???

Appendix H: Villages E and O suitable arable soil maps



Appendix I: Comparison of the Best and the Worst of EFO farmers in the villages

COMPARISON OF THE BEST AND THE WORST OF EFO

ITEM	BEST (village E)	WORST (village M)
Typology **Age**: **a** = <18; **b**= 19-34; **c** = 35-49; **d** = 50 – 64; **e** = 65^{+}	**Age**: b; d & e 1 youth; 13 >50yrs **Edu**: 1,2,3,4 & highly skilled 14 females	**Age**: b; c & d 1 youth; 11 =35-64yrs **Edu**: 1,2,3 & 4 12 females
Community type	Combined the group is highly skilled and experienced with mainly mature members. Group also has members who are organization visionaries with the agricultural future outlook. Agriculturally active and energetic = healthy	True representation of typical rural people in agriculture have limited schooling & unskilled, no income, and their ages are from 45 to 64 years. Agriculturally not active, not employed and not of good health
Internal capacity	Many members received good training *wrt* managerial, administrative, leadership, conflict resolution, financial skills as they previously occupied important positions within the organization. Group has systems and strategies in place for ease of work and harvest continuity in extending the amadumbe season	General members of EFO with no specific capacity built within the group. Individual effort in every aspect of production including the small marketed fraction. No aspects of research intervention practised. Continued monocrop with limited yields
Farm land (sizes)	Increased and intensified up to 4Ha	Drastically reduced 2500m^2
Affiliation	Secondary EFO	Primary EFO
Type of cropping	Mixed with livestock Adequate access + use of legumes (dry beans and cowpeas)	Mainly crops (esp. cane) with very few livestock No access to manure

ITEM	BEST (village E)	WORST (village M)
Socially	Main livelihood strategy with almost all the households in the valley producing. Valley has proper grazing arrangements as the fields are not fenced, so all livestock is kept in the range lands thus no stray livestock.	Agric. not a livelihood strategy. Many villagers work in adjacent commercial cane farms as casual labours. Few households still own livestock which is mostly stray and thus planted fields are not protected. Also have a problem with wild hog
Production motives	Market supply (both formal and informal) as well as walk-ins. Good market networks and socially known to be the hub of produce. Highly knowledgeable in the production, input resources and markets on amadumbe. Have unlimited access to manure sources since many have converted to can production.	Mainly for subsistence with limited informal market sales. Known for very small plots <0.5Ha and area's reputation not about good organic production but perceived as a semi-rural/urbanized due to ease of public transport and proximity to tarred road. Access to production inputs and market information is limited.
Mechanization	Prioritized by the EFO tractor since many members have converted to cane. Thus, able to plant all our land on time as EFO tractor rates are reasonable. However, with EFO tractor break downs it is difficult to plant large areas, but have access to local tractor contractor services (are slightly expensive) and can afford the services. Over the years with EFO disintegration tractor repairs are neglected due to bad admin	Due to very small areas planted and geographic location (outskated and far), area is not prioritized as first on the tractor services list, but eventually are attended. In the event of EFO tractor breakdown, have no access to local tractor services due to distance and affordability
Sustainability	Environmentally: use of legume intercrop and rotation in the	None of the sustainability pillars are observed due to lack of social

ITEM	BEST (village E)	WORST (village M)
	farming system ensures sustainability indicated by high yields Socially: village cohesion and strong social bonds ensures good labour force and efficiencies Economically: access to a variety of markets and ability to make profit ensures economic sustainability	cohesion thus disadvantaging the group to negotiate various production aspects i.e. bulk planting to marketing, transportation, access to markets
Genetic property cognizance	With the combined capacity of well taught members who have dealt with variety of external stakeholders this group are fully aware of their comparative advantage regarding the purity of their local cultivar strains and available genetic resources and its used to their advantage	Farmers do not have an appreciation of the value of their natural and genetic resources. Also, do not understand issues regarding purity of the amadumbe cultivar strains and using this as an advantage
Stakeholder engagement (research)	Relationship with UKZN research has always been valued as a catalyst towards advancing EFO's production capacity since its inception. Participated in the recent ARC cultivar evaluation trial to ensure best yielding cultivar (from the local varieties) for the market	Part of the bigger group that rejected all developmental endeavors by various stakeholders, thus contradicting the foundations that EFO was laid on for decades.
Additional factor	Historically (from inception) EFO leadership has been concentrated in this village, having members in the executive committee for all	Individual household scattered throughout the village. Sole effort in all field operations.

ITEM	BEST (village E)	WORST (village M)
	leadership terms with the only exception during the disintegration phase when EFO was disbanded. Mr Mkhize: 1st chairperson of EFO = good understanding of foundation and inception objectives of the EFO. Worked as packhouse **quality controller** with market experience and contacts for years. Good **understanding of post-harvest operations** experiences good/advantageous for current operations. Male figure influence strengthening of female group with great appreciation of the EFO's image/reputation and status used as an advantage. Value of networks that existed for EFO and used to further the village's development. **Close field vicinity** for all members, ease and synergy of field work operations. Whole Mkhize valley is occupied by farming homesteads. **Family bonds** as all members belong to the Mkhize clan	Village has a smaller fraction of farming households in general and the culture of farming is slowly dying with the exception of sugarcane

Appendix J: Focus Group Discussion and Questionnaire Results

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
General information	Age: d & e Edu: 1,2,3 & 4	Age: c & d Edu: 1,2,4 & other	Age: 1b; d & e Edu: 1,2,3 & 4	Age: b; c & d Edu: 1,2,3,4 & highly skilled
EFO opinion then *vs* now	*Good life *Associate research team with financial progress *inspired to diversify into other crops due to market availability: sweet potato; *lost baby potato seed material *livelihood gained: built houses; education for children/graduates/ more cane fields -lack of formal markets -challenge in pursuit of informal markets in	General opinion based on availability of guaranteed market (Woolworths). LIFE WAS GREAT. Aware of EFO funding which made running of organization easy. Were also aware that funding will end one day Grateful for tractor, vehicle & packhouse though not utilized for its purpose as it lacks the necessary infrastructure. Rejected crop led to financial losses as produce was returned weeks later, nothing could be done.	Farmers are still suffering absence of gatekeeper; they feel like EFO cannot operate without him. Because of their geographic location they feel left out and somewhat forgotten. They depend on EFO bakkie for transport to the meetings, trainings *etc*. which half the time is not available. There is no public transport from their village to viilage O where EFO operates. Previously their plight was prioritized now this has led to many being discouraged. The collapse of EFO left	Great organization that work efficiently in their cooperation. Progressive in various ways, leaders in rural agriculture in comparison with other areas. EFO was a mainstay of small scale farming. We really loved and loved the EFO. Got exposure and training on the following: pest and diseases, cooperative management, field measurements, underground water assessment, soil sampling, short courses on livestock management & poultry, home gardens. Part of executive management of EFO for several years. Change of term and appointment of new committee led to development of secondary EFO group segregated from the primary structure. The secondary group was officially registered with only the village E membership. Old committee was fired and new self-elected committee comprised of older, lack skills and capacity members. This unsavoury phase

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	Isipingo and Amanzimtoti -wild hog main pest damaging all crops (taro, sweet potato, groundnut & potatoes) at night Except dry beans -Dry beans have mole problem Need the return of gatekeeper for progressive leadership. Don't trust committee to lead towards successful commercialization. Presence of money within development agenda result in questionable integrity of many thus causing internal squabbles. Hence only the gatekeeper has earned	Lost the Woolworths market just before packhouse intentions were realized Challenges: expired organic certificate, renewal fee too high due to external/foreign inspectors for authenticity,	many confused. Still part of EFO with the hope that institutional arrangements will change.	resulted in the sudden death of EFO as the structure collapsed. During this phase EFO lost its organic certificate and Woolworths market. Slowly the EFO lost its membership and only a few were left with the new committee. It was now a farmer for themselves in all their activities. ARC Vegetable institute brought a taro cultivar evaluation project to be implemented for 5 years within the EFO. Primary EFO rejected the project, it was then presented to the secondary coop and it was accepted and implemented at village E.

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	complete trust with everyone on issues of transparency and. honesty			
Land and Production	Size: taro land reduced 11/2 as a result of lost market, gatekeeper's departure also due to climate change with too much rain crop damage Same 6/2. No increased size. General planting patterns have not changed (old technology) with monocropping Males have additional cane land. 6m contour purposely left to separate taro fields from cane land: chem. seepage	26/2 planted more land than before. Everyone maintained the same area as before. More farmers joined the EFO from farmer-2-farmer engagements. A few left immediately when EFO lost the validity of the certificate	Has been gradually decreasing over the years. No males involved with taro production or registered as members of EFO. Productivity is very low in smaller areas <0.25Ha common for the fewer farmers in this village as the culture of promoting an agricultural livelihood is dying and mostly dead, crop in poor condition including cane.	SANPAD and NDA financial support ensured that EFO excelled. Post the support EFO struggled to the point of reducing crop diversity because of lack of markets for the variety previously supplied: taro, sweet potato, beans, groundnuts & cowpeas. Current production now well informed as it based on ARC research results of specific cultivars that yield best at village E with high nutritional properties. Local varieties were compared with others from all over SA. These results assisted us to carve a specific niche markets for our produce with good eating qualities and higher yields. Recently we have increased our production area to ensure that we maintain our new market at Isipingo supplying Toyota plant employees and DUT in Durban. Through DUT we were able to attend many exhibitions and market our

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
				product which brought a lot of business. Since the ARC we have increased our land area every planting season. Animosity prevented primary EFO to engage with us when we advise. We may have lost the Woolworths market but we got an equally good market that does not need us to verify our organic status.
Mixed cropping	Limited to amadumbe, maize, pumpkins and beans. Very few home gardens seen or practised. Viewed as time consuming and water demanding Request additional land: Chief No grazing camps -challenge of stock theft -reduced herds of cattle/stock esp. goats sold at abattoirs	Limited activity on vegetable gardens with much effort given to field crops. Livestock is getting less especially cattle. Mixed cropping with the dominance of crops taro and cane as main crops and legumes (beans & cowpeas) as intercrops and rotation crops	Mainly crops with very limited livestock in the area which leads to limited access to manures. No vegetable gardens reported	Mixed cropping with same/equal amount of livestock from previous times and an increased taro land area. When others were jumping into cane production we kept ours as was and intensified our taro production. All other land use remained the same. Together with our livestock the use of cowpeas for fertility management satisfy our manure requirements.

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	-high cost of manure R150/ton transport costs (Ngcongo family Odidini village) -goat manure too hot must be broadcasted. Each farmer fends for self no formal structure in place -use of bean shells composted and irrigated in combination with kraal manure			
Land use	Grazing land is not a priority Home gardens remained the same More land used for residential purposes due to growing family members	No grazing land Greater residential space as homesteads are building bigger houses. More households plant taro, very few home gardens. Generally, have no idea of their production areas. Productivity is measured by experience of comparing previous seasons to	Communal land of which mostly is used for residential purposes. Taro production areas has remained the same (few) and fast decreasing (more) with the aging farmer. EFO has only one female representing the youth for the whole village. Lifestyle in this	Dominated by both taro and sweet potato on more land. Being in the valley our micro climate and upper contour seepage advantage our crop and has allowed us to intensify our efforts. Don't have a measuring tool to measure exactly how big our production areas are now, but we know how its done. Home gardens still serve their purpose despite their size remaining the same.

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	Rotational crop changes land area slightly Many farmers don't know exactly how big (Ha) their fields are, men remember measuring years ago but don't have the measurements	the current factoring climate changes over the seasons	village is not based on farming	
Production motives	Household – small portion Formal markets – previously Informal markets – current and challenging thus limiting production area Livelihood strategy and part of lifestyle	Both formal and informal markets. Have always been selling produce during good and bad seasons. Encouraged others to join EFO when research team was still present	It seems people are farming primarily for household consumption and relatives especially after the collapse of EFO. The older women are finding it hard to seek markets hence the overall reduction in quantities of produce. Also lack proper exposure to the world of agric diversity, cannot access seedlings, plant their own. The only planting material they	Only livelihood strategy that is consistent and perceived to be sustainable in the long term. New markets found that pays well without need of valid organic certificate. Produce sells its self because of the high quality it possesses. In recent years we were able to take our children to University and now have 4 graduates with 1 post graduate; 2 UKZN Agric graduates; 1 Geologist at UCT and 4 ICT students because of the taro profits and our better exposure.

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
			have is sourced individually from previous harvest. Rather needy village and seriously resource poor.	
Farming challenges Rating 1:most important 3: Average 5:least important	-Climate change (too much rain, destructive, crop loss) -Lack of financial capital -Access to **fair** markets. Departure of Prof our leader -access to informal markets -Crop is labour intensive for R150/20L: dig, peel, transport on public transport. No assistance from EFO bakkie due to individual sales -Human capital very expensive for aging	Climate change – village has experienced both the good and bad sides of climate change: hit by destructive hail twice in 2015 & 2018. Were fortunate in 2014/15 season crop was not affected by draught. Equipment: access to tractor services is limited as EFO is serviced by 1 tractor. Access to manure is still an issue to date. Costs involved in getting manure are too high. Stock theft on the rise can't keep livestock. Older women with old age ailments are there ones struggling the most. At	Reliable transport to attend meeting. Departure of Prof our leader Capacity building in cooperative management and other technical support. Access to markets Tractor assistance Aging farmers, agriculture is slowly fading Fencing of fields to keep away wild animals	Drought in 2014/15 season Transport for produce to Durban and Isipingo Fence material to manage wild hog Tractor assistance on time to ensure early planting to gain early markets

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	farmers as born-free kids don't enter the fields -Tractor works: challenge to help everyone at the same time -High need for 2nd tractor Fence material to manage wild hog	times flesh goes against sentiments of farming. No fencing in our field		
Extension services	19/21 have not seen the Eo. But heard of him Eo not interested in EFO, seen in the area but never engages EFO farmers feel robbed of DARD services and assistance Perceived to have research assistance, disregarded!	Everyone is aware and have access to Eo., received vegetable seeds that did not germinate due to lost vigour as a result of poor quality. Poorest households were selected to benefit from these planting starter packs, sadly no progress was made. Extension services has not assisted us in EFO matters ever since	Many have not seen the eo. But heard of him. Eo not interested in EFO, seen in the area but never engages EFO farmers feel robbed of DARD services and assistance Perceived to have research assistance, disregarded!	We are all aware of Eo. But do not have access to them. Lack of interest in our taro work. Despite our knowledge of protocol and capacity to engage officials it has been rather difficult to access extension services in our area. Extension visits are rare in our area. We believe that Eo neglect us because they think that we are well resourced because of the research teams working in our area. When in fact they deprive us of Departmental benefits due to all farmers.

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	No access due to other reasons unknown to many, speculated to be lazy and just not interested in farming. Strongly agree to Eo not being a farmer		No access due to other reasons unknown to many, speculated to be lazy and just not interested in farming. Strongly agree to Eo not being a farmer	
Research impact	*Manly risk management -record keeping of every activity -planting inputs; harvest measurements; consumed; relatives & sold -rotation: above/below ground -field assistance: cost involved *Soil fertility management	Vegetable production with pest & disease assessment but no feedback was returned by UKZN student between 2012-2015 -soil fertility management using vermicompost-previously used in both field and garden production with very good results on yield. Would love to have/own wormeries again as they were lost during the storm. Little went a long way. Introduction of cowpeas as fertility improver and supplement beans for others. Still plant cowpeas both	Learned a lot during the UKZN research team era and nothing ever since. Still practice some technologies in a small scale. Still need technical support with improving yield and alternative manure sources.	*Manly risk management -record keeping of every activity -planting inputs; harvest measurements; consumed; relatives & sold -rotation: above/below ground -field assistance: cost involved *Soil fertility management *Marketing Research never addressed livestock issues-No emphasis on livestock integration Research changed our farming for the better – still use most technologies but need repeat of

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	*Marketing Research never addressed livestock issues- No emphasis on livestock integration Research changed our farming for the better – some farmers still use a few technologies but need repeat of earthworms for vermiculture and mushroom production	as monocrop during rotation and intercrop. Many don't eat cowpeas but they plant it specifically for soil fertility management		earthworms for vermiculture and mushroom production. More capacity has been received from the ARC research to enhance what we have already learned with the UKZN research team. Now we understand exactly why are we doing the specific activities, we have increased our efficiencies in our farming style i.t.o managing our labour and efforts for each enterprise. Leadership capacity built us as a village gave us confidence to engage different external stakeholders who brought development and progress to our endeavours. UKZN research was a solid foundation of our farming into the future
Intercropping	Mainly taro and dry beans in rows during ploughing open furrows hand furrowing after 1st weeding then plants beans - Maize and groundnuts;	Row intercrop 17/26 Strip intercrop 5/26 = ease of planting since tractor opens the furrows before planting. Row intercrop has not been adapted, farmers are still practising what they were taught. Following land prep for taro by tractor, hand hoes are used to open	Row intercrop of Maize and groundnuts (few); Maize and pumpkins Few members intercrop taro with beans but it seen as labour intensive	Both row and contour intercropping on taro and dry beans in rows during ploughing open furrows then hand furrowing after 1st weeding then plant beans - Maize and groundnuts; - Maize and pumpkins

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	- Maize and pumpkins Few (5/21) farmers got seed from Prof and planted maize and cowpeas Supplement dry beans with cowpeas, will keeps seed from current harvest for next planting Home gardens serve winter planting to avoid rainy season crop damage caused by climate variability extremes	furrow between taro rows after Understand intercropping as best use of space as 2 crops are harvested in the same field taro planting. Weeding is not a problem. Cowpea monocrop followed by taro gives the best taro yield with very little manure applied. Practised by many and efficient in dealing with access to manures		Intercropping principles: canopy of main crop not to overshadow intercrop, as well as crop combination of above and below ground crops simultaneously. Since research impact intercropping is the rule for all of us as we understand the benefits plus weed management because we now only weed taro once instead of 3 times before we were intercropping. The only monocrop in our fields is sugarcane.
Organic manures & soil fertility management	Only use kraal and goat manure with composted bean shells for others -lost wormeries long ago and could not re-start vermiculture	Wormeries lost during the storm. Research trials showed us the benefits of vermicompost and cowpeas, since then we have adopted cowpea in our farming system. Research helped us understand the manipulation of soil fertility	Only limited cattle manure is used and is not sufficient for crop requirements, need more sources	Use kraal, goat and poultry manures that is sourced internally within the village as much quantities as often as possible to build soil's resilience and reduce production risk. Value of organic amendments can never be overemphasized. Continuous build-up of organic matter content in the soil. Research demonstration trials exposed us to variety of

[females: males]	**Village O lower & upper [17:4] (May)**	**Village N 19; 7(May)**	**Village M 12 females (June)**	**village E lower 14 females (July &Aug)**
	Research interventions taught us benefits of high nutrient concentrations in vermicompost and the need for small quantities when planting	to satisfy the market requirement of specific sizes, also got exposure to other innovations that include value adding of various vegetables		legumes, importance of space for correct plant population to ensure good yields without creating nutrient competition and know market quantities of the produce
Delivery methods	Facilitation = No for all Demonstrations = yes All agree on research interventions as a continuous learning tool All happy to have UKZN students as they bring new innovations/technologies for our better farming ways	Facilitation = No for all Demonstrations = yes All agree on research interventions as a continuous learning tool All happy to have UKZN students as they bring new innovations/technologies for our better farming ways	Facilitation = No for all Demonstrations = yes All agree on research interventions as a continuous learning tool All happy to have UKZN students as they bring new innovations/technologies for our better farming ways	Facilitation = Yes for all Demonstrations = yes Technologies can be learnt by other means not always with research involvement because reality of funding is such that it just cannot be continuous, it is not practical or sustainable. Extension services could assist in this regard. Happy to have UKZN students when available but know that it is for a specified period

* Research impact: assessment of scientific knowledge (awareness/facts/practices) integrated with local knowledge (experience) based farming techniques in the formation of appropriate methods (best practices)

[#] engagement is referring to the research engagement the time when researchers were still around in the area executing their various research works

[$]upper Ezigeni has <5 members who form part of upper Ogagwini (and included in the Ogagwini groups) due to their proximity *i.t.o* distance

Appendix K: Methods/*Izindlela*

Data was primarily collected using qualitative methods such as focus group discussions (FGDs), semi-structured interviews with farmers, and in-depth interviews with key informants who are local leader farmers. This was complemented by a limited amount of quantitative data derived from the interviews. The fieldwork that was conducted in villages covering the implementation of four crop trial research sites of the projects.

The purposive sampling method was used for the selection of participants of both the FGDs and in-depth interviews Three field trips to Son La were made, in December 2012, September 2013 and July 2014.

The initial findings were reported back to the participants in order to elicit their feedback and validate the data. All the gathered primary data and information was recorded, reviewed and translated into English. Thematic analysis was used for data analysis and interpretation of the research findings. This involved cleaning the quantitative and qualitative data, coding the data based on its themes or patterns

The research results indicate that

A short-term and economic focus was taken in the impact assessments of most research projects in the region. The impact assessment efforts aimed to measure direct research outputs, report scientific findings and analyse cost-effectiveness for donors and funding agencies rather than account for the sustainable livelihoods of the target communities. Weak mechanisms for sharing impact assessment results with and getting feedback from stakeholders was also identified as a major cause of a low level of contribution of impact findings to local livelihood development. These weaknesses also led to poor evidence on how the AR4D projects had contributed to – or rather, failed to deliver – sustainable impacts.

The steps involved are as follows:
Familiarize yourself with your data.
Assign preliminary codes to your data to describe the content.
Search for patterns or themes in your codes across the different interviews.
Review themes.
Define and name themes.
Produce your report.
Jan 30, 2020
How to Do a Thematic Analysis of User Interviews | Interaction ...
www.interaction-design.org › literature › article › how-to-do-a-thematic...
Themes get identified by physically sorting the examples into piles of similar meaning.

Types of in-depth interviews dealing with the research questions

In-depth interview	**Research questions focus**	**Key issues to explore in research questions (RQs)**
In-depth interview with EFO committee	RQ1: perception of research intervention then and now RQ2: leadership role RQ3: Production motives RQ4: Farming style & challenges RQ5: Extension services	Overall impact on production Presence gatekeeper Markets/livelihood Soil fertility strategies (intercropping; legumes Delivery methods
With household which had crop trials	RQ1: perception of research intervention then and now RQ2: leadership role RQ3: Production motives RQ4: Farming style & challenges RQ5: Extension services	Overall impact on production Presence gatekeeper Markets/livelihood Soil fertility strategies (intercropping; legumes Delivery methods

Members then and now	RQ1: perception of research intervention then and now RQ2: leadership role RQ3: Production motives RQ4: Farming style & challenges RQ5: Extension services	Overall impact on production Presence gatekeeper Markets/livelihood Soil fertility strategies (intercropping; legumes Delivery methods
Members now	RQ1: perception of research intervention RQ3: Production motives RQ4: Farming style & challenges RQ5: Extension services	Overall impact on production Markets/livelihood Soil fertility strategies (intercropping; legumes Delivery methods

Appendix L: Questionnaires/Interview Schedule

SEMI STRUCTURED QUESTIONNAIRE/ INTERVIEW GUIDE FOR FARMERS

TOPIC:

Soil agronomy research in a rural subsistence farming homestead/context

Biological soil fertility strategies in a social context of traditional farming

This questionnaire is prepared to collect data that will be used in the study of the above subject.

NOTE: it is important to note that the information of interviewees will only be used for purposes of the research and will be held confidentially.

General information:

Name of the Municipality						
Municipal ward no.						
Name of the village						
Name of the farmer						
Age	< 18					
	19 - 34					
	35 - 49					
	50 - 64					
	65+					
Gender	Male		Female			
Marital status	Single		Married	Divorced	Widow/er	
Years of education	No formal education	Primary	Secondary	ABET	Tertiary	Other (specify)
Cell phone number						
Farm/field size (Ha)						

What is your view of EFO organization then (during research team activities)?

……
……

……
……

In your opinion how is the EFO organization now?

……
……

……
……Share thoughts about your land and production then (during trials) and now?

……
……

……
……

4. Types of farming activity

1.Crop		2.Livestock		3.Mixed	

What is the type of tenure in which your land is held/allotted?

Permit to occupy	
Private ownership	

Rented land	
Communal land	
Other (specify)	

How much land do you have access to for the following purposes?

Activity	During trial area (Ha)	Currently area (Ha)
Residential (size exclude any other land use)		
Growing crops (field)		
Grazing land (communal)		
Home garden		

What are the main reasons/motives/ for your production or involvement in farming?

Household consumption	
Formal markets	
Informal markets	
Other	

Challenges you face in your farming enterprise

Land size	
Access to markets	
Lack of financial capital	
Human capital (skills and labour)	

Lack of inputs and implements	
Drought	
Other, specify	

Rating the responses in the order of importance: 1: most important 3: Average 5: least important

Extension Services

Are you aware of extension services in your area? (Tick)

Yes ☐	No ☐

Do you have access to extension services (Tick)

Yes ☐	No ☐

if no chose the reason/s why you do not have access to extension service.

Distance from my home ☐

I do not know how to contact them ☐

I do not trust them I can do my own farming …… ☐

Other

How is access to extension services? (Tick)

Easy ☐ Difficult ☐

How often do the extension officer's visit you? (Tick the appropriate)

Weekly ☐ Monthly☐ Quarterly☐ Annually Other, specify …….

Challenges	Strongly agree	Agree	Undecided	Disagree	Strongly disagree

Insufficient visits					
Advice that is not useful					
Feedback takes too long					
Extension officers are not farming					
Extension officers are too young					
Advice is too technical					
Advice not relevant					
Other (specify) …….					

Impact of research interventions by students from UKZN

What kind of research interventions have you received concerning your farming activities?

Pest and disease management ☐

Risk management ☐

Crop/livestock management ☐

Weed control ☐

Soil fertility management ☐

Record-keeping ☐

Marketing ☐

other specify ….....

With the services you received from research team were there changes in your farming practices?

Yes ☐	No ☐

if yes please provide an explanation

……
……
……
……..

if no please provide an explanation

……
……
……
……..

in your opinion do you think that research interventions helped your farming.

Yes ☐	No ☐

if yes please provide an explanation

……
……

……
……

If no please explain why, what did not work.

……
……

……
…….

Has the advice given by researchers met your farming needs(Please Tick)	Strongly agree	Agree	Undecided	Disagree	Strongly disagree

About intercropping technology

Do you practice intercropping?

Yes ☐	No ☐

What type of intercropping and why that type?

What crops are in your type/form for intercropping?

What is important to remember when intercropping?

About organic manures and soil fertility management

Do you use vermicompost or any form of organic manure in your crop production?

Yes ☐	No ☐

If yes, elaborate which kind and how it is accessed

If no, explain why not used?

What beneficial information did you receive from the demonstration trials (about soil fertility)?

……
……

……
……

……
……

If no beneficial information was received, please explain why?

……
……

……
……

……
……

How would you rate the quality of research interventions you get? (Tick)

Very good ☐ Good ☐ Neutral ☐ Poor ☐ Very Poor ☐

Farmers' perception on research intervention

Farmers to weigh the importance of these statements then score them

SCORING: Strongly agree: 10 Undecided: 5 Strongly disagree: 1

Farmers' perception on research intervention	**Weight rank**	**Score**	**How many**
Learning is a continuous process thus should not be based on or limited to research fund cycles			
Research interventions improved agricultural income			
Research interventions should focus/prioritize market access for farmers			
I don't think research intervention helped to increase yields			
Intercropping practice is difficult to establish and maintain			
Rotation is far more practical than intercropping to practice			
I don't intercrop because land is not a constraint			
Intercropping is for people with limited land for their production needs			
How important was vermiculture to you			
How valuable is organic manure to your farming			
Never heard of cowpeas and wild mustard until research intervention			
Cowpeas are not important to my farming			
What was important about wild mustard			
What made your produce organic			
Do you believe in the value of organic produce			
Is it still worth doing organic farming now like it was then?			
If research funds come to an end a continuous monitoring programme should be in place to avoid collapse of structures and practices			
Being left to my own devices will affect my farming morale			

Research intervention modalities

Rating the responses in the order of importance: 1: strongly disagree 3: Average 5: strongly agree

	Yes/No	Rating
Research interventions should be delivered to you as an individual in your farm?		
Research interventions should be delivered to you as a group of farmers?		
Research interventions should be delivered through mass media (Radio)?		
Research interventions should be delivered through mass media (Television)?		
Research interventions should be delivered through mass media (Newspaper)?		

Delivery methods (facilitation, demonstration)

Would you prefer if interventions/technologies were transferred through facilitation (teaching)?

Yes ☐	No ☐

Would you prefer if interventions/technologies were transferred through demonstrations?

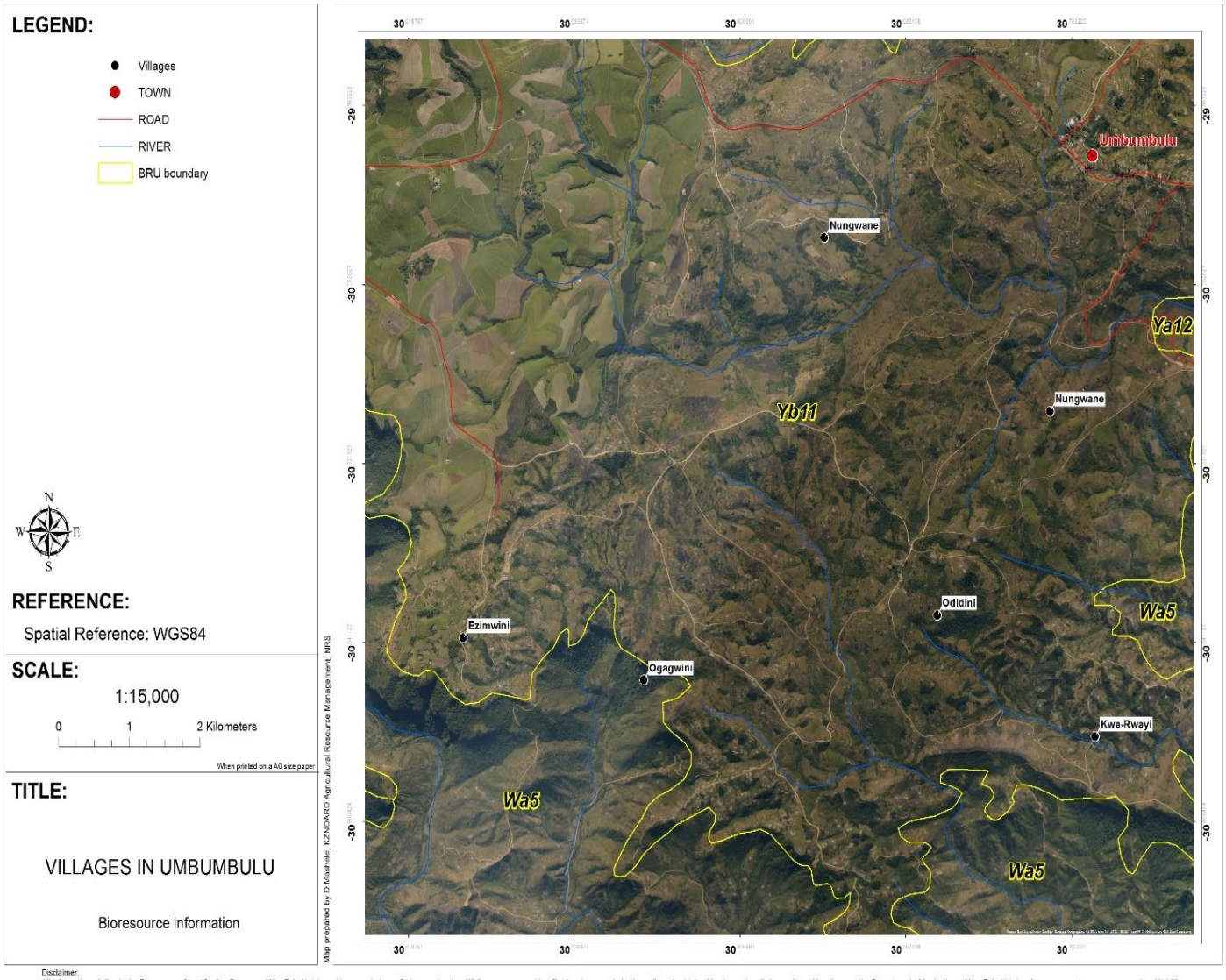
Yes ☐	No ☐

Would you prefer if interventions/technologies were learnt through research involvement?

Yes ☐	No ☐

What is your view on the research done by other UKZN students in this community?

Appendix M: Villages in Umbumbulu (*with EFO members in all*)



Appendix N: Farming Life and Diversity: Commercial Farming Strategies in Umbumbulu

Appendix O: SASAE conference proceedings 2023 (Poster presentation)

A decade of agronomic research impact assessment on sustainability of commercializing traditional homestead production of amadumbe in Umbumbulu KwaZulu Natal

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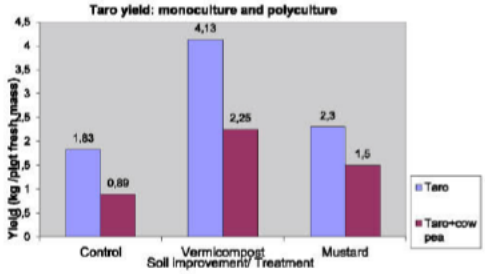
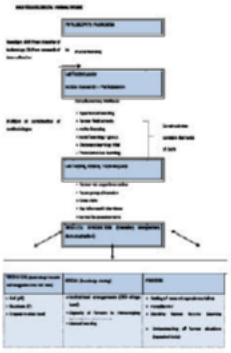
Introduction: There is an urgent need for establishing methods and systems that support viable and attractive sustainable agriculture in the advent of climate change. Progressively, it has been shown that agricultural research needs to be supplemented by other efforts that address institutional and socio-economic constraints for sustainable development to be realised (Ndlovu et al., 2022). In addressing unsustainable natural resource degradation specifically in rural areas amongst smallholder farmers this study assessed the decade impact of a research intervention of commercializing homestead agriculture in a traditional production system.

Methods and data sources: The first three years (2007 – 2009) was field work through trial experiments with Ezemvelo Farmers Organization (EFO) farmers at individual homestead level, collectively at community level (community gardens). Simultaneously, data was collected amongst all stakeholders (farmers, researchers, extension, markets). Post project fund phase (2010 -2019) data collection continued to monitor the level of adoption and adapting of traditional farming methods towards sustainable agriculture with the use of locally available resources to strengthen market involvement and sustain livelihoods.

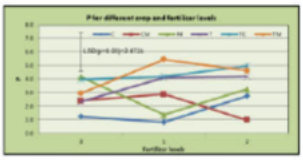


Key Results and impact:

- importance of local knowledge in the development of best technological practices, survival of local agronomic traditions whilst maintaining productive capacity of the soil resource.
- systemic integrity through displaying wisdom of strong leadership, incremental technological integration and learning for sustainability.
- continued capacity of the soil to sustain productivity through high yields as well as maintained soil quality and health.
- Re-organization of social relationships created the capacity to co-operate towards social change
- Established interactions preserved and created new forms of social cohesion
- Technology shifted from something to be applied to something leveraged for networking and organizing
- Quantitatively results revealed significantly higher yields for both mono and intercrops under the vermicompost treatment relative to wild mustard.



- Intercropping taro with wild mustard together with level 1 fertilizer continued to give good yields with the highest residual P compared to other treatments



Conclusions

The study presented examples of technical and socio-institutional innovation to improve crop productivity that have been developed by EFO farmers relying on available local resources. Learning through experimentation and building on local knowledge and practices blending with new ideas resulted in strengthened problem solving. Similarly, to the study (Opiyo et al., 2015) EFO's ability to adapt to the effects of climate variability was influenced by many factors that included socio-economic characteristics, of a household such as household size, age, gender, education level and marital status of the household head.

Technically the adoption of cowpea and wild mustard intercrops with taro also gave an indication of improved soil quality for sustainable productivity.

References

Ndlovu P.N, J.M. Thamaga-Chitja, T.O. Ojo, (2022). Impact of value chain participation on household food insecurity among smallholder vegetable farmers in Swayimane KwaZulu-Natal, Scientific African, Volume 16, https://doi.org/10.1016/j.sciaf.2022.e01168

Opiyo, A.M., Mungai, N.W., Nakhone, L.W. and Lagat, J.K., 2015. Production, status and impact of traditional leafy vegetables in household food security: A case study of Bondo District-Siaya County-Kenya. *ARPN J. Agric. Biol. Sci*, 10(9), pp.330-338.

Appendix P: 8th Biennial LandCare Conference 2018 (Oral paper presentation)

Intercropping taro, cowpea and wild mustard

A social agronomy study

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Subtheme 3: LandCare partnerships restoring agricultural health for lasting food security

Introduction

Taro was observed to grow taller in response to intercropping with a legume *Crotalaria juncea* and the yield was not affected (da Silva *et al.*, 2008). Locally known as *amadumbe*, taro [*Colocasia esculenta* (L.) Schott.] is considered an important food security crop in many rural areas of South Africa as well as a staple for the majority of the populations in Africa and Asia. In Umbumbulu, taro crops grown by farmers in their yards are characterized by dryland production with low soil fertility levels as a result of the lack of access to organic manures that in turn impact on the growth and yield of taro. Land area under taro cultivation has been observed to increase due to growing niche market for taro in South Africa (Modi,2003)

Since taro is a starchy crop, intercropping it with cowpeas and wild mustard may have beneficial effects, with respect to diversifying household nutrition and increasing food security. More recently, Rivas *et al.*, (2016) concluded that the maintenance of leaf water status and photosynthesis under drought stress conditions are important traits found in cowpea species, enabling plants to overcome the stressful conditions and to recover more rapidly after rehydration. Cowpeas [*Vigna unguiculata* (L.) Walp.] and wild mustard [*Brassica juncea* (L.) Czern. & Coss] are some of the underutilised crops in South Africa. Azam-Ali (2010) noted that underutilised crops, the cropping systems in which they are cultivated and the people who manage, protect and consume them represent elements of agro-biodiversity. Hence the necessity to re-introduce these crops to the larger community especially in consideration of the

predicted changes in climate that may lead to extreme events, such as increased precipitation and long drought periods (IPCC, 2007).

In countering the lack of access to kraal manures vermicompost was used as the alternative organic soil fertility amendment. During vermicomposting, plant essential nutrients are converted into more soluble forms which aids in their uptake by plants (Mehta and Kanrwall 2013). Furthermore, vermicompost is a good soil conditioner as it increases plant growth and yield as a result of improving the physical condition of the soil to support better aeration for plant roots, drainage, facilitation of cation exchange, sustained availability of nutrients, and thereby the uptake by the plants resulting in enhanced growth (Atiyeh *et al.,* 2000). In Umbumbulu farmers are already growing taro and the study aimed to establish whether intercropping it (taro) with cowpeas and wild mustard using sustainable production practices would positively impact the yield. This system allows farmers to mimic historical diversity that existed in traditional agroecosystems.

Methods

An eddoe type taro landrace (*Mgingqeni*) was obtained from subsistence farmers in the Ogagwini village of Umbumbulu rural district (30°63'S; 30°94'E) in KwaZulu-Natal. Seeds of wild mustard landrace were collected from subsistence farmers in Msinga (28°45'S; 30°32'E), KwaZulu-Natal and cowpea seeds of cultivar PAN311 purchased from a local seed company (Panaar Seeds). All crops were planted at the same time. The trial was set up as a completely randomized block design with three replications. Component crops were taro, cowpeas and wild mustard. Treatments included taro and cowpeas sole crops, respectively; intercrop combinations were a 1:1 (taro: cowpea) and a 1:1:1 combination (taro: cowpea: wild mustard). Factors tested in the experiment were: (1) vermicompost application and wild mustard planted between crop rows of taro sole crop and taro-cowpea intercrop at 50% as living mulch; (2) cropping system of monocrop taro and monocrop cowpeas versus intercrop; and (3) site differences (soil) as they affect yield. For all the experiments, each plot had five rows (0.6m apart) with the three middle rows used for data collection. Soil samples (results not reported in this paper) and yield measurements were taken to assess yield and soil improvements. Based on local practice or organic manure application, vermicompost from earthworms (*Eisenia fetida*) application of 25 t/ha on sole taro, sole cowpea and taro-cowpeas intercrop was done at planting. **Table 1** shows the chemical analysis of vermicompost used in the experiments. All

crops were hand planted in furrows and cultural practices including thinning kept uniform for all the treatments according to local practices. Wild mustard (*Brassica juncea*) living mulch was manually distributed between crop rows at 50% planting density of the crop stand of both sole taro and sole cowpea with 30 cm open on either side of the planted row as well as in the intercrop. Crop performance of the intercrop was evaluated using the Land Equivalent Ratio (LER) as described by Mead and Willey (1980)

$$LER = L_A + L_B = \frac{Y_A}{S_A} + \frac{Y_B}{S_B} \quad (1)$$

where L_A and L_B are the partial LERs of taro and cowpea, respectively, Y_A and Y_B are the intercrop yields of taro and cowpea, respectively, and S_A and S_B are their respective sole crop yields. Data were analyzed using analysis of variance (ANOVA) procedure of the (GenStat® 2007 and 2008). Thereafter, Fishers' protected t-test was used to separate means at the 5% level of significance (Payne *et al.*, 2007).

Results and Discussions

In both experimental sites the addition of vermicompost increased taro yield significantly ($P<0.05$) relative to wild mustard and control treatments in both the sole and intercrop systems (**Fig 1**). An advantage commonly claimed for intercropping systems of greater yield stability than sole cropping was observed when all treatments revealed above unity (1) values for land equivalent ratio (LER). Land use efficiency determined by LER was found to be highest (2.21) under vermicompost followed by (1.57) wild mustard and (1.46) control treatments thus suggesting that intercropping was more productive than sole cropping (**Fig 2**). Again, cowpea yield. Similar trend was also observed in cowpea yield where the addition of vermicompost significantly increased yield especially so with the second cowpea harvest (**Fig 3**).

Conclusions and Recommendations

These findings indicate that taro production may be improved significantly through farming system alteration combining intercropping, the use of a legume, as well as soil mineral improvement from living mulch and organic soil amendment with vermicompost. It is also concluded that vermicompost is capable of improving soil health and nutrient status, thus maintaining productive soils and higher yields. It is concluded that the taro production system by Umbumbulu farmers has indications of sustainability since their nutrient management

system is organically based and minimal soil disturbance is practised. Over and above the increased biodiversity as well as resilience of farmers' cropping systems, intercrops used – cowpeas and wild mustard ensured diversified household nutrition and food security. These results also supported a new way of thinking about local resources that is not only farming as a way of living but a livelihood with a potential for profit gains. Socially, the study provided a platform for experiential learning about the science of soil fertility and productivity to ensure livelihood sustainability. Subsistence agricultural activity was observed to be moving towards market focus for the majority of farmers in the community. It (study) also ensured that existing technologies are adapted rather than displaced to address local production challenges whilst preserving biodiversity and safeguarding technology ownership and uptake.

References

Atiyeh RM, Subler S, Edwards CA, Bachman G, Metzger JD, Shuster W. **2000**. Effects of vermicompost and compost on plant growth in horticultural container media and soil. *Pedobiologia* 44: 579-590.

Azam-Ali, S.N. **2010**. Fitting underutilised crops within research-poor environments: lessons and approaches. S. Afr. J. Plant & Soil 27:293-298.

da Silva, E.E., de Azevedo, P.H.S., Almeida, M.M.T.B., De-Polli, H. and Guerra, J. **2008**. Influence of intercropping and irrigation frequency in the leaf development and taro (Cocoyam) productivity under organic management. 16th IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008. Archived at http://orgprints.org/12595.

Mead R, Willey RW. **1980**. The concept of a land equivalent ratio and advantages in yield from intercropping. *Experimental Agriculture* 16: 217-218.

Mehta N, Karnwall A. **2013**. Solid waste improvement with the help of vermicompost and its applications in crop improvement. *Journal of Biology and Earth Sciences* 3: B8-B16.

Modi, A.T. **2003**. What do subsistence farmers know about indigenous crops and organic farming? Preliminary case in KwaZulu-Natal. Development Southern Africa 20:673-682.

Rivas R, Falcão HM, Ribeiro RV, Machado EC, Pimentel C, Santos MG. **2016**. Drought tolerance in cowpea species is driven by less sensitivity of leaf gas exchange to water deficit and rapid recovery of photosynthesis after rehydration. http://dx.doi.org/10.1016/jsajb 2015.08.008

IPCC, **2007**. Climate change: the physical science basis. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge. http://refhub.elsevier.com/S0254-6299(15)00392-0rf0175

Payne RW, Murray DA, Harding SA, Baird DB, Soutar DM. **2007**. GenStat for Windows® (10th Edition) Introduction. VSN International, Hemel Hempstead, UK.

Keywords: LER, living mulch, organic amendment, taro, underutilized crops

Table 1: Chemical analysis of earthworm vermicompost used

Cation elements (mg/kg)	**Anion elements (mg/kg)**
Ca (200) 100.44	Phosphate 11.42
Mg (100) 58.00	Nitrite (4.0) 30.64
Na (400) 133.53	Nitrate (44.0) 525.80
K (400) 1643.21	Sulphate (500) 200.90
	Bicarbonate 1439.60
	Chloride (250) 429.22

Figures in brackets are the recommended maximum values for human use in mg/kg